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Assessment of Some Heavy Metals in Fish and Water Samples from Oguta Lake, Imo State, Nigeria

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Abstract
Evaluation of some heavy metal in fish and water samples from Oguta Lake, Imo State was carried out for three months from October to December, 2023, to examine the levels of heavy metals such as lead, mercury, arsenic, cadmium and zinc, in water and muscle of three different fish species namely; Citharinus citharus (Moonfish), Distichodus rostratus (Grass eater) and Clarias gariepinus (African Catfish) from Oguta Lake. Imo State, Nigeria. The fish and water samples were digested and analyzed using a Varian AA240 Fast Sequential Flame Atomic Absorption Spectrophotometer (AAS). A one-way analysis of variance (ANOVA) was employed to reveal significant differences in the measured variables. The results obtained indicated that the heavy metals concentrations in the fish and water were found to be within the permissible limits set by the World Health Organization/Food and Agriculture Organization. The overall concentrations of heavy metals in the fish species were ranked as follows; Zinc>mercury>lead>arsenic>cadmium. The overall concentrations of heavy metals in the water samples were ranked as follows; Mercury>lead>arsenic>cadmium>lead. Thus, the study revealed that there is very low heavy metal pollution in these fish species sampled from Oguta Lake and the consumption of the available fish species in the river may not be harmful to human beings.
Keywords*: Heavy metals, Water, Fish, Environmental Pollution*

INTRODUCTION

Heavy metals are metals which have relatively high densities and are toxic or poisonous at high concentration and negatively affect life in any form. They are usually greater than $5.00g/cm^3$ and are harmful when they exceed threshold limits [1]. Heavy metals occur during natural processes such as erosion, volcanism and weathering. Heavy metals are also obtained during anthropogenic activities that takes place in the; industry, mining, metal smelting, oil refining, agriculture and fertilization and drainage] 2]. Aquatic environment is an important ecosystem, a factor in development of various civilizations, the abode for some organisms, water supply, a recreation center, means of transportation, and fishing pot for both the fishing trawlers and artisanal fishermen [3]. Water is an important natural resource for man both directly and indirectly by means of the fish and seafood resources. In the water bodies, both nutritive substances and polluting substances enter the fish body through the gills and through the hundreds of capillaries existing at this level. Hence, the aquatic environment with its water quality is considered the main factor controlling the state of health and disease in both cultured and wild fishes and other sea foods [4].

These heavy metals are substances that occur naturally in the environment but in trace amounts with no important biological role to play in human existence; causing many toxic effects that lead to malfunctioning of the body systems and disruption of metabolic process. [5].These heavy metals are commonly found in the environment and diet. They cannot be degraded or destroyed. These metals are necessary for maintaining various biochemical and physiological functions in living organisms when in very low concentrations, however they become harmful when they exceed certain threshold concentrations [6]. Although it is well known that heavy metals have many adverse health effects and last for a long period of time, heavy metal exposure continues and is increasing in many parts of the world. Heavy metals are significant environmental pollutants and their toxicity is a problem of increasing significance for ecological, evolutionary, nutritional and environmental reasons [7].

The most commonly found heavy metals in waste water include Arsenic, Cadmium, Chromium, Mercury, Copper, Lead, Nickel and Zinc, all of which cause risks for human health and the environment. Heavy metal toxicity can lower energy levels and damage the functioning of the brain, lungs, kidney, liver, blood composition and other important organs. Long-term exposure can lead to gradually progressing physical, muscular, and neurological degenerative processes that imitate diseases such as multiple sclerosis, Parkinson's disease, Alzheimer's disease and muscular dystrophy. Repeated long-term exposure of some metals and their compounds may even cause cancer [8]. Heavy metal content in the tissues and organs of fishes indicates their accumulation in food chains. Since fishes are an integral component of the human diet, they need to carefully screen to ensure that unnecessary high level of heavy metals are not being transferred to human population through consumption of fish [9]. Therefore, it is important to observe the level of heavy metals in consumed fishes to get some ideas about the safety of fish protein supplied to the consumers and to understand its harmful effects on individuals, population or ecosystem.Fish is a basic and important food for human nutrition, providing protein, healthy fatty acid with low cholesterol level that is healthy for consumption and capable of reducing the risk of heart diseases and stroke as well as essential minerals and vitamins [10]. The role of Fisheries in the ecosystem serving as food along the food chain, hence their presence and importance cannot be overlooked as the heavy metal accrued in fish results to an impact in human health [11].

