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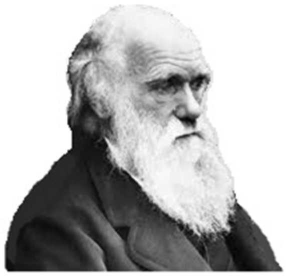

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Assessment of Heavy Metals Concentration in Water and its Bioaccumulation in Fish Species from River Niger, Kogi State, Nigeria

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ABSTRACT

Pollution of the aquatic environment with toxic heavy metals has become a worldwide problem in recent years, because of their negative effects on human health. Three toxic heavy metals (Cd, Cr and Pb) were investigated in the river and organs (intestine, gills and flesh) of ten (10) different fish species (*Heterotis niloticus, Heterobranchus longifilis, Protopterus annectens, Clarias lazera, Tilapia zilli, Clarias anguillaris, Clarias gariepinus, Mormyrus rume, Synodontis clarias* and *Auchenoglanis biscutatus)* harvested from River Niger in Idah Metropolis were analyzed using atomic absorption spectroscopy (AAS) techniques. The mean obtained showed the following concentration of heavy metals (mg/L) in the river: Cr = 0.3727, Cd = 0.1092, Pb = 2.0928. Cadmium was detected in four (4) out of the ten (10) fishes sampled with mean concentration values being *H. longifilis* = 2.3 ± 1.63 mg/kg, *T. zilli*= 10.7 ± 8.11 mg/kg, *C. gariepinus* = 3.4 ± 4.19 and *A. biscutatus* = 1.6 ± 1.19 mg/kg with *T. zilli* having the highest concentration value of Cd. Chromium was detected in all the fish species sampled with mean concentration values all higher than the WHO permissible limit of 0.15mg/kg. Lead was detected in five (5) out of the ten (10) fishes sampled, in the following concentration level; *C. lazera* > *P. annectens* > *C. gariepinus* > *A. biscutatus* > *H. niloticus*. The levels were all higher than the WHO recommended limit for fish and fish products of 2.0mg/kg. The result shows that the bioaccumulation factor of heavy metals in both the water and fishes was in the order Cr > Pb > Cd. Results revealed that, the bioaccumulation factor of the heavy metals in the fishes are beyond the tolerable levels, which indicated that the fishes are unfit for human consumption. Consequently, close monitoring and urgent mitigation strategies of these metals' pollution of river Niger in Idah Metropolis, Kogi State is recommended with a view to minimizing the risk of health of the population that depend on the river for their water and fish supply.

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***Keywords*:** Toxic Heavy Metals, Fish Organs, Digestion, Atomic Absorption Spectroscopy, bioaccumulation factor

1. INTRODUCTION

Water is an important natural resource used for drinking and other developmental purposes in our lives and safe drinking water is necessary for human health all over the world (Bibi *et al*., 2016). Drinking water in various countries does not meet WHO standards and 3.1% deaths occur due to the unhygienic and poor quality of water (Khan *et al.*, 2013; Pawari and Gawande, 2015).

Water pollution occurs when unwanted materials enter in to water, changes the quality of water and harmful to environmental compartments (Alrumman *et al.*, 2016). Discharge of domestic and industrial effluent wastes, leakage from water tanks, marine dumping, radioactive waste and atmospheric deposition are major causes of water pollution.

In the aquatic environment, heavy metals are partitioned between water, sediments and biota and effects of their presence include; inhabitation of photosynthesis and plankton growth, mortality, delayed embryonic development, malformation of stunted growth in adults of aquatic organisms like fish (Biney *et al.*, 1994). As heavy metals cannot be degraded, they are deposited, assimilated or incorporated in water, sediment and aquatic animals and thus, causing heavy metal pollution in water bodies. Therefore, heavy metals can be bioaccumulated and biomagnified via the food chain and finally assimilated by human consumers resulting in health risks (Agah *et al.*, 2009). As a consequence, fish are often used as indicators of heavy metals contamination in the aquatic ecosystem because they occupy high trophic levels and are important food source (Eneji *et al*., 2011).

Fish is a good source of protein, fatty acids, minerals and vitamins for man and contains fatty acids that help to reduce the risk of certain types of cancer and cardiovascular disease (La Vecchia *et al.*, 2001). Fish production from inland water resources (rivers, lakes and streams) is under threat from pollution, habitat alteration and degradation, changes in river flows and over exploitation (Gupta, 2006). When pollutants like heavy metals enter rivers, they change water quality, bind to sediments and accumulate in aquatic biota causing anaemia, disturbance of physiological functions and mortalities of aquatic plants and animals.

