INTERNATIONAL JOURNAL OF
INNOVATIVE RESEARCH & DEVELOPMENT

ISSN: 2278 – 0211 (Online)

Bio-Accumulation Of Heavy Metal In Silver Catfish Chrysichthys Nigrodigitatus, Tilapia Zillii And Macrobrachium Macrobrachion Caught In Badagry Creek, Lagos Nigeria

Aderinola, OJ
Department of Zoology, Faculty of Science, Lagos State University, Ojo
Kusemiju, V
Department of Zoology, Faculty of Science, Lagos State University, Ojo
Clarke, E.O
Department of Fisheries, Faculty of Science Lagos State University, Ojo
Olarinmoye OM
Department of Fisheries, Faculty of Science Lagos State University, Ojo

Abstract:

The people of Lagos state depends on fishes and other aquatic products for their source of protein. Thus, the need to verify the safety of the fishes for consumption by the people. The sampling, handling and process were as directed by American Public Health Association (APHA).The species checklist indicated that the Bagrids, Chrysicthys nigrodigitatus; Cichlids, Tilapia zillii and fresh water prawn of genus Macrobrachium were the dominant fin and shell fish species in the Creek.

Results of the analysis of trace metals in the organs of Tilapia zillii indicated that the metals were differentially accumulated in different organs of the fish. In the tissue, the orders of accumulation were gills (52.360±25.964 Fe), Gut (2.180±0.480 Zn), Gills (0.300±0.056 Mn), Bone (0.091±0.125 Pb), Bone, gills, Gut and flesh (0.010±0.00 Cr) and 0.001±0.000 Cd) is uniform for all the organs under investigation in mg/kg respectively.

While the order of metals bioaccumulation in the Macrobrachium macrobrachion (most dominant freshwater prawn) the order of bioaccumulation is Cu > Zn > Mn > Fe >Cr > Pb > Cd with the value of 26.100±6.280, 21.250±1.744, 14.585±28.277, 6.067±3.608, 0.257±0.049, 0.023±0.009, 0.002±0.000 respectively with all values in Mg/Kg .However, the general trend of accumulations in all the organisms were Tilapia zillii > Chrysichthys nigrodigitatus> Macrobrachium macrobrachion. The results of analysis of variance showed that different organisms accumulate different metals in their organs differently (P<0.05).

The observed level of metals in the sediments and different organisms analyzed were below the WHO standards. Therefore, there is no foreseeable adverse health problem that may arise from the consumption of the analyzed fish species.

Keywords: *Chrysicthys nigrodigitatus, Macrobrachium macrobrachion, bioaccumulation, pollution Badagry creek*

1.Introduction

The presence of heavy metals in our environment as a result of their uses in modern society has called for concern to both politicians, authorities, environmentalists, institutions and the public. Studies has shown that the major source of metals into aquatic ecosystem is basically from anthropogenic source which includes emission from vehicles, industrial effluents, fossil fuel combustion, indiscriminate waste disposal, and agricultural chemicals run-offs {kakulu *et al* 1987}.

Most of the heavy metals constitute a potential hazard to aquatic organisms in that they could cause elimination of keystone species (Coin, 1996; Schindler 1987) especially those predators at the top of a food chain or web It may also cause a shortening of the food chain and removal of species from the food web Carpenter (1985) Odum (1985). Consequently Most of these impacts have led to environmental pollution which may put living resources and human health at risk when such resources that contained such metals. Forstner and Wittmann (1981). Research has shown that these metals may generally persist in the aquatic environment, as there are no natural processes that remove metals from aquatic systems because they bind to minerals and sediments. This also leads to higher concentrations of metals in the system, as more metals are added, and the existing metal is not removed (Forstner, 1983; (Hernandez-Hernandez *et al.*, 1990; Tyler, 1972).) However, the study of metal bioaccumulation in marine organisms (Hernandez-Hernandez *et al.* (1990), reported the accumulation ability in crustaceans, molluscs and fish, which generally depends on their exposure time and the concentrations of metals in the water. When fishes are exposed to elevated levels of metals in a polluted aquatic ecosystem, they tend to take these metals up from their direct environment (Du Preez and Steyn, 1992; Seymore, 1994). It is assumed that most metals are taken up in the ionic form and that this uptake is influenced by various environmental factors such as pH and temperature. The metals enter the body of the fish via the gills and skin, or through the intake of contaminated food or drinking water. Transport of metals in the fish occurs through the blood where ions are usually bound to proteins. The metals are thus brought into contact with the organs and tissues of the fish and consequently accumulated to a different extent in different organs/tissues.

Robinson and Avenant-Oldewage (1997) highlighted the fact that the effect of two or more toxicants may be additive, antagonistic or even synergistic. Heavy metals, such as Cu and Zn, are being mobilized by man at ten times the natural rates expected from geological weathering from urban runoff (Stark, 1998).

The above trend necessitated the need for determination of base line information on metal bioaccumulation by fin fish samples from Badagry Creek, Lagos -Nigeria.

