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APPRAISAL ON HEAVY METAL CONTAMINATION IN TISSUES (GILLS, INTESTINE, LIVER, AND FILLET) OF *PARACHANNA OBSCURA* AND THE PHYSICOCHEMICAL PROPERTIES OF OGUTA LAKE, SOUTH-EASTERN NIGERIA.

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ABSTRACT

The aim of this study is to provide baseline data on the investigation of concentrations of copper (Cu), lead (Pb), iron (Fe), manganese (Mn), and zinc (Zn) in various tissues (gills, intestine, liver, and fillet) of Parachanna obscura in Oguta Lake, and to assess physicochemical properties of Oguta lake to determine level of pollution and contamination. Twenty fish samples in total were collected at the fishermen landing site of the lake and analyzed using the Atomic Absorption Spectroscopy (AAS). Dissolved oxygen and temperature were measured on site using dissolved Oxygen meter (model-5509) and Mercury-in-glass thermometer respectively, while other parameters were analyzed in the laboratory. Results indicated Fe had the highest concentrations (1.479±0.003 mg/kg) especially in the gills, while Mn recorded least concentrations (0.001±0.000) mg/kg) of all metals analyzed. Values for Cu (0.026±0.002 mg/kg), Mn (0.001±0.000 mg/kg), Zn (.782±0.015 mg/kg), *and Fe (1.479±0.030 mg/kg) levels were within FAO/WHO permissible limits in all tissues, whereas Pb (1.438±0.015 mg/kg) exceeded standard limits especially in the gills and intestines, indicating potential contamination and threats to aquatic and human health. Heavy metal concentrations in the tissues followed the order: gills > intestine > fillet > liver. The physicochemical properties assessment of Oguta Lake indicated a stable temperature with mean value of (28.02±022 C). The lake's temperature supports aquatic life, but challenges like low transparency (*1.22±0.13 m), *acidic pH levels (*5.83±0.09), *elevated ammonium levels (*0.63±0.03 mg/l), *low nitrate-nitrogen levels (*0.0±50.00 mg/l), *and fluctuating dissolved oxygen (*6.50±0.29 mg/l) *levels suggests pollution from agricultural runoff or sewage. The findings proffer effective management through pollution control, enhanced buffering capacity, and rigorous monitoring to safeguard biodiversity and ensure long-term ecological health.*

Keywords: Heavy Metals, *Parachanna obscura,* Tissues, Oguta Lake.

INTRODUCTION

The presence of various agents like free metals in trace forms and other contaminants has been a long-standing threat to both aquatic environments and humans, given their toxicity, persistence, and their ability to bio-accumulate over time. (Ogueri et al., 2018; Morillo et al., 2004). Heavy metals are

metallic elements with higher density than water which can be toxic at low concentrations Ajima et al., 2015). Furthermore, studies have shown that these trace elements find their way in aquatic environments through human activities, such as industrial waste disposal, geochemical structure and processes, as well as increased mining activities which have led to increased levels of heavy metals (Singh et al., 2007). These elements when found in various aquatic ecosystems bioaccumulate in the tissues and organs of organisms as they come in contact with the environment (Franca et al., 2005). Bioaccumulation and biomagnification of these elements poses significant risks to the well-being of organisms and those who consume aquatic resources. The rate of heavy metals uptake by organisms and subsequent concentrations of these metals in various tissues of aquatic organisms like fish can be influenced by factors such as the immediate aquatic habitat of the fish, the species, feeding habits and other biological factors. (Adaka et al., 2017; Ogueri et al., 2018).

Freshwater fish species such as *Parachanna obscura* usually inhabit specific micro-habitats within inter-connected ecosystems. Contamination of these ecosystems with heavy metals can cause fish species to migrate to less populated segments of the river/stream, ultimately disrupting the food chain (Rashed, 2004). Fish reacts greatly to high levels of heavy metals, which is why they are used as indicators of environmental conditions in aquatic ecosystems, making their use important in recent years (Yilmaz, 2007). Fish, as the apex predators in aquatic environments, tend to accumulate high levels of certain metals present in water (Mansour and Sidky, 2002). Although some metals are essential for human health, excessive amounts can be detrimental. Copper (Cu), zinc (Zn), and iron (Fe) are among the heavy metals that play essential roles in enzymatic and metabolic functions in fish, while cadmium (Cd), lead (Pb), and mercury (Hg) are toxic and can adversely affect DNA and enzymatic processes (Cajaraville et al., 2000). Furthermore, in the human body toxic metals are known to attack proteins particularly enzymes, and their toxic effects accumulate over time causing slow poisoning of the system (Ukpebor et al., 2005).

Amongst the vast number of species of economic importance in the Oguta Lake is the *Parachanna obscura*. The *P. obscura* serves as a local component of fishery in the lake and is popular amongst the locals, offering cheap alternative for fish protein compared to other highly sort after species found in the lake. Generally, *P. obscura* is known to be a carnivorous feeder, formidable predator, and a typical piscivorous fish (Green et al., 2023). Its Juveniles feed on earthworms, tadpoles, shrimps, smaller fishes and other aquatic animals thereby increasing risks of accumulation of metals and pollutants in its tissues and systems.

The study aims to analyze the concentrations of heavy metals in the tissues of *P. obscura* collected at the fish landing site of the Oguta lake, thereby assessing the levels of metal accumulation in the gills, fillet, liver, and intestine with a view of ascertaining the likelihood of toxicity of heavy metals associated with fish consumption in this region. Determining the levels of heavy metals contamination in the fish species is critical for formulating suitable management plans and strategies to forestall possible health hazards. This finding will make available valuable insights into the current state of heavy metals and knowledge about the species (*P. obscura*) in particular which is considered scarce in the water body, thus contributing to up-to-date policy making processes for environmental conservation and the safety of human health in Oguta Lake. Furthermore, many forms of heavy metals have low toxicity thresholds, thus their presence in high concentrations can wipe out fish and other sea foods. The persistence and accumulative ability of the heavy metals up the food chains makes them a serious health hazard risk to man that feeds highly on sea foods. Findings from this work will be of immense benefit in regulating

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activities that account for increasing heavy metals levels in Nigerian coastal waters in general. Information from this work will also provide a means of appraising the adequacy and levels of compliance with existing regulatory standards and guidelines on heavy metals.

MATERIALS AND METHODS

Study Area

Oguta Lake, which is the largest natural lake in South-eastern Nigeria, is located in Oguta, Oguta Local Government Area of Imo State. The lake is bounded by Latitudes 5º41'N to 5º44'N and Longitudes 6º41'N to 6º50'E, and its elevation is 50 m above sea level (Figure 1). It occupies an area ranging between 1.8km^2 and 2.5 km^2 and has a shoreline length of 10km. The lake's mean depths are 5.5m. The lake has three tributaries, which are rivers Njaba, Utu, and Awbuna respectively, and empties into River Niger through River Orashi (Nwadiaro, 1989). The sampling point was determined representing areas prone to anthropogenic activities and run-off.

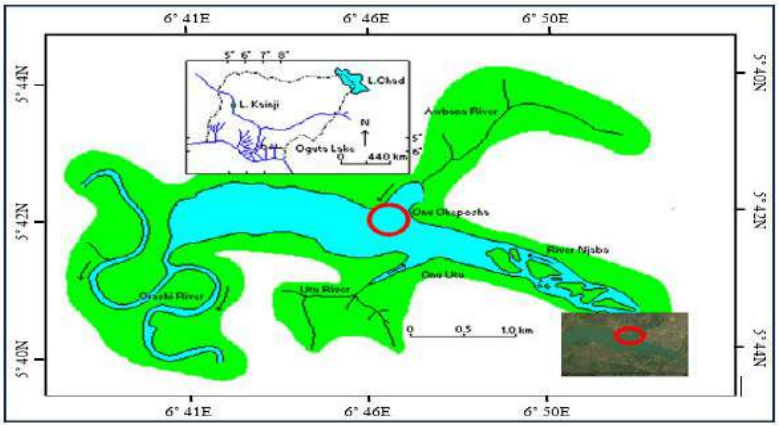

Figure 1: Map of Oguta Lake showing the study area. (Source: Adaka et al., 2017).

Experimental Design and Sample Collection

Physicochemical parameters were sampled bi-monthly at the site from 8.00am to 11.00am for four months during the rainy season period (March – June) at the main point of fish aggregation from several parts of the lake. This site is also the point for major anthropogenic discharges from runoff, sewage and domestic use. Temperature was measured in situ using Mercury-in-glass thermometer, while water samples for Dissolved oxygen (D.O), Carbon (iv) oxide, total hardness, alkalinity, and ammonium, nitrate-nitrogen were collected in 1liter sterile plastic bottle, tightly stored in a clean, dry, dark sack bag material and transported to the laboratory of the Department of Fisheries and Aquaculture Technology, Federal University of Technology, Owerri, Imo state prior analysis. Preparation of samples and analysis were carried out using procedures as specified by (APHA, 2017).

A total of 20 samples of *P. obscura* with a weight range of 40-90g, measuring between 30-90cmwere obtained from fishermen at the fish landing site of Oguta lake with each fish sample tagged alphabetically. Each sample was dissected at the site to obtain the desired organ (gill, intestine, liver, and fillet). The fish organs and tissues were extracted, preserved in the freezer prior to its transportation to the Central Laboratory, Federal University of Technology Akure, Ondo State, Nigeria in an ice-chest for heavy metals analysis. All the analysis was done using a standard analysis method as described by (APHA 1998). In each of the 20 samples of fish collected, gill, intestine, liver and fillet were all extracted for the analysis.

Determination of Physicochemical Parameters of Oguta Lake

Transparency

The transparency was measured using a secchi disk to which was attached a calibrated line on the upper side. The secchi disk was lowered into the water until it just disappeared and the depth was recorded. It was lowered a little more and raised until just appeared and the depth was recorded. The average of the two depth readings was taken as the secchi disk reading.

Temperature

Mercury-in-glass, general test precision grade, -5 to 50^0C, thermometer (model 545, code 1066) was used to measure the water temperature at the time of collection of water sample for physicochemical analysis.

Hydrogen Ion Concentration (pH)

The Glass Electrode method of standard methods for the examination of water and waste water 16^{th} edition, 1995, was used by employing a pH meter which utilizes an immersion type electrode. The pH meter (model 191) was calibrated against standard buffer solutions with pH values of 4, 7 and 10. Calibrations were carried out intermittently during the pH testing period.

Dissolved Oxygen (DO) (Wrinkle's Method)

Preparation of Reagents

1. Manganous sulphate solution/ 48g of $MnSO_4 \cdot {}^{4H}{}_2O$ was added to about 25mls of distilled water in a large beaker. This was transferred to a volumetric flask and made up to 100ml with distilled water.
2. Alkaline Potassium iodide reagent. 70g of KOH and 15g KL were dissolved in 75ml of distilled water. The solution was cooled and the made up to 100ml.
3. Sulphuric acid, concentrated.
4. Starch solution, a pinch of soluble starch was added to about 20ml of distilled water, boiled and cooled, fresh starch solution was prepared every 30days.
5. Sodium thiosulphate standard solution 0.6205g of $Na_2S_2O_3$was dissolved I freshly boiled and cooled distilled ware and diluted to 100ml.
6. Standard potassium dichromate solution 0.613g of $K_2V_{r2}O_7$ (dried at 125oc) was dissolve in 500ml of distilled water. The strength of this solution was equivalent to 0.025n.

Standardization of Thiosulphate with Dichromate

About 2g of KL was dissolved in an Erlenmeyer flask with 100mls of distilled water. 10mls of 90% solution of H_2SO+4+ was added followed by 20ml of standard $K_2C_{r2}O_7$ solution. This was place in the dark for 5 minutes, diluted to 400ml, and titrated with 0.25n thiosulphate. Each ml of 0.025n thiosulphate was equivalent to 0.2mg oxygen.

Procedure

2ml of $MnSO_4$ solution was added well below the surface of the liquid in the sample bottle (300ml) followed by 2ml of alkaline KI reagent. The sample bottle was stoppered with care to completely exclude any air bubbles and mixed by inventing the bottle a few times when the precipitate had settled, the stopper was carefully removed and immediately 2ml of concentrated H_2SO_4 was added to run down the neck of the bottle. The bottle was stoppered and mixed by gentle inversion until dissolution of precipitate was completed then 203ml of the treated sample was taken in a conical flask and titrate with 0.025N thiosulphate to a pale straw (pale yellow) colour. 2 ml of freshly prepared starch solution was added and the titration was continued to the first disappearance of the blue colour.

Total Alkalinity

The total alkalinity of the systems water was determined using the procedure outlined in LaMotte freshwater aquaculture test kit AQ-2/code 3633-03.

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Total Hardness

The total hardness of the systems water was also determined using the procedure outline in LaMotte freshwater aquaculture test kit model AQ-2/code 3633-03.

Total Ammonia-Nitrogen

The total ammonia-nitrogen or the systems water was determined using the procedure outlined in LaMotte freshwater aquaculture test kits model AQ – 2/ code 3633-03.

Free Carbondixide

Preparation of Reagents

1. 0.023N Sodium Hydroxide:
   0.91 grams of sodium hydroxide was dissolved in 500m of distilled water and made up to 1 liter.
2. 0.5% Phenolphthalein Indicator Solution:
   0.5g of phenolphthalein was dissolved in 99.5 mls of 50% ethyl alcohol.

Procedure

100 ml of water sample was pipetted into a conical flask of small exposed surface area. 10 drops of phenolphthalein indicator solution were added to the sample and titrated again 0.023N N_aOH, keeping water (titrate) in motion, avoiding splashing till light pink colour (end point) persisted.

Equation of reaction.

$H_2CO_3 + 2N_aOH \; N_{a2}CO_3 + 2H_2O$.

Calculation

The free CO_2 in mg/1 was calculated using the following equation:

$$\frac{MaVa}{MbVb} = \frac{b}{a}$$

Where: Ma = morality of carbonic acid in water sample (mg/1)

Mb = molarity of N_aOH solution (mg/1)

Va = volume of water sample.

Vb = volume of N_aOH solution (titrant) used.

a = moles of carbonic acid in balanced equation.

b = moles of NaOH solution in balanced equation.

Alternatively, the free CO_2 in mg/1 is equal to 10times the number of mls of N/44 N_aOH solution (titrant) used.

Nitrite-Nitrogen

The total nitrite-nitrogen of the systems water was determined using the procedure outline in LaMotte freshwater aquaculture test kits model AQ – 2/ code 3633-03.

