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Alinnor IJ
Department of Chemistry, Federal University of Technology P.M.B. 1526, Owerri, Imo State, Nigeria

Ayuk AA
Department of Chemistry, Federal University of Technology P.M.B. 1526, Owerri, Imo State, Nigeria

Igbomezie MC
Department of Chemistry, Federal University of Technology P.M.B. 1526, Owerri, Imo State, Nigeria

Correspondence
Alinnor IJ
Department of Chemistry, Federal University of Technology P.M.B. 1526, Owerri, Imo State, Nigeria

Distribution of elemental contaminants in water and fish samples from Oguta Lake, Nigeria

Alinnor IJ, Ayuk AA and Igbomezie MC

Abstract
The heavy metals in water and fish samples from Oguta Lake were studied. The elements studied were Pb, Hg, Cr, Cd and Cu. Three water samples and three samples of different fish species were collected from different locations in the lake. The water and fish samples were analysed for heavy metal using Atomic Absorption Spectrophotometer (AAS). The heavy metals Pb and Cr were identified in appreciable amounts in fresh fish species *Clarias anguillaris* of mean values 36.00 mg/kg and 4.34mg/kg, respectively. The accumulation of copper in fish species *Protopterus annectens* and *Clarias anguillaris* were of mean values 30.10mg/kg and 22.31mg/kg, respectively. The levels of elemental contaminants Pb, Cr, Cd and Cu from the water samples have mean values 0.740mg/L, 0.413mg/L, 0.106mg/L and 0.280 mg/L, respectively. The level of accumulation of copper in different fish species were in the order:- *Protopterus annectens* > *Clarias anguillaris* > *Sarotherodon galilaeus* > *Clarias submarginatus* > *Chysichthys nigroiditaus*. A lot of activities go on at Oguta lake including artisans that discharge their waste into the lake and inhabitants depend on the lake for fishing and other domestic uses. In view of this, there is a need to determine the level of pollution of the lake. This study is aimed at determining the level of heavy metal toxicants in fish and water samples from the lake. The effect of these elemental contaminants and the associated health hazards were examined.

Keywords: associated health hazards, contamination of water sample, fish sample, bioaccumulation factor.

1. Introduction
Pollution is the introduction of a contaminant into the environment. These contaminants can be as a result of human activities and also can be as a result of natural disasters [1, 2]. Pollution has a detrimental effect on any living organism in an environment, making it virtually impossible to sustain life [3]. Water pollution has been extensively documented as a contributor to health problems in humans and marine animal ecosystems. Water pollution occurs when pollutants are directly or indirectly discharged into water bodies without adequate treatment to remove harmful compounds [1, 2, 4].

Water pollution has become one of the most serious problems in Nigeria, especially in Oguta town. Oguta lake flows in Imo State of Nigeria. Oguta is not a commercial town but there is a lot of activities going on near the lake such as fishing activities and artisans who are battery charges, motor mechanics etc. All these artisans discharges their waste into Oguta lake. The lake acts as a source of drinking water, fishing and other domestic uses for the inhabitants. In view of the activities of these artisans, that discharge their waste into the lake, it is necessary to investigate the level of pollution in the lake.

Heavy metals constitute one of the most dangerous groups among the water pollutants. This is because of their persistent nature, toxicity, tendency to accumulate in organism and undergo food chain processes. They are also non bio-degradable [5]. Asonye *et al* [6] studied some physico-chemical characteristics and heavy metal profiles of Nigeria rivers, streams and water ways. The heavy metals studied were Pb, Cr, Cd, Fe, Zn, Mn and Cu. They reported that among the heavy metals studied that Pb, Cd, Cr, Zn and Mn levels were above the guidelines of World Health Organization (WHO).

Wangboje and Ekundayo [7] investigated the heavy metals in surface water of Ikpoba reservoir, in Benin City, Nigeria. The study revealed that the concentration of heavy metals in surface water varied. The mean concentrations of Cd. Fe, Pb, Ni and Zn, exceeded the WHO maximum permissible level for drinking water. Their findings indicated that water from the reservoir is unsafe for human consumption.