2.Material And Methods

2.1.Samples Collection, Handling And Storage

The Fish samples and handling were carried out as recommended in guidelines and standards as recommended APHA *et al* ,1985; FAO (1982) FAO/SIDA (1993)

2.2.Digestion Process

Ten fishes of Tilapia niloticus and Chrysichthys nogrodigitatus with mean length of between 18.80-28.39 and 21.26-32.45 cm with average weight of 163.98 and 179.6g respectively were collected from Badagry Creek .After collection, the specimens were placed immediately in plastic bags they were transported to the laboratory for identification and chemical analysis. The tissues, gills, gut and scales of the fish were dissected with the aid of a stainless steel knife which had been cleaned with acetone and rinsed with hot distilled water prior to use. From the fish dissected, 10g of tissue was accurately weighed and placed in a 100 ml Pyrex vessel that had been soaked in 70% nitric acid reduction of the potential lead contamination in the vessels. 5 mL of 65% nitric acid and 1.5 mL of 30% hydrogen peroxide (GR grade, Merck Company) were then added to the sample. The experiment was left to run for 24 hrs. Each vessel was then put on top of hotplate and gently heated to a temperature varying between 75~80^{0}C for few hours until the digestion was complete. The digested solution was cooled at room temperature and the solutions were then filtrated into polypropylene tubes and distilled water was added to make up to 25ml. The solution in vial plastic tubes were then sent to the laboratory for examination of heavy metal concentrations The digestion method used in this study followed that reported in (Chen *et. al* 1992) Concentrations of zinc, copper, cadmium and lead in the digested samples were determined with a flame atomic absorption spectrometer (Perkin Elmer-AA100)

3.Bioaccumulation Results

Contaminants can bioaccumulate in the aquatic food web through both water-borne and sediment-borne sources. Table 1 gives the mean values of cadmium, chromium, copper, iron, lead, manganese and zinc concentrations in scales, guts, muscle tissues, gills and bones of Tilapia zillii, Chrysichthys nigrodigitatus and Macrobranchium macrobrachion caught from Badagry creek.

Organs		**Zinc (mg/kg)**	**Chromium (mg/kg)**	**Copper (mg/kg)**	**Cadmium (mg/kg)**	**Lead (mg/kg)**	**Manganese (mg/kg)**	**Iron(mg/kg)**
Bone	Mean	.500	.0100	.640	.001	.005	.013	.765
	Std. Dev	.141	.000	.226	.000	.000	.004	.163
	Min	.400	.0100	.480	.001	.005	.010	.650
	Max	.600	.0100	.800	.001	.005	.015	.880
Flesh	Mean	1.700	.0100	.310	.003	.008	.425	7.480
	Std. Dev	.566	.000	.127	.003	.003	.092	1.669
	Mi	1.300	.0100	.220	.001	.006	.360	6.300
	Max	2.100	.0100	.400	.005	.010	.490	8.660
Gills	Mean	1.640	.0100	.400	.001	.010	.325	27.400
	Std. Dev	.283	.000	.141	.000	.003	.120	30.264
	Min	1.440	.0100	.300	.001	.008	.240	6.000
	Max	1.840	.0100	.500	.001	.012	.410	48.800
Gut	Mean	1.315	.0100	.120	.001	.005	.170	3.690
	Std. Dev	.021	.000	.000	.000	.000	.028	.509
	Min	1.300	.0100	.120	.001	.005	.150	3.330
	Max	1.330	.0100	.120	.001	.005	.190	4.050
Total	Mean	1.289	.0100	.368	.002	.007	.233	9.833
	Std. Dev	.567	.000	.229	.001	.003	.177	15.979
	Min	.400	.0100	.120	.001	.005	.010	.650
	Max	2.100	.0100	.800	.005	.012	.490	48.800

Table 1

The species diversification indicated that the Bagrids, Chrysicthys nigrodigitatus; Cichlids, Tilapia zillii and fresh water prawn, Macrobrachion Macrobrachium were the dominant fish species in the Creek. Results of the analysis of trace metals in the organs of Tilapia zillii indicated that the metals were differentially accumulated in different organs of the fish. In the tissue, the orders of accumulation were gills 44.976, muscles 8.419, bones 8.08, guts 6.087, and scales 0.0040 in mg/kg respectively. In Chrysichthys nigrodigitatus however, the orders of accumulation were gills 51.500, muscles 17.675 bones 17.725, and guts 10.900 in mg/kg respectively. However, the general trend of accumulations in all the organisms were Chrysichthys nigrodigitatus>Tilapia zillii > Macrobrachium macrobrachion. The results of analysis of variance showed that different organisms accumulate different metals in their organs differently ($P<0.05$).

Considering the heavy metal concentrations in different organs of different organisms, the results of the ANOVA showed that it is statistically significant ($P<0.05$), an indication that different animals and different organs accumulates different pollutants differently except the scales of Tilapia zillii (Table 2).

Organs		Lead (mg/kg)	Manganese (mg/kg)	Iron (mg/kg)	Zinc (mg/kg)	Chromium (mg/kg)	Copper (mg/kg)	Cadmium (mg/kg)
Bone	Mean	0.091	.150	1.625	1.150	.0100	1.260	.001
	Std. Dev	.126	.042	.417	.212	.000	.226	.000
	Min	.002	.120	1.330	1.000	.0100	1.1000	.0010
	Max	.180	.180	1.920	1.300	.010	1.4200	.0010
Flesh	Mean	.005	.185	9.350	2.160	.010	.500	.001
	Std. Dev	.000	.049	3.889	.339	.000	.424	.000
	Min	.005	.150	6.600	1.920	.0100	.2000	.0010
	Max	.005	.220	12.100	2.400	.010	.800	.001
Gills	Mean	.005	.300	52.360	1.085	.010	.350	.001
	Std. Dev	.000	.057	25.965	.233	.000	.071	.000
	Min	.005	.260	34.000	.920	.010	.300	.001
	Max	.005	.340	70.720	1.250	.010	.400	.001
Gut	Mean	.006	.110	6.100	2.180	.010	.320	.001
	Std. Dev	.006	.000	3.959	.481	.000	.000	.000
	Min	.002	.110	3.300	1.840	.010	.320	.001
	Max	.010	.110	8.900	2.520	.010	.320	.001
Total	Mean	.027	.186	17.358	1.643	.010	.607	.001
	Std. Dev	.0619	.082	24.000	.617	.000	.449	.000
	Min	.002	.110	1.3300	.920	.0100	.200	.001
	Max	.180	.3400	70.7200	2.520	.0100	1.420	.001

Table2: shows the level of bioaccumulation of metals by Tilapia zillii caught from Badagry Creek.