D**igestion of Tissues**

About 5g of the sample was placed in a macro Kjeldahl digestion flask with the addition of 20 ml of concentrated nitric acid together with about 120 ml of water. The combination was heated until the amount was decreased to roughly 20ml. After cooling, 10ml of concentrated sulphuric acid was added and subjected to further boiling. Small quantities of nitric acid were added as the liquid began to blacken. The liquid was heated continuously until dense white fumes evolved, which was then cooled upon the addition of 10 ml of saturated ammonium oxalate solution. This was to facilitate the removal of colored nitro compounds. The digest was then transferred with water to a 100 ml volumetric flask and made up to mark according to (FAO**,** 2004).

Analysis of Heavy Metals

The sample extracts were analyzed using the Atomic Absorption Spectrophotometer (AAS) technique for Lead (Pb), Zinc (Zn), Manganese (Mn), and Copper (Cu). The wavelength of light emitted by the hollow cathode lamp was precisely chosen to match the absorption line of each metal. The absorbance values from the analysis were then compared to a calibration curve to determine the metal concentration in the sample. To ensure accuracy and reliability, quality control procedures, including duplicate analyses and spike recovery tests, were regularly performed.

Statistical Analysis

The study's findings were displayed in tables indicating means and standard error. The 20.0 statistical package for social sciences (SPSS) version was utilized to analyze the heavy metal levels in fish tissues, and a one-way analysis of variance (ANOVA) was conducted to verify treatment means. Descriptive statistics and graphs were produced utilizing Graph-Pad Prism 5 Software. To verify distinctions at $P < 0.05$, the Duncan Multiple Range Test was conducted.

RESULTS AND DISCUSSION

The Physicochemical Parameters of the Oguta Lake

The physicochemical assessment of Oguta Lake reveals critical insights into the ecological and health risks facing its aquatic ecosystem (Table 2). The temperature (28.02 ± 0.22°C) is conducive for aquatic life but challenges such as low transparency (1.22 ± 0.13 m) which represents the level of transmission of light into the water body can hinder photosynthesis and harm aquatic plant communities, impacting overall ecosystem productivity (Sader, 2017).

The acidic pH levels (5.83 ± 0.09) below the recommended range (6.5-8.5) can adversely affect fish and other organisms, potentially disrupting the lake's biodiversity and ecological balance (Etim and Adie, 2012). While alkalinity (85.06 ± 5.81 mg/l) provides some buffering against pH fluctuations, it requires enhancement to effectively counteract acidification processes that threaten aquatic life (Renforth and Campbell, 2021).

Elevated ammonium levels (0.63 ± 0.03 mg/l) exceeding permissible limits indicate significant pollution inputs, likely from agricultural runoff or sewage discharge. This poses toxicity risks to aquatic organisms, potentially leading to reduced species diversity and ecosystem resilience (Jadon et al., 2022). Low nitrate-nitrogen levels (0.05 ± 0.00 mg/l) suggest limited nutrient availability, which may restrict primary productivity and ultimately affect higher trophic levels in the food chain (Romanelli et al., 2020).

While dissolved oxygen (6.50 ± 0.29 mg/l) generally meets acceptable standards, fluctuations could stress aquatic organisms during periods of low oxygen availability, affecting their growth and reproductive success (Shelley and Rajts, 2020; van Der Lee et al., 2020). The safe hardness levels (104.91 ± 6.11 mg/l) ensure essential mineral supply without causing adverse effects related to water hardness (WHO 2010). Carbon IV oxide levels (17.59 ± 1.89 mg/l), though within permissible limits, require continuous monitoring to prevent potential acidification that could further degrade water quality and harm aquatic life.

The findings highlight significant ecological risks to Oguta Lake posed by pH imbalance, elevated ammonium levels, and nutrient limitations. Effective management strategies, including pollution control measures, enhancing buffering capacity, and regular monitoring of water quality parameters, are essential to mitigate these risks. Collaborative efforts among stakeholders, supported by stringent environmental regulations, are crucial to safeguarding the lake's biodiversity and ensuring its long-term ecological health.

The Concentration of Heavy Metals in Fish Tissues (gills, intestine, liver, and fillet)

The concentration of heavy metals Cu, Pb, Mn, and Zn determined in fish tissues (gills, intestine, liver, and fillet) is presented in Table 1, as well as in figure 2 to 6 respectively.

Results of the analysis on variation of the heavy metal analysis in Table 1 revealed that concentrations of Cu, Pb in all the tissues were significantly different at $P<0.05$. However, there was no significant differences at $P<0.05$ for the concentrations of Fe in the gill and fillet, as well as for Zn in the intestine and fillet respectively. Mn also showed no significant difference in the fillet and liver respectively. Heavy metal concentrations in the tissues analyzed followed a descending trend in magnitude as; gill > intestine > fillet > liver.

