

Model Assessment of Potential Risk Associated with Common Fish Species from Oguta Lake, Nigeria

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Abstract: Fish can bioconcentrate heavy metals which become absorbed into the human body through the food chain. In this study, four fish species from Ogutalake were analysed for metal concentration and data subjected to some chemometric assessment. 1g each of the 4 fish samples were weighed and digested in 5mL of nitric acid. The digested samples were analysed for heavy metals using GBC scientific sensAA dual Atomic Absorption Spectrophotometer. Contamination factors were generally low ($Cf < 6$). However, contamination factors were significant except for manganese, zinc and copper in all fish samples. The pollution load index are in the order Okpo>Ubu>Ifuru>Egu respectively. Okpo showed highest daily dietary intake amongst all fish species with about 0.826 mg/kg/Bw/day in children, while adults EDI had 0.142 mg/kgBWday⁻¹. Other fishes showed much lower values of EDI in the following order: Egu<Ifuru<Ubu<Okpo. All fish exhibited values lower than the recommended daily intake (12500 mg/kg/day) set by NRC. The mean EDI were in the following order: Zn>Mn>Ni>Cd>Cu. Weak positive correlations were exhibited by Ni/Mn (0.26) and Zn/Cd (0.14) while strong positive correlations were between Cd/Mn (0.81) and Zn/Cu (0.83). Significant negative correlations were exhibited between Ni/Zn (-0.96), Ni/Cu (-0.79) and Cu/Mn (-0.64) respectively. The positive and negative correlations suggest that the metals had similar and dissimilar sources of contamination. The study showed that, consumption of fish from Ogutalake could pose health hazards.

Keywords: Anthropogenic, Contamination, Pollution, Toxicity, Species, Health hazards.

1. INTRODUCTION

Fish is a good source of protein and it is consumed by most people in the world. Fishes have been recognised as good accumulators of organic and inorganic pollutants [1]. Oguta Lake has a history of oil spillage. Moreover, the lake is used for transportation and there is constant dredging activities going on the lake which could contribute to the concentration of these pollutants through emission from the exhaust and possible leakages of the oil from the tanks of the machines. Again, the lake serves as a source of water and fish for Oguta people and also an outlet for sewage.

Studies have shown that the various anthropogenic activities at the lake are detrimental to the water quality as well as fishes in the water. A researcher [2] assessed some important physical and environmental aspects of Oguta Lake and its watershed, Niger Delta Basin. The result from the study showed that the areas covered by the Oguta Lake water body is about 1,870.4 m² (68.2%) while degraded portions of the lake occupied an area of 1152.25 M² (38.8%). The degraded portion according to the work was with a total area of 1099.97 m² (36.91%), areas covered by sediments and eutrophication with total areas of 41.3 m² (1.39%) and 14.9 m² (0.5%), respectively which was attributed to anthropogenic activities in the lake. The study also showed that built-up areas outside the vicinity of the lake with an area of about 4,983.3 m² have very strong positive correlation ($R^2=1$) with the degradable portions of the lake. This means that the lake is polluted and anthropogenic activities are mainly responsible for the degradation of the lake. Research [3] assessed the quality of water and heavy metal content of fish species from Oguta Lake in Imo state. Chromium, iron, nickel, cadmium and copper were detected and lead, mercury and arsenic were absent. The concentrations of the metals were higher in Mudfish and Tilapia while the lower concentrations alternated between Catfish and Ifuru. Cadmium, nickel and iron levels exceeded permitted limit of Nigerian Industrial Standard (NIS) in all the samples except for copper. It was concluded that the water of Oguta Lake will sustain aquatic life

because of the high level of dissolved oxygen and low level of BOD. However, the raw domestic use of the water without treatment is reported to be dangerous as the levels of Turbidity, Nitrate, Total Coliform, Iron, Cadmium and Nickel exceeded the maximum permissible limit of Nigerian Industrial Standard.