The main aim of this study is to determine the concentrations of most toxic heavy metals in water and ten (10) species of fish (*Protopterus annectens, Heterobranchus longifilis, Clarias gariepinus, Tilapia zilli, Heterotis niloticus, Mormyrus rume, Clarias lazera, Clarias anguillaris, Synodontis clarias* and *Auchenoglanis biscutatus*) from River Niger in Idah metropolis. This will be achieved by determine the levels of selected heavy metals (Cr, Cd, Pb, and As) in River Niger water and fishes from Idah Metropolis, Kogi State.

2. EXPERMENTALS (MATERIALS AND METHODS)

All glassware and plastic containers used were rinsed in water, soaked in 10% nitric acid for 24 hours, cleaned thoroughly with distilled water and dried to ensure no contamination occurs. All reagents were of analytical grade.

Sample collection: Water sample was taken below the water surface in the river using one (1) liter acid-leached polythene bottles. The actual sampling was done midstream by dipping the sample bottle at approximately 20-30 cm below the water surface, projecting the mouth of the bottle against the flow direction and closed tightly (Edward *et al.,* 2013). Fish samples were bought from fisher men at the river. These were taken to Department of Fisheries and Aquaculture, Federal University of Agriculture, Makurdi for identification.

Preservation and Pre-treatment: Fish samples were wrapped with polyethylene bags and all the samples were kept on ice and subsequently transported to the laboratory where they were frozen in a deep freezer (Edward, *et al.*, 2013). The Fish samples were dissected with knife to remove the flesh, gills and intestine. The fish samples organs (gills, intestine and tissues) were dried separately for 24 hours to constant weight in an oven at 105 °C. The various organs of each species collected were pooled and milled with a mortar and pestle. They were put in dry labeled plastic containers and stored in desiccator until digestion (Eneji, *et al.,* 2011).

Digestion process: Standard method of digestion was used to bring all the metals into solution i.e. 100 mL of the water sample was measured into a 250 mL conical flask. 5 mL of conc. HNO_3 was added to the flask. It was covered with a watch glass, kept and heated on a hot plate at 60 °C for 20 minutes until the solution appeared light coloured and clear. It was removed from heating and cooled to room temperature. The beaker and the watch glass were rinsed with distilled water and the sample was filtered into a clean filter flask while the filter was rinsed with 3 mL of distilled water. The filtrate was transferred to a 100 mL volumetric flask, rinsing the filtering flask with 5 mL distilled water and added to the filtrate in the volumetric flask. The sample was made up to 100 mL mark with distilled water, agitated to mix very well and kept for analysis (Ademoroti, 1996; Tukura *et al*., 2005). Fish samples were digested as described by Olaifa *et al.,* (2004) as follows: 5 g of fish tissue samples was weighed and placed in a beaker. Exactly 10 cm^3 of freshly prepared concentrated HNO_3/H_2O_2 (1:1) solution was added and the beaker covered with watch glass for initial reaction to subside. The beaker was placed on water bath and boiled at a temperature of 160 °C for two hours to reduce the volume to 3 cm^3. The solution was cooled and transferred to a 50 cm^3 volumetric flask, made up to volume with distilled water and used for metal analysis. About 2 g of organs of fish samples were digested with nitric acid hydrogen peroxide, filtered and made up to 100 mL mark in a volumetric flask with deionized water and kept for analysis (Olaifa *et al.,* 2004). The heavy metals were determined using Atomic Absorption Spectroscopy (AAS) at Sheda Science and Technology Complex (SHESTCO) in Sheda town, Kwali, Abuja.

Preparation of aqueous stock solutions: A stock solution of each metal of interest was prepared from the soluble compound of the salt. Five serial dilutions of each stock were injected into the instrument (AAS), for which a plot of absorbance or peak area versus concentration of the metal in the standard solution was made.

2. 1. Study area

Idah local government is located at the South East of Kogi State, bounded by Ibaji local government to the North East while to the South, is a part of Edo State by River Niger (Figure 1). On the Northern part, lies Igalamela/Odolu local government which was carved out of Idah along with Ibaji local government in 1996 by the Late General Sani Abacha's administration. River Niger passes through Idah metropolis, the river is in the Eastern part of Idah town, it has latitude of 7° 07' N and longitude of 6° 42' E and serves as a natural boundary between Idah in Kogi State and Agenabode in Edo State. The 2006 provisional census figure placed the population of Idah local government at 79,815 who are predominantly farmers.

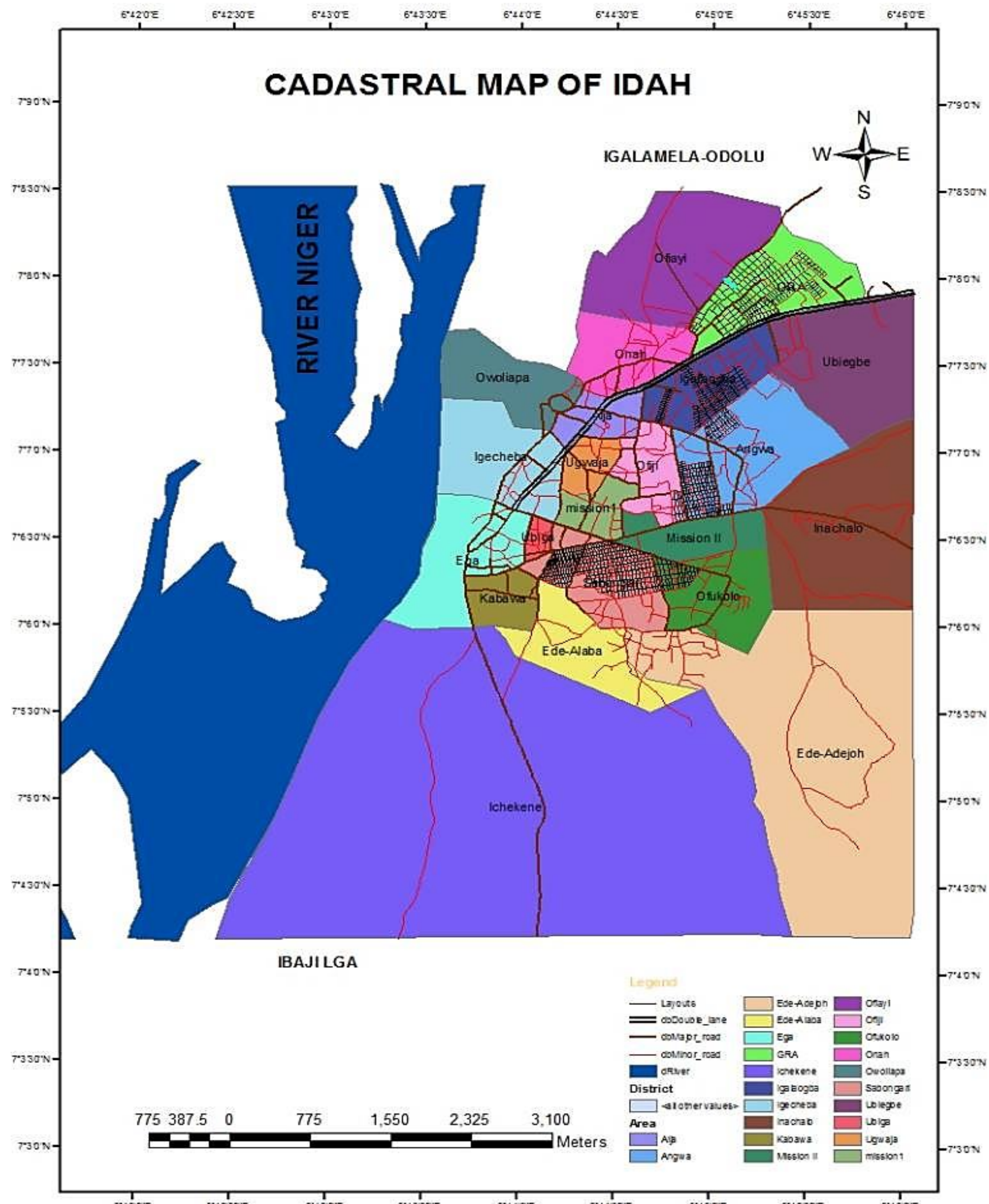

Figure 1. Cadastral Map of Idah showing the Sampling Station.

2. 2. Sample preparation

Water sample: The water sample was filtered through whatman filter paper immediately after the sample was transported to the laboratory. The filtered sample was acidified with HNO_3 and was kept at 4 °C prior to analysis

Plate 1. *Heterotis niloticus* (HN)

Plate 2. *Heterobranchus longifilis* (HL)

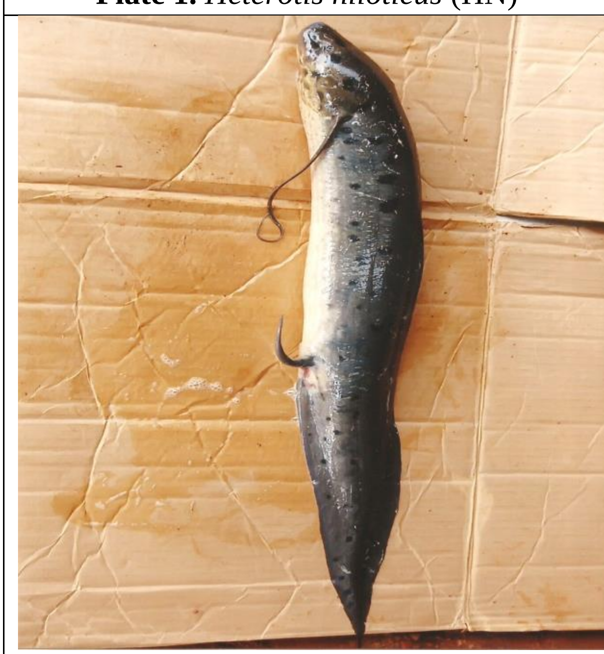

Plate 3. *Protopterus annectens* (PPA)

Plate 4. *Clarias lazera* (CL)

Plate 5. *Tilapia zilli* (TZ)

Plate 6. *Clarias gariepinus* (CG)

Plate 7. *Mormyrus rume* (MR)

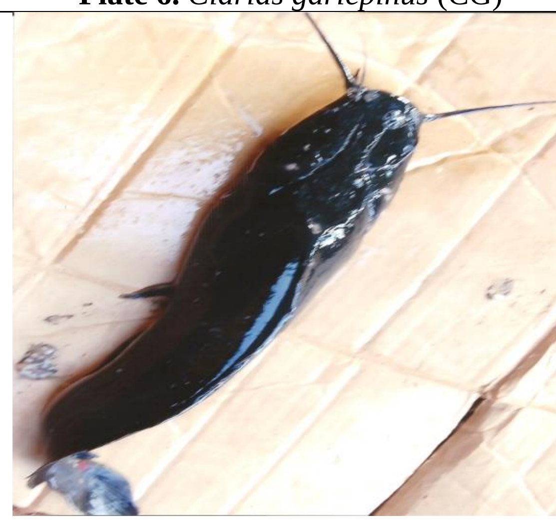

Plate 8. *Clarias anguillaris* (CA)

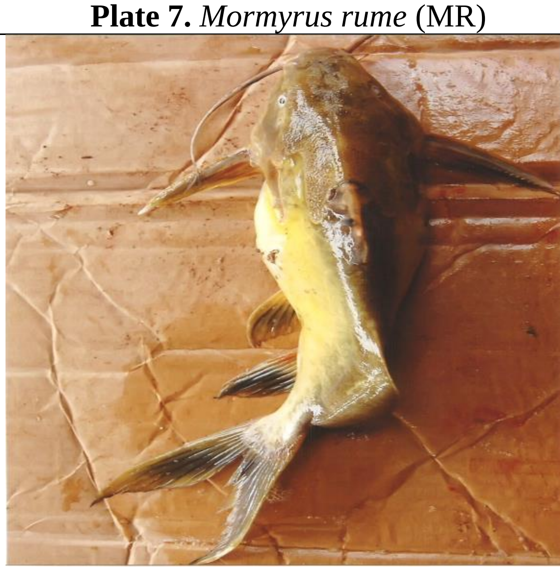

Plate 9. *Synodontis clarias* (SC)

Plate 10. *Auchenoglanis biscutatus* (AB)

2. 3. Data treatment and statistical analysis

The results obtained from this work were analysed using SPSS 21.0 one-way Anova for mean, standard deviation. Data obtained from this work were compared with the national and international standards for maximum acceptable limits for heavy metals in fish and drinking water.

3. RESULTS

The results of all the physico-chemical properties analyzed in the sampled water were presented in Table 1 and 2

Table 1. Some Physico-chemical Properties of the Sampled Water

Parameters	Values
pH	6.87
TDS (mg/L)	42.4
Conductivity (µs/cm)	170.2
Temperature (°C)	17.9
TSS (mg/L)	11.22
Total alkalinity (mg/L)	2.56
Total hardness (mg/L)	56.34
Nitrate (mg/L)	2.133
Phosphate (mg/L)	0.96

The results of heavy metal concentration of the sampled water were presented in Table 2.

Table 2. Heavy Metal Concentration (mg/L) in the Sampled Water

Metals	Cr	Cd	Pb	As
Concentration	0.3727	0.1092	2.0928	-

Results of heavy metal concentration (mg/g) in the organs of the sampled fishes were presented in Table 3.

Table 3. Heavy Metal Concentration (mg/g) in the Organs of the Fish species.

Fish specie	Organs	Cd	Cr	Pb	As
HN	intestine	ND	0.3967	0.1604	ND
	Gills	ND	0.4617	ND	ND
	Flesh	ND	0.3369	ND	ND
HL	intestine	0.0033	0.3322	ND	ND
	Gills	ND	0.6640	ND	ND
	Flesh	0.0036	0.4561	ND	ND
PPA	intestine	ND	0.4302	0.2162	ND
	Gills	ND	0.5666	0.4594	ND
	Flesh	ND	0.4173	0.4724	ND
CL	intestine	ND	0.1778	ND	ND
	Gills	ND	0.5246	1.1962	ND
	Flesh	ND	0.3587	0.2821	ND
TZ	intestine	0.0126	0.0848	ND	0.0019
	Gills	ND	0.1863	ND	ND
	Flesh	0.0196	0.0977	ND	0.0043
CG	intestine	0.0093	0.2196	ND	ND
	Gills	ND	0.3299	ND	ND
	Flesh	0.0009	0.1511	0.3171	ND
MR	intestine	ND	0.2057	ND	0.0041
	Gills	ND	0.1964	ND	ND
	Flesh	ND	0.1476	ND	ND
CA	intestine	ND		ND	ND
	Gills	ND	0.1497	ND	0.0014

	Flesh	ND	0.1092	ND	ND
SC	intestine	ND	0.2178	ND	ND
	Gills	ND	0.1564	ND	ND
	Flesh	ND	0.2217	ND	ND
AB	intestine	0.0028	0.3424	0.3029	ND
	Gills	0.0021	0.3770	ND	ND
	Flesh	ND	0.3296	ND	ND

HN*: Heterotis niloticus,* HL: *Heterobranchus longifilis,* PPA: *Protepterus anectens,* CL: *Clarias lazera*, TZ: *Tilapia zilli*, CG: *Clarias gariepinus*, MR: *Mormyrus rume,* CA: *Clarias anguillaris,* SC: *Synodontis clarias,* AB: *Auchenoglanis biscutatus* ND; not detected

Results of Cadmium concentration levels in the sampled fishes were presented in Table 4.

Table 4. Cadmium Concentration in Fishes

Fishes	Mean Conc. (mg/g)	Conc.(mg/kg)
HL	0.0023	2.3 ± 1.63
TZ	0.0107	10.7 ± 8.11
CG	0.0034	3.4 ± 4.19
AB	0.0016	1.6 ± 1.19

Intestine = 2.8 mg/kg, Gills = 0.2 mg/kg, Flesh = 2.4 mg/kg.

Results of Chr0mium concentration levels in the sampled fishes were presented in Table 5.

Table 5. Chromium Concentration in Fishes

Fishes	Mean Conc. (mg/g)	Conc. (mg/kg)
HN	0.3984	398.4 ± 50.96
HL	0.4829	484.1 ± 136.89
PPA	0.4714	471.4 ± 67.54
CL	0.3537	353.7 ± 141.62

TZ	0.1229	122.9 ± 45.11
CG	0.2335	233.5 ± 73.66
MR	0.1832	183.2 ± 206.43
CA	0.0863	86.3 ± 63.22
SC	0.1986	198.6 ± 29.91
AB	0.3497	349.7 ± 20.02

Intestine = 240.7 mg/kg, Gills = 360.9 mg/kg, Flesh = 262.6 mg/kg.

Results of Lead concentration levels in the sampled fishes were presented in Table 6.

Table 6. Lead Concentration in Fishes

Fishes	Mean Conc. (mg/g)	Conc. (mg/kg)
HN	0.0535	53.5 ± 75.61
PPA	0.3827	382.7 ± 117.83
CL	0.4928	492.8 ± 510.56
CG	0.1057	105.7 ± 149.48
AB	0.1009	101 ± 142.78

Intestine = 67.9 mg/kg, Gills = 165.6 mg/kg, Flesh = 107.2 mg/kg.

Results of Arsenic concentration levels in the sampled fishes were presented in Table 7.