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Furthermore, the results also revealed that cumulatively, concentrations of the metals analyzed in the tissues of *P. obscura* followed a descending trend in magnitude as; Fe > Pb > Zn > Cu > Mn respectively. Concentrations of the heavy metals in all the tissues analyzed were within permissible limits set by WHO/FAO (2011) except for Pb which exceeded 1.0mg/kg in the gill and intestine respectively. Although Davies et al. (2024) reported lower levels, of Pb, the result was in line with those reported by Vieira et al., (2011) especially in the gill and intestine. In addition, results in Pb corroborates findings especially in Oguta Lake as reported by Adaka et al., (2017); Ekeanyanwu et al. (2015) suggesting some form of Pb contamination from battery effluents and car residue wastes that may have been washed down into the lake from so many artisanal activities from local mechanics, etc.

Pb is known to be very toxic heavy metal even at low concentrations and does not break down in the environment, thus elevated levels are found in soil, water and air environments (Horsefall and Spiff, 2001). Its toxicological symptoms in humans include high blood pressure, anemia, kidney damage, memory and learning difficulties. Others include miscarriage, decreased sperm production and reduced intelligent quotient especially in children. Pb concentrations in the tissues analyzed followed a descending trend in magnitude as thus; gill > intestine >fillet> liver.

Furthermore, results indicated that concentrations of Fe was the highest of all heavy metals investigated, and Mn the lowest. Fe recorded highest concentrations in the gill with a mean value of 1.479±0.030 mg/kg, while the liver recorded the lowest concentrations of Fe with a mean value of 0.095±0.059 mg/kg.

Fe, Pb, and Zn showed relatively high concentrations from the results. Fe in particular is considered an essential metal because of its biochemical and physiological role in blood cells, hemoglobin synthesis, and cofactor of many enzymes (Peace et al., 2021; Edward et al., 2014; Gorur et al., 2012). However, the seeming high concentrations of Fe above the physiological level in living organisms may result in Fe overload (Stancheva et al., 2014).

Results indicated that highest mean concentration of Fe was 1.479±0.030 mg/kg in the gills but did not exceed 4.3 indicated by WHO/FAO (2011) for metal contaminants in fish tissues. This result of high levels of Fe and Zn is consistent with studies by Davies et al., 2024; Musa et al., 2017. The accumulation of high levels of Fe according to Obasohan (2007) may be due to the fact that it is freely available in soils, mud flats and other areas, and the tendency to get accumulated in high concentrations by fishes and other bottom dwellers like *P. obscura* could be the reason for their high accumulations in tissues of aquatic organisms.

The results from the study further revealed that cumulatively, most metals were preferentially accumulated in the gills, while the liver accumulated the lowest concentrations. This could be adduced to the fact that the gills are not just the most active organ of fishes, but also because of their respiratory functions and are exposed more with the physical environment of the fish. This was also reported by (Ogueri et al., 2018; Ajima et al., 2015) who further stated that the gills are known to concentrate heavy metals due to the formation of complex ions in the mucus, which may not be completely removed from the gill lamellae before preparation for analysis.

This result and line of thought is also consistent with studies conducted by Musa et al., (2017), and Ekeanyanwu et al., (2015) which also regarded concentrations of heavy metals in the gills as a fair indicator of the levels of metals in the fish habitat.

Of all the tissues analyzed, the liver recorded the lowest concentration of heavy metals. The liver is known to perform detoxificative functions and as such accumulated materials in the liver are constantly metabolized speedily and passed out of the body of the fish to reduce toxic effects on the fish. These substances after

deamination and detoxification are mostly defecated by the fish and in some ways account for the reduction of toxic substances, including heavy metals that may have accumulated in the fish liver. Yilmaz, 2007 and Davies et al. (2023) also revealed that bioaccumulation factors of most metals in the organs of the fishes are generally higher due to the ingestion by the fishes while feeding, however these metals in their forms are not easily assimilated and hence may not be readily available in some organs of the fish. Furthermore, fishes can take up heavy metals either in their diets or through their gills and bio-accumulate them at different rates in different organs and tissues, demonstrating decrease in heavy metals due to dilution effects of the liver (Adaka et al., 2017; Yilmaz, 2007).

The intestine and fillet also recorded relative amounts of heavy metals, although concentrations in the intestine were slightly higher than in the fish fillet. Ukachukwu, (2012) reported relatively high levels of heavy metals in the intestine and fillet, adducing that organs such as lungs, gills, and intestines are prone to higher accumulations of these metals due to their activeness, especially in metabolic processes. Furthermore, high levels of heavy metals in the intestine could be attributed to the feeding habits of the species. *P. obscura* is widely seen as a piscivorous-insectivorous-carnivorous fish, relying mostly on various forms of zooplanktons found at the bottom water, juvenile fishes, crustaceans, as well as large fishes (Kopugue et al.,2013).

The relative concentrations of these metals in the intestine could also be traced to bioaccumulation from other feed sources which upon ingestion will be stored in the intestine before proper digestion (Otchere, 2003). Concentrations of heavy metals in the fillet from this study was however in disagreement with the findings of Ekeanyanwu et al.,(2015) ; Effiong and Gilbert,2012) who reported very low concentrations in the fillet but in agreement with results in the fillet reported by Obasohan (2007) and Adaka et al. (2017) who adduced that presence of reasonable amounts of heavy metals could be attributed to the pronounced cycloid scales on the body of the fish some fish species which are constantly in contact with the fish environment especially as they move at the bottom of their habitat.

Heavy metals present in the scales could bioaccumulate over time due to the presence of protein bio-compounds in the fish flesh and could easily rise to reasonable levels. (David and Isangedighi,2019). The study revealed that the build-up and deposition of heavy metals in Oguta Lake could be linked to various factors, such as the operations of oil and gas industries, as well as the use of insecticides and pesticides in small-scale agricultural practices which are subsequently washed into the lake. Additionally, the accumulation of heavy metals was also found to be caused by practices such as trash incineration, bush burning, and unregulated waste disposal into the lake (Ogueri et al., 2018).

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Table 1: Range and Mean concentrations of heavy metals (mg/kg) in the tissues of *P. obscura* from Oguta Lake

Parameter (mg/kg)	Gill	Intestine	Liver	Fillet	WHO/FAO (2011)
Copper (Cu)	0.026±0.002[a]	0.018±0.002 [ab]	0.016±0.050 [b]	0.000±0.000 [c]	0.5
Range	0.002-0.039	0.002-0.027	0.001-0.125	0.000-0.000	
Lead (Pb)	1.438±0.020 [a]	1.296±0.052 [b]	0.000±0.000 [d]	0.432±0.015 [c]	1.0
Range	1.310-1.550	0.975-1.775	0.000-0.000	0.000-0.000	
Manganese (Mg)	.003±0.001[a]	.003±0.000 [ab]	.001±0.000 [c]	.000±0.000 [c]	5.3
Range	0.001-0.020	0.001-0.005	0.001-0.003	0.002-0.097	
Zinc (Zn)	.508±0.015 [b]	.745±0.037 [a]	.045±0.038 [c]	.782±0.015 [a]	5.0
Range	0.395-0.805	0.259-0.951	0.001-0.850	0.659-0.925	
Iron (Fe)	1.479±0.030 [a]	0.681±0.062 [b]	0.095±0.059 [c]	1.423±0.030 [a]	4.3
Range	1.210-1.750	40.000-1.600	0.001-1.310	1.260-1.710	

Values with same superscript along same row are not significantly different at P<0.05

**WHO/FAO (2011): World Health Organization/Food and Agricultural Organization.*

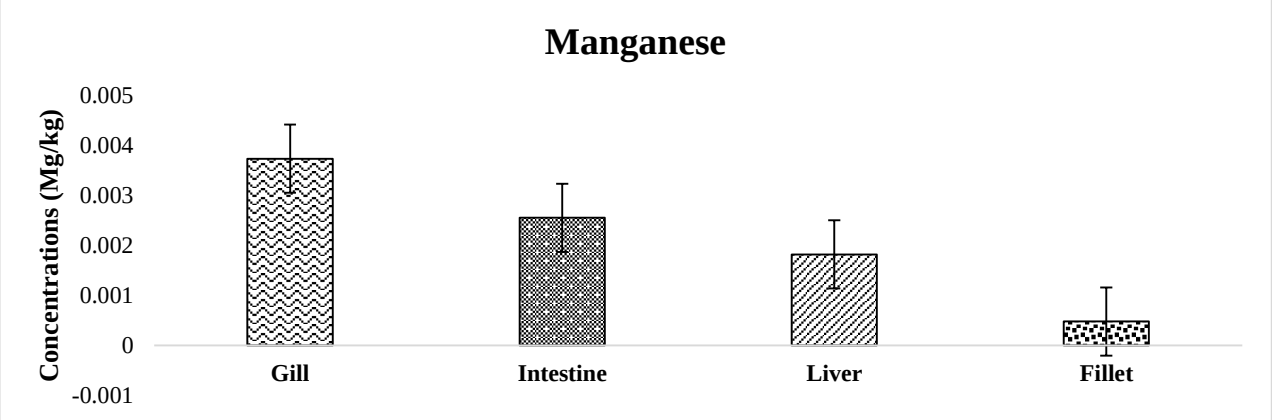

Figure 2: Manganese concentrations in different tissues of *Parachanna obscura* from Oguta Lake

