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Biochemical Profile and Bio-Concentration of Cu, Hg, Pb and Zn in Tilapia guineensis inhabiting Lagos lagoon, Nigeria

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Abstract

This study investigated Aspartate aminotransferase (AST), Alanine aminotransferase (ALT) and Alkaline Phosphatase (ALP) in the liver tissue as well as bio-concentration of Zn, Cu, Pb and Hg in Tilapia guineensis inhabiting Lagos lagoon, Nigeria. Serum biochemical enzymes were determined using calorimetric assay and phenolphthalein monophosphate method while heavy metals by atomic absorption spectrophotometry. The concentration of biochemical enzymes were in the order of ALP>AST>ALT. The AST and ALT ranged from 59.20 ± 21.03IU/L to 108.33 ± 30.48IU/L and 21.87 ± 7.49IU/L to 81.44 ± 37.09IU/L (means of 88.56 ± 33.38IU/L and 48.94 ± 33.48IU/L respectively) while the mean ALP in the fish was 113.55 ± 82.33IU/L (minimum and maximum of 43.47 ± 17.50IU/L and 183.09 ± 91.16IU/L respectively). The concentration of Cu, Zn, Hg and Pb in water was 1.88 ± 2.94mg/L, 25.49 ± 44.27mg/L, 0.00 ± 0.00mg/L and 0.25 ± 0.49mg/L respectively. Also, the concentration of Cu, Pb, Hg and Zn in T. guineensis of Lagos lagoon was 0.0093 ± 0.01mg/kg, 0.0005 ± 0.00mg/kg, 0.0000 ± 0.00mg/kg and 0.0248 ± 0.04mg/kg respectively. The Bio-Concentration factor was as low as 0.00 (Hg), 0.005 (Cu), 0.002 (Pb) and 0.001 (Zn). The result also revealed negative correlation (r= -0.06, P=0.85) between AST and Cu in fish. Similarly, ALT was significantly correlated with Cu (r=0.66, P=0.02), Pb (r= -0.59, P=0.05) and Hg (r= -0.63, P=0.03) in water. This study established that metals' concentrations imposed negative effects on the enzymes.

Keywords: Alkaline Phosphatase (ALP); Heavy Metals; Alanine Aminotransferase (ALT); Pollution; Aspartate Aminotransferase (AST) and Fish Biology

1. Introduction

Aquatic pollution is a global issue of great concern due to its severe damages on aquatic biota, which consequently threatens the public water supplies (Mourad *et al.,* 2017 and Nagaran *et al.* 2023). The direct and unchecked pollutants released directly or indirectly by industries, agricultural and anthropogenic activities are received by aquatic ecosystems (Xinyue *et al.,* 2022). Therefore, aquatic biota subjected a great stress that may impair the molecular and the cellular components of the organisms as well as enzymatic and biochemical alterations (Mourad *et al.,* 2017 and Ahmed *et al.* 2022).

Also, there could be inducement of biochemical, histological and morphological alterations in aquatic biota, particularly fish, due to prolong exposure to pollutants (such as heavy metal) even in a minute concentration in water (Josephine, 2022). Killian *et al.,* (2022) reported that biochemical profiles offer early signaling of harmful changes in stressed organisms. Chronic heavy metal exposure resulted in variation in the enzymes levels with increase in Aspartate Aminotransferase (AST) and decreases in Alanine Aminotransferase (ALT), contributed to the stress induced by the heavy metals (Nagaran *et al.,* 2023). Biochemical changes in blood are important indicators used in monitoring physiological and pathological changes in fish as they supply reliable information on metabolic and molecular disorders (Satheeskumar *et al.,* 2011). Therefore, uses of biochemical changes are useful biomarkers because they are most sensitive indices of the stress state of an organism.

Changes in biochemical profile as a result of the induced stress by the pollutants can also give a reflection of the general health status of the aquatic organisms, which can be used as biomarkers (Esilaba *et al.,* 2020). AST, ALT, and Alkaline Phosphatase (ALP) are enzymes commonly measured in blood tests to assess liver function and detect certain medical conditions. While they can provide valuable information, it's important to note that these levels alone cannot definitively diagnose specific diseases. However, elevated levels of AST and ALT are commonly associated with liver damage or injury. Also, while AST and ALT are primarily related to liver health, elevated levels may be observed in certain cardiovascular conditions such as congestive heart failure, myