Canadian Open Fisheries and Aquaculture Journal
Vol. 1, No. 1, August 2014, pp. 1 - 12
Available online at http://crpub.com/Journals.php

Open Access

Research article

BIOACCUMULATION OF HEAVY METALS IN THREE DIFFERENT FISH SPECIES, WATER AND SEDIMENT OF SHAGARI EARTH DAM

I. MAGAWATA AND A.B. DAKIN-GARI

Department of Fisheries and Aquaculture, Faculty of Agriculture, Usmanu Danfodiyo University, PMB 2346, Sokoto.

E-mail address of the correspondence author: dantsafe@yahoo.com OR ibrahimmagawata@gmail.com
Phone number: +234 809 467 1044

ABSTRACT

The study was carried out in Shagari earth dam for the purpose of assessing the quality of fish, water, and sediment as it relates to heavy metals accumulation. The fish, water and sediments were collected on monthly basis (May – August) and analysed for heavy metals and proximate composition. The results of this investigation revealed that the concentration of lead (pb) was higher in *H. bebe occidentalis* (0.1247±0.0440) than in water and sediments but less than the acceptable limit recommended by WHO (2.0mg/l) and FEPA (2.0mg/l) in all the four months. The levels of cadmium were higher significantly ($P<.05$) in water (0.0403±0.0307) than in fish and sediment but less than the recommended level by WHO (0.05mg/l) and FEPA (0.05mg/l) respectively. The concentration of Copper (Cu) content was higher in sediment (0.0982±0.0873) than in fish and water but still less than the recommended rate by WHO (1.0mg/l) and FEPA (<1.0mg/l). On the basis of comparison, mean metals levels in fish, water and sediment from May-August with that of the recommended acceptable limits by WHO and FEPA indicated that, both the water, fish and sediment of Shagari earth dam were safe from heavy metals contamination and are therefore in good condition for human consumption and drinking, and other domestic uses. It is however recommended that regular investigations to at least once every year should be carried out to ascertain the safety of water, soil and the fish itself.

Keywords: Heavy metals, Fish, Macro Nutrients, Sediments and Water

INTRODUCTION

Fisheries occupy a unique position in the agricultural sector of the Nigerian economy, with fish contributing to about 40% of the animal's protein intake of the average Nigerian [6]. Eating of fish is known to provide many nutritional benefits to humans.

Apart from being a good source of protein, fish and fish products are known worldwide as a very important diet for human consumption, because of their nutritive quality and significance in improving human health, fish is known to contain omega-3-fatty acid that helps to reduce the risk of cardiovascular disease [14].

The uptake of heavy metals in fish was found to occur through absorption across the gills surface or through the gut wall tract [16]. The increasing importance of fish was as a source of protein and the interest in understanding the accumulation of heavy metals at the trophic level of the food chain, extend the focus toward fin fish [12]; [7]; [18].

The use of fish as bio indicator of metal pollution of aquatic environment and suitability for human use from toxicological view point has been documented [23]; [7]. All heavy metals are potentially harmful to most organisms at some levels of exposure and absorption [14]. At low concentration of many heavy metals including mercury, cadmium, lead, arsenic and copper inhibit photosynthesis and phytoplankton growth. Reference [5] reported delay in embryonic development, malformation and reduce growth of adult fish, mulluscs, and crustaceans under similar condition.

The River Gawon Gulbi is the major source of portable water to the surrounding villages. It is important not only for fisheries production, but also for agricultural activities. Similarly a large number of fishermen served along the river axis and depend on it for their source of livelihood. Some villages and town that are along the site of the river banks are Gamgam, Shagari Yarturmi, Gidan Zabarmawa, Tarkarmawa, Rugga Buda, Lambara, Doruwa, Gidan Baura, Illela da Bore, Gidan Ardo etc.

The presence of metals pollution in fresh water is known to disturb the balance of aquatic ecosystem and this has been noticed to manifest in the presence of irregularities in fish physiology as fishes tend to concentrate some metal in their body tissue. Thus heavy metals such as Pb, Cu, Zu, Cd, Ni, Cr and Hg are responsible not only regarding the water quality of a river or sea but for killing a number of water organisms [3].

