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Bio-Concentration of Heavy Metal Pollution in Water and Fish of Majidun River, Southwest, Nigeria

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Abstract: **Bio-concentration of heavy metals pollution in water and fish was investigated in Majidun River, Lagos, Southwest, Nigeria. Water and three commercially available fish species (*Chrysichthys nigrodigitatus, Sarotherodon galilaeus* and *Hemichromis fasciatus*) were collected for 15 weeks (October, 2013 to January, 2014) and five organs from each fish were used. All the water and fish samples collected were subjected to heavy metals analysis using Atomic Absorption Spectrophotometer (AAS) in accordance to standard analytical methods. Data obtained were subjected to statistical analysis (ANOVA) to find out the significant difference of heavy metals in the water body throughout the sampling period and in each organ of the sampled fishes. There was variability in the concentrations of heavy metals in the river body which may be as a result of different natural and anthropogenical activities that might make the river to be unsafe for human consumption. Lead and Cadmium across the organs were not significantly different ($p > 0.05$) to each other while iron, manganese and zinc were significantly different ($p < 0.05$) across all the organs, except in liver and heart. Highest metal accumulation occurred in descending order as *H. fasciatus* > *S. galileaus* > *C. nigrodigitatus* and all the fish species accumulated highest in descending order as Fe > Zn > Cr > Pb > Mn > Cu > Cd. It was found that fish from this study area accumulated essential heavy metals (Fe, Zn, Cr, Mn) in their body in higher concentrations than non-essential ones (Pb, Cd, Cu).**

Keywords: **Bio-concentration, Majidun River, Heavy Metals, Human Activities, Fish.**

1. INTRODUCTION

Water is the most important natural resource which is abundant in nature and covers about two thirds of the earth's surface. In the last decades, aquatic contamination by heavy metals has become a global crisis which enters aquatic systems from different natural and anthropogenic sources. Metals may enter aquatic systems from different natural and anthropogenic (human activities) sources which may include industrial or domestic wastewater, application of pesticides and inorganic fertilizers, storm runoff, leaching from landfills, shipping and harbour activities, geological weathering of the earth crust and atmospheric deposition (Yilmaz, 2009).

Presence of trace metals in the atmosphere, soil and water can cause serious problems to all organisms and its bioaccumulation in the food chain can be highly dangerous to human health (Orebiyi *et al.,* 2010). Fishes are known for their ability to concentrate metals in their muscles and since they play important role in human nutrition, they need to be carefully screened to ensure unnecessary high level of these toxic trace metals which were transferred to man through consumption (Adeniyi and Yusuf, 2007).

Sequel to previous research work done and widespread consumption of fish, it calls for a need to find out the rate of absorption of heavy metals contains therein in the River. Water and fish in a river of an industrialized and polluted environment where construction, transportation, fishing and sand escalation were carried on are posed and subjected to heavy pollution of metals which have a long effects in the water body.

Bioaccumulation of some or all chemicals in a river may be of great consequences to the present and future generation of that community and the nation as a whole if the extent of the exposure is high. Since the river is useful to the community and its environments ranging from swimming, transportation, fishing, domestic use, recreational, sand digging and many more. The present work was aimed to assess the trace metals in water and fish contained in Majidun River, Lagos state, Nigeria. Also, to evaluate heavy metals' accumulation levels in the water and fish of the river.

2. MATERIALS AND METHODS

The Study Area:

Majidun River was located on latitude 6°36′N 3°30′E and longitude 6.600°N 3.500°E (Fig. 1). Also, it was known as Majidun Ilaje creek because the major inhabitants are mainly from Ilaje, Ondo State with the time zone of Lagos/Africa (Ayejuyo et al., 2003). Majidun is located in Ikorodu, which is a city and one of the Local Government Areas in Lagos State, located along Lagos Lagoon that share boundary with Ogun State (Fig. 1). The river is one of the major resources of the local government and the state which has a wide water front at Lagos Lagoon and numerous streams and distributaries especially those of Ogun and Osun rivers.

Ikorodu definitely possess a lot of potentials for development with vast area of uncultivated land while the industrial estate is yet to be fully exploited and if all the resources were used, it will grow not only in size but also in importance (Balogun, 1991). Ikorodu was located at the upland area of the topography as such drainage with this area is very effective on the slopes and through several rivers which flow into the Lagos lagoon and only the 5Km wide stretch of the Ogun-Majidun valleys is swampy (Asiwaju, 1976).

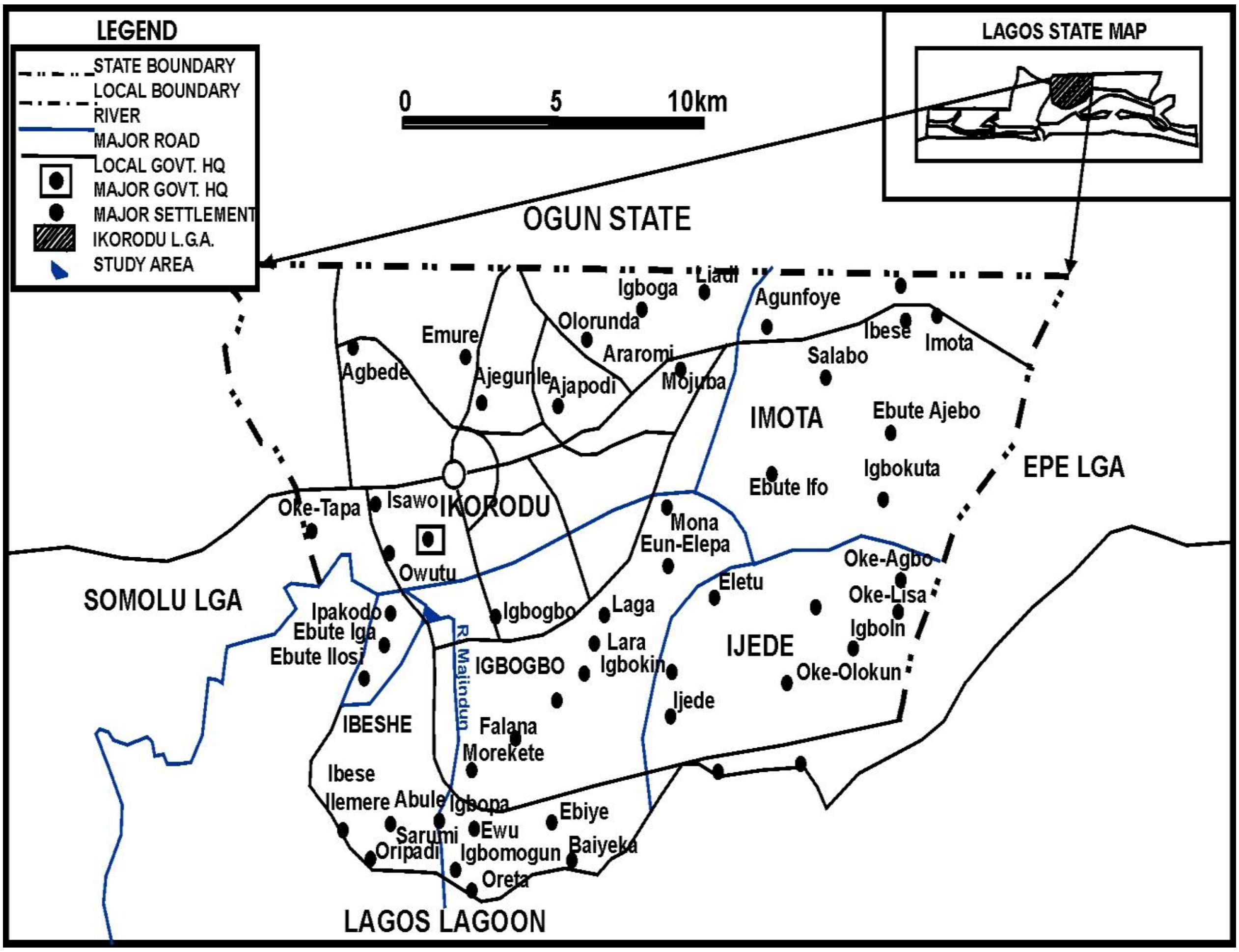

Figure 1: Map of Ikorodu Local Government Showing the Study Area (Majidun River)

Water Sampling and Analysis:

Water samples were collected weekly from the study area (Majidun River) for a period of fifteen (15) weeks between October 2013 and January 2014. The samples were collected in a covered water tight lid plastic 2 Litre Keg which had been detergent washed, rinsed with dilute HNO_3, double de-ionized distilled water and the river water with caps three times prior to the collection. The container was immersed into the river to about 15 cm below its surface for the collection in line with standard method employed by Gregg, (1989) as reported by USEPA, (2007).

At each sampling day, water samples were immediately transported to laboratory for the metal analysis. One hundred (100) ml of the water samples were transferred into Pyrex beakers containing 10ml of concentrated Nitric acid (HNO_3) and were boiled slowly till evaporated to 20ml on hot plate. The beakers were allowed to cool, while another 5ml of concentrated Nitric acid (HNO_3) was added and heated until digestion was completed. The samples were then evaporated again to dryness and the beakers were cooled, followed by the addition of 5ml of hydrochloric acid (HCl) solution (1:1 v/v).

The solution was warmed, 5ml of 5M sodium hydroxide (NaOH) was added and then, filtered. The filtrates were transferred to one hundred 100ml volumetric flasks and diluted with distilled water to be used for the elemental analysis. Lead (Pb), zinc (Zn), copper (Cu), iron (Fe), manganese (Mn), cadmium (Cd) and chromium (Cr) were determined using computer controlled Atomic Absorption Spectrophotometer (VGB 210 Bulk Scientific). All the measurements were carried out in triplicate as a standard procedure by USEPA, (2007) as described by Agah *et al.* (2009).

Fish Sampling and Analysis:

Three commercially available fishes in the study area viz *Chrysichthys nigrodigitatus*, *Sarotherodon galilaeus* and *Hemichromis fasciatus* were obtained. The three fish species were collected with the water samples within 5 months (i.e October, 2013 to January, 2014). The fishes at every weekly collection were transported immediately to the laboratory for analysis in a covered plastic container placed on iced to avoid autolysis of the fish samples. Five organs (gill, liver, eye, heart and flesh) were removed from the total 135 fishes collected in the laboratory using dissecting sets which were accurately labeled, coded in capital letters and immediately prepared for metal concentration analysis.

All organs removed were dried in an oven of about 105^0C for 24 hours. They were ground and milled, then put in a plastic container and stored in desiccators until digestion. Some precautions were taken in order to prevent contamination, such as using 10% (v/v) Nitric acidic (HNO_3) solution and de-ionized water to clean all bottles, plastic tubes and glass wares prior usage. At each step of the digestion processes, acid blanks (laboratory blank) were prepared using identical procedure to ensure that the samples and chemicals used were not contaminated from any of the mentioned possible sources.

They contain the same digestion reagents as the real samples with the same acid ratios but, without the fish sample. They were analyzed by Atomic Absorption Spectrophotometer before the real samples, to check if it will read the exact values of heavy metals in real samples. Each organ removed was oven dried and 2g were taken into 300ml dry digestion tube. 10ml of Nitric acid (HNO_3) was added into each organ samples in a glass tube well labeled and then placed on digestion block which was heated for 20 minutes at 150°C. The temperature was raised to 230°C and the tubes were rotated for the HNO_3 to be given off uniformly for about 20minutes till everything turned into colourless solution. The tubes were removed, allowed to cool for about 30minutes, then, 10ml of distilled water was added and poured into 50ml volumetric flask while gently mixed thoroughly.

This method was in accordance with USEPA, (2007) as described by Agah *et al.* (2009). After digestion, all the samples were analyzed for the trace metal (Pb, Zn, Cu, Fe, Mn, Cd and Cr) concentrations using computer controlled Atomic Absorption Spectrophotometer (VGB 210 Bulk Scientific). The AAS was calibrated with standard solution settings and operational conditions were done in accordance with the manufacturers' specifications and instructions. Each metal has its own hollow cathode lamp which was inserted into the AAS and the rubber tube connected was dipped into each organ solution. The concentrations value of each metal on AAS are read and recorded.

Statistical Analysis:

Data obtained were subjected to statistical analysis using Statistical Package for Social Sciences (SPSS) version 16.0. These analyses include descriptive statistics and one-way analysis of variance (ANOVA) to find out the significant differences of the metals in the water body and in each organ of the fishes as described by Ayejuyo *et al*. (2003). Mean values were separated using Duncan Multiple Range Test (DMRT) of variance to determine the variations due to sampling errors and the differences in mean values were not rejected as being significantly different if $p < 0.05$.

3. RESULTS AND DISCUSSION

All the metals mean concentrations in the river were found to be significantly higher ($p < 0.05$) in week 11 - 15 > week 1 - 5 > week 6 - 10 except Cd which was highest in week 11 - 15 > week 6 - 10 > week 1 – 5 (Table 1). All the metals studied were not significantly different to each other throughout the sampling period except in Pb which differs in weeks 6 – 10 (Table 1). Also, they were found to be above WHO, (2004) and USEPA, (2007) maximum permissible limit for human consumption except Cu and Zn (Table 2).

The fluctuation in the metals concentrations among the weeks might be due to the ecological and climatic condition of the study period. The week 1-5 fell in the month of October - November which rainfall persisted and week 6 - 10 (December - January) fell on the dry season. The metal mean concentrations in the Majidun river was not significantly different to each other ($p > 0.05$) except Pb between weeks 1 – 10 (Table 1) of the study period that falls on the rounding period of rain.

This finding was not in line with the results obtained by Bala et al. (2008) on the determination of some heavy metals collected from two pollution-prone irrigation areas around Kano metropolis which showed the mean values of all metals (with the exception of Zn) in the water studied as significantly high ($p < 0.05$) with mean values exceeded the acceptable limits. The highest metal mean concentration was acute in week 11 - 15 which was due to dry seasonal encroachment and anthropogenic activities such as washing, swimming, bathing, transportation and waste disposing which continuously increases the amount of heavy metals in the water body as supported by Giguere et al. (2004). Also, increase in population, urbanization, industrialization and agriculture practices has further aggravated the situation (Gupta et al., 2009).

In S. galilaeus, Cd and Cr mean concentrations was found to be highest in descending order as L > H > G > F > E, while Mn and Cd was highest in descending order as H > L > F > E > G of C. nigrodigitatus, which also follow the same trend for Cu and Mn in H. fasciatus (Table 3). Copper exhibits great significant difference ($p < 0.05$) across all the organs except in gill and eye which are not significantly different ($p > 0.05$) to each other as well as liver and heart in the river fishes (Table 3). The mean concentrations of Cu, Fe, Pb and Zn in S. galilaeus were not significantly different ($p > 0.05$) while Mn, Cd and Cr were significantly different ($p < 0.05$) in the organs (Table 3).

The mean concentrations of Mn and Cr in C. nigrodigitatus organs were significantly different ($p < 0.05$) while Cu, Fe, Pb, Zn and Cd were not (Table 3). The mean concentrations of Cu, Pb and Cd in H. fasciatus organs were not significantly different ($p > 0.05$) to each other unlike Fe, Mn, Zn and Cr which were significantly ($p < 0.05$) different (Table 3).

Table 1: Weekly Mean Concentrations (ppm) of Heavy Metals in Majidun River Water

	Cu	Fe	Pb	Mn	Zn	Cd	Cr
weeks 1 – 5	$0.030{\pm}0.00^a$	$0.570{\pm}0.02^a$	$0.108{\pm}0.01^b$	$0.132{\pm}0.01^a$	$0.032{\pm}0.01^a$	$0.048{\pm}0.01^a$	$7.518{\pm}0.01^a$
weeks 6 – 10	$0.022{\pm}0.00^a$	$0.536{\pm}0.01^a$	$0.104{\pm}0.01^b$	$0.132{\pm}0.00^a$	$0.032{\pm}0.01^a$	$0.050{\pm}0.01^a$	$7.512{\pm}0.02^a$
weeks 11 – 15	$0.034{\pm}0.00^a$	$0.574{\pm}0.03^a$	$0.152{\pm}0.02^a$	$0.146{\pm}0.02^a$	$0.044{\pm}0.01^a$	$0.054{\pm}0.01^a$	$7.526{\pm}0.02^a$

Mean values (±Standard Error) in the same column with the same superscripts are not significantly different (P > 0.05)
Key:- *Cu – copper; Fe – iron; Pb – lead; Mn – manganese; Zn – Zinc; Cd – cadmium; Cr - chromium*

Table 2: Maximum Permissible Limits For Heavy Metal Consumption in Water (ppm)

Organization/Metals	Pb	Fe	Cr	Mn	Cd	Zn	Cu
WHO, 2004	0.01	0.3	0.05	0.5	0.01	3.0	2.0
USEPA, 2007	0.005	-	-	-	0.005	-	1.0

Source: *Bala et al., 2008; Ozturk et al., 2009*

H. fasciatus generally accumulated highest metals in their body except in Fe which was *S. galilaeus*, while *C. nigrodigitatus* accumulated least metals except in Cr which was slightly above *S. galilaeus* and not in *H. fasciatus* (Figure

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2). The metals mean concentrations were significantly different ($p < 0.05$) across all the organs except Pb which was not (Table 4).