With regards to period of sampling, in this research, animals were collected in the months of June (Peak of rain) and December (Peak of dry). Results of the analysis of variance showed that seasons did not have influence in the habitation of the organisms ($P > 0.05$).

4.Bio-Accumulation Analysis

Direct uptake from a medium e.g. air and water (Phytoplankton), bio-accumulation which is indirect uptake through food and bio-magnification which is a build up along the food chain are continuous exercise going on in the environment. Thus, contaminants can bioaccumulate in the aquatic food web through both water and sediment-borne sources. Table 17 gives the mean values of cadmium, chromium, copper, iron, lead, manganese and zinc concentrations in guts, muscle tissues, gills and bones of Tilapia zillii, Chrysichthys nigrodigitatus and Macrobranchium macrobrachion caught from Badagry Creek.

The species diversification indicated that the Bagrids, Chrysicthys nigrodigitatus; Cichlids, Tilapia zillii and fresh water prawn, Macrobrachium Macrobrachion were the dominant fish species in the Creek. Results of the analysis of trace metals in the organs of Tilapia zillii indicated that the metals were differentially accumulated in different organs of the fish.

In the organs of Tilapia zillii, the order of iron accumulation were gills (52.360±25.964); Flesh (9.350±889); Gut (6.100±3.959); Bone (1.625±0.417). Zinc concentration is in the order of Gut (2.180±0.480), Flesh (2.160±0.339), Bone (1.150±0.212), Gills (1.085±0.233).In Manganese, the order is Gills (0.300±0.056), Flesh (0.185±0.049), Bone (0.150±0.042), Gut (0.110±0.000).In lead, the order is Bone (0.091±0.125), Gut (0.062±0.005), Flesh (0.005±0.000), Gills (0.005±0.000).Chromium value is (0.010±0.00) for Bone, Gills, Flesh and Gut. Cadmium value is 0.001±0.000) is uniform for all the organs under investigation.

In Chrysichthys nigrodigitatus, the order of bioaccumulation of Iron in the organs of the organism is as follows: Gills (27.400±30.264), Flesh (7.480±1.660), Gut (3.692±0.509), and Bone (0.765±0.162). Manganese is bioaccumulated as Flesh (0.425±0.091), Gills (0.325±0.120), Gut (0.170±0.028), and Bone (0.012±0.003. The order of lead in Gills is (0.010±0.002), Flesh (0.08±0.002), Bone (0.005±0.000) and Gut (0.005±0.000). Cadmium is in order of Flesh (0.003±0.002), Bone (0.001±0.000), Gills (0.001±0.000) and Gut (0.001±0.000).Copper is bioaccumulated thus, Bone (0.64±0.226), Gills (0.40±0.141), Flesh (0.310±0.127) and Gut (0.120±0.000). Zinc on the other hand was bioaccumulated thus Flesh (1.700±0.565), Gills (1.64±0.282), Guts (1.315±0.021) and Bone (0.500±0.141). However, Chromium uniformly bioaccumulated in the organs to the tune of 0.01±0.000).

In the fresh water prawn Macrobrachium macrobachion the flesh of the organism bioacumulated metals in the order of Cu > Zn > Mn > Fe >Cr > Pb > Cd with the value of 26.100±6.280, 21.250±1.744, 14.585±28.277, 6.067±3.608, 0.257±0.049, 0.023±0.009, 0.002±0.000 respectively. All values are in Mg/Kg. Considering the heavy metal concentrations in different organs of different organisms, the results of the ANOVA showed that these value were not statistically significant ($P<0.05$), except iron an indication that this metal has to be watched out for.

Summarily, the order of metals bioaccumulation in Tilapia zillii is Fe > Zn > Mn > Pb >Cr > Cd. In Chrysichthys nigrodigitatus, the order is Fe > Zn > Mn > Pb >Cr and Cd. And in Macrobrachium macrobachion the order is Cu > Zn > Mn > Fe >Cr > Pb > Cd.

Table 1 shows the level of bioaccumulation of metals by Chrysichthys nigrodigitatus caught from Badagry Creek.

Fishes that are exposed to elevated levels of metals in a polluted aquatic ecosystem tend to take these metals up from the environment (Du Preez and Steyn, 1992; Seymore, 1994). It is assumed that most metals are taken up in the ionic form and that this uptake is influenced by various environmental factors such as pH and temperature. The metals enter the body of the fish via the gills and skin (bioconcentration), or through the intake of contaminated food or drinking water (bioaccumulation). Transport of metals in the fish occurs through the blood where ions are usually bound to proteins. The metals are thus brought into contact with the organs and tissues of the fish and consequently accumulated to a different extent in different organs/tissues.

Generally in Badagry Creek, the accumulation of essential elements namely, irons, zinc, and copper. They were the largest and the values were 52.360±25.964, 2.180±0.480 and 26.100±6.280 mg/kg respectively. The essential elements such as zinc are regulated to maintain certain homeostatic status in fish (Chen and Chen, 1999). On the contrary, the non-essential elements, such as cadmium chromium and lead, have no biological function or requirement and their concentrations in fish tissues examined were generally low as seen in Figs.1, 2 and 5 which agreed with the result of Thompson (1990). Though, most of these non essential metals are present in Badagry creek in low concentrations, one may not rule out the fact that the metals may be substantial in the Creek but the values were low because all the metals taken up are not accumulated since fish have the ability to regulate their body metal concentration to a certain extent. This could account for low values concentrations recorded in their organs. As excretion of metals can occur through the gills, bile (via faeces), and kidney and skin (Romanenko et. al., 1986; Heath, 1987). The amount of a metal bioaccumulated is influenced by various environmental and biological factors, leading to differences in metal bioaccumulation between different individuals, species, seasons and sites.

Not only that, different degrees of the metals accumulated in various tissues depend on the biochemical characteristics of the metal (Farkas et. al., 2000) Generally in fishes, the gill is the tissue that is more often found to have high heavy metal concentrations (Amundsen et. al., 1997; Farkas et. al., 2000; Romeo et. al., 1999; Lundebye et. al., 1999). This could probably account for high concentration of iron recorded in the gills of both Chrysicthys nigrodigitatus and Tilapia zillii as shown in fig. 4. However, feeding habits and the metal concentrations in the environment could be responsible for metals accumulation in various tissues in fishes (Farkas et. al., 2000).

In this study it was discovered that the metal concentrations in the gills were mostly higher than those in the muscle tissues indicating that the metal uptake was mostly through gills absorption. Thus, the concentrations of metals in gills reflected the concentrations of metals in the water, where the fish species lives (Romeo et. al., 1999).

Furthermore, metal accumulations in tissues are generally found to be species specific. The observed differences between the metal concentrations in fishes may be related to their feeding habits and the bio-concentration capacity of each species (Farkas et. al., 2000, Farkas et. al., 2000)

The minimal concentration of, cadmium, chromium, lead and manganese (Figs. 1, 2, 5,6) found to have been deposited in the guts of Tilapia zillii and Chrysicthys nigrodigitatus might indicate that the metals concentration level could be high in the water of the fish habitat and it could originate naturally. Cadmium naturally exists in the earth's crust at an average concentration of about 0.1 mg/kg and, higher levels are present in sedimentary rocks: marine phosphates often contain about 15 mg/kg (GESAMP, 1984) as well as from non-point pollution sources from Badagry city. WHO (1992) and Environmental Protection Administration (1991), reported that Municipal refuse contains cadmium derived from discarded nickel-cadmium batteries and plastics containing cadmium pigments and stabilizers. The incineration of refuse is a major source of atmospheric cadmium release at country, regional, and worldwide level.

Also, cadmium upon getting to the environment as reported by WHO (1992) may interact with the calcium metabolism of animals and in fish may cause hypocalcaemia, probably by inhibiting calcium uptake from the water. However, high calcium concentrations in the water (Table 8) protect fish from cadmium uptake by competing at uptake sites.

Tissues muscle generally has been reported to concentrate low metal in fishes (Amundsen et. al., 1997, Al-Yousuf et. al., 2000, Romeo et. al., 1999), which is in line with this research.

Copper has been found in low but significant concentrations in flesh of the fresh water prawn Macrobranchium macrobrachion. The possible explanation for this low concentration when compared to WHO standards could be due to high alkalinity of Badagry Creek. Svobodova et. al., (1993) reported that in water with high alkalinity, copper forms hydroxides of low solubility, also in waters with a high bicarbonate/carbonate, copper precipitates as poorly soluble or insoluble cupris carbonate. This is because compounds that are slow to dissolve or are soluble are unlikely to be taken up to any extent into the fish body, so their toxicity to fish is low. This simply means that the uptake and toxicity of copper in freshwater organisms generally decreases with increasing water hardness and alkalinity (Erickson et. al., 1998)

Conversely, Macrobranchium macrobrachion bioaccumulated copper most, though the values are within the WHO standard but however, the value is a pointer to the gradual concentration of copper in the Creek which may eventually constitute a burden to aquatic system. Copper is an essential trace element required by most aquatic organisms Cairns et. al., (1978). Copper is readily accumulated by plants and animals; bioconcentration factors ranging from 100 to 26 000 have been recorded for various species of phytoplankton, zooplankton, macrophytes, macroinvertebrates and fish (Spear and Pierce 1979). Toxic effects of metals occur when the rate of uptake exceeds the rates of physiological or biochemical detoxification and excretion (Rainbow, 1996). The sources of copper into the environment could be traced the uses of the metal compounds in fish culture and fisheries as algaecides and in the prevention and therapy of some fish diseases (Svobodova et. al., 1993).

Copper compounds including cuprous oxide, cupric sulphate and cupric acetate are used as fungicides, in the manufacture of wood preserving agents, rayon and paint pigments. In products such as wire, piping and plated metal copper is generally immobilized, although some release can occur, for example, from water heating systems. Copper from fungicide products may also find its way into the aquatic environment. Using copper sulphate as an algaecide can result in its direct addition to water supply reservoirs (Mance et al., 1984). Copper is also an essential nutrient and is therefore present in human and animal wastes.

The animals used in this research showed a trend of increasing iron concentration in all the organs studied. It was observed that the concentration of iron was consistent.

Organs		**Lead (mg/kg)**	**Manganese (mg/kg)**	**Iron (mg/kg)**	**Zinc (mg/kg)**	**Chromium (mg/kg)**	**Copper (mg/kg)**	**Cadmium (mg/kg)**
Flesh	Mean	.024	14.585	6.068	21.250	.258	26.100	.002
	Std. Dev	.009	28.277	3.608	1.745	.049	6.281	.000
	Min	.012	.260	1.200	19.700	.200	20.300	.002
	Max	.035	57.000	9.450	23.000	.320	34.300	.002
Total	Mean	.024	14.585	6.068	21.250	.258	26.100	.002
	Std. Dev	.009	28.277	3.608	1.745	.0492	6.281	.000
	Min	.012	.260	1.200	19.700	.200	20.300	.002
	Max	.035	57.000	9.450	23.000	.320	34.300	.002

Table 3: shows the level of bioaccumulation of metals by Machrobrachium macrobrachion caught from Badagry Creek