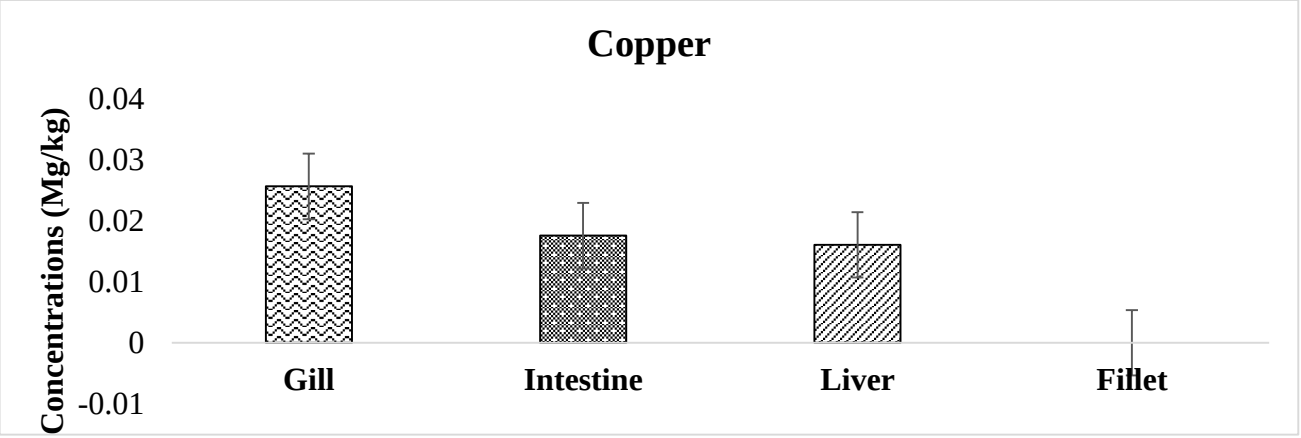

Figure 3: Copper concentrations in different tissues of *Parachanna obscura* from Oguta Lake.

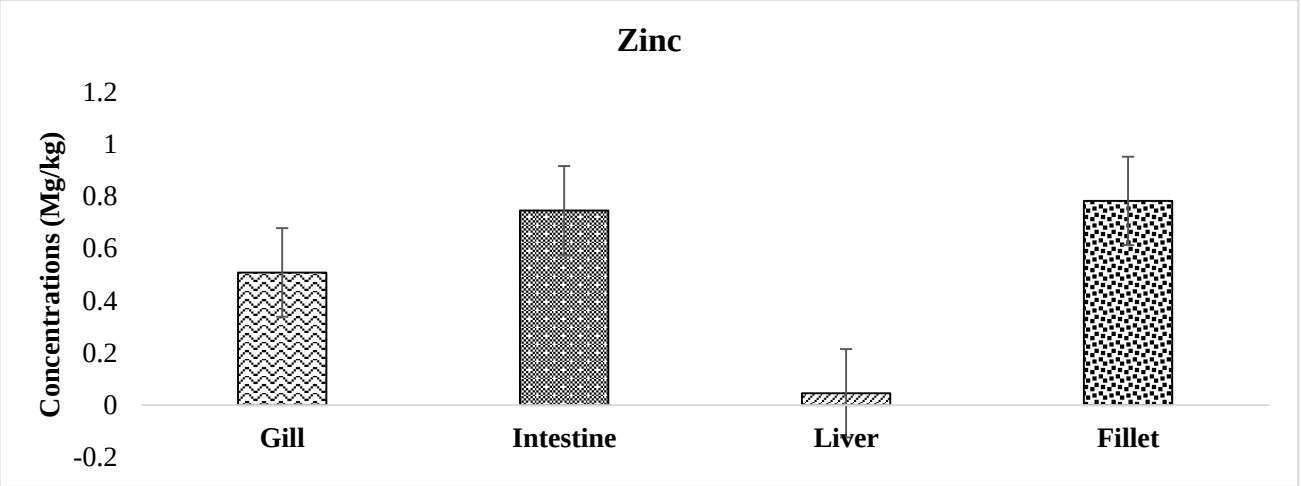

Figure 4: Zinc concentrations in different tissues of *Parachanna obscura* from Oguta Lake

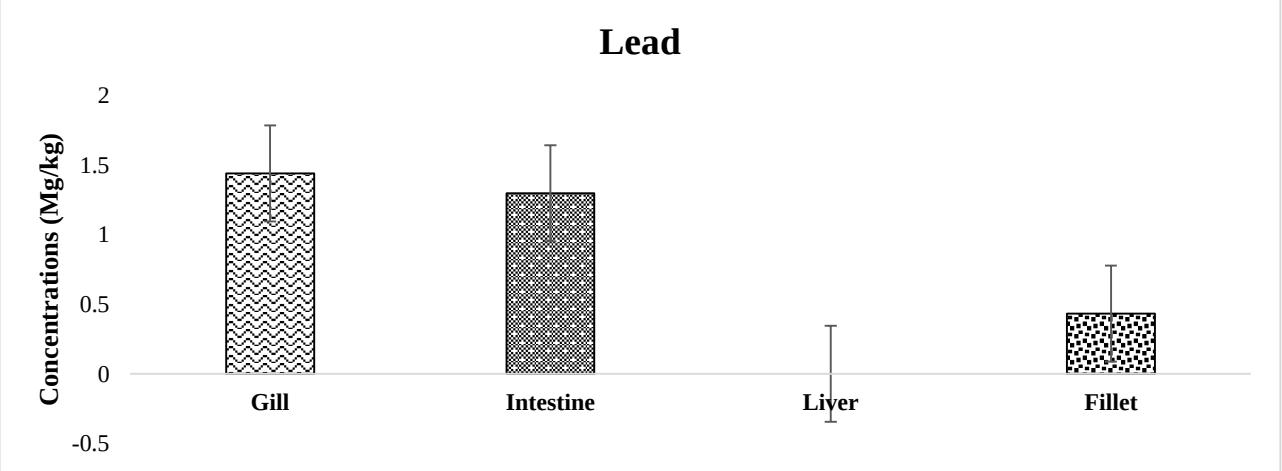

Figure 5: Lead concentrations in different tissues of *Parachanna obscura* from Oguta Lake