Generally, all the fish species accumulated the trace metals in descending order as Fe > Zn > Cr > Pb > Mn > Cu > Cd while all the metals concentrations were significantly different ($p < 0.05$) to each other except Cu and Cr (Table 4). Lead and cadmium are well known toxicants that have several deleterious effects even at very low concentrations and are considered as non-essential metals for biota (Umar and Opaluwa, 2010). In this study, the mean concentrations of Cd level in all the fishes were minimal with 0.00mg/g in C. nigrodigitatus and 0.01mg/g in both S. galileaus and H. fasciatus.

The maximum acceptable limit for Pb consumption in fish is 1.5mg/kg while that of Cd is 0.2mg/kg (WHO, 2004). Chromium plays an important role in glucose metabolism and its bioaccumulation in fish has been reported to cause impaired respiratory and osmo-regulatory dysfunctions through structural damage to gill epithelium (Heath, 1991). It often accumulates in aquatic life, adding to the danger of fish consumption that has been exposed to high levels of chromium. Low-level exposure can irritate the skin and cause ulceration while its long-term exposure can cause damage to the kidney, liver, circulatory system and nerve tissues (Yilmaz, 2003).

Table 3: Metal Concentrations (mg/kg) in Organs of *Sarotherodon galilaeus, Chrysichthys nigrodigitatus* and *Hemichromis fasciatus*

Fish spp.	Fish Organs	Cu	Fe	Pb	Mn	Zn	Cd	Cr
Sarotherodon galilaeus	GILL	0.042±0.01^{a}	0.885±0.18^{b}	0.063±0.02^{a}	0.051±0.01^{b}	0.327±0.10^{b}	0.006±0.00^{ab}	0.215±0.04^{bc}
	EYES	0.051±0.01^{a}	1.331±0.16^{b}	0.071±0.02^{a}	0.059±0.01^{b}	0.327±0.09^{b}	0.003±0.00^{b}	0.155±0.03^{c}
	LIVER	0.068±0.02^{a}	5.772±1.04^{a}	0.099±0.02^{a}	0.108±0.01^{a}	1.203±0.23^{a}	0.007±0.00^{a}	0.426±0.07^{a}
	HEART	0.059±0.01^{a}	5.481±1.28^{a}	0.079±0.01^{a}	0.080±0.01^{ab}	1.340±0.25^{a}	0.006±0.00^{ab}	0.308±0.05^{ab}
	FLESH	0.034±0.01^{a}	1.066±0.22^{b}	0.053±0.01^{a}	0.060±0.01^{b}	0.499±0.12^{b}	0.005±0.00^{ab}	0.177±0.03^{c}
Chrysichthys nigrodigitatus	GILL	0.028±0.01^{ab}	1.844±0.17^{a}	0.053±0.01^{a}	0.051±0.01^{b}	0.478±0.09^{a}	0.003±0.00^{ab}	0.201±0.05^{b}
	EYES	0.019±0.01^{b}	1.749±0.25^{a}	0.049±0.01^{a}	0.052±0.01^{b}	0.704±0.15^{a}	0.003±0.00^{b}	0.333±0.05^{ab}
	LIVER	0.044±0.01^{ab}	2.034±0.24^{a}	0.087±0.03^{a}	0.076±0.01^{ab}	0.775±0.13^{a}	0.006±0.00^{a}	0.327±0.06^{ab}
	HEART	0.053±0.01^{a}	2.027±0.24^{a}	0.120±0.04^{a}	0.093±0.01^{a}	0.743±0.17^{a}	0.006±0.00^{ab}	0.437±0.06^{a}
	FLESH	0.053±0.01^{a}	1.343±0.20^{a}	0.058±0.01^{a}	0.061±0.01^{ab}	0.508±0.10^{a}	0.004±0.00^{ab}	0.212±0.03^{b}
Hemichromis fasciatus	GILL	0.035±0.01^{b}	1.977±0.59^{a}	0.071±0.02^{a}	0.068±0.01^{b}	1.013±0.23^{a}	0.006±0.00^{b}	0.200±0.03^{c}
	EYES	0.041±0.01^{ab}	2.281±0.72^{a}	0.107±0.05^{a}	0.076±0.01^{b}	0.728±0.21^{a}	0.009±0.00^{b}	0.248±0.03^{bc}
	LIVER	0.068±0.01^{ab}	3.540±0.59^{a}	0.143±0.04^{a}	0.116±0.01^{a}	1.182±0.21^{a}	0.008±0.00^{b}	0.395±0.04^{a}
	HEART	0.076±0.01^{a}	3.461±0.56^{a}	0.139±0.05^{a}	0.139±0.01^{a}	1.232±0.17^{a}	0.019±0.00^{a}	0.340±0.04^{ab}
	FLESH	0.061±0.01^{ab}	2.221±0.48^{a}	0.113±0.03^{a}	0.082±0.01^{b}	0.963±0.21^{a}	0.005±0.00^{b}	0.398±0.05^{a}