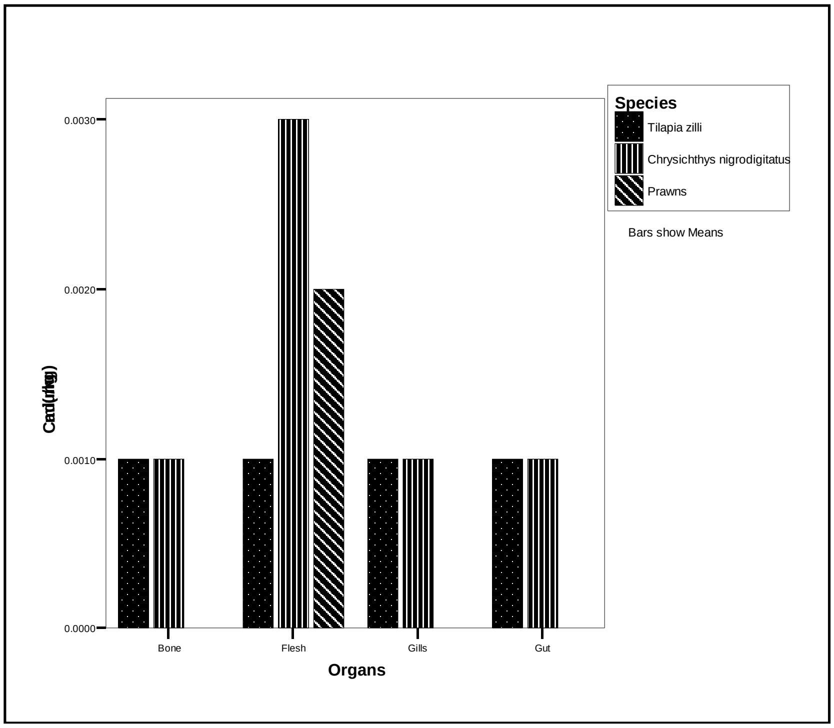

Figure 1: Bioaccumulation of cadmium by various organs of Tilapia zillii, Chrysichthys nigrodigitatus and genus of Machrobrachium from Badagry creek

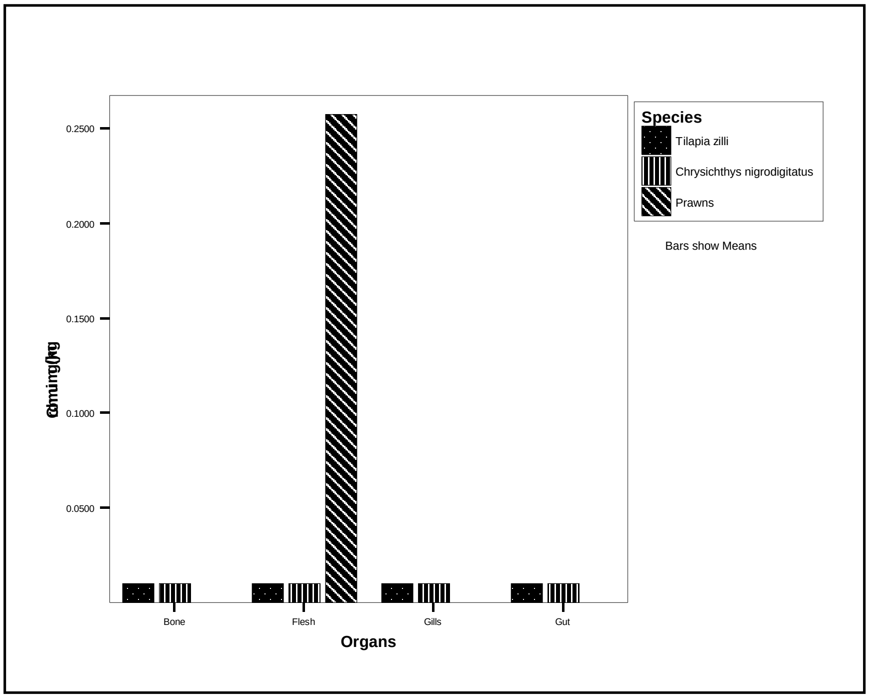

Figure 2: Bioaccumulation of chromium by various organs of Tilapia zillii, Chrysichthys nigrodigitatus and genus of Machrobrachium from Badagry creek

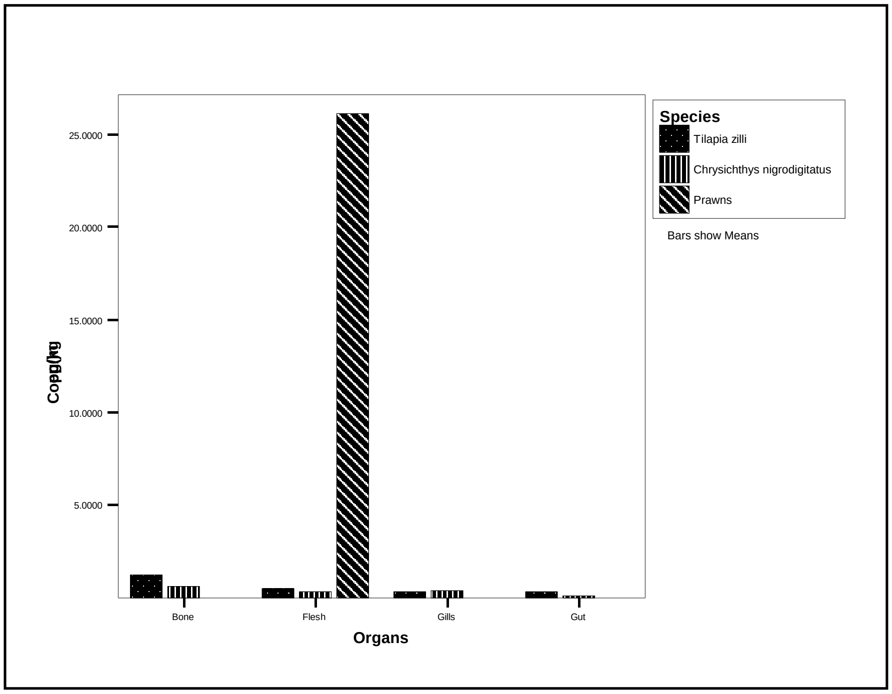

Figure 3: Bioaccumulation of copper by various organs of Tilapia zillii, Chrysichthys nigrodigitatus and genus of Machrobrachium from Badagry creek