Alinnor and Obiji [8] assessed the trace metal (Pb, Fe, Cd, Hg, Cu, Zn) composition in fish samples from Nworie river. They also examined the effects of these elemental toxicants and the associated health hazard. They reported that only one species of fish (Tilapia) was found in the river. Akan *et al* [9] studied bioaccumulation of some heavy metals in fish samples from River Benue in Vininkilang, Adamawa State of Nigeria. Their result indicated that the highest level of all the heavy metals studied was observed in the gills and liver of the fish samples. Emere and Dibal [10] reported the accumulation of heavy metals in some tissue organs of fresh water fish (*Clarias gariepinus*) from Kaduna river. They reported that gills which is used for respiration and also constantly exposed to water accumulated more heavy metals than liver. They attributed the pollution of the river to industrial effluents and agricultural chemicals that were discharged into the river untreated.

Materials and Method

Collection of Water Samples

Polythene containers of 2.5dm^3 were washed with soap solution, rinsed with distilled water, and were finally rinsed with deionised water. The water samples were collected using sterile 2.5dm^3 polythene containers from three different points in the lake during the dry season precisely November. The sampling points were shown in Figure 1. The water samples were preserved with concentrated hydrochloric acid (2cm^3 acid/dm^3 water) and stored at 4^{o}C until use.

Collection of Fish samples

The fresh fish samples collected from the lake were African lung fish (*Protopterus annectens*), Nigroid catfish (*Chrysichthys nigrodigitatus*), Tilapia galilae (*Sarotherodon galilaeus*), Mould /Africa cat fish (*Clarias Submarginatus*) and Mould cat fish (*Clarias anguillaris*). These were carried out with the help of fishermen. The fresh fish samples were collected with locally made wire net of 2.5mm diameter. Three samples each of different species of fish were collected from various locations in the lake. The samples were stored below 4^{o}C in a refrigerator until use.

