BIO-ACCUMULATION OF HEAVY METALS IN FIVE FISH SPECIES IN THE LOWER NIGER RIVER AT ILLAH, DELTA STATE.

***EKELEMU, J.K., AND K.O. OKORO**
Department of Fisheries, Delta State University, Abraka
***Corresponding Author**: ekelemujerimoth@gmail.com.

Abstract
The bio-accumulation of heavy metals in the muscles, gills, liver, and gonads of five fish species sampled from River Niger at Illah, were determined, using the atomic absorption spectrophotometer (AAS). Data collected were analyzed using the bio-accumulation Quotient, Transfer Factor, Analysis of Variance and LSD at 5% probability. Nine heavy metals namely Copper (Cu), Nickel (Ni), Cobalt (Co), Chromium (Cr), Lead (Pb), Cadmium (Cd), Iron (Fe), Zinc (Zn), and Manganese (Mn)) were detected. There was a significant difference ($P < 0.05$) in the concentrations amongst the different organs. The order of accumulation in the organs was: liver > gonads > gills > muscles, except for Zinc, which had the order liver > gills >gonads > muscles. Generally, the order of accumulation was Zn > Fe >Mn> Ni > Cu > Cr > Co >Pb> Cd. The most accumulated metal was iron, while the least was Cadmium. Accumulation in all the organs combined were significantly different ($P < 0.05$). The values recorded were higher than the WHO acceptable limits showing the river at Illah to be under stress, polluted, and fishes contaminated with heavy metals.
Key Words: Accumulation, pollution, limit, organs, fish, River Niger.

INTRODUCTION

Pollution is defined as the introduction of substances into an environment in greater amounts than the natural conditions in the environment, deleteriously affecting it and the organisms present in it. The destructive influence of man on the aquatic environment due to the discharge of pollutants is resulting in chronic stress conditions, with the attendant negative effects on aquatic life. Following the astronomic population growth, the danger of rivers being reduced to sewage dumps with pollutants that could harm fish and other aquatic life before getting to man for consumption spells great danger for a healthy nation (Idodo-Umeh, 2005). Already the increased industrialization, growing human population and oil exploration amongst other factors have been implicated as man-made pollutants in the aquatic environment and these have subjected it to ecological degradation (Giguere *et. al.*, 2004; Gupta *et al*., 2009).

On the whole, gross pollution of water bodies does obvious harm to the environment through rendering the waters uninhabitable for fish and interfering with the life cycle of numerous aquatic organisms. It is now increasingly clear that, a great deal of the pollutants do not simply end in the sea as was earlier believed. Anthropogenic activities and discharge of wastes into our inland and coastal waters, has continuously increased the amount of heavy metals in the aquatic ecosystem. Consequently, the levels of these heavy metals in aquatic ecosystem are increasing at an alarming rate, and has become an important global problem (Malik *et al*, 2010). Many potentially toxic heavy metals and organochlorides accumulate in the sediments where they may remain inert or be absorbed by living organisms; especially when these heavy metals are bio-accumulated in fish or other aquatic organisms used as food. The concentration-effect by these species is the main cause of concern as both heavy metals and the organochloride may build up within an organism to the extent that, an individual eating it maybe seriously harmed. For example, mercury accumulates in fish as methyl-mercury, arsenic is concentrated in shellfish, and cadmium and manganese are concentrated in various marine organisms while polychlorinated-biphenyls are concentrated in fish (Idodo-Umeh, 2005). Heavy metal presence in water is capable of disturbing the balance in the aquatic ecosystem, which could ultimately affect the physiological state of fish as they bio-accumulate these metals within their body parts (Amoo, *et al.*, 2015). The ability of fish to bio-accumulate heavy metals is often utilized in monitoring the pollution status of water bodies because they are very sensitive to changes in the aquatic environment (Mondon, *et al*., 2001). Although some of these heavy metals which are bio-accumulated are essential elements, they are potentially toxic when accumulated beyond permissible limits because they are persistent, non-degradable and have the potential to cause harm (Storeli*et al*., 2005)

Artisanal fishing is a major activity along the River Niger with a high likelihood of harvesting fishes contaminated with heavy metals that could portend health hazards if consumed. Monitoring the bioaccumulation status of fish in pursuit of food consumption safety, and regulation of the activities around river ecosystems are very important. The aim of this study, therefore, was to ascertain the heavy metal levels in some common fish species in the lower Niger River at Illah, Delta State, Nigeria.