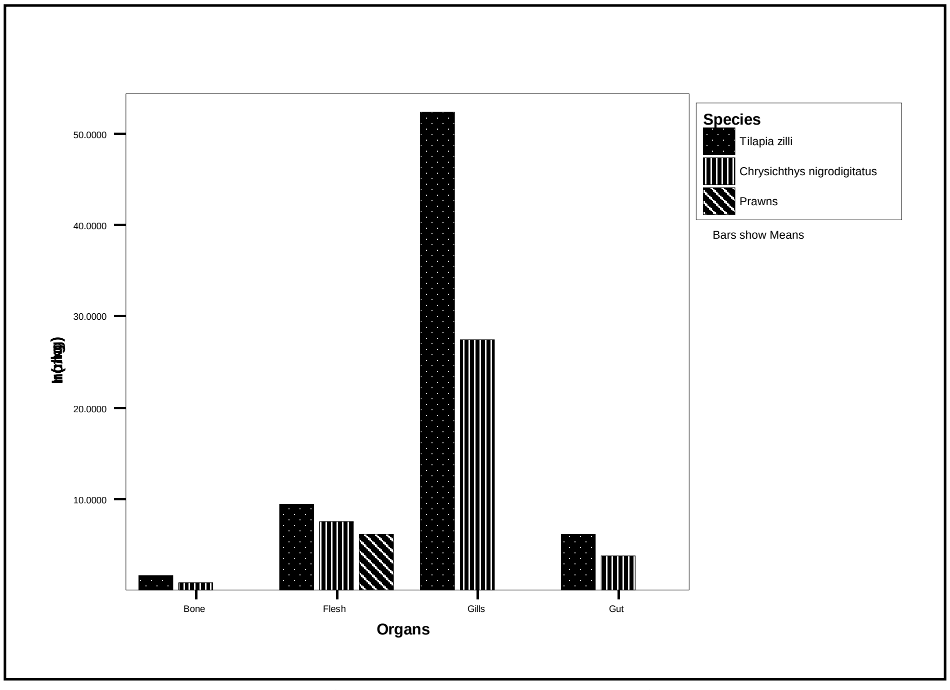

Figure 4: Bioaccumulation of iron by various organs of Tilapia zillii, Chrysichthys nigrodigitatus and genus of Machrobrachium from Badagry creek

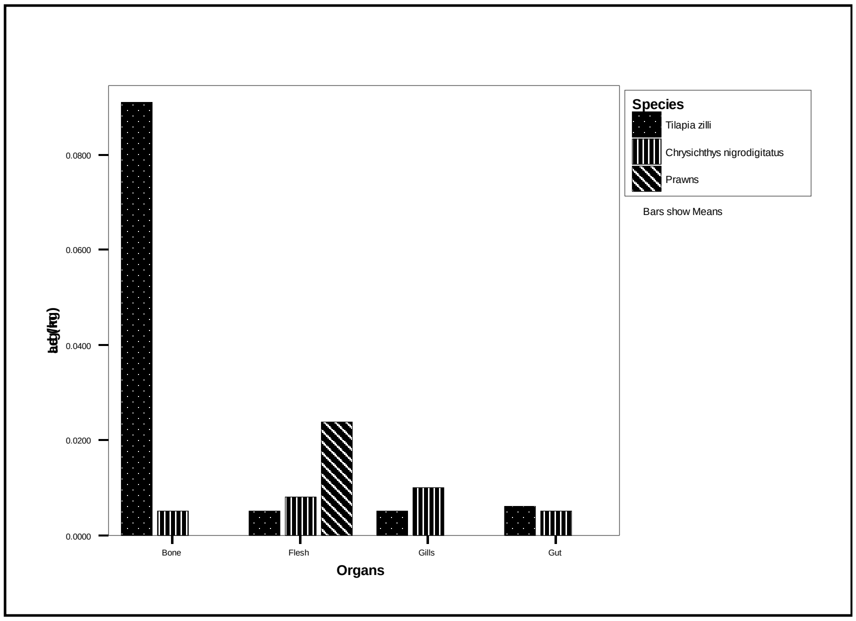

Figure 5: Bioaccumulation of lead by various organs of Tilapia zillii, Chrysichthys nigrodigitatus and genus of Machrobrachium from Badagry creek