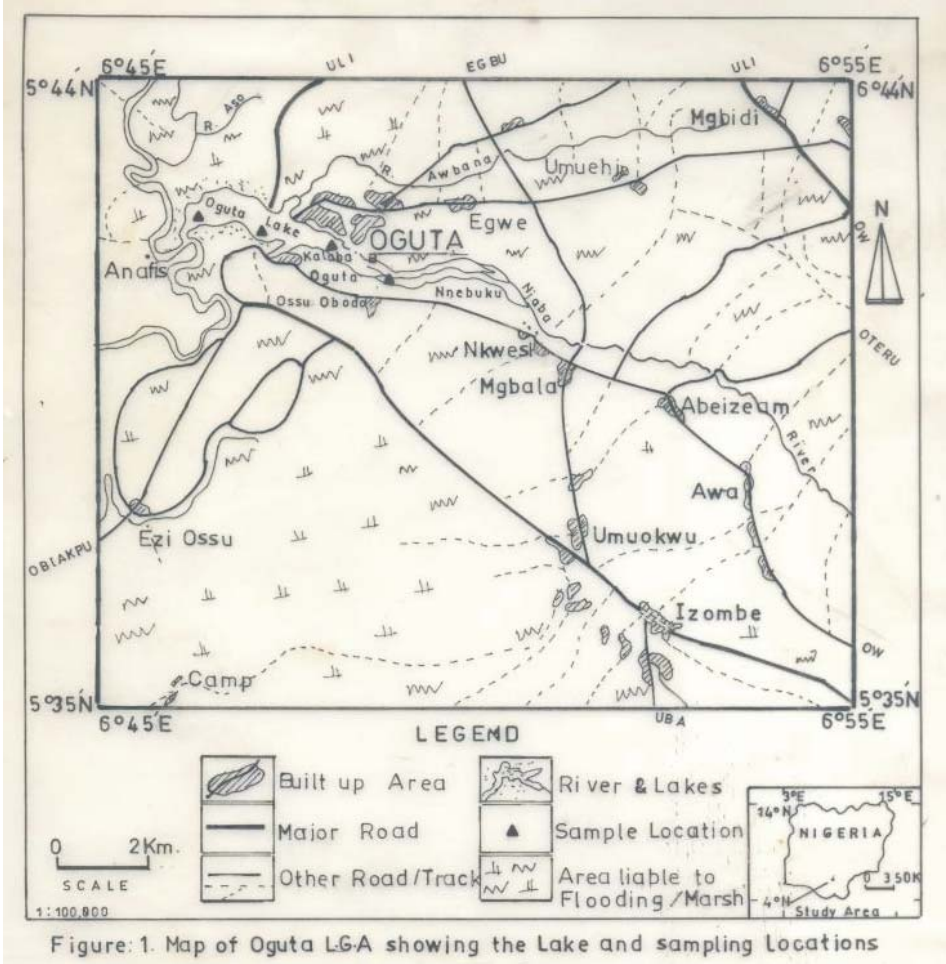

Figure: 1. Map of Oguta LGA showing the Lake and sampling Locations

Analysis of Water Samples

Water samples were pre-treated by repeated evaporation with analar grade nitric acid (HNO_3) as outlined in the standard methods for the Examination of Water and Waste-Water (APHA-AWWA-WPCF) [11]. Heavy metal contaminants in the water samples were determined using Solar Unicam 969 Atomic Absorption Spectrophotometer (AAS).

Analysis of Fish Samples

The whole fish were dried in an electric oven at 70-80^{o}C for 3 days. A homogenized 2g of the ground fish was weighed in an analytical balance and ash in a furnace at 550^{o}C. The samples were put in flasks, and 10ml each of concentrated HNO_3 and HCl were added. The samples were digested for 2-3h until brown fumes ceased to evolve [12, 13].

Filtration was done through a Whiteman GFK glass filter and solution made up to 100ml mark with deionized water and

kept ready for AAS analysis. The digested samples were analysed using Solar Unicam 969 AAS according to the technique as described by Frank *et al.* [14]. All chemicals used were of analytical reagent grade.

Results and Discussion

It has been reported [13] that Aba river is contaminated with elemental toxicants because of industries that discharge untreated waste into the river and other human activities. Oguta lake flows in Imo State of Nigeria and there is a lot of human activities going on in the lake. In view of this, the lake was investigated to ascertain the level of heavy metal contamination. Table 1 showed that the lake is contaminated with Pb from the waste discharged into the lake at stations 1, 2, 3 and 4 of mean values 0.643mg/L, 0.536mg/L, 0.740mg/L and 0.690mg/L, respectively. Alinnor[15] working on Aba river, Nigeria reported Pb contamination from the waste discharged by Paterson Zochonis (PZ) Plc, International Glass Industry (IGI) Plc and Nigeria Breweries (NB) Plc of mean values 0.719ppm, 0.80ppm and 0.90ppm, respectively. Eneji *et al* [16] Working on River Mada in Nasarawa state of Nigeria reported Pb concentration of mean value range 0.398 – 0.569 in both rainy and dry season, respectively. This study showed that Aba river was contaminated with Pb when compared to values obtained from Oguta lake. This may be attributed to industries that discharge their waste into Aba river. However, this study indicated that Oguta lake has high level of Pb in all the stations studied than River Mada. High concentration of Pb in Oguta lake when compared to River Mada may be attributed to various artisans such as battery chargers, motor mechanics etc. working near the lake. The WHO acceptable concentration for Pb in drinking water is 0.01mg/L. The result of this study showed that Oguta lake is contaminated with Pb. Lead is a well-known toxicant that has several deleterious effects on human being even at low concentrations because it is cumulative. Pb reduces neuro-psychological functions leading to inattention and intelligence Quotient (IQ) deficiency [17]. Mercury was not detected in all the stations studied.

Table 1: Concentration (mg/L) of some heavy metals in water samples from Oguta lake.

Station	Water sample	Pb	Hg	Cr	Cd	Cu
1	A	0.542	ND	0.04	0.007	0.17
	B	0.345	ND	0.046	0.009	0.10
	C	1.034	ND	0.028	0.005	0.26
	Mean	0.643	ND	0.038	0.007	0.182
	S.D	±0.35	ND	±0.009	±0.002	±0.05
2	D	0.58	ND	0.267	0.006	0.094
	E	0.46	ND	0.188	0.003	0.142
	F	0.57	ND	0.259	0.009	0.042
	Mean	0.536	ND	0.238	0.006	0.093
	S.D	±0.07	ND	±0.04	±0.003	±0.05
3	G	0.70	ND	0.490	0.008	0.301
	H	0.46	ND	0.258	0.003	0.220
	I	1.06	ND	0.490	0.012	0.320
	Mean	0.740	ND	0.413	0.008	0.280
	S.D	±0.30	ND	±0.13	±0.005	±0.05
4	J	0.60	ND	0.172	0.094	0.27
	K	0.38	ND	0.195	0.142	0.31
	L	1.09	ND	0.155	0.082	0.25
	Mean	0.690	ND	0.174	0.106	0.277
	S.D	±0.36	ND	±0.02	±0.03	±0.03