The inhabitants of Oguta local government and the surrounding communities depend on Oguta Lake for their source of fish and water for domestic uses and fishes are known for their ability to bioconcentrate toxic substances in their muscles and fats. The consumption of fishes that are contaminated with heavy metals is detrimental to human health. These facts therefore, and the risks of consuming fish and fish products that are contaminated with heavy metal propelled the necessity of this research work to ascertain the quality of fishes from Oguta Lake. To achieve the aim of the study the following specific objectives were set; to determine the contamination level and pollution status of heavy metals in the fish samples from the lake, to estimate the daily exposure of heavy metals in the fish species from Oguta lake, to determine the significant relationship between the concentration of the heavy metals among the fish species from the lake

The extent of this research work covered the assessment of heavy metal such as Zinc (Zn), Copper (Cu), Nickel (Ni), Cadmium (Cd), and Manganese (Mn) in fish species from Oguta Lake. This research will help to ascertain the toxic level of fishes from Oguta Lake and afterwards, will provide useful information on the quality of fish from the Lake. Plates a and b show some anthropogenic activities taking place in and around Oguta lake.



2. MATERIALS AND METHODS

2.1. Location of Study

Oguta Lake is the largest natural Lake in south eastern Nigeria. It is natively called 'OHAMIRI' which is interpreted as the goddess of the lake [4]. The Lake is about 30 miles (48.27 km) from Ndoni and Urashi junction, 5 miles (8.05 km) long from east to west and one and half miles wide [5]. It lies approximately within Latitude $5^{\circ}41'$ and $5^{\circ}44'$ North and Longitude $6^{\circ}50'$ and $6^{\circ}45'$ east. It receives inflow from Njaba river, Awbamariver, Orashi river and Utu river. The lake has maximum surface area of 2.48 km² with maximum depth of about 8m [6]. The lake serves as a source of transportation, tourism, and water for domestic uses, fish and also an outlet for sewage [6]. Ongoing activities in the lake include; transportation by means of paddle and dugout canoe or the use of engine-powered boat, peeling, washing and fermentation of cassava. Other activities are washing of clothes, cars, motorcycles, kitchen utensils, bathing and fishing.

2.2. Samples Collection

Four fish samples that are mostly consumed by the inhabitants of the study area were bought from fisher men at the bank of the lake, put in a polyethene bags and transported to Imo State University laboratory. The fishes collected were; mochokidae, perpyroclanusalpha, cintharinidae and ciclidae, they are locally known as Okpo, Ubu, Ifuru and Egu respectively. Each fish species was properly washed with distilled water to remove debris, plankton and external adherent and were drained under folds of filter, weighed and wrapped in aluminium foil. All the four samples were then separately stored inside deep freezer and allowed to thaw. The scales were removed and washed with clean water.

2.3. Sample Preparation

Prior to extraction, the four fish samples were dried in the laboratory oven until a constant dry weight was obtained from each sample. The dried samples were ground to powder using ceramic mortar and pestle. Ground samples were then sieved with 2mm sieve.

2.4. Samples Digestion

1g each of the fish samples were weighed and digested in 5mL of nitric acid. The mixtures were allowed to stand for nine hours. Each sample was digested twice then the digested samples were transferred into volumetric flask and made up to the mark using distilled water. The digested samples were analysed for heavy metals using GBC scientific sensAA dual Atomic Absorption Spectrophotometer.

2.5. Data Analysis

The data obtained were interpreted using some statistical analysis such as mean, standard deviation and correlation analysis and chemometric assessment using assessment models such as contamination factors, pollution load index, estimated dietary intake and target hazard quotient.

2.5.1. Statistical Analysis

The data were analysed using mean, standard deviation and Spearman's correlation coefficient. Graphs and charts were also used to compare data obtained from the different fish samples. Spearman's correlation coefficient was employed for the purpose of establishing relationships between heavy metals found in the four fish samples.

2.5.2. Chemometric Assessment

The data obtained were subjected to chemometric analysis using some assessment models such as contamination factors, pollution load index, estimated dietary intake and target hazard quotient.