In recent years, the increasing level of heavy metals in fish is alarming and has spurred scientist to make researches in the dangers caused by the heavy metals resulting to heavy metal accumulation and bioaccumulation to life cells. Evidently, fish form the link for the transfer of toxic heavy metals from water to humans [12]. Essential heavy metals are important for normal metabolism of fish but become toxic at higher concentrations while non-essential heavy metals have no beneficial role in fish and are toxic at even low concentrations. Essential metals include iron, copper, chromium, magnesium, manganese and zinc whereas non-essential metals are mercury, lead, nickel and cadmium[13]. Heavy metals are easily accumulated in fishes because they are readily taken up by body parts of fishes such as body surface, gills, digestive tract, liver and muscles. The highest point of heavy metal levels of concentration in the organs of organisms are often the gills then the liver and then the muscle shows the lowest concentration levels. However, the muscles are the most source of heavy metal intake to the body since the muscles are the largest consumed parts of the body hence the ability to cause negative impact towards health [14].

Since fish is known for the bioaccumulation of heavy metals in its body, it is a suitable bio monitor of the presence of heavy metal (lead, zinc and copper) in their water. In rural areas, fish is an important source of food for the human population and its procurement is not always controlled, therefore, there is more often a risk for those people who consume contaminated fish. Increasing human influences through heavy metal pollution have over the years led to the depletion of our aquatic biodiversity. As a result, several important endemic fish species have become threatened [15]. Realizing this, concern for assessment of trace or heavy metals in fish species in most of our water bodies have increasingly been gaining ground throughout the world [16]. The characteristic feature of heavy metal is their strong attraction to biological tissues and in general their slow elimination from biological systems. They are environmentally stable, non-degradable and induce toxic effects. When concentration of metals exceeds the acceptable limit, they create environmental hazards. Many aquatic organisms are known to accumulate metals at relatively higher concentration than the surrounding environment. Freshwater fishes are more prone to Heavy metal pollution because of their higher ability to bio-accumulate thus are easily exposed and vulnerable [17]. The consequence of heavy metals pollution can also be hazardous to man through his food. Therefore, it is important to monitor heavy metals in aquatic environments (water sediments and biota). This study assess some heavy metals in fish and water samples from Oguta Lake, Imo State, Nigeria.

MATERIALS AND METHODS

Description of the Study Area

The study was carried out in Oguta Lake, Imo State, Nigeria. **Oguta Lake** is a lean 'finger lake' formed by the damming of the lower Njaba River with alluvium. It is the largest natural lake in Imo State, Southeastern Nigeria; within the equatorial rainforest region of Niger Delta. Oguta Lake's catchment area comprises the drainage area of the Njaba River and a part of the River Niger floodplain in the region south of Onitsha. The lake is situated in Oguta about 50 kilometres (30 mi) from the junction of the Ndoni and Orashi River. It is about eight kilometres (5 mi) long from east to west and 2.5 kilometres (1+½ mi)wide. The lake is 5:41-5:44N, 6:41-6:50E; <50 m above sea level. The stream from Njaba River is the major inflow to Oguta Lake. The map of Oguta Lake showing the sampling stations: Station 1(upstream), Station 2 (midstream) and Station 3 (downstream). Are sghown in Figure 1 and Plate 1.