Therefore, there is need to investigate the heavy metals concentration level such as Pb, CD, Zu, Cu and Mu in water, sediment and in some commercially important fish specie such as *Hyperopisus bebe occidentalis, Hydocynus forskalii* and *Synodontis clarias,* in the newly constructed dam. This would enable information/data acquisition that relate to the safely or otherwise of the aquatic organism exploited and consumed by the members of the immediate communities who constantly depend on the water body for drinking, irrigation and protein supply.

The main objective of this study is to assess the quality of the water in Shagari earth dam as it relates to the heavy metals accumulation. The specific objectives are:

1) To determine the levels of Pb, Cd, Cr, Cu, Zn, and some important minerals in the tissues of the three species of fish, water and sediment of the dam.
2) Evaluate the most susceptible heavy metals accumulation between fish tissue, water and sediments.
3) To analyze the proximate composition of the three species under study.

MATERIALS AND METHOD

Description of Study Area

This study was carried out in Shagari earth dam (formally known as Gawon Gulbi River) in Shagari Local Government Area. The area of study is located at latitude 12^0 and 13^0 North, latitude 3^0 and 5^0 East, south east of Sokoto city and 50km south from Sokoto city. Shagari falls into the typically tropical climate which has distinct wet and dry season [23].

The River Gawon Gulbi is usually filled to the capacity only during the rainy season. The flood plane is very wide (1000m) and farmers around the area grow varieties of crops both during the raining season. The source of water to the river are from Tureta through Jan-dutsi and Tafkoki villages run down to Kamba-sullubawa area at the eastern part of Shagari, flowing to North-west of Shagari metropolis where it is supported with some tributaries and streams from neighboring villages in which the river over flood during heavy torrential rainfall. The dam was constructed by federal government of Nigeria on the river Gawon Gulbi and was officially commissioned by his Excellency Chief Olusegun Obasanjo (GCFR) in 2005. The maximum height of the spill way is about 20 meters and extend up to 35km in the eastern direction. The dam was constructed basically of the purpose of fishing, irrigation and supply of drinking water to the peasants.

Sample and Sampling Techniques

Collection of Fish Sample

24 fish samples of three species were collected from three different fishermen at the landing sites on monthly basis (May-August 2012) that is six samples per month in river Gawon Gulbi Shagari Local Government. The fish samples were caught with gill net of different mesh size of 2" mesh, 2½", 3" mesh size inch. The fish sample were cleaned in flowing water to remove adhering dirt and then transported to the central laboratory Faculty of Agriculture, Usmanu Danfodiyo University, Sokoto.

Collection of Water Sample

Water samples were collected as described by [11]; water sample bottles were treated with 10% nitric acid and rinsed with distilled water before collection. [13]. 250ml plastic bottles of water sample were collected between 8-10m from the bank's in shallow part of the water with depth of 1.2 meters. The water samples were then transported to the above mentioned laboratory for further analysis.

Collection of Sediment Sample

Sediment samples were collected in the same place and at the same time where the above mentioned samples were collected. The sediment samples were collected in the polythene bags that has been already soaked in 10% HNO_3 and 1:1 HCI, following by rising with distilled water and then air dried immediately when transporting into the laboratory for analysis.

Heavy Metals Analysis

2 grams of each fish sample (muscles) were weighed using 500g weighing balanced into the micro kjeljdal flask, 8ml of prepared 80% concentrated nitric acid (HNO_3) and 2ml of 70% perchloric acid ($HCIO_4$) was added to the sample where the solution was then taken into kjeljdal chamber for digestion. The heating took about 15 minutes until the sample turned to orange golden colour immediately after digestion. The solution was then carefully filtered through a Millipore acid resistance membrane filter paper, and the sample was then collected into small plastic bottle/container washed with distilled water, and also distilled water was added into the sample in a glass measuring cylinder to a known volume of 50ml and poured back to container and preserved for heavy metals and trace dement analysis (Cr, Cd, Cu, Zn, Pb, Na, Mg, Ca, P, K).

50ml of each water sample were put into a washed air-dried kjeljdal flask tube, and 10ml of prepared 50% concentrated Nitric acid (HNO_3) was added for digestion. The sample was then filtered with the same procedure as already mentioned above, and preserved also for heavy metals and trace element determination.