2.5.3. Contamination Factor and Pollution Load Index

The results obtained for heavy metals were interpreted with contamination and pollution index models. The contamination factor and pollution load index were determined mathematically as expressed in equation (1) and (2) respectively. This was done to determine the contamination level and pollution status of heavy metals in the fish samples.

$$CF = \frac{C_m}{C_b} \dots \dots \dots (1)$$

Where C_m is the concentration of the metal in the fish and C_b is the reference concentration of the metal. FAO standards for heavy metals in fish were taken as the reference concentration. The values were Ni- 0.06 mg/kg, Cd- 0.05 mg/kg, Zn- 40 mg/kg, and Cu-10 mg/kg. Manganese was as 20 mg/kg taken from the proposed permissible limit of manganese concentrations in fish species as recorded by Turkish guidelines known as Turkish Food Codes (TFC) [7], [8], [9], [10].

$$PLI = (CF_1 \times CF_2 \times CF_3 \dots \dots CF_n)^{1/n} \dots \dots \dots (2)$$

Where n is the number of metals considered in the study and CF_i is the contamination factor for each individual metal.

2.5.4. Estimated Dietary Intake (EDI)

The EDI of metals (polar and nonpolar) in fish from consumption was evaluated using the mathematical expression

$$EDI \text{ (ug/kgbw)/day} = \frac{MI \times CM}{BWA} \dots \dots \dots (3)$$

MI= mass of fish ingested per day, CM = concentration of metal in fish, BWA = body weight for average adult is 70 kg. The mass of the fish ingested per day in Nigeria is 7.6 kg which is equivalent to 20.8 g per day. In the case of children the mass of BWC was taken as 12 Kg (Ref). RFD = oral reference dose. This is an estimate of daily exposure to human population that is likely to be without an appreciable risk of deleterious effect during life time.

2.5.5. Target Hazard Quotient (THQ)

The THQ of metals in fish from consumption was evaluated using the mathematical expression

$$THQ = \frac{EF \times ED \times EDI}{RFD \times AT} \times 10^{-3} \dots \dots \dots (4)$$

EF = exposure frequency 365 days, ED = exposure duration which corresponds to average life expectancy in Nigeria (54.5 years), AT = averaging exposure time for non-carcinogens (19892.5 days),

RFD = Oral Reference Dose. Some oral reference dose include Cd 0.001 mg/kg-day, Cu 0.04 mg/kg-day, Zn 0.3 mg/kg-day, Ni 0.02 mg/kg-day, Mn 0.14 mg/kg-day [11].

3. RESULTS AND DISCUSSION

The concentrations and statistical summary of nickel, manganese, zinc, copper and cadmium in the fish species are shown in (table 1). Heavy metal were present in all fish species in Oguta Lake. This may be due to the ability of fish to bioaccumulate these metals into their body tissues from the aquatic environment. The bioaccumulation of metals by fish has been reported by many researchers including [12]. Metals including Ni, Mn, Zn, Cu and Cd were bioaccumulated to varying levels. This is because fish like other aquatic organisms, have the ability to concentrate heavy metals in their tissues to concentration levels which comprised of several orders of magnitude higher [13].

3.1. Nickel (Ni)

There is evidence of uptake and accumulation of nickel in fishes. Nickel is an essential trace element in animals, although the functional importance of nickel has not been clearly demonstrated. It is considered essential based on reports of nickel deficiency in several animal species. Nickel deficiency is manifested primarily in the liver; effects include abnormal cellular morphology, oxidative metabolism, and increases and decreases in lipid levels. Decreases in growth and haemoglobin concentration and impaired glucose metabolism have also been observed. The essentiality of nickel in humans has not been established, and nickel dietary recommendations have not been established for humans [14]. Nickel compounds are known carcinogens in both human and animal models [15], [16]. There is evidence that the genotoxic effects of nickel compounds may be indirect through the inhibition of DNA repair systems. As a result of this inhibition it has been suggested that accumulation of nickel in breast tissue may be closely related to malignant growth process [17], [18], [19].