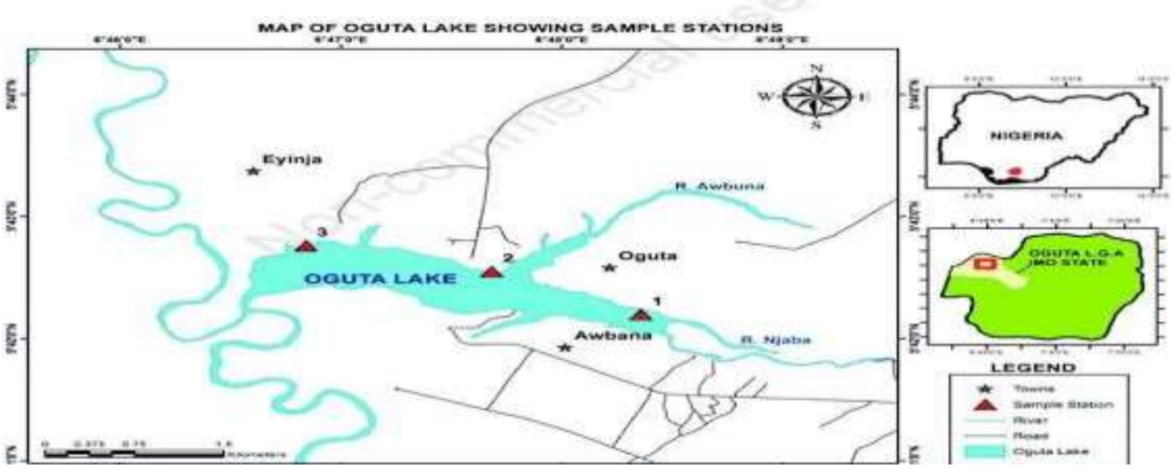

Fig 1: Map showing sampling stations

Plate 1: Oguta Lake

Fish Sample Collection

The fish samples used were caught from the three stations: Station 1(upstream), Station 2(middle stream) and station 3 (downstream) of Oguta Lake. These include three species of Citharinus citharus, Distichodus rostratus and Clarias gariepinus. The fish samples were then taken to the laboratory for analysis. Sample preparation and analysis were conducted on the muscles of the fish sample for heavy metal determination.

Table 1: The collected fish samples with their local and scientific names

Species	Common Names	Scientific Names	Local Names
Lutefish	Moon Fish	*Citharinus citharus*	Azu mpete
Grass eater	Grass eater	*Distichodus rostratus*	-
Catfish	Catfish	*Clarias gariepinus*	Arira

Plate 3: ***Distichodus rostratus***

Plate 2: ***Citharinus citharus***

Plate 4: ***Clarias gariepinus***

Water Sample Collection

The water samples used were collected using a container from the 3 sampling stations: Station 1(upstream),Station 2 (midstream) and Station 3 (downstream) of Oguta Lake. The water samples were then taken to the laboratory for analysis. Sample preparation and analysis were conducted on the water sample for heavy metal determination.

Preparation of Samples

A clean washed sharp knife was used to cut 2g wet weight of the fish tissue (muscle) along the lateral line and the liver. After dissection, all the samples were labeled according to their species.

Procedures for Digestion of Heavy Metals

For Fish:

Weigh out 2g of the samples each into a digestion flask and add 20ml of the acid mixture, “aquaregia" (65ml conc HNO_3, 8ml perchloric acid and 2ml conc H_2SO_4). Heat the flask until a clear digest is obtained. Dilute the digest with 100ml of distilled water. The digested sample is then filtered with filter paper and the filtrate collected. 1ml of the filtrate is injected into the Atomic Absorption Spectrophotometer (AAS) analyzer and the reading of each heavy metals tested is taken from the output screen.

For Water:

The sample is thoroughly mixed by shaking, and 100ml of it is transferred into a glass beaker of 250ml volume, to which 5ml of conc. nitric acid is added and heated to boil till the volume is reduced to about 15-20ml, by adding conc. nitric acid in increments of 5ml till all the residue is completely dissolved. The mixture is cooled, transferred and made up to 100ml using metal free distilled water. The sample is aspirated into the oxidising air-acetylene flame. When the aqueous sample is aspirated, the sensitivity for 1% absorption is observed.

Methods For The Heavy Metal Analysis

Heavy metal analysis was conducted using Varian AA240 Atomic Absorption Spectrophotometer, according to the method of APHA 1995(American Public Health Association).

RESULTS

The overall mean results of heavy metals in the fish and water samples from upstream, midstream and downstream in Oguta Lake, Imo State is presented in the tables 2-7 below: In October, Moonfish from downstream(Station III) have the highest concentration of heavy metals of which Zinc have the highest value and Arsenic with the lowest value. In October, water downstream (Station III) have the highest concentration of heavy metals of which Mercury have the highest value and Cadmium with the lowest value. In November, fish downstream(Station III) have the highest concentration of heavy metals of which Zinc have the highest value and Cadmium with the lowest value. In November, water downstream (Station III) have the highest concentration of heavy metals of which Mercury have the highest value and Cadmium with the lowest value. In December, fish upstream (Station I) have the highest concentration of heavy metals of which Zinc have the highest value and Cadmium with the lowest value. In December, water downstream (Station III) have the highest concentration of heavy metals of which Mercury have the highest value and Cadmium with the lowest value. Table 8 represents the comparison between the heavy metals in the muscle of the three fish species; C. citharus, D. rostratus and C. gariepinus and the approved WHO/FAO and EU standard. Based on the measured heavy metal levels in the fish species and tissues, all the samples are within the permissible limits set by both the WHO/FAO and EU. This shows that the fish samples analyzed meet the standards for heavy metal content. Table 9 represents the comparison between the heavy metals in the water samples from upstream, midstream and downstream and the approved WHO/FAO, USEPA and EU standard. Based on the measured heavy metal levels in the water samples, lead, mercury arsenic are above the permissible limits set by WHO/FAO, USEPA and EU. Cadmium: water upstream and midstream (November), and water upstream (December) are above the permissible limits set by WHO/FAO, USEPA and EU while Cadmium: water upstream, midstream and downstream (October), water downstream (November) and water midstream and downstream (December) are within the permissible limits set by WHO/ FAO but above the permissible limits set by USEPA and EU. Zinc is within the permissible limits set by WHO/FAO, USEPA and EU