The soil sediment were ground to powder and sieved through 2mm mesh screen to remove coarse materials. I gram of each sediment sample were weighed and put into the digestion tube where 8ml of nitric acid (HNO_3) were added to the samples for digestion and latter filtered immediately after digestion through filter paper, and then preserved for the above mentioned analysis.

Finally, these heavy metals and other trace elements were determined using AAS machine Atomic Absorption Spectrophotometer; AAS (Buck Model 210-VGP, 1992).

Proximate Analysis

All the proximate components; moisture, crude protein ash, ether extract were determined using the methods of [4] method of analysis.

Statistical Analysis

The data obtained were analyzed on the level of heavy metal concentration of fish, water, and sediments. Test of significance between the fish species, water and sediment was carried out. Using the analysis of variance (ANOVA) of the statistical Package for Social Science (SPSS) computer programme to analyse mean, standard deviation, least significant different (Lsd).

RESULTS

Concentration of Metals (PPM) and Macro Nutrients in Fish Muscle

Table 1 shows the mean concentration of heavy metals fish muscles. The mean concentration of lead is significantly higher ($P<0.05$) in *H. bebe occidentalis* (0.074±0.141) than in *S. clarias* (0.040±0.054) and *H. forskalii* (0.029±0.045).

There is no significance difference ($P>0.05$) of cadmium between the three species however, *H. bebe occidentalis* tended to have higher levels (0.012±0.02) while *S. clarias* had the least (0.003±0.003). The levels of chromium was not significantly different ($P>0.05$) between the species with *H. bebe occidentalis* having the highest concentration (0.021±0.014) while *H. forskalii* has chromium levels of 0.015±0.010. In terms of copper, there is no significance difference (P>0.05) between the species with *H. forskalii* (0.020±0.020) having the highest while *S. clarias* (0.015±0.014) having the least.

The mean concentration of zinc is not significantly higher (P>0.05) between the three species in which the levels ranges from 0.127±0.039) in *H. bebe occidentalis* to 0.092±0.018 in *S. clarias.*

The macro nutrients i.e calcium, magnesium, sodium, and potassium are not significantly different (P>0.05) between the species with *H. forkalii* having the highest content of calcium (0.093±0.023) and magnesium (0.135±0.070) while *H. bebe occidentalis* having the least of calcium (0.079±0.035) and *S. clarias* in magnesium (0.018±0.054). But in sodium *H. bebe occidentalis* have the highest concentration (69.37±19.81) while *H. forskalii* having the least content (64.37±16.39). In potassium *S. clarias* have highest content (729.1±368.1) while *H. forskalii* (682.8±235.0) have the least.

There is significance difference (P<0.05) of phosphorus between the three species with *H. forskalii* have the highest (4.862±1.782) while *S. clarias* having the least (3.68±0.450).

Mean Monthly Concentration of Metal (PPM) and Macro Nutrients in Fish Muscle

Table 1:

	Metals (ppm) (mg/L)							Percentage (%)		
Species	Pb	Cd	Cr	Cu	Zn	Ca	Mg	P	Na	K
H.B	0.074±0.141[b]	0.012±0.02[b]	0.021±0.014[a]	0.016±0.019[b]	0.127±0.039[a]	0.079±0.035[b]	0.122±0.043[a]	4.100±1.170[a]	69.37±19.81[a]	729.1±368.1[a]
S. Cl	0.044±0.054[bc]	0.003±0.003[b]	0.018±0.010[a]	0.015±0.014[b]	0.092±0.018[a]	0.087±0.025[b]	0.018±0.054[a]	3.68± 0.450[bc]	65.7± 22.6[a]	789.2±1072.2[a]
H.F	0.029±0.045[bc]	0.012±0.002[b]	0.015±0.010[a]	0.020±0.020[b]	0.097±0.040[a]	0.093±0.028[b]	0.135±0.070[a]	4.862± 1.782[a]	64.37± 16.39[a]	682.8±235.0[a]

Mean with same letter are not significantly different (P>0.05)

Table 2 shows the mean monthly concentration of heavy metals and macronutrients in water sample.