The concentration of nickel ranged from 0.094 mg/kg in Ubuto 0.221 mg/kg in Ifuru with mean of 0.158 mg/kg (table 2). The mean value of Ni in the fish samples were in the order Ubu<Egu<Okpo<Ifuru. The concentrations of Ni were generally higher than FAO standard of 0.06 mg/kg. This implies that fish from Oguta Lake shows possible contamination and could be considered unsafe for human consumption. High level of Ni from this study may be as a result of domestic wastewater from numerous activities near the lake as well as mechanized activities conducted on the river and this could provide possible explanation for this finding.

3.2. Manganese (Mn)

Manganese is essential for normal development and body function across the life span of all mammals [20]. Manganese binds to and/or regulates many enzymes throughout the body. It is a required co-factor for arginase, which is responsible for urea production in the liver, superoxide dismutase, which is critical to prevent against cellular oxidative stress, and pyruvatecarboxylase, an essential enzyme in gluconeogenesis. The brain is the major target organ for manganese toxicity as it retains manganese much longer than other tissues. Following chronic overexposure, manganese can produce a progressive, permanent neurodegenerative disorder, with few options for treatment and no cure [20], [21], [22].

Fish species can have up to 5 mg/kg and mammals up to 3 mg/kg in their soft tissues, although typically they have around 1 mg/kg due to its vital role in human health, however, excesses or lacks of manganese concentrations level can cause health effects [23]. The concentrations of Mn were ranged from 0.024 to 0.474 mg/kg with a mean concentration of 0.175 mg/kg. The proposed permissible limit of manganese concentrations in fish species as recorded by Turkish guidelines known as Turkish Food Codes (TFC) is about 20 mg/kg [24]. In general it can be seen that the concentrations of Mn found in edible part of the fishes in the present study are still considered as those of uncontaminated fish (<20). However, Mn was recorded highest in Okpo and Egu recorded lowest.

Table1. Statistical summary of metal concentration in the various fish species

Parameter	Okpo	Ubu	Ifuru	Egu	Mean	FAO(1983)
Ni (mg/kg)	0.162±0.04*	0.094±0.02*	0.221±0.02*	0.154±0.03*	0.158	0.06
Mn (mg/kg)	0.474±0.17	0.050±0.02	0.151±0.05	0.024±0.03	0.175	N A
Zn (mg/kg)	0.585±0.06	0.852±0.12	0.401±0.04	0.527±0.18	0.591	4 0

Cu (mg/kg)	0.009±0.00	0.026±0.02	0.012±0.01	0.014±0.01	0 . 0 1 5	1 0
Cd (mg/kg)	0.075±0.08*	0.026±0.01	0.010±0.01	0.033±0.01	0 . 0 3 6	0 . 0 5

*= indicates concentration higher than the permissible limit set by FAO (1983).

3.3. Zinc (Zn)

Zinc is an essential nutrient in humans and animals and is necessary for the function of a large number of metalloenzymes. These enzymes include alcohol dehydrogenase, alkaline phosphatase, carbonic anhydrase, leucineaminopeptidase, superoxide dismutase, and deoxyribonucleic acid (DNA) and ribonucleic acid (RNA) polymerase. An acute oral dose of zinc may cause symptoms such as tachycardia, vascular shock, dyspeptic nausea, vomiting, diarrhoea, pancreatitis and damage of hepatic parenchyma [25], [26].

When high levels of zinc are ingested inhibition of copper absorption through interaction with metallothionein at the brush border of the intestinal lumen occurs. Both copper and zinc appear to bind to the same metallothionein protein; however, copper has a higher affinity for metallothionein than zinc and displaces zinc from metallothionein protein. Copper complexed with metallothionein is retained in the mucosal cell, relatively unavailable for transfer to plasma, and is excreted in the faeces when the mucosal cells are sloughed off. Thus, an excess of zinc can result in a decreased availability of dietary copper, and the development of copper deficiency [27], [28].