Table 2: The mean concentration of heavy metals in the muscle of Moonfish (*Citharinus citharus*) in the month of October, 2023.

Heavy metals	Fish Upstream (Station I)	Fish midstream (Station II)	Fish downstream (Station III)
Lead	0.08 ± 0.00[a]	0.08 ± 0.00[a]	0.07 ± 0.00[a]
Mercury	0.08 ± 0.00[a]	0.09 ± 0.00[a]	0.08 ± 0.00[a]
Arsenic	0.02 ± 0.00[a]	0.02 ± 0.00[a]	0.04 ± 0.00[a]
Cadmium	0.03 ± 0.00[a]	0.01 ± 0.00[a]	0.02 ± 0.00[a]
Zinc	0.80 ± 0.00[a]	0.90 ± 0.00[a]	1.32 ± 0.00[b]

Mean within the row with different superscripts are significantly different (P<0.05)

Table 3: The mean concentration of heavy metals in water samples in the month of October,2023

Heavy metals	Fish Upstream (Station I)	Fish midstream (Station II)	Fish downstream (Station III)
Lead	0.06 ± 0.00[a]	0.05 ± 0.00[a]	0.06 ± 0.00[a]
Mercury	0.07 ± 0.00[a]	0.08 ± 0.00[a]	0.11 ± 0.00[b]
Arsenic	0.06 ± 0.00[a]	0.02 ± 0.00[a]	0.06 ± 0.00[a]
Cadmium	0.01 ± 0.00[a]	0.01 ± 0.00[a]	0.01 ± 0.00[a]
Zinc	0.05 ± 0.00[a]	0.02 ± 0.00[a]	0.02 ± 0.00[a]

Mean within the row with different superscripts are significantly different (P<0.05)

Table 4: The mean concentration of heavy metals in the muscle of Grass eater (*Distichodus rostratus*) in the month of November, 2023

Heavy metals	Fish Upstream (Station I)	Fish midstream (Station II)	Fish downstream (Station III)
Lead	0.08 ± 000[a]	0.08 ± 0.00	0.07 ± 0.00
Mercury	0.08 ± 0.00[a]	0.09 ± 0.00	0.08 ± 0.00
Arsenic	0.01 ± 0.00[a]	0.02 ± 0.00	0.04 ± 0.00
Cadmium	0.03 ± 0.00	0.01 ± 0.00	0.02 ± 0.00
Zinc	0.68 ± 0.12	0.90 ± 0.00	1.32 ± 0.00

Mean within the row with different superscripts are significantly different (P<0.05)

Table 5: The mean concentration of heavy metals in water samples in the month of November,2023

Heavy metals	Fish Upstream (Station I)	Fish midstream (Station II)	Fish downstream (Station III)
Lead	0.05 ± 0.00[a]	0.05 ± 0.00[a]	0.05 ± 0.00[a]
Mercury	0.07 ± 0.00[a]	0.07 ± 0.00[a]	0.09 ± 0.00[a]
Arsenic	0.05 ± 0.00[a]	0.02 ± 0.00[a]	0.06 ± 0.00[a]
Cadmium	0.05 ± 0.02[a]	0.01 ± 0.00[a]	0.01 ± 0.00[a]
Zinc	0.04 ± 0.00[a]	0.02 ± 0.00[a]	0.02 ± 0.00[a]

Mean within the row with different superscripts are significantly different (P<0.05)

Table 6: The mean concentration of heavy metals in the muscle of Catfish (*Clarias*