In May, the mean concentration of heavy metals in water was found to be significantly different (P<0.05) with chromium content having the highest (0.175±0.431) while cadmium having the least (0.042±0.030). In month June, there is significance difference (P<0.05) between the metals in water with chromium having the highest content (0.144±0.321) while lead having the least (0.015±0.031). In July, the level of chromium is highest (0.174±0.430) in water with lead having the least content (0.016±0.041). The concentration of chromium in water is higher (P>0,05) than the other elements in August.

Mean Monthly Concentration of Heavy Metals and Macro Nutrient in Water Sample

Table 2:

	Metals (ppm) (mg/L)							Percentage (%)		
Months	Pb	Cd	Cr	Cu	Zn	Ca	Mg	P	Na	K
May	0.070±0.042[c]	0.042±0.030[a]	0.175±0.431[a]	0.045±0.068[b]	0.083±0.029[a]	0.289±0.381[a]	0.169±0.390[a]	3.944±0.267[b]	0.094±0.065[b]	0.316±0.262[b]
June	0.015±0.031[c]	0.022±0.020[c]	0.114±0.321[a]	0.042±0.046[bc]	0.062±0.018[b]	0.245±0.321[bc]	0.147±0.370[c]	4.244±0.467[a]	0.081±0.054[c]	0.304±0.220[b]
July	0.016±0.041[c]	0.041±0.030[bc]	0.174±0.430[a]	0.043±0.057[bc]	0.082±0.026[b]	0.267±0.350[bc]	0.168±0.370[c]	3.841±0.277[a]	0.095±0.066[c]	0.314±0.261[b]
Aug	0.016±0.040[c]	0.040±0.030[b]	0.155±0.421[a]	0.033±0.046[bc]	0.023±0.018[c]	0.247±0.361[b]	0.159±0.370[bc]	2.744±1.167[a]	0.083±0.054[c]	0.216±0.182[b]

Mean with same letter are not significantly different (P>0.05)

Table 3 shows the mean monthly concentration of heavy metals and macro nutrients in sediment. There is significance difference (P<0.05) in May between the heavy metals found in sediment with chromium having the highest concentration (0.168±0.371) while cadmium had the least (0.009±0.002). The mean concentration of heavy metals in sediment was significantly different (P<0.05) between the elements in June with chromium having the highest mean (0.148±0.331) while cadmium was the least (0.007±0.001). In July and August, the levels of chromium was also found to be highest (P<0.05) than the other elements.

However, in macronutrients the levels of potassium was found to have the highest concentration (P<0.05) than the other nutrients throughout the months.

Mean Monthly Concentration of Heavy Metals (ppm) and Macronutrients in Sediment

Table 3:

	Metals (ppm) (mg/L)							Percentage (%)		
Months	Pb	Cd	Cr	Cu	Zn	Ca	Mg	P	Na	K
May	0.124±0 .044^{a}	0.009±0 .002^{b}	0.168±0 .371^{a}	0.098±0 .087^{a}	0.113±0 .153^{a}	0.104±0 .170^{d}	0.099±0 .035^{c}	3.331±0 .284^{c}	5.625±2 .477^{b}	9.377±7 .197^{a}
June	0.114±0 .024^{b}	0.007±0 .001^{c}	0.148±0 .331^{a}	0.078±0 .056^{c}	0.103±0 .123^{bc}	0.101±0 .150^{d}	0.079±0 .025^{c}	2.331± 0.184^{c}	4.625± 1.477^{b}	7.377±5 .187^{a}
July	0.123±0 .034^{b}	0.008±0 .002^{c}	0.166±0 .361^{a}	0.095±0 .086^{c}	0.112±0 .143^{bc}	0.103±0 .160^{d}	0.098±0 .034^{c}	3.330± 0.274^{c}	5.624± 2.476^{b}	9.357±7 .175^{a}
Aug	0.104±0 .021^{b}	0.005±0 .001^{c}	0.128±0 .281^{a}	0.068±0 .047^{c}	0.102±0 .122^{b}	0.102±0 .160^{d}	0.087±0 .026^{c}	2.331± 0.242^{c}	4.425± 1.277^{b}	6.352±3 .172^{a}

Mean with same letter are not significantly different (P>0.05)

Proximate Composition of Some Fish Species in Shagari Earth Dam

Table 4:

Fish	Moisture (%)	Ash (%)	C.P (%)	EE (%)	NFE (%)
H. bebe	68.04^{a}	2.47^{a}	17.10^{b}	6.24^{a}	6.35^{b}
S. Clarias	63.26^{c}	2.83^{a}	18.89^{a}	5.05^{b}	9.05^{a}
H. foskalii	66.45^{b}	2.38^{a}	16.15^{c}	5.77^{b}	9.04^{a}

Means with the same letter are not significance (P>0.05)

CP = crude protein, EE = Ether extract, NFE = Nitrogen free extract

In this study, the moisture content among the species were significantly different (P<0.05) with *Hyperopisus bebe occidentalis* having the highest (68.04%) while *Synodontis clarias* having the least (63.26%). There is no significance difference (P>0.05) between the Ash of all the species. The table indicates that the crude protein content of the species differs significantly (P<0.05) between *S. clarias* on the other hand and *H. bebe occidentalis* and *H. forskalii* on the other.

Similarly, there is significance difference (P>0.05) of EE between species with *H. bebe occidentalis* having the highest (6.24) while *S. clarias* had the least (5.05) on the other hand the levels of NFE is higher (P<0.05) in *S. clarias* and *H. forskalii* than in *H. bebe occidentalis.*

DISCUSSION

The process whereby an organism concentrates metals in its body from the surrounding medium or food, either by absorption or ingestion is known as bioaccumulation [10]; [17].

The levels of heavy metals (pb) recorded in the present investigation in May, June, July and August was higher in fish than in sediment and water indicating bioaccumulation. This agree with the work of [17]; [18] who reported that lead and Nickel presence at high concentration in their study areas could be related to industrial and other technical uses most at which are: electric storage batteries, petroleum refining catalysts, chemical pigment and alloy production, leachate from refining sludge lagoon containing Nickel-cadmium batteries and Nickel plate items.

The concentration of cadmium in water in May, June, July and August was higher than the levels in fish and sediments as a result of rock weathering soil erosion, inflow of herbicides, pesticides, household wastes such as paints, which support the earlier findings of [8]; [17] in view of the fact that the major source of water in his study area is fishing and domestic, the concentration levels of cadmium recorded exceeded that recommended value by WHO for aquatic ecosystem, therefore it is of great concern since cadmium is extremely toxic and the consumption of water high in cadmium could cause adverse health effect to end users, since cadmium has been found to be toxic in fish and other aquatic organism.

The levels of copper in sediment in May, June, July and August was higher than the concentration in fish and water as a result of dumping of some woody materials treated with chemicals, Agricultural activities which correlate with the work/findings or [19] who worked on seasonal variation of heavy metals distribution in the sediments of major dams in Ekiti State with value ranges of 0.0025 – 0.013.

However, the levels of macronutrient calcium (Ca) recorded in this investigation in May, June, July and August is higher in water than in fish and sediments as a result of weathering of rocks, mineral supplement e.g limestone ($CaC0_3$) dumping at animal bones in the water which support the work of [who says the levels of calcium in the water influence in uptake of the calcium from the food and vice-vasa.

The concentration of phosphorus, sodium and potassium in May, June, July and August is higher in fish than in water and sediments due to accumulation of benthic particles by fish which composed of these nutrient. Other source of phosphorus, sodium and potassium in water is dumping of animal by-products, grass, hay and straws around the water body and other human activities and sewage.

Conclusion

The result of this investigation/research based on the comparison of mean metals level in fish, water and sediments of Shagari earth dam with that of WHO and FEPA recommended ranges shows that both the fish, water and sediment of the river are safe from heavy metals contamination and are therefore, in good condition for human consumption and also has no harmful effect to the people living around the area who use the water body as their source of livelihood.

Recommendations

The following recommendations are pertinent if adequate care is to be provided for safe water and fish of the water body:

- Regular determination of heavy metals concentration should be made to ascertain the levels of accumulation and subsequent checks that can be adopted to reduce the effect
- Enlightenment campaign should be made to alert the public through various media, traditional councils at the grass root concerning the impending dangers of indiscriminate oils, slaughter houses, agricultural activities domestic dumps and effluent discharge from neighboring villages around the water body either directly or indirectly.