SD = Standard Deviation
ND = Not Detected

Table 1 showed that Cr concentration in stations 1,2,3, and 4 were of mean values 0.038mg/L, 0.238mg/L, 0.413mg/L and 0.174mg/L, respectively. This study revealed that chromium concentration was high in the lake with stations 2 and 3 being appreciably high. Aiyesanmi [18] working on Ominla and Oluwa rivers in Okitipupa, Ondo State of Nigeria reported Cr concentration of mean values 0.013 and 0.006mg/L, respectively. Shabanda *et al* [19] working on River Jega in kebbi state of Nigeria reported high Cr concentration of mean value 0.193mg/L. The WHO acceptable value for Cr in drinking water is 0.05mg/L. The result indicated that the lake was contaminated at stations 2 to 4. However, the value obtained in station 1 is within the acceptable recommended limit of WHO. Alinnor and Alagoa [20] working on Nkisa river reported Cr concentration at stations 1, 2, 3, 4 and 5 of mean values 0.103, 0.084, 0.089, 0.078 and 0.053mg/L, respectively. Chromium is carcinogenic when inhaled. The chief health problems associated with chromium compound are related to chromium (VI). The breathing of dust or mists containing chromium (VI) compounds leads to ulceration and eventual perforation of cartilaginous portions of the nasal septum.

The result of this study showed that water sample obtained from stations 1,2,3 and 4 as shown in table 1 were contaminated with Cd of mean values 0.007, 0.006, 0.008 and 0.106mg/L, respectively. Alinnor [15] working on Aba river reported high Cd concentration in water sample of mean value 0.212mg/L at discharged point of wastes into the river from Paterson Zochonis (PZ) Plc. Obodo[21] working on River Niger reported that Cd concentration was below detection level. Alinnor and Alagoa [20] working on Nkisa river reported Cd concentration of mean values 0.025, 0.018, 0.023, 0.018 and 0.015mg/L at stations 1,2,3,4 and 5, respectively. The WHO acceptable concentration for Cd in drinking water is 0.003mg/L. The high concentration of Cd is Aba river when compared to Oguta lake may be attributed to industries that discharge their wastes into the river. The result of the analysis indicated that Oguta lake is contaminated with Cd when compared to WHO standard. Cadmium is not an essential element in biological processes. Instead it is toxic and poisoning occurs through inhalation and ingestion. On

inhalation cadmium causes acute bronchitis and pneumonitis and inflammation of the liver.

Table 1 showed copper concentration in water samples of this study. The stations 1, 2, 3 and 4 showed copper concentration of mean values 0.182, 0.093, 0.280 and 0.277mg/L, respectively. Aiyesanmi [18] reported copper concentration of mean value 0.303mg/L in water sample from Ominla river. Ibe *et al* [22] working on Imo river at Ihitte-Uboma Local Government of Imo State, Nigeria report Cu concentration of mean values in the range 0.230-0.350mg/L in water samples. Alinnor and Alagoa [20] working on Nkisa river reported Cu concentration of mean values 0.053, 0.039, 0.047, 0.043 and 0.034 mg/L at Stations 1, 2, 3, 4, and 5, respectively. The WHO recommended acceptable level for Cu in drinking water is 2.0mg/L. This study indicated that Oguta lake has copper concentrations below the recommended WHO limit. The presence of copper in water samples from the lake may be attributed to welding and battery charging activities of the artisans that go on near the lake.

Table 2: Concentration (mg/kg) of some heavy metals in fish samples from Oguta lake.

Name of fish	English name	Fish sample	Pb	Hg	Cr	Cd	Cu
Protopterus	Africa	A	18.00	ND	3.74	0.40	30.00
annectens	lung fish	B	17.10	ND	2.85	0.30	31.30
		C	19.10	ND	4.65	0.50	28.90
		Mean	18.10	ND	3.75	0.41	30.10
		S.D	±1.00	ND	±0.90	±0.10	±1.20
Chrysichthys	Nigroid	D	ND	ND	0.07	ND	8.90
Nigrodigitatus	cat fish	E	ND	ND	0.06	ND	7.50
		F	ND	ND	0.05	ND	9.70
		Mean	ND	ND	0.06	ND	8.70
		S.D	ND	ND	±0.01	ND	±1.11
Sacrotherodon	Galilae	G	ND	ND	0.17	ND	19.80
galilaeus	fish	H	ND	ND	0.15	ND	18.50
		I	ND	ND	0.04	ND	21.30
		Mean	ND	ND	0.12	ND	19.90
		S.D	ND	ND	±0.07	ND	±1.40
Clarias	Mud	J	3.00	ND	0.17	ND	12.60
Submarginatus	cat fish	K	2.40	ND	0.10	ND	14.10
		L	4.10	ND	0.26	ND	10.10
		Mean	3.20	ND	0.18	ND	12.30
		S.D	±2.68	ND	±0.08	ND	±2.20
Clarias	Mud	M	38.30	Nd	4.45	0.34	24.50
Anguillaris	cat fish	N	32.70	ND	3.44	0.41	20.10
		P	37.00	ND	5.04	0.29	23.50
		Mean	36.00	ND	4.34	0.35	22.81
		S.D	±2.93	ND	±0.82	±0.06	±2.36

S.D. = Standard deviation

ND = Non – detectable (below detection level)

Table 2 showed the levels of heavy metal contamination in different species of fresh fish samples obtained from Oguta lake. Pb concentration in *Protopteus annectens*, *Clarias submarginatus* and *Clarias anguillaris* were of mean values 18.10,3.20 and 36.00mg/kg, respectively. The result of this study indicated that *Clarias anguillaris* accumulate more lead when compared to other species of fish sample found in Oguta lake. Obodo [23] working on Anambra river reported Pb concentration of mean values 61.32 and 62.79mg/kg for *Synodontis* and *Tilapia*, respectively.

Akan and Abiola [24] working on Lagos Lagoon in Nigeria reported Pb concentration of mean values 17.98, 12.81, 15.75 and 11.66 mg/kg in fish species *Tilapia guineenis, Liza grandisquainis*, *Chrysichthys nigrodigitatus* and *Psettias sebae*, respectively. Alinnor and Alagoa [20] working on Nkisa river recorded Pb concentration of mean values 0.98, 0.76 and 0.87 mg/kg in fish species *Protopterus annectens*, *Gymnarchus niloticus* and *Clarias gariepinus*, respectively. Emeshili and Egboh[25] working on Ase river in Delta State of Nigeria reported Pb concentration of mean values 1.87 and 0.56mg/kg in *Uca pugilator* and *Drepane Africana*, respectively.

Lead is a known toxicant that has deleterious effect even at low concentration. The limit recommended by the Australian National Health and Medical Research Council (ANHMRC) for Pb in sea food is 2.00ppm. The result of the analysis showed that some of the fish samples from Oguta lake were contaminated with Pb when compared to ANAHMRC standard. The level of accumulation of Pb in fish species from Oguta lake were *Clarias anguillaris* > *Protopterus annectens* > *Clarias submarginatus* whereas *Chrysichthys nigrodigitatus* and *Sarotherodon galilaeus* were below detection level. The Pb in the fish sample may be transferred to human being on consumption of fish that is contaminated with Pb which poses health hazards. Mercury was below detection level in all the fish species studied.