Table 7. Arsenic Concentration in Fishes

Fishes	Mean Conc. (mg/g)	Conc. (mg/kg)
TZ	0.0021	2.1 ± 1.75
MR	0.0014	1.4 ± 1.93
CA	0.0005	0.5 ± 0.66

Intestine = 0.6 mg/kg, Gills = 0.1 mg/kg, Flesh = 0.4 mg/kg.

Results of the bioaccumulation factor of heavy metals concentration in the sampled fishes were presented in Table 8.

Table 8. Bioaccumulation Factor of Heavy Metals (L/kg).

Fishes	Cd	Cr	Pb	As
HN	-	1069.0	25.6	-
HL	21.1	1295.7	-	-
PPA	-	1264.8	182.9	-
CL	-	949.0	235.5	-
TZ	98.3	329.8	-	-
CG	31.1	626.5	50.5	-
MR	-	491.5	-	-
CA	-	231.6	-	-
SC	-	532.9	-	-
AB	14.7	938.3	48.2	-
Mean	16.5 ± 29.3	772.9 ± 361.8	54.3 ± 294	-

4. DISCUSSION

Concentration of Heavy Metals in Water: Water was taken from river Niger in Idah metropolis, Kogi State and analysed for heavy metals. The levels of Cr, Cd and Pb in the water are presented in Table 2.

Concentration of Heavy Metals in the Organs of Fishes : Ten (10) different fishes from river Niger in Idah, Kogi State were analyzed for heavy metals in some of their organs (intestine, flesh and gills). The concentration levels of Cd, Cr, Pb and As obtained from the organs of the ten (10) fishes from river Niger in Idah, are presented in Table 3 above.

Cadmium (Cd) in the fishes: The mean concentrations of Cd in the fishes was found in the range of 0.0016-0.0107 mg/g (1.6 ± 1.19 to 10.7 ± 8.11 mg/kg) in only four (4) out of the ten (10) fishes sampled. The levels in *Auchenoglanis biscutatus*, 0.0016 mg/g (1.6 ± 1.19 mg/kg), *Heterobranchus longifilis*, 0.0023 mg/g (2.3 ± 1.63 mg/kg), *Tilapia zilli*, 0.0107 mg/g (10.7 ± 8.11 mg/kg) and *Clarias gariepinus*, 0.0034 mg/g (3.4 ± 4.19 mg/kg) are all above the WHO recommended limit for fish and fish products of 0.2 mg/kg (WHO/ FAO, 2011). Cadmium concentration was recorded highest in the intestine with mean value of 0.0028 mg/g (2.8 mg/kg) and lowest in the gills with mean value of 0.0002 mg/g (0.2 mg/kg). These levels therefore constitute an immediate hazard to both aquatic fauna and human consumers. Therefore, the consumption of fish should be cautious as cumulative effects might constitute health hazards to aquatic life and man who feeds on fish (Oronsaye *et al*., 2010). Ingestion of Cd can rapidly cause feelings of nausea, vomiting, abdominal cramp and headache, as well as diarrhoea and shock. Itai-itai disease in Japan was identified among people living in Cd polluted areas where rice was irrigated and the target organs include liver, placenta, kidneys, lungs, brain and bones. The presence of Cd in the fishes could be attributed to discharge of industrial effluents and municipal wastes, geology of river bed and catchment area (Obasohan, 2008; Kar *et al*., 2008). The higher levels recorded in *Tilapia zilli* and *Clarias gariepinus* could be attributed to what they feed on, as they mostly feed on water plants, epiphytes and living or dead animal matter that would have bioaccumulated the heavy metals in the river. Based on this study it was recommended that regulatory agencies and other concerned parties to strictly monitor and stop the discharge of industrial effluent and municipal wastes into the river water which is a source of drinking water for the inhabitants of Idah. The study therefore, recommends that monitoring the river which is a source of water for drinking and irrigation for the inhabitants, be regular.