Materials and Method

Study Area

This study was conducted in River Niger at Illah. Illah is a small agrarian community in Oshimilli North Local Government Area of Delta State, Nigeria, where artisanal fishing is practiced. It is situated on the west bank of the lower River Niger. The town is about 31Km from Asaba metropolis and lies between longitude $6^{0}39^{1'}$ – $6^{0}65^{1'}$E and latitude $6^{0}25^{1'}$ -$6^{0}42^{1'}$N of the equator. Three stations: (upstream, midstream and downstream), 500m apart were delineated and used as sampling sites for the study.

Sampling Procedure

Samples of water and sediment were collected monthly between the hours of 7.00 to 10.00am on sampling days and used for determination of heavy metal, using standard methods as described by Adams *et al*, (1980) and APHA, (1989).

Fish samples were collected on sampling days from the three Stations in the study area with the help of fishers for twelve (12) months (January, 2016toDecember, 2016). The fish samples were transported in ice chests to the laboratory. In the laboratory, they were thawed, sorted and identified using the keys according to Idodo-Umeh (2003).

Sample preparation

Five most common fishes in the catches were used for the study. The fish samples were dissected, to remove the dorsal muscles, gills, liver, and gonads. The wet weight of these organs were taken to the nearest 0.01g. They were later oven-dried at a temperature of 70.0 ºC and the dry weight taken to the nearest 0.01g.

Fish organs were digested according to Sreedevi *et al* (1992). The solution was filtered through a Whatman filter paper (No. 42) into a 50ml volumetric flask and analyzed for heavy metal using the Atomic Absorption Spectrophotometer (AAS).

Table 1: Checklist of Fish samples used for the Study.

1. Family: Claroteide
   Genus: *Chrysichthys* (Bleeker, 1858)
   Species: *nigrodigitatus*. (Lacepede, 1803)
   Common name: Silver catfish (Ugani)

2. Family: Mocholddae
   Genus: *Synodontis* (Cuvier, 1817)
   Species: *clarias* (Linnaeus, 1766)
   Common name: Upside-down catfish (Okpo-apetei)

3. Family: Citharinidae
   Genus'.*Citharinus* (Cuvier 1817)
   Species: *citharus* (Geoffrey St Flilaire, 1809)
   Common name: Moonfish (Ifulu)

4. Family: Clariidae
   Genus: *Clarias* (Scopoli, 1777)
   Species: *gariepinus* (Burchell, 1822)
   Common name: Sharptooth catfish or Mudfish (Echim)

5. Family: Cichlidae
   Genus: *Oreochromis* (Gunther, 1889)
   Species: *niloticus* (Linnaeus, 1758)
   Common name: Tilapia (Egwu)

Determination of Bio-accumulation Quotient (BQ)

The bio-accumulation quotient (BQ) which expresses the ability of fish to accumulate heavy metals above the abiotic environment was determined using the equation according to Adams *et al.* (1980) and Fodeke*et al* (1989) thus

$$BQ = \frac{\text{Metals in Fish or Fish Organs}}{\text{Metals in Water}}$$

Transfer factor (TF) in fish tissues from the aquatic ecosystem (water and bottom sediment) was determined according to Kalfakakour and Akrida-Demertizi (2000) and Rasheed (2001) as follows:

$$TF = \frac{\text{Metal concentration in fish organ or tissue}}{\text{Metal concentration in water or sediment}}$$

Statistical Analysis

Data collected were analyzed using Analysis of Variance (ANOVA) and the mean separated using the least significant difference (LSD) at 5 % level of probability (Statistical Analysis System, 2010)

Results

Five of the most dominant fish species sampled were used for the study. A checklist of these fish species are presented in Table 1. Fish diversity in the study area was low.

The heavy metal concentrations in fish organs from the study area are presented in Table 2.

The results revealed that, there were significant differences ($P < 0.05$) in the concentrations of heavy metals amongst the organs; liver, gonads, gills, and muscles assayed. The concentrations of heavy metals accumulated in the fish samples were highest in the liver and least in the muscles.

The transfer factors in different organs from the sediments and water column are shown in Table 3

The results showed that, the transfer factors of water was greater than sediments. All the transfer factors of the heavy metals with respect to water were greater than one (>l) while some of those of sediments were less than one (<l); and though some transfer factors were not less than one (<l), they were much less than the transfer factors of water in all the organs except in the case of the transfer factors of Cobalt (Co) from the sediments to the different organs.

The Results of the bioaccumulation quotient (BQ) of the heavy metals as determined in the fish species are presented in Table 4. Zinc had the highest value of 5500, while manganese with a value of 14, was the least. The mean bio-accumulation values of the different heavy metals in each of the fish species are presented in Table 5. *Clarias gariepinus* and *Synodontis clarias* bio-accumulated the heavy metals more than the other fishes.