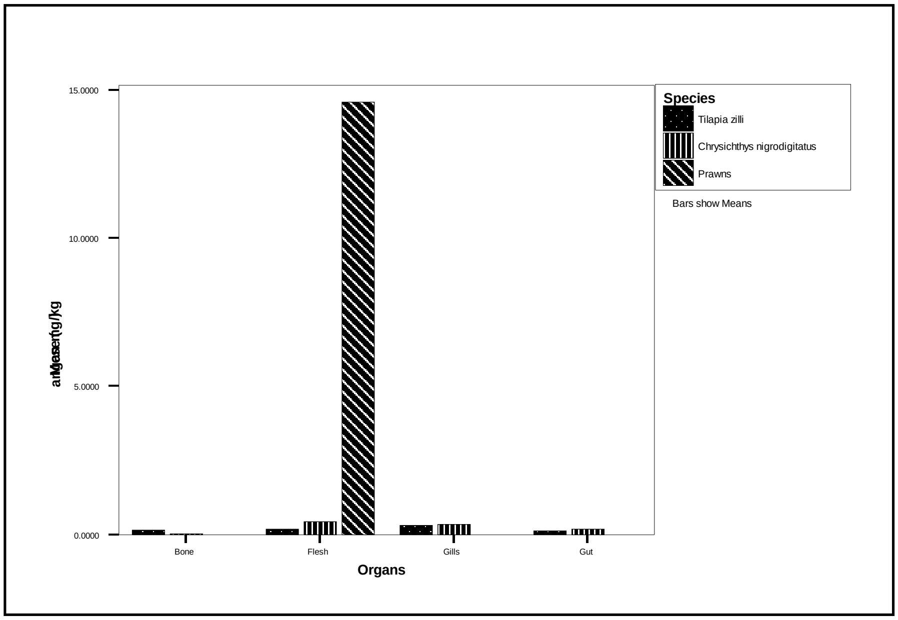

Figure 6: Bioaccumulation of manganese by various organs of Tilapia zillii, Chrysichthys nigrodigitatus and genus of Machrobrachium from Badagry creek

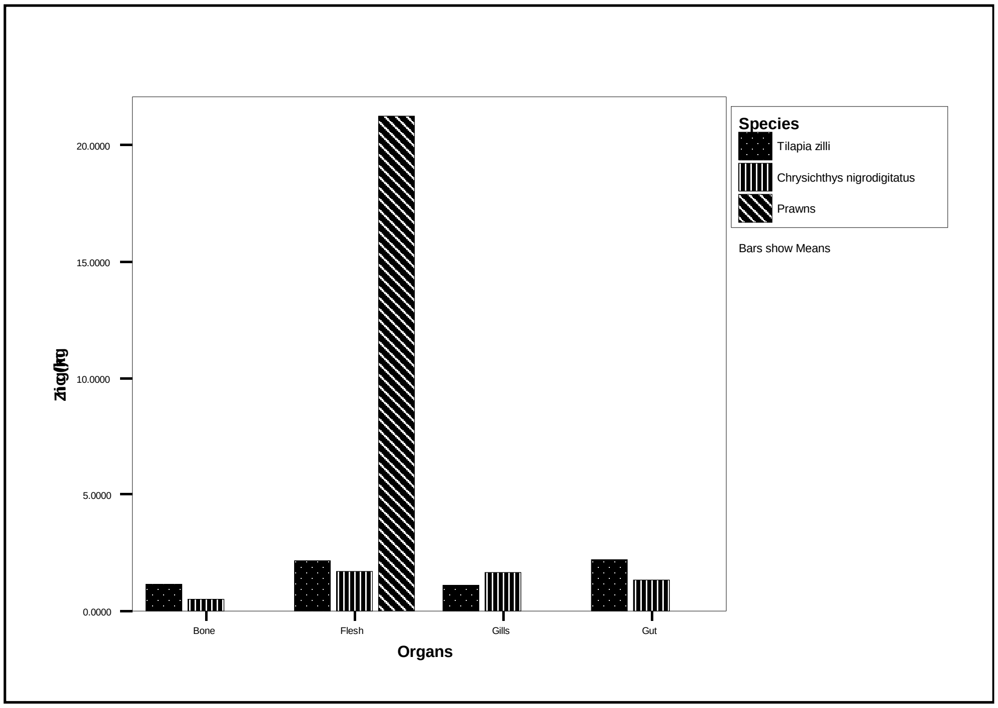

Figure 7: Bioaccumulation of zinc by various organs of Tilapia zillii, Chrysichthys nigrodigitatus and genus of Machrobrachium from Badagry creek

5.Consumption Safety

Based on this study the maximum amounts of zinc and copper concentrated in the flesh of fish from Badagry Creek were 2.003±0.386~4.895±6.690mg/kg and 0.001±0.000~0.260±0.428 mg/kg, respectively, if the flesh is consumed by man the most dominant animal protein available then the above will be transferred to man. In this case the amount of the essential metal zinc, copper and iron that will be getting to man is far below the acceptable daily intake (ADI) set by the USA (National Research Council, 1989). (ADI: Zn = 15 mg therefore, under normal consuming habits, the intake of zinc from the fisheries of the Creek should not pose any health problems. Copper was slightly higher in Creek and needed to be addressed though the ADI for copper is 2~3 mg. Thus, if proper actions are not taken to checkmate the continuous influx of metallic copper compound into the Creek, it may pose health problems to the consumers in future. Cadmium and Lead are elements toxic to human, but their concentrations in fish muscle in this study are far lower than the consumption safety tolerance set for seafood by most countries in the world .The estimated daily intake (Cd: 0.001±0.000~0.009±0.017mg/kg; Pb:0.001±0.000~0.009±0.005mg/kg) is also far lower than the acceptable daily intake set by WHO (1992) (JECFA, 2000, 2001) (Provisional Tolerable Daily Intake, PTDI: Cd =

70 µg; Pb = 250 µg, for body weight of 70kg). The cadmium and lead concentrations in guts of the fish species were within the safety standard set by some countries. However, since muscle was the major consuming portion in fish, while guts were rarely consumed, there should not be any health threat to the public. Chromium, though have no dietary value is also very much low and at the moment will not pose any harm to human.