Table 2 showed the level of contamination of fish species in Oguta Lake. The concentration of Cr in various fish species *Protopterus annetens, Chrysichthys nigrodigitatus, Sarotherodon galilaeus, Claries submargintus* and *Clarias anguillaris* were of mean values 3.75, 0.06, 0.12, 0.18 and 4.34mg/kg, respectively. The result of the analysis indicated that Cr accumulates more in *Clarias anguillaris* than other species of fish found in Oguta lake. The order of accumulation of Cr in fish species were:- *Clarias anguillaris* > *Protopterus annectens* > *Clarias submmarginatus* > *Sarotherodon galilaeus* > *Chrysichthys nigrodigitatus*. Shabanda *et al* [19] working on Jega river reported Cr concentration of mean values 0.243 and 0.466mg/kg in fresh fish samples *Tilapia miligi* and S*ynodontis sorex*, respectively. Alinnor [15] working

on Aba river reported Cr concentration in Sadillina and *Hetretis niloticus* of mean values 1.00 and 0.12ppm, respectively. High concentration of Cr in muscle and liver of fish species, tilapia have been reported by Nsikak *et al* [26]. The recommended limit for Cr in seafood set by Hong Kong standard is 1.0µgg^{-1}. Therefore, the chromium concentration found in fish species *Clarias anguillaris* and *Protopterus annectens* were contaminated when compared to Hong Kong standard.

Table 2 showed the level of accumulation of Cd in different fish species from Oguta lake. The concentration of Cd in fish species *Protopterus annectens* and *Clarias anguillaris* were of mean values 0.41 and 0.35mg/kg, respectively. The result indicated that *Protopterus annectens* accumulate more Cd than other species of fish studied. The order of accumulation of Cd in fish species were *Protopterus annectens* > *Clarias anguillaris*, whereas *Chrysichthys nigrodigitatus, Sarotherodon galilaues* and *Clarias submarginatus* were below detection level. Alinnor and Ukiwe [27] working on Mbaa river, Imo State, Nigeria reported Cd concentration 0.033 and 0.05ppm in *Tilapia guineensis* and *Synodontis mambrabace*, respectively. Etesin and Nsikak [28] reported low concentration of Cd in tissue of *Ethmalosa fimbrita* and *Tilapia guineensis*. Alinnor and Alagoa [20] working on Nkisa river reported Cd concentration values 0.79, 0.08 and 0.05mg/kg for *Protopterus annectens*, *Gymnarchus niloticus* and *Clarias gariepinus*, respectively. The WHO recommended limit for Cd in seafood is 0.2µgg^{-1}. The result of the analysis indicated that fish species *Protopterus annectans* and *Clarias anguillaris* were contaminated with Cd when compared to the WHO standard.

Table 2 revealed the accumulation of copper in different fish species obtained from Oguta lake. The concentration of copper in fish species *Protopterus annectens, Chrysichthys nigrodigitatus, Sarotherodon galilaeus, Clarias Submarginatus* and *Clarias anguillaris* were of mean values 30.10, 8.70, 19.90 12.30, and 22.81 mg/kg, respectively. The result of the analysis indicated that *Protopterus annectens* accumulate more copper than other species. The order of accumulation of Cu in fresh fish species were: *Protopterus annectens* > *Clarias anguillaris* > *Sarotherodon galilaeus* > *Clarias sumbarrginatus* > *Chrysichthys nigrodigitatus*. Obodo [29] working on lower reaches of River Niger reported Cu concentration of mean value 8.33mg/kg in *Synodontis membranaceus*. Alinnor and Obiji [8] reported copper concentration of mean value 1.247ppm in *Tilapia guineensis* from Nworie river, Imo State, Nigeria. Okoye *et al* [30] working on Warri river in Nigeria reported Cu level of mean value 2.02ppm in aquatic animal. Ibe *et al* [22] working on Imo river at Ihitte/Uboma reported Cu concentration 10.00 and 12.00mg/kg in fish species Catfish and Tilapia, respectively. High concentration of Cu in Oguta lake may be attributed to artisan activities near the river, especially battery chargers and motor mechanics. Copper is an essential element that promotes the activity of certain enzyme systems in the body. It is toxic to man and animals when ingested in large amount. The WHO acceptable limit for copper in seafood is 2.0µgg^{-1}. The result of the analysis indicated that Oguta lake is contaminated with copper especially with the fish species *Protopterus annectens*, when compared to WHO standard.

Table 3 showed the concentration of heavy metals in different fish species and corresponding bioaccumulation factors. The order of biacccumulation factor in *Protopterus annectens* were Cu> Pb> Cd= Cr. The fish species *Protopterus annectens* has bioaccumulation factor of 130 for Cu and bioaccumulation factor of 27 for Pb. Obodo [29] working on lower reaches of River Niger reported bioaccumulation factors of 220 and 23 for Pb and Cu, respectively in *Synodontis membranaceus*. Emeshilli and Egboh [25] working on Ase river reported bioaccumulation factors of 95 and 71 for Cu and Pb, respectively in *Uca pugilator*. The bioaccumulation factor of Cu obtained in this study for *Protopterus annectens* was more than the values obtained from *Synodontis membranaceus* and *Uca pugilator*.