Chromium (Cr) in the fishes: The levels of Cr for all considered samples are recorded in Table 3 and 5 above. The ten (10) sampled fishes recorded Cr mean levels that ranged from 0.0863 to 0.4829 mg/g (86.3 ± 63.22 to 484.1 ± 136.89 mg/kg). The concentrations recorded in all the sampled fishes were far above the recommended limit of 0.15 mg/kg for chromium in fish and fish products (WHO, 2008). The highest concentration was recorded in the gills of the fishes, with the mean value of 0.3609 mg/g (360.9 mg/kg) and the lowest in the intestine of the fishes with the mean value of 0.2407 mg/g (240.7 mg/kg). This means that consumption of fish from river Niger in Idah, Kogi State poses immediate and great threat to the population consuming fish as far as Cr concentration is concerned. Higher concentrations than those reported by the current study have been reported in various rivers (Oguzie and Izevbigie, 2009). A 1.38 mg/kg Cr mean levels in fish gills have been reported from Ikpoba River Nigeria during the dry season. In this study, it was reported that the levels recorded in fishes do not constitute immediate hazards because the values fell far above the recommended limit in fish and fishery products by the Food and Agricultural Organization of the United Nations (FAO, 2003). The high level of these metals in both the water and sediment samples are as a result of the runoffs during the rainy season from agricultural fields and the dumping of domestic wastes in the water body at different points along the length of the stream as they are known to contain heavy metals such as Cr, As, Cd, Co, Cu, Fe, Hg, Mn, Pb, Ni and Zn which will eventually end up in this aquatic ecosystem (Opaluwa *et al.*, 2012). Toxicity levels varies with hexavalent Cr being known to be very toxic and mutagenic when inhaled and also a human carcinogen with long term exposure causing damage to liver, kidney, circulatory and nerve tissues, as well as skin irritation. Based on this study it was recommended that regulatory agencies and other concerned parties to strictly monitor and stop the discharge of industrial effluent, use of agro chemicals around the water and municipal wastes into the river water which is a source of drinking water for the inhabitants of Idah, to monitor the pollution rate.

Lead (Pb) in the fishes: The mean concentration of Pb in the fishes was found in the range of 0.0535 to 0.4928 mg/g (53.5 ± 75.61 to 492.8 ± 510.56 mg/kg). Lead (Pb) was detected in five

(5) out of the ten (10) fishes sampled in the following way; *C. lazera*> *P. anectens* > *C. gariepinus*> *A.biscutatus*> *H. niloticus*. The levels were higher than the WHO recommended limit for fish and fish products of 2.0 mg/kg (WHO, 2003). The gills recorded the highest concentration with mean value of 0.1656 mg/g (165.5 mg/kg), and the intestine recorded the lowest with mean value of 0.0679 mg/g (67.9 mg/kg). These levels therefore constitute an immediate hazard to both aquatic fauna and human consumers. The high levels of Pb recorded in these fishes were therefore attributed to high usage of automobile engine boats, industrial and urban effluents discharges on the river water (Kumar, 2011; Mwegoha and Kihampa, 2010). In addition, long term exposure of Pb may result in slowly progressing physical, muscular and neurological degenerative processes, as well as cancer (Oguzie, 2003). The concentration of Pb in fish gills found in this study didn't agree with concentrations reported previously in river waters. Concentrations of 0.2 mg/kg and 0.33 mg/kg reported in fish gills from Ikpoba and Forcados rivers, respectively did not constitute immediate hazard to aquatic fauna and human consumers (Agatha, 2010). The difference in concentration could have resulted from untreated sewerage, industrial effluent and difference in geological features (Kar *et al*., 2008).

Table 9. Mean Values of Cadmium (Cd) Concentration (mg/g) in Organs of Fishes

ORGANS	HN	HL	PPA	CL	TZ	CG	MR	CA	SC	AB	MEAN
INTESTINE	-	0.0033	-	-	0.0126	0.0093	-	-	-	0.0028	0.0028
GILLS	-	-	-	-	-	-	-	-	-	0.0021	0.00021
FLESH	-	0.0023	-	-	0.0196	0.0009	-	-	-	-	0.002441
MEANS	-	0.0023	-	-	0.010733	0.0034	-	-	-	-	0.001633

HN*: Heterotis niloticus,* HL: *Heterobranchus longifilis,* PPA: *Protepterus anectens,* CL: *Clarias lazera,* TZ: *Tilapia zilli,* CG: *Clarias gariepinus,* MR: *Mormyrus rume,* CA*: Clarias anguillaris,* SC: *Synodontis clarias,* AB: *Auchenoglanis biscutatus*

Table 10. Mean Values of Chromium (Cr) Concentration (mg/g) in Organs of the Fishes

ORGANS	HN	HL	PPA	CL	TZ	CG	MR	CA	SC	AB	MEAN
INTESTINE	0.3967	0.3322	0.4302	0.1778	0.0848	0.2196	0.2057	-	0.2178	0.3424	0.24072
GILLS	0.4617	0.6604	0.5666	0.5246	0.1863	0.3299	0.1964	0.1497	0.1564	0.377	0.3609
FLESH	0.3369	0.4561	0.4173	0.3587	0.0977	0.1511	0.1576	0.1092	0.2217	0.3296	0.2626
MEANS	0.3984	0.4829	0.4714	0.3537	0.1229	0.2335	0.1832	0.0863	0.1986	0.3497	