***gariepinus*) in the month of December, 2023**

Heavy metals	Fish Upstream (Station I)	Fish midstream (Station II)	Fish downstream (Station III)
Lead	0.08 ± 0.00 [a]	0.08 ± 0.00 [a]	0.06 ± 0.00 [a]
Mercury	0.07 ± 0.00 [a]	0.09 ± 0.00 [a]	0.08 ± 0.00 [a]
Arsenic	0.01 ± 0.00 [a]	0.02 ± 0.00 [a]	0.05 ± 0.00 [a]
Cadmium	0.03 ± 0.00 [a]	0.01 ± 0.00 [a]	0.02 ± 0.00 [a]
Zinc	1.77 ± 0.00 [a]	0.91 ± 0.00 [a]	0.65 ± 0.00 [a]

Mean within the row with different superscripts are significantly different ($P<0.05$)

Table 7: The mean concentration of heavy metals in water samples in the month of December,2023.

Heavy metals	Fish Upstream (Station I)	Fish midstream (Station II)	Fish downstream (Station III)
Lead	0.05 ± 0.00 [a]	0.05 ± 0.00 [a]	0.06 ± 0.00 [a]
Mercury	0.07 ± 0.00 [a]	0.07 ± 0.00 [a]	0.11 ± 0.00 [a]
Arsenic	0.05 ± 0.00 [a]	0.02 ± 0.00 [a]	0.06 ± 0.00 [a]
Cadmium	0.05 ± 0.02 [a]	0.01 ± 0.00 [a]	0.01 ± 0.00 [a]
Zinc	0.04 ± 0.00 [a]	0.02 ± 0.00 [a]	0.02 ± 0.00 [a]

Mean within the row with different superscripts are significantly different ($P<0.05$)

Table 8: Comparison between the heavy metals in the muscles of the three fish species; *C. citharus, D. rostratus* and *C. gariepinus* and the approved WHO/FAO and EU standard

Fish Species	Lead	Mercury	Arsenic	Cadmium	Zinc
C.citharus (upstream)	0.08±0.01	0.08±0.01	0.02±0.00	0.04±0.01	0.80±0.01
C.citharus (midstream)	0.08±0.01	0.09±0.01	0.02±0.00	0.01±0.00	0.90±0.01
C.citharus (downstream)	0.07±0.01	0.08±0.01	0.04±0.00	0.02±0.00	1.32±0.01
D.rostratus (upstream)	0.08±0.01	0.08±0.01	0.01±0.00	0.04±0.01	0.68±0.01
D. rostratus (midstream)	0.08±0.01	0.09±0.01	0.02±0.00	0.01±0.00	0.90±0.01
D. rostratus (downstream)	0.07±0.01	0.08±0.01	0.04±0.00	0.02±0.01	1.32±0.01
C.gariepinus (upstream)	0.48±0.01	0.07±0.01	0.01±0.00	0.04±0.01	1.77±0.01
C.gariepinus (midstream)	0.08±0.01	0.09±0.01	0.02±0.00	0.01±0.00	0.91±0.01

C.gariepinus (downstream)	0.06±0.01	0.08±0.01	0.05±0.00	0.02±0.00	0.65±0.01
WHO/FAO	**0.5**	**0.5**	**1.0**	**0.05**	**50**
EUPermissible Limit	**0.3**	**0.5**	**1.0**	**0.1**	**50**

Table 9: Comparison between the heavy metals in the water samples and the approved WHO/FAO, USEPA and EU standard.

Fish Species	**Lead**	**Mercury**	**Arsenic**	**Cadmium**	**Zinc**
Water upstream October	0.06	0.07	0.06	0.01	0.05
Water midstream October	0.05	0.08	0.02	0.01	0.02
Water downstream October	0.06	0.11	0.06	0.01	0.02
Water upstream November	0.05	0.07	0.05	0.05	0.04
Water midstream November	0.05	0.07	0.02	0.05	0.02
Water downstream November	0.05	0.09	0.06	0.01	0.02
Water upstream December	0.05	0.07	0.05	0.05	0.04
Water midstream December	0.05	0.07	0.02	0.01	0.02
Water downstream December	0.06	0.11	0.06	0.01	0.02
WHO/FAO	**0.5**	**0.5**	**1.0**	**0.05**	**50**
EUPermissible Limit	**0.3**	**0.5**	**1.0**	**0.1**	**50**

DISCUSSION

The findings showed the concentration of heavy metals (lead, mercury, arsenic, cadmium, and zinc) in the muscle of fish gotten from Oguta Lake in mg/kg (milligram per kilogram) and water gotten from Oguta Lake in mg/l (milligram per liter). Among the five (5) heavy metals analyzed, in fish, the concentration of arsenic is very low while that of Zinc is higher than the other metals in each month. In water, the concentration of cadmium is lower while mercury is higher than other metals in each month. Heavy metals can contaminate water surface and groundwater through leaching from the soil which can violate water quality standards and pose risks to human and aquatic life [18]. Water pollution has been linked majorly to the presence of heavy metals which can be very detrimental to the aquatic habitat. The presence of heavy metals could be attributed to various human, industrial and agricultural activities within the river and effluents from industries [19].