Table 3: Heavy metal concentration in fish (mg/kg) and water samples (mg/L) and corresponding Bioaccumulation factors

Protopterus annectens				*Chrysichthys nigroidigitaus*				*Sarotherodon galilaeus*				*Clarias submarginatus*				*Clarias anguillaris*			
Heavy Metal	**Water Sample**	**Fish Sample**	**Bf ratio**	**Heavy Metal**	**Water Sample**	**Fish Sample**	**Bf ratio**	**Heavy Metal**	**Water Sample**	**Fish Sample**	**Bf ratio**	**Heavy Metal**	**Water Sample**	**Fish Sample**	**Bf ratio**	**Heavy Metal**	**Water Sample**	**Fish Sample**	**Bf ratio**
Pb	0.652	17.33	27	Pb	0.652	ND	ND	Pb	0.652	ND	ND	Pb	0.652	3.10	5	Pb	0.652	36.50	56
Hg	ND	ND	ND	Hg	ND	ND	ND	Hg	ND	ND	ND	Hg	ND	ND	ND	Hg	ND	ND	ND
Cr	0.216	2.30	11	Cr	0.216	0.035	0.161	Cr	0.216	0.079	0.361	Cr	0.216	0.135	0.625	Cr	0.216	3.25	15
Cd	0.032	0.35	11	Cd	0.032	ND	ND	Cd	0.032	ND	ND	Cd	0.032	ND	ND	Cd	0.032	0.268	8
Cu	0.208	27.08	130	Cu	0.208	6.66	32	Cu	0.208	17.03	82	Cu	0.208	10.87	52	Cu	0.208	19.06	92

The fish species *Chrysichthys nigrodigitatus* and *Sarotherodon galilaeus* showed similar bioaccumulation factor of heavy metals. The order of bioaccumulation factor for *Chrysichthys nigroditaus* and *Sarotherodon galilaeus* were Cu > Cr, respectively. However, the bioaccumulation factor of 82 for Cu was recorded for *Sarotherodon galilaeus* whereas *Chrysichthys nigroiditaus* recorded bioaccumulation factor of 32 for Cu.

Table 3 showed the order of bioaccumulation of heavy metals in *Clarias submarginatus* and *Clarias anguillaris*. The order were as follows:- Cu > Pb > Cr for *Clarias submarginatus*, whereas the order for *Clarias anguillaris* were Cu > Pb > Cr > Cd. Egboh and Emeshili [31] working on River Umon in the Niger Delta region of Nigeria reported bioaccumulation factor of 36 for Cd in *Uca Pugilator*. The result of this study indicated bioaccumulation factor of 8 for Cd. The bioaccumulation factor was lower than the value obtained from *Uca Pugilator*. The result of the analysis indicated that *Clarias anguillaris* accumulate more Pb when compared to other fish species studied.

The high bioaccumulation factor for Cu in this study suggested that either the Oguta lake has high concentration of heavy metals associated with artisans works going on near the lake such as welding works and battery charging by auto electricians. The order of accumulation of Cu in different fish species studied were: *Protopterus annectens* > *Clarias aguillaris* > *Sarotherodon galilaeus* > *Clarias submarginatus* > *Chysichthys nigroiditaus*. The high accumulation of heavy metal in fish species may be attributed to poor mechanism for digesting and eliminating of these heavy metals from the fish species. It could also be attributed to concentration of heavy metals in the surrounding soil as well as the feeding habits of the fish species. The high accumulation for Cu may imply that the fish species *Protopterus annectens* may be a better indicator to monitor copper in rivers and water bodies.

Conclusion

The present study has shown that concentration levels of heavy metals especially copper could be monitored by the use of *Protopterus annectens* due to its high bioaccumulative ratio. Since fish is a good source of protein for man, there is need for enlightenment for the inhabitants about the consequences of heavy metal intake by man through consumption of fish.

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