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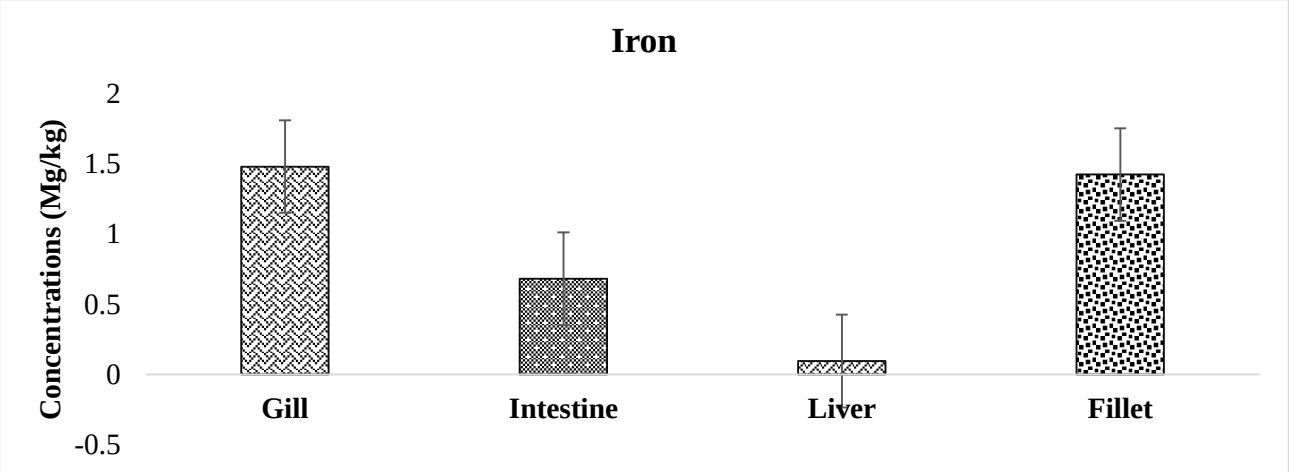

Figure 6: Iron concentrations in different tissues of *Parachanna obscura* from Oguta Lake

Table 2: Summary of Range and Mean Values of Physicochemical Parameters of Oguta Lake.

Parameter	Min. values	Max. values	Mean values	±SD	NESREA (2011)	WHO (2011)	USEPA (2017)	DPR (2002)
Temperature (°C)	27.00	29.50	28.02	0.22	A	24.8-30	27 - 30	22.32-25
Transparency (m)	0.40	2.25	1.22	0.13	NS	5	-	-
pH	5.00	6.00	5.83	0.09	6.5-8.5	6.5-8.5	6.5 - 8.5	6.5-8.5
Alkalinity (mg/l)	36.00	132.00	85.06	5.81	NS	-	-	-
Ammonium (mg/l)	0.32	0.91	0.63	0.03	<0.1	<0.1	<0.1	<0.1
Nitrate-Nitrogen (mg/l)	0.05	0.05	0.05	0.00	9.1	≥10.0	10.0	10.0
Dissolved Oxygen (mg/l)	4.60	10.00	6.50	0.29	≤6.00	6.00	7.50	5.00
Hardness (mg/l)	52.00	156.00	104.91	6.11	NS	500	-	-
Carbon IV Oxide (mg/l)	6.00	32.00	17.59	1.89	<20.0	40	-	10

***Note:* *NESREA (2011):** *National Environmental Standards and Regulations Enforcement Agency*
***WHO (2011):** *World Health Organization*
***EPA (2017):** *Unite State Environmental Protection Agency*
***DPR (2002):** *Department of Petroleum Resources.*

CONCLUSION

This study provides insights into the heavy metal concentrations in *Parachanna obscura* from Oguta Lake, highlighting significant accumulations in the gill. While Manganese (Mn), Zinc (Zn), and Iron (Fe) levels were within permissible limits, elevated Lead (Pb) concentrations raise concerns about potential toxicity. The physicochemical assessment revealed challenges such as low pH and elevated ammonium levels, indicating pollution sources that pose risks to aquatic and human health. The findings underscore the need for continuous monitoring and comprehensive assessments encompassing both rainy and dry seasons to capture seasonal variations. These efforts are crucial for establishing robust baseline data and informing sustainable management practices.

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