On the other hand zinc deficiency has been associated with dermatitis, anorexia, growth retardation, poor wound healing, hypogonadism with impaired reproductive capacity, impaired immune function, and depressed mental function; increased incidence of congenital malformations in infants has also been associated with zinc deficiency in the mothers [29]. This can be observed in the table 3.0 where higher values were obtained for zinc and lower values for copper.

Zinc concentrations in general were below the limit of 40 mg/kg set by [30] with mean of 0.591 mg/kg and were in the order of Ifuru<Egu<Okpo<Ubu respectively. The zinc concentrations could be considered safe for consumption in these fishes.

3.4. Copper (Cu)

Copper is an essential nutrient that is incorporated into a number of metalloenzymes involved in haemoglobin formation, drug/xenobiotic metabolism, carbohydrate metabolism, catecholamine biosynthesis, the crosslinking of collagen, elastin, and hair keratin, and the antioxidant defense mechanism. Copper-dependent enzymes, such as cytochrome C oxidase, superoxide dismutase, ferroxidases, monoamine oxidase, and dopamine β- monooxygenase, function to reduce activated oxygen species or molecular oxygen. Symptoms associated with copper deficiency in humans include normocytic, hypochromic anaemia, leukopenia, and osteoporosis [31].

Although copper homeostasis plays an important role in the prevention of copper toxicity, exposure to excessive levels of copper can result in a number of adverse health effects including liver and kidney damage, anaemia, immunotoxicity, and developmental toxicity. Many of these effects are consistent with oxidative damage to membranes or macromolecules. Copper can bind to the sulfhydryl groups of several enzymes, such as glucose-6-phosphatase and glutathione reductase, thus interfering with their protection of cells from free radical damage [32].

The mean concentration of Cu in fish caught in Oguta Lake was low. The low copper level could be due to the high zinc concentrations in the fishes, as excess of zinc can result in a decreased availability of dietary copper, and the development of copper deficiency [27], [28]. However, the mean value of Cu (0.033 mg/kg) in cichlidae was higher than values recorded in Okpo, Ubu and Ifuru. The values recorded in the different fishes from at the Lake were lower than the standard limit of 10 mg/kg recommended by FAO for fish and fishery products. This implies that fishes from Oguta Lake could be considered safe for consumption for copper.

3.5. Cadmium (Cd)

Cadmium (Cd) is one of the most toxic elements to which man can be exposed at work or in the environment. Once absorbed, Cd is efficiently retained in the human body, in which it accumulates throughout life [33]. Bioaccumulation of cadmium takes place at tropic level and found to be highest in

algae [34]. It also accumulates in considerable concentrations in various organs of fish [35], [36]. Ref. [12] reported that cadmium accumulates in tissues of carp *Cyprinus carpio* in following order: kidney> Liver> Gills. Ref. [37] also reported similar accumulation pattern in *Clarias batrachus* in an experimental study. Kidney is the prime target organ for cadmium. The liver also stores a considerable part of the accumulated cadmium. Cadmium is redistributed to these organs directly following uptake through the gills and intestine, but there may also be redistribution of cadmium from other organs [38]. High levels of Cd in fish are potential risk concern on human consumer's health such as kidney damage (renal tubular damage).

The found cadmium concentrations were ranged from 0.010 to 0.075 mg/kg with a mean concentration of 0.036 mg/kg. This finding is in agreement with previous observations recorded by Suresh et al., (2007) for commercially valuable marine eatable fishes from Parangipettai coast, south east coast of India (0.18-0.54 mg/kg dry wt.). Ref. [39] documented higher concentrations of Cd as compared with this study where Cd mean concentrations were ranged between 0.37 and 0.79 mg/kg in the fish species of Mediterranean Sea. Ref. [40] reported higher concentrations of Cd as compared to the present study with mean concentration of 0.058 mg/kg for fish muscles collected from Kapar and Mersing coastal waters in Malaysia. Additionally, the Cd concentrations in the muscles of different marine fishes harvested from Masan Bay, Korea (0.02 µg/g to 0.05 µg/g, dry weight) [41] were lower than those reported in this present study. The proposed limits of Cd set by [42] for eatable fish is about 0.05 mg/kg. All fish samples are lower than this limit except for Okpo (0.075±0.08 mg/kg). Thus, cadmium appears to present a contaminant hazard to Okpo within this range of concentrations.