REFERENCES

[1] Ajayiso, Osibanjo, O. (1981). Pollution studies in Nigeria Rivers, water quality of some Nigeria rivers. Environ Pollution (Series B) 2: 87-95

[2] Amao, J.O., I.B Oluwatayo and F.K. Osuntope (2006). Economics of fish demand in Lagos State, Nigeria; Department of Agricultural economic, University of Ibadan, Ibadan, Nigeria. J. Hum. Ecl. 19(1):25-30.

[3] Ayodele, J.T and Abubakar M. (2001): Chromium and copper in water, sediment and their bioaccumulation by fresh water Bivalve in Tiga Lake, Kano – Nigeria Journal of Environ. Scis, 5(1) 172 – 34

[4] AOAC (2002). Official Methods of Analysis. (17th Ed) Association of Official Analytical Chemists. Arnington Wshington D.C. 1040p

[5] Baney, C.A., Amuzu, A.T., Calamari, D., Kaba, N., Naeva H., Sana MAH (1991). Review of heavy metals in the African Aquatic Environment. Ecotoxical Environ. Sat. 8:134-159: F.A.O. Fish Rep. (471) 17-43

[6] Dada, B.F. and A.S. Cananadoss (1983). Nigerian fresh water development-challenge opportunities of the 1980 S. in: Processing of the 3rd annual conference of the FISON (1983). Pp 14-24.

[7] Deb S.C. and Sentra, S.C. (1997). Bioaccumulation of heavy metals in fishes. An in viro experimental study of sewage feel Ecosyste, The environmentalist 17:27-32.

[8] DWAF (1996). South Africa water quality guideline Vol. 7: Aquatic ecosystem, 1st Cdn department of water affair and forestry.

[9] Forstner, U and G.T.W. Wittmann, 1979. Metal pollution in the aquatic environment, Berlin, Springer-verley.

[10] Forstner, U. Wittman GTW (1981). Metals pollution in the Aquatic Environment Spring-Varley, Bercil Heidelberg, New York. P. 486.

[11] Gregg, L.W. (1989). Water Analysis Handbook, H.A. C.H. Company USA pp 33-39.

[12] Greig, R.A. Wenzloof DR, MCkenzit cl, merill AS, Zda nowiles Vc (1978). Trace metals in the sea scallops pace leaden magelanicus from eastern united state. Bull. Environ, contam. Toxicol. 19:326-334.

[13] Laxen D.P.H. Harrison, R.M. (1981). A. Scheme for the physiological specification of fish sample science Tot environ. 19:59 – 82.

[14] Laverchia, Chatenolid, L. Altear: A and Talvani A. (2001) and CArkovascular disease in Italy, Mutri, metabol cardiou, Dis, 11:10-15

[15] Lloyd, R. (1992). Pollution and Freshwater fish. Ministry of Agriculture. Fishing News Books. UK

[16] Mathis BJ, Cummings T.F (1973).Selected Metals in sediments, water and biota in the Illinois River. J. wat. Pollunt, Cont. Fed., 45:1573-1583.

[17] Marian E. (1991). Metals and their compound in the environment occurrence analyses and biological relevance UCH, Wentrein-New York.

[18] Obasnohan EE, Oroanye JAO (2004). Bioaccumulation of heavy metal by some C, child's from ogba river, Benin City Nigeria. Niger Ann. Mat. Sci 5(2): 11-27.

[19] Olojo, AAA, Olurin, KB, Mbaka, G and Oluwami MO (2004). African journal of Biotechnology. 4 (1) 117-122

[20] Robison's J. (1996). Evaluation of a health assessment index with reference to bioaccumulation of metal in oreochromis massambicus (Peter 1852).

[21] Suzuki K.T. Sunaga, H. Ako, Y., Harakeyama, S., Sumi, Yana Suzuki, T., 1988. Binding of cadmium and copper in the may fly baetis termicus larvae that inhibu in a river polyted with heavy metals. Conp. Biochem. Physiol. 91C: 487-492.

[22] Udeti, S.S. (2003). From Guinea worm scourge to metals toxicity in Ebonyi State, Chemistry in Nigeria as the New Mulunium unifolds 2(2): 13014.

[23] Udo, R.K (1978). Geographical Region of Nigeria Hernemann Educational books Ltd London.