6.Reference

1. Al-Yousuf, MH., El-Shahawi, MS. and Al-Ghais, SM.,(2000). Trace metals in liver, skin and muscle of Lethrinus lentjan fish species in relation to body length and sex. Sci. Total Environ. 256: 87-94.
2. American public Health Association, American Water works Association, and water Pollution control Federation. (1985) Standard methods for the examination of water and waste water. 16th editions. American Public Health Association, Washington D.C 1268 pp.
3. Amundsen, PA., Staldvik, FJ., Lukin, A A., Kashulin, NA., Popova, OA. and Reshetnikov, YS. (1997). Heavy metal contamination in freshwater fish from the border region between Norway and Russia. Sci. Total Environ. 201: 211-224.
4. APHA, AWWA & WEF 1995. Standard methods for the examination of water and wastewater. American Public Health Association, American Water Works Association and Water Environment Federation, Washington, USA, 2–1 to 2–3.
5. Avenant-Oldewage A and Marx HM (2000) Bioaccumulation of chromium, copper and iron in the organs and tissues of Clarias gariepinus in the Olifants River, Kruger National Park. Water SA 26 (4) 569-582.
6. Carvalho RA, Benfield MC and Santschi PH (1999) Com-parative bioaccumulation studies of colloidally complexed and free-ionic heavy metals in juvenile brown-shrimp Penaeus aztecus (Crustacea: Decapoda: Penaeidae). Limnol. Oceanogr. 44 (2) 403- 414.
7. Chen, MH. and Chen, CY. (1999). Bioaccumulation of sediment-bound heavy metals in grey mullet, Liza macrolepis. Mar. Pollut. Bull. 39: 239-244.
8. Chen, YC. and Chen, MH. (2001). Heavy metal concentrations in nine species of fishes caught in coastal waters off Ann-Ping, S.W Taiwan. J. Food Drug Anal. 9: 107-114.
9. Du Preez HH and 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 Na-tional Park, South Africa. Water SA 18 (2) 131-136.
10. Environmental Protection Administration. (1991). General reports of surveys of heavy metal content of soil in Taiwan: (IV) East and island regions: I-Lan, Hualien, Taitung and Penghu counties. Environmental Protection Administration, R.O.C., Taipei, pp 47-160.

11. FAO (1982): Manual of methods in Aquatic Environmental research part 6, Toxicity Tests. FAO Fisheries Technical Paper No185, 23pp.
12. Farkas, A., Salanki, J. and Varanka, I. (2000). Heavy metal concentrations in fish of Lake Balaton. Lakes Reserv. Res. Manag. 5: 271-279.
13. Farkas, A., Salanki, J. and Varanka, I. (2000). Heavy metal concentrations in fish of Lake Balaton. Lakes Reserv. Res. Manag. 5: 271-279.
14. Forstner U and Wittmann GTW (1981) Metal Pollution in the Aquatic Environment. Springer-Verlag, New York. Ambio 1 (2) 52-59.
15. Forstner, U. and GTW. Wittmann (19790. Metal pollution in the aquatic environment .Springer- Verlag. Berlin, Heidelberger, 486pp.
16. GESAMP (1984) IMO/FAO/UNESCO/WMO/IAEA/UN/UNEP Joint Group of Experts on the Scientific Aspects of Marine Pollution: Report of the fourteenth session, Vienna, 26-30 March, 1984, Vienna, International Atomic Energy Agency (Reports and Studies No. 21).
17. Heath AG (ed.) (1987) Water Pollution and Fish Physiology. CRC
18. Hernández-Hernández F, Medina J, Ansuátegui J and Conesa M (1990) Heavy metal concentrations in some marine organisms from the Mediterranean Sea (Castellón, Spain): Metal accumulation in different tissues. Sci. Mar. 54 (2) 113-129.
19. JECFA. (2001). Evaluation of certain food additives and contaminants. WHO Technical Report Series, No. 901. Fifty-fifth Meeting Report of the Joint FAO/WHO Expert Committee on Food Additives. Geneva, 6-15 June 2000.
20. JECFA. (2000). Evaluation of certain food additives and contaminants. WHO Technical Report Series, No. 896. Fifty-third Meeting Report of the Joint FAO/WHO Expert Committee on Food Additives. Rome, 1-10 June 199
21. Kakulu SE (1988) heavy metal in Niger delta. Impact of petroleum industry on the baseline level. PH.D Thesis of the University of Ibadan, Nigeria
22. Koli AK, Williams W.R, McClarey E.B, Wright E.L and Burrel T.M (1977) Mercury levels in freshwater fish in the state of South Carolina. Bull. Environ. Contam. Toxicol. 17 (1) 82-89.
23. Mance G., Brown VM. and Yates, J. (1984) Proposed Environmental Quality Standards

24. National Research Council. (1989). Recommended dietary allowances. 10th ed. National Academy Press, Washington, D.C., U.S.A.Press, Inc., Florida, USA. 245 pp.
25. Rainbow PS. (1990) "Heavy metal levels in marine invertebrates" In: Heavy Metals in the Marine Environments (R. W. Furness and P. S. Rainbow, Eds.), (CRC Press, Boca Raton, FL), pp. 67-70.
26. Stark J.S (1998) Heavy metal pollution and macrobenthic assem-blages in soft sediments in two Sydney estuaries, Australia. Mar.Freshwater Res. 49 533-540.
27. Svobodova Z, Lloyd R, Machova J & Vykusova B 1993. Water quality and fish health. EIFAC technical paper no 54, FAO, Rome.
28. Thompson DR. 1990. Metal levels in marine vertebrates. In: Furness, V. and Rainbow, P.S. (Eds.), Heavy Metals in the Marine Environment. CRC Press, Boca Raton, FL, pp. 143-182.
29. Tyler G (1972) Heavy metals pollute nature, may reduce productiv-ity.Ambio 1 (2) 52-59.
30. WHO (1992) Environmental Health Criteria 134: Cadmium. Geneva, World