The degree of contamination was calculated to determine the extent and pollution status of the studied metals in the fish samples. The following terminologies were used to describe the degree of contamination; $Cf < 6$, low degree of contamination; $6 \leq Cf < 12$, moderate degree of contamination; $12 \leq Cf < 24$, considerable degree of contamination; $Cf \geq 24$, very high degree of contamination. In the present study, all studied heavy metals generally were low since $Cf < 6$. However, contamination factors were significant except for manganese, zinc and copper in all fish samples (figure 2). The pollution load index is a potent tool in heavy metal pollution evaluation that provides a simple and comparative means for assessing the level of heavy metal pollution. The PLI represents the number of times by which the metal content in the fish exceeds the standard concentration, and gives a summative indication of the overall level of heavy metal toxicity in a particular sample. The PLI value of > 1 is polluted, < 1 indicates no pollution whereas values of $PLI = 1$ indicate heavy metal loads close to the standard. Therefore, the five studied fish isn't polluted for the metals studied. However, the PLI are in the order; Okpo>Ubu>Ifuru>Egurespectively.

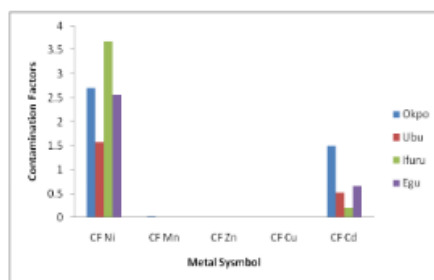


Figure2. CF for the studied metals in the different fish

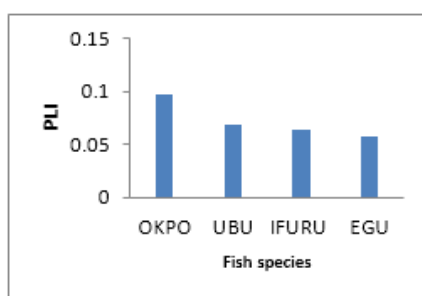


Figure3. PLI of metals in fish samples from Ogutalake

Table 2.shows the provisional tolerable daily intake in adult and children who consumed fish species from Oguta Lake. Okposhowed highest daily dietary intake amongst all fish species withup to 0.826

mg/kg/Bw/day in children, while adults EDI had 0.142 mg/kgBWday⁻¹. Other fishes showed much lower values of EDI in the following order: Egu<Ifuru<Ubu<Okpo. All fish exhibited values lower than the recommended daily intake (12500 mg/kg/day) set by [43]. The mean EDI for the various metals in the fish species from Oguta Lake were in the following order: Zn>Mn>Ni>Cd>Cu.

Table2. Estimated Dietary intake and Target Hazard Quotient of metals from fish species