Heavy metals are among the leading hazards to both terrestrial and marine habitats once they are discharged from natural and anthropogenic sources [20]. Heavy metals contaminate water bodies underlying sediments, air and the soil [22]. Lead, Mercury and Arsenic are known to be highly toxic to humans and aquatic life in large quantities which may lead to kidney problems in addition to genotoxic carcinogens. The results from these findings are similar to Seiyaboh *et al*.,[23] findings that the mean concentrations were below regulatory limits and individual samples showed elevated levels indicating the need for improved quality control measures. Earlier study by Wangboje *et al*.[24] showed high concentrations of zinc in fish species from River Niger.

The bioaccumulation of heavy metals in living organisms and bio magnifications describes the processes and pathways of pollutants from one trophic level to another. In bioaccumulation process the tissues of a living organism can absorb toxic metals if their availability is very high in the environment or food [25]. Heavy metals in rivers can enter the human food chain through the consumption of contaminated fish and other aquatic organisms. Prolonged exposure to heavy metals such as mercury, lead and cadmium can lead to various health problems including neurological disorders, kidney damage, developmental issues in children and an increased risk of cancers [26]. Removing heavy metals from rivers can be challenging and costly. To mitigate the impacts of heavy metals in Oguta Lake regulatory measures should be implemented. Government and Environmental agencies should set standards and regulations to limit the discharge of heavy metals into waterbodies. Additionally, monitoring programs should be established to assess the levels of heavy metals and track their sources enabling targeted pollution control [27].

Fish can take up heavy metals either as their diets or through their gills and bio accumulate them at different rates in their tissues [28]. According to Rainbow *et al*. [29], the rate of accumulation and the ability of the fish to detoxify particular metals differ greatly. This may account for the variation in the concentration of heavy metals found in the fish and water investigated in this study. The presence of the heavy metals could be attributed to various human, industrial and agricultural activities within the river and effluents from industries. Burger,*et al.*,[30] and Dusek, *et al.*,[31], reported that fish species accumulate heavy metals relative to their position in the food web. Oguta Lake exhibit heavy metal concentrations in fish which is generally below the WHO/FAO permissible limits. Based on the measured heavy metal levels in the water samples, lead, mercury arsenic are above the permissible limits set by WHO/FAO, USEPA and EU which might be as a result of human, industrial and agricultural activities. This suggests that the contamination of heavy metals in these fish is relatively low and within safe limits for consumption.

CONCLUSION

From the results obtained from the study, it is evident that fish and water contains some degree of heavy metals such as lead, mercury, arsenic, cadmium, zinc etc. Overall, the heavy metal concentrations level in the fish species were below the standard acceptable limits which may not pose threat to aquatic life while the heavy metal concentrations level in the water samples were above the permissible limits which poses threat to aquatic life and humans. Therefore, the consumption of fishes from Oguta Lake is safe to human beings. The present status should be protected to save the aquatic biota of the lake from pollution in near future and more adequate measures should be taken to ensure better fish quality and aquatic life of Oguta Lake. However, continuous monitoring is necessary to ensure that the fish are safe for human consumption. To mitigate the impacts of heavy metals in Oguta Lake regulatory measures should be implemented. Government and environmental agencies should set standards and regulations to limit the discharge of heavy metals into the Lake to make the water safe for humans and aquatic life.

RECOMMENDATIONS

Heavy metal contamination poses significant risks to aquatic ecosystems, biodiversity, and human health. By implementing the following recommendations, we can work towards mitigating these problems and safeguarding our valuable water resources.

- It is recommended that the level of heavy metals in water should be monitored regularly. Such data should be used for the assessment of health risk in the human population.
- Agricultural and industrial wastes should be treated effectively before discharge into the water body.
- Proper awareness should be provided to the public about the harmful effect of heavy metal toxicity in our environment.
- More scientific research should be encouraged and promoted about the toxicity of heavy metals, their effect on the environment and human health.

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