DISCUSSION

The results of this study have shown that, all the fish samples assayed were contaminated by one or more of the heavy metals. The liver had the highest concentration of all the metals compared to gonads and gills, while the muscles had the least. This was in line with the study of Opaluwa *et al*. (2012), on heavy metals in water, fish, and sediments of Uke stream. This showed that, the liver had higher bio-accumulation of heavy metals than the gonads, gills, and muscles respectively. This study has shown that, the fish species assayed accumulated heavy metals more from the waters. This was supported by the work of Ekpo, *et al.* (2008), on some fish species from Ikpoba River, with accumulation patterns of heavy metal contaminants that depended on the uptake rates from the environment. The high levels of accumulation of the heavy metals in the excised fish organs were indications of the pollution state of the water in the study area.

The mean concentration of Cr in the different fish organs (liver > gonad > gill > muscles) were 3.42mg/kg, 3,26mg/kg, 1.73mg/kg and 1.19mg/kg respectively. This same pattern was observed for all the other metals except for Zinc, where the gills accumulated more than the gonads. The results showed that, the accumulation of heavy metals was highest in the liver compared to the other organs studied. This was supported by the report of Eitokpah *et al*., (2018), who stated the order of accumulation of heavy metals in fish species to be Liver > gonad > gills, in their study of heavy metal concentrations in *Clarias agboyiensis* and *Synodontis clarias* in Epe and Lekki Lagoons. The Liver concentrated the highest values of all the heavy metals in the order of Fe > Zn > Mn > Cu > Ni > Co > Cr > Pb> Cd. This was contrary to the findings of Opaluwa *et al.* (2012), who reported that, Zinc was the highest bio-accumulated heavy metal in their study on the assessment of heavy metal bio-accumulation in parts of two fish species in Uke River. Zn was concentrated the most in all the fish tissues, among the heavy metals analyzed. This result was supported by the findings of Amoo *et al*. (2015), Horsfall *et al*. (1998) and Sadik (1990), who respectively worked on heavy metals in fish from Lake Kainji, Mudskippers in mangrove swamp and Nigeria marine fishes respectively. The mean concentrations of Zn were 137.32mg/kg, 76.52mg/kg, 76.57mg/kg and 34.38mg/kg in liver, gonad, gills, and muscles respectively. On the whole, except for Zn, all the other heavy metals studied were concentrated in the organs in the order Liver > Gonad > Gill > Muscles. Generally, the order of heavy metal concentrations in the different fish organs was: Zn > Fe > Mn > Ni > Cu > Cr > Co > Pb> Cd.

From the results, the BQ values for Zn, Cd, and Fe had the highest levels of 5500, 4312 and 271 respectively while others were Cr (175), Pb (150), Ni (22), Co (24), Co (88) and Cu (17). The least mean bio-accumulation quotient of 14 was recorded for Mn. The rank profile was: Zn > Cd > Fe > Cr >Pb> Co >Ni >Cu >Mn. The mean bio-accumulation quotient (BQ) determined did not follow the same pattern with the heavy metal concentrations in fishes sampled. Cadmium which was the least bio-accumulated surprisingly had a high BQ, second to Zinc in ranking. The pollution status of the river may be responsible for the high concentrations of some of these heavy metals in the fish tissues studied. Apart from this, the high levels of some of these metals could be due to the roles they play in the physiology of the fish. For example, zinc (Zn) and Copper (Cu) are essential mineral elements absorbed by fishes, because of their role in enzymatic activity. Iron (Fe) is also important because it helps in haemoglobin formation in the blood. The low mean concentrations of Lead (Pb) and Cadmium (Cd) 0.21 mg/Kg and 0.430 mg/Kg respectively, recorded in this study could be due to the fishes adapting to a low tendency of bio-accumulating them or have developed a good ability to excrete them from their body systems. This view is in line with the studies conducted by Amoo *et al.* (2015).

The study revealed that all five fish species sampled, bio-accumulated Zinc at concentrations above WHO (1984) acceptable limit for consumption. The range of bio-accumulation was 20.68 – 357.45mg/Kg, compared to the WHO value of 10mg/Kg. *Clarias.gariepinus* and *Synodontis clarias* were the most contaminated fishes as they bio-accumulated all the nine heavy metals identified in the study, Bio-accumulation of Cadmium, Copper, Manganesse, Nickel and chromium in all the fish specimen studied were within the WHO acceptable limits.

The study revealed that the transfer factors of all the heavy metals in fish from the water of lower River Niger were greater than one (>1) in this study and this meant that, the fish bio-accumulated these heavy metals from the water. This agreed with the findings obtained in Hanifar water by Kalfakakour and Akrida-Demertzi (2000) and Rashed (2001).

CONCLUSION

Concentration Zinc, iron, Cobalt and Lead, out of the nine heavy metals recorded for all fish tissues in the study area were above the WHO (1984) acceptable limits for consumption and so constitutes public health concern. However, to mitigate this problem, consumers of fish should concentrate on eating the muscles which is less contaminated. This notwithstanding, there is a need for regular monitoring of effluents and wastes discharged into the river as well as, the levels of heavy metal concentrations in fishes of the Lower River Niger to prevent consumption of contaminated fishes

REFERENCE

Adams, T.G., Archison, G.A. and Vetter, R.J. (1980). The Impact of Industrially Contaminated Lake on Heavy Metal Levels in its Effluents Stream. *Hydrobiologia,*69 (1 – 2): 187 – 193.

Amoo, L.A., Adebayo, O.T.andLateef, A.J. (2000). Evaluation of heavy metals in fishes, water and sediments of Lake Kainji, *Nigeria Journal of Food, Agriculture, and Environment*, Vol 3(1): 209 – 212

APHA [American Public Health Association] (1989).“Standard Methods for the Examination of water and wastewater” Edited by Lenore S. Clesceri, Arnold, E., Greenberg and R. Rhodes Trusseli. 17th Edition 3144 pp

Ekpo, K.E., Asia, I.O., Amayo, K.O. and Jegede, D.A. (2008). Determination of Lead, Cadmium, and Mercury in Surrounding water and Organ of some Species of Fish from Ikpoba River, Benin City, Nigeria *International Journal of Physical Science, Vol. 3 (11): 289 – 292*

Eitokpah, E. P., Chukwu, L O., Lawal – Are, A. O. and Bassey, O. B. (2018). Assessment of Heavy Metal Pollution in *Clariasagboyiensis* and *Synodontisclarias*inEpe and Lekki Lagoons, Nigeria. *Nigerian Journal of Fisheries*Vol 15(1): 1359 - 1364

Fodeke, V.A.A., Ekundayo, J.A. and Fisher, K.J. (1989). Studies of the Heavy Metal Contamination of *Sarotherodonmelanotheron*(Rupple) from two sites of the Lagos Lagoon. *Nigeria Journal of Natural Science,* 4(1 & 2): 99 – 104

Giguere, A., Campbell, P.G.C., Hare, L, Mcdonald, D.G., and Rasmussen, J.B (2004). Influence of Lake Chemistry and Fish Age on Cadmium, Copper and Zinc Concentrations Iin Various Organs of Indigenous Yellow Perch (*Percaflavescens*) *Canadian Journal of Fisheries and Aquatic Science,* 61: 702 – 716.

Gupta, A., Pandey, D.K. and Sharma, B. (2009). Analysis of Some Heavy Metals in the riverine Water, Sediments and Fish from River Ganges at Allahabad. *Environmental Monitoring Assessment,* 157: 449 - 458.

Horsfall, D., Blackers, J., Hifferman, L., Ryman, N., Smith, M. and Waterford, M. (1999). *Doing Community Differently: Ordinary Resistances and New Alliances*. Paper presented at Communities, Identities, and inadequacies in Western Sydney Conference, University of Sydney. 45pp.

Idodo-Umeh, G. (2003) Freshwater Fishes of Nigeria. (Taxonomy, Ecological Notes, Diets, and Utilization) Idodo-Umeh Publishers, Nigeria. 232 pp

Idodo-Umeh, G. (2005) Heavy Metal and Petroleum Hydrocarbons of River of Areba: Effects on fish Community and Human Health. Paper presented in a Seminar organized by the Ministry of Environment, Delta State Asaba. 35pp.

Kalfakakon, V. and Akrida-Demertzi, K.(2009) Transfer Factors Heavy Metals in Aquatic Organisms of Different Trophic Level In HTML Publications. 1:768 – 786

Malik, N., Biswas, A.K., Qureshi, T.A., Borana, K. and Virha, R. (2010) Bio-accumulation of Heavy Metals in Fish Tissues of a Freshwater Lake of Bhopal. *Environmental Monitoring Assessment,* 160: 257 – 267

Mondon, J. A., Duda, S. and Nowak, B. F. (2001). Fish as a bio-indicator species. *Aquat. Toxicol*, 54: 231 - 247.

Opaluwa, O.O, Aremu, M.O., Ogbo, L.O., Magaji, J.I., Odiba, I.E. andEkpo, E.R. (2012) Assessment of Heavy Metals in Water, Fish and Sediments from UKE Stream, Nasarawa State, Nigeria. *Current World Environmental*,Vol. 7(2): 213 – 220

Rasheed, M.N. (2001). Monitoring of Environmental Heavy Metals in Fish from Nasser Lake. *Environmental International*,27: 27 – 33

Sadik, O.A. 1990. Heavy metal contaminants in some Nigerian marine fishes of commercial importance National Institute for Oceanography and Marine Research, Lagos. NIOMR Technical Paper No. 63

Statistical Analysis System (2010), SAS User’s Guide. Statistics Version 5, SAS Institute Inc.Raleigh, North Carolina, USA. 956 pp

Storeli, M. M., Storeli, A.., D'ddabbo, R.., Marano, C., Bruno, R., and Marcotrogiano, G.O. (2005) Trace elements in loggerhead turtles (*Carettacaretta*) from the eastern Mediterranean sea. Overview and evaluation, *Environ. Pollution*, 135: 163 – 170.

Sreedevi,P., Suresh, A., Siraramakrishna, B., Prebhavathi, B. and Radhakrishnaiah, K. (1992) Bio-accumulation of Nickel in the Organs of the Freshwater Fish, *Cyprinuscarpio* and the Freshwater Mussel *Lamelhdens marginalis* under Lethal and Sub-lethal Nickel Stress. *Chemosphere* 24 (1): 29 – 36

World Health Organization (1984) Guidelines for Drinking Water Quality, Health Criteria, and Other Supporting Information. *Recommendations. WHO Geneva Vol. 1: 130 pp*

Table 2: Mean Heavy Metal Concentration in Some Organs of fish Sampled

Fish Organs	**Concentration of Heavy Metals** (mg/kg)								
	Cr	**Mn**	**Fe**	Co	Ni	Cu	Zn	Pb	Cd
Liver	3.42	6.18	171.9	4.36	5.12	5.92	137.32	2.03	0.052
Gonad	3.26	5.26	48.7	2.48	3.57	3.61	76.52	1.15	0.037
Gill	1.73	5.10	28.8	1.43	3.50	2.29	76.57	0.93	0.022
Muscle	1.19	0.93	15.8	1.17	1.81	2.02	34.38	0.76	0.007
L.S.D (0.05)	0.41	1.11	9.12	0.28	0.85	1.14	10.20	0.21	0.430

Table 3: Transfer factors of Heavy Metals from the environment to Fish organs.

Parameter	Cr	Mn	Fe	Co	Ni	Cu	Zn	Pb	Cd
Water/Liver	342	25.75	175.41	11.21	13.13	15.18	490.43	203	390
Sediment/Liver	10.06	1.11	4.87	71	0.80	0.93	28.37	29	48.75
Water/Gonad	3.26	21.92	49.6	6.53	9.16	9.26	273.29	115	260
Sediment/Gonad	9.59	0.94	1.38	41.33	0.55	0.56	15.80	16.42	32.50
Water/Gills	173.0	21.25	29.38	3.76	8.97	5.87	273.46	93.00	160
Sediment/Gills	5.08	0.91	0.81	23.83	0.55	0.36	15.82	10.86	13.75
Water/Muscles	119	3.88	16.12	3.08	4.64	5.18	122.79	76.00	110.00
Sediment/Muscles	3.5	0.17	0.45	19.5	0.29	0.32	7.10	10.86	13.75

Table 4: Mean Bio-accumulation Quotients of the Metals Studied

Metals	**Mean BQ**
Zn	5500
Fe	271
Cr	175
Pb	150
Cu	17
Mn	14
Cd	4312
Co	24.88

Table 5: Bio-accumulation of Heavy Metal in Fish Samples in the Study area (mg/Kg)

Fish species Assayed	Zn	Cd	Cu	Fe	Mn	Co	Ni	Pb	Cr
Citharinus citharus	20.687	-	1.950	389.134	4.992	37.220	4.006	5.783	0.913
Clarias gariepinus	1.33.296	0.333	19.677	364.999	15.812	12.560	12.985	5.584	2.695
Synodontis clarias	89.052	0.648	4.135	202.305	4.286	3.359	10.115	6.442	3.159
Oreochromis niloticus	357.448	0.620	7.493	187.565	18.962	0.775	-	1.151	1.940
Chrysichthys nigrodigitatus	45.033	-	2.373	131.529	6.527	16.099	2.936	0.995	1.191
WHO limit	10.000	20.0	200.0	300.0	50.0	2.0	80.0	1.5	13.0