Metals	Okpo		Ubu		Ifuru		Egu		Mean ± SD	
	Adult	Children	Adult	Children	Adult	Children	Adult	Children	Adult	Children
Estimated Dietary intake of metals from fish species										
Ni	0.018	0.103	0.010	0.059	0.024	0.139	0.017	0.098	0.017±0.006	0.098±0.033
Mn	0.051	0.300	5.43E-3	0.032	0.016	0.096	2.61E-3	0.015	0.019±0.022	0.111±0.131
Zn	0.064	0.370	0.093	0.539	0.044	0.254	0.057	0.333	0.065±0.021	0.374±0.120
Cu	9.77E-4	5.69E-3	2.82E-3	0.016	1.30E-3	7.59E-3	1.52E-3	8.87E-3	0.002±0.000	0.009±0.005
Cd	8.15E-3	0.047	2.82E-3	0.016	1.09E-3	6.33E-3	3.58E-3	0.021	0.004±0.003	0.022±0.017
∑EDI	0.142	0.826	0.114	0.662	0.086	0.503	0.082	0.476	0.107±0.052	0.614±0.306
Target Hazard Quotient of metals from fish species										
Ni	0.0009	0.0052	0.0005	0.0029	0.0012	0.0069	0.00085	0.0049	0.00±0.0002	0.05±0.002
Mn	0.00036	0.0021	0.00004	0.00023	0.00011	0.00069	0.00002	0.00107	0.00±0.0001	0.001±0.001
Zn	0.00021	0.0012	0.00031	0.0018	0.00015	0.00085	0.0019	0.0011	0.00±0.0008	0.0012±0.00
Cu	0.00024	0.00014	0.000071	0.0004	0.00003	0.00019	0.00004	0.00022	0.00±0.0000	0.00±0.000
Cd	0.0082	0.47	0.0028	0.16	0.0011	0.0063	0.0036	0.21	0.004±0.003	0.212±0.193
∑THQ	0.0099	0.4786	0.0037	0.1653	0.0025	0.0149	0.0064	0.2163	0.004±0.0041	0.2622±0.196

For adult, nickel showed EDI values ranging from 0.010 Mg/Kg/Bw/day (Ubu) to 0.024 Mg/Kg/Bw/day for Ifuru, Manganese showed values ranging from 2.61E-3 Mg/Kg/Bw/day in Ubu to 0.051 Mg/Kg/Bw/day in Okpo, Zinc showed mean EDI values ranging from Ifuru (0.044) to Ubu (0.093). Copper had mean EDI values of Ifuru (1.30E-3) to Okpo(9.77E-4). While Cadmium showed mean EDI ranging from 1.09E-3 Mg/KgBw/day for Ifuru to 8.15E-3 Mg/KgBw/day for Okpo. However, for children, nickel showed EDI values ranging from 0.059 Mg/Kg/Bw/day (Ubu) to 0.139 Mg/Kg/Bw/day for Ifuru, Manganese showed values ranging from 0.015 Mg/Kg/Bw/day in Egu to 0.3 Mg/Kg/Bw/day in Okpo, Zinc showed EDI values ranging from Ifuru (0.254) to Ubu (0.539). Copper had mean EDI values of Ifuru (0.016) to Egu (5.69E-3). While Cadmium showed mean EDI ranging from 6.33E-3 Mg/KgBw/day for Ifuru to 0.047 Mg/KgBw/day for Okpo.

EDI for fish species from Oguta Lake showed that amongst the heavy metals that may be toxic to living systems Zn had highest value in the case of children and adults followed by manganese, then nickel, cadmium and copper. These EDI: Zn<Mn<Ni<Cd<Cu values though low, could constitute a source of danger for consumers of fish.

THQ is the hazard quotients for substances that affect the same target organ or organ system. Also, it is the ratio of the potential exposure to the substance and the level at which no adverse effects are expected. A hazard quotient less than or equal to one indicates that adverse noncancer effects are not likely to occur, and thus can be considered to have negligible hazard. HQs greater than one is not a statistical probability of harm occurring. Instead, they are a simple statement of whether (and by how much) an exposure concentration exceeds the reference concentration (RfC) [45]. However, in the present study the THQ were generally less than one. This implies that the fishes from Oguta Lake can be considered safe for consumption and adverse noncancer effects are not likely to occur.

Figures 3-6 is show the THQ for various metals in the different fish samples from the lake.