Mean values (±Standard Error) in the same column for each fish species with the same superscripts are not significantly different ($p > 0.05$)

Key:- Cu – copper; Fe – iron; Pb – lead; Mn – manganese; Zn – Zinc; Cd – cadmium; Cr - chromium

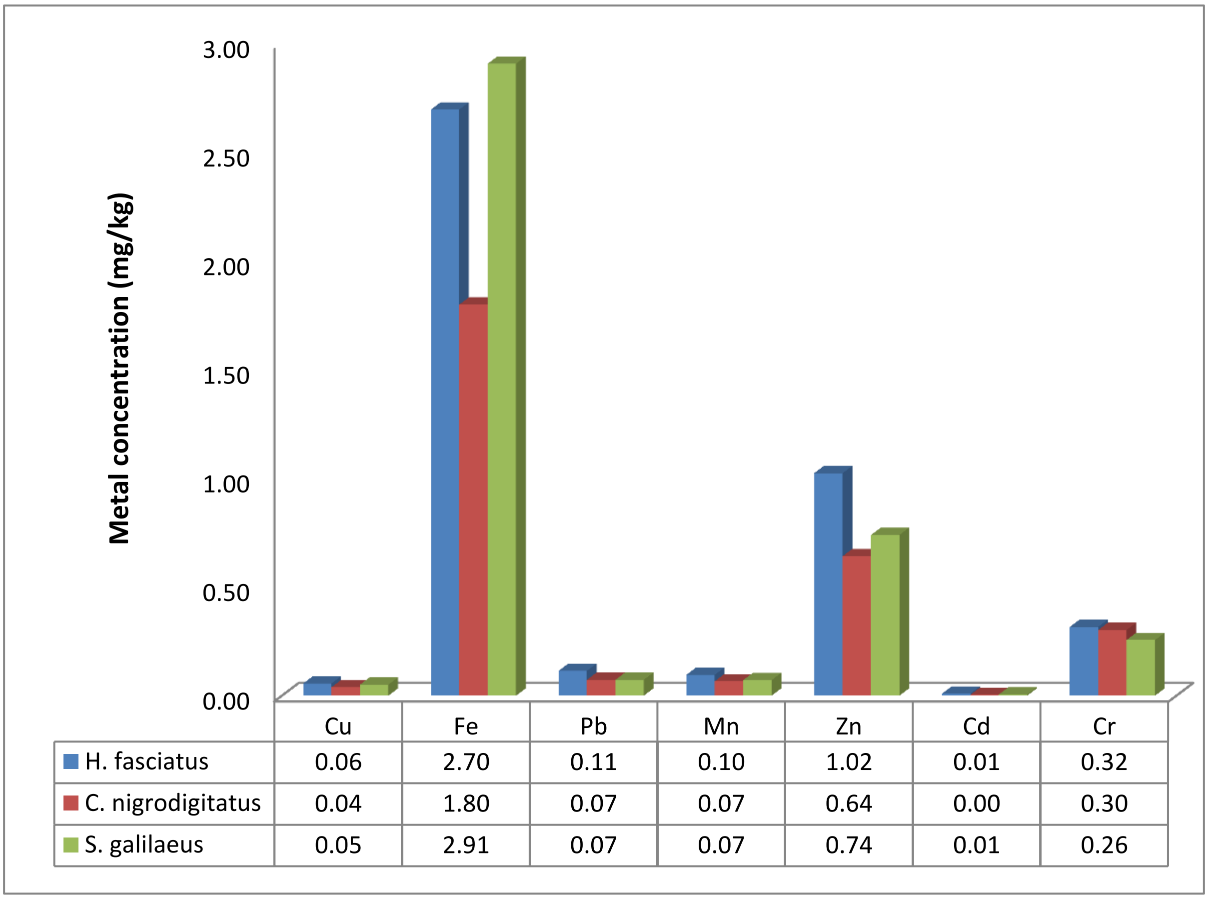

Figure 2: Concentrations of Heavy Metals (mg/kg) in the Sampled Fish Species

Manganese activates several enzymatic systems and supports the utilization of vitamin C, E and B (Underwood, 2002). Its inadequate content in the body can result to critical conditions such as myasthenia gravis (loss of muscle strength). All the three fish species in this study showed low mean concentrations of Mn with maximum concentration of 0.10mg/g as detected in H. fasciatus while the minimum concentration was 0.07mg/g in both S. galilaeus and C. nigrodigitatus. WHO, (2004) and USEPA, (2007) identified the maximum tolerable limit of Mn consumption in fish to be 2.5mg/kg and 0.05mg/kg respectively. Flesh accumulates low metal concentrations in relation to heart, liver and eyes in accordance with Christopher et al. (2009) studies on the distribution of Pb, Zn, Cd, As and Hg in bones, gills, livers and muscles (flesh) of O. niloticus from Henshaw town beach market in Calabar.

Table 4: Metal Mean Comparison of Metal Concentration (mg/kg) in Different Fish Organs

Fish Organs	Cu	Fe	Pb	Mn	Zn	Cd	Cr
GILLS	0.035 ± 0.04^{b}	1.569 ± 1.48^{b}	0.062 ± 0.06^{a}	0.056 ± 0.03^{b}	0.606 ± 0.65^{b}	0.005 ± 0.00^{b}	0.205 ± 0.15^{b}
EYES	0.037 ± 0.04^{b}	1.787 ± 1.74^{b}	0.076 ± 0.12^{a}	0.063 ± 0.04^{b}	0.586 ± 0.62^{b}	0.005 ± 0.01^{b}	0.245 ± 0.16^{b}
LIVER	0.060 ± 0.05^{a}	3.782 ± 3.08^{a}	0.109 ± 0.12^{a}	0.100 ± 0.05^{a}	1.054 ± 0.76^{a}	0.007 ± 0.01^{b}	0.383 ± 0.22^{a}
HEART	0.063 ± 0.05^{a}	3.656 ± 3.41^{a}	0.113 ± 0.15^{a}	0.104 ± 0.05^{a}	1.105 ± 0.80^{a}	0.010 ± 0.01^{a}	0.362 ± 0.19^{a}
FLESH	0.049 ± 0.05^{ab}	1.543 ± 1.33^{b}	0.075 ± 0.08^{a}	0.068 ± 0.04^{b}	0.656 ± 0.61^{b}	0.005 ± 0.00^{b}	0.262 ± 0.18^{b}

Mean values (±Standard Error) in the same column with the same superscripts are not significantly different ($p > 0.05$)

Key:- Cu – copper; Fe – iron; Pb – lead; Mn – manganese; Zn – Zinc; Cd – cadmium; Cr - chromium

Table 5: Maximum Acceptable Levels of Heavy Metals Consumption in Fish (mg/kg)

Organization/Metals	Pb	Fe	Cr	Mn	Cd	Zn	Cu
WHO, 2004	1.5	-	-	2.5	0.2	150	-
USEPA, 2007	0.05	0.1	-	0.05	-	5.0	1.0

***Source:** Ikema and Egieborb, 2005; Obasohan, 2008; Ozturk et al., 2009*

Highest concentrations of metal were accumulated in heart and liver. This highest value might be due to the importance of these organs for their functional role in a living animal while the least in gills may be as a result of just ordinary contact with the water during respiration. Iron was found to be significantly ($p < 0.05$) highest in liver for all the fish samples which may be as a result of liver being the organ for excess glucose storage, centre for deamination and blood production.

It is very difficult to compare the metal concentrations even between the same tissues or organs in different species because of the different factors in the aquatic environments, types and level of water pollution, feeding habits (omnivorous or carnivorous), level of fish presence in water and habitat (pelagic or benthic) (Yilmaz, 2009). Kamaruzzaman *et al.* (2010) indicated that there were relationship among metal concentrations and several other intrinsic factors in fish such as its size, genetic composition and age.

This study clearly revealed that different fish species contained different concentrations of a certain metal across the organ which Kalay *et al*. (1999) reported that different fish species accumulate metals in their tissue in significantly different values. Also, Canli and Atli (2003) reported that levels of heavy metals in fish vary in various species and different aquatic environments. Iron is a major component of heamoglobin which is responsible for the oxygen transportation in the body which may also be toxic to man and animals when ingested in large amount.

The maximum mean concentrations of Fe in this study was 2.90mg/kg as seen in *S. galileaus* while the minimal was 1.80mg/kg as detected in *C. nigrodigitatus*. Fish being the major natural source of Fe in man, is expected to be high, but its accumulation above maximum acceptable limit in fish consumption to be 0.1mg/g (USEPA, 2007) may pose adverse effects. Among all the metals concentrations examined, Fe was the highest in all the fish samples which in contrary to Saeed and Shaker (2008) who reported about concentrations of Fe, Zn, Cu, Mn, Cd and Pb in *O. niloticus* tissues, water and sediments in northern Delta Lakes and found the edible part of *O. niloticus* from Lake Edku and Manzala contained the highest levels of Cd and Pb respectively.

Apart from Fe concentrations, Zn concentrations were found to be highest in all the fish in relation to Cr, Pb, Mn and Cd. This agreed with several studies in many countries (Huang, 2003) found the order of concentrations of four heavy metals in common benthic fishes in decreasing order as: Zn > Cu > Cd = Pb. In addition, Chen and Chen (2001) ordered the concentrations of some metal in fish as the following: Zn = Fe> Cu = Mn> Cd and Bahnasawy *et al*. (2009) also opined that the average concentrations of the metals in fish tissues from Lake Manzala, Egypt exhibited the following order: Zn > Cu > Pb > Cd. Zinc is an essential trace element in human diet that is required for the synthesis of DNA, RNA, protein and thus for cell division.

These Zn values were far below the maximum acceptable limit of WHO, (2004) and USEPA, (2007) which limit the maximum concentration of Zn consumption in fish to be 150mg/g and 5.0mg/g respectively. The level of Cd accumulation in *C. nigrodigitatus* was relatively low or absent, while *S. galilaeus* maintained a constant mean concentration in Pb and Mn accumulations. This may be as a result of their feeding habit and ecological habitat which makes them less vulnerable to the metals. *Chysichthys nigrodigitatus* accumulated least metal in descending order Cd < Mn < Pb < Cr < Zn < Fe and generally in all the trace metals investigated among the fish sampled except in Cr.

This finding was in agreement with Lakshmanian *et al.* (2009) investigation on the concentrations of Zn, Pb, Cr, Co and Cd in five of the most commercially important fishes in the Parangipettai coast, India. However, *H. fasciatus* was found to accumulate highest metal among all fish except in Fe which *S. galilaeus* was the highest which may be as a result of both species fed mostly on planktons (Fafioye and Omoyinmi, 2007). The mean concentration of all the metals was highest ascending order in H > T > C except in Fe and Cr which *S. galilaeus* was highest and least respectively. This highest accumulation in *H. fasciatus* may be as a result of their feeding habits as they prey on *Tilapia spp* fry which have been exposed to the contaminated river.

Generally, fish in this study accumulated essential metals (Fe, Zn, Cr and Mn) in their body organs in higher levels than non-essential ones (Pb, Cd and Cu) and this shows that Majidun river fish contains metals in measurable quantities. Although, metals level in the fish species were within the safe limit for human consumption as set by WHO (2004) and USEPA (2007) (Table 5). These low concentrations of metals in the river might be due to less agro-chemical usage around the study areas and less industrial activities which are the major sources of heavy metal contamination in aquatic environments (Banjo *et al*., 2010). Periodic monitoring of Majidun River is recommended in view of the nutritional and socio-economic importance of the river to the inhabitants of the area and the general public.

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