Table 11. Mean Values of Lead (Pb) Concentration (mg/g) in Organs of the Fishes

ORGANS	HN	HL	PPA	CL	TZ	CG	MR	CA	SC	AB	MEAN
INTESTINE	0.1604	-	0.2162	-	-	-	-	-	-	0.3029	0.062795
GILLS	-	-	0.4594	1.1962	-	-	-	-	-	-	0.16556
FLESH	-	-	0.4724	0.2821	-	0.3171	-	-	-	-	0.10716
MEANS	0.053467	-	0.382667	0.492767	-	0.1057	-	-	-	0.100967	

Table 12. Mean Values of Arsenic (As) Concentration (mg/g) in Organs of the Fishes

ORGANS	HN	HL	PPA	CL	TZ	CG	MR	CA	SC	AB	MEAN
INTESTINE	-	-	-	-	0.0019	-	0.0041	-	-	-	0.006
GILLS	-	-	-	-	-	-	-	0.0014	-	-	0.0014
FLESH	-	-	-	-	0.0043	-	-	-	-	-	0.00043
MEANS	-	-	-	-	0.002067	-	0.00137	0.000467	-	-	

Table 13. Mean Concentration Values for Cd in the Fishes

FISHES	MEAN(Cd)
HN	-
HL	0.0023
PPA	-
CL	-
TZ	0.011
CG	0.0034
MR	-
CA	-

SA	-
AB	0.002

Table 14. Mean Concentration Values for Cr in the Fishes

FISHES	MEAN (Cr)
HN	0.3984
HL	0.4829
PPA	0.4714
CL	0.3537
TZ	0.1229
CG	0.1832
MR	0.0863
CA	0.1986
SC	0.3497
AB	0.2335

Table 15. Mean Concentration Values for Pb in the Fishes

FISHES	MEAN (Pb)
HN	0.0535
HL	-
PPA	0.3827
CL	0.4928
TZ	-
CG	0.1057
MR	-
CA	-
SC	-
AB	0.101

Table 16. Mean Concentration Values for as in the Fishes

FISHES	MEANS (As)
HN	-
HL	-
PPA	-
CL	-
TZ	0.0021
CG	-
MR	0.0014
CA	0.0005
SC	-
AB	-

Table 17. Set of Standards for Maximum Allowable Limits for Drinking Water and Fish

	Water(mg/L			Fish (mg/kg)	
Metals	FDA	WHO	EPA	WHO	CGCCTF
Pb	0.005	0.01	0.05	2.0	-
Cd	0.005	0.003	-	0.2	-
Cr	-	0.05	-	0.15	-
As	-	0.01	-	-	3.5

CGCCTF = Canadian Guidelines for Chemical Contaminants and Toxins in Fish and Fish Products.

Bioaccumulation Factor (BAF): Table 8 shows the bioaccumulation factor, and it was obtained by using this formula, (equation 1).

$$BAF = \frac{C_B}{C_W}$$

where: C_B = concentration of chemical in the aquatic biota and C_W = concentration of chemical in the ambient water.

The concentration for the fishes was gotten from the mean concentration value of each of the fishes. From the results of bioaccumulation factor obtained in Table 8, it was observed that only Chromium has the highest mean value of 0.7729. Cadmium has 0.0166, Lead has 0.0543 respectively. However, all the heavy metals studied has mean BAF values higher than the 1.00 L/kg recommended limits of WHO/FEPA. Table 8 shows that the bio-accumulation factor of heavy metals in both water and fishes was in the order Cr>Pb>Cd>As.

5. CONCLUSIONS

All the sampled fishes obtained from river Niger in Idah Metropolis in Kogi State were found to contain all the analyzed heavy metals (Cd, Cr, Pb, and As) at different levels. Concentrations of Cd, Cr, and Pb in the fishes and water sample obtained from river Niger in Idah metropolis in Kogi State were found to have exceeded the WHO recommended limits. As was found in three (3) out of the ten (10) fishes sampled, though, at concentrations below the WHO recommended limits. As was found to be below the detection limit of the equipment in the water sample analyzed. This work also reveals that the river is comparatively not suitable for usage as drinking water in terms of heavy metal loads since most of the heavy metals analyzed were above the recommended limits. Also, in terms of other water quality parameters, the river could be acceptable for drinking with little or no much treatment since these parameters were found to be below the recommended set limits as found out.

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