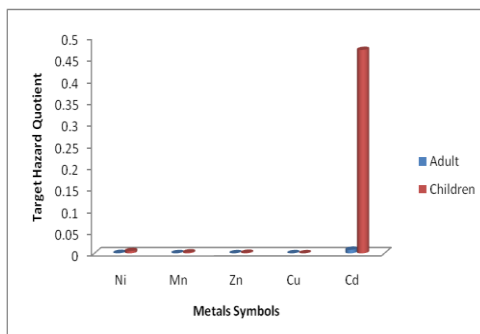


Figure4. Target Hazard Quotient in Okpo for adults and children

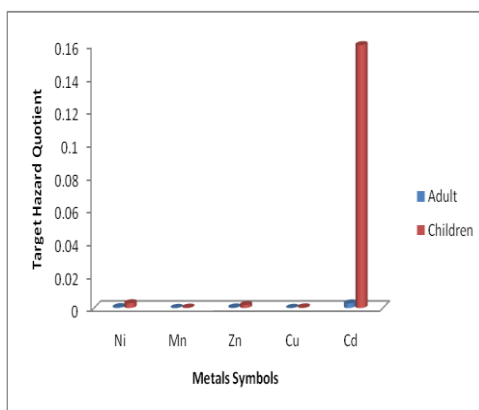


Figure5. Target Hazard Quotient in Ubu for adults and children

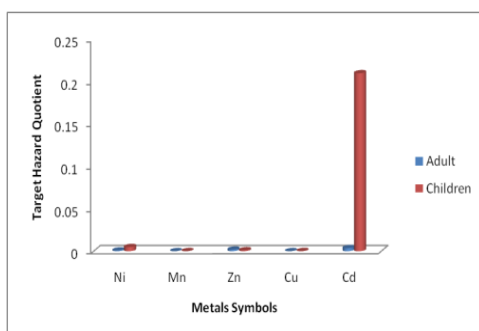


Figure6. THQ in Ifuru for adults and children

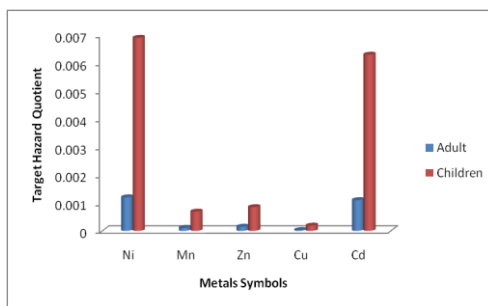


Figure7. THQ in Egu for adults and children

Table3. Correlation matrix of metals in the various fish species

	Ni	Mn	Zn	Cu	Cd
Ni	1				
Mn	0.257	1			
Zn	-0.960	-0.171	1		
Cu	0.786	-0.637	0.833	1	
Cd	-0.192	0.813	0.1448	-0.424	1

The correlation matrix was used to establish relationship between data of metal concentrations in fish and also helps to establish similar or dissimilar source of contamination. The matrix is ranked from +1 (positive correlation), 0 (no correlation), and -1 (negative correlation). The correlation matrix of metals is presented in table 5. Weak positive correlations were exhibited by Ni/Mn (0.26) and Zn/Cd (0.14) while strong positive correlations were between Cd/Mn (0.81) and Zn/Cu (0.83). Significant negative correlations were exhibited between Ni/Zn (-0.96), Ni/Cu (-0.79) and Cu/Mn (-0.64) respectively. The positive and negative correlations suggest that the metals had similar and dissimilar sources of contamination. Therefore, Cd/Mn, Zn/Cu has similar sources of contamination while *Ni/Zn, Ni/Cu and CU/Mn had different sources of contamination

4. CONCLUSION

All the fish species studied had higher THQ in children than in adults; so, children are at a higher risk of harm than adults. Though the pollution levels of the heavy metals were generally low, the study

showed that the fish samples from Oguta Lake were contaminated with Nickel and Manganese, therefore the amount of fishes from Oguta lake that is consumed should be checked as they could constitute health hazards arising from heavy metals contamination. Heavy metals contamination levels of fish from Oguta lake should be regularly monitored because there is the possibility of a high pollution of the metals in the fish from Ogutalake emanating from bioaccumulation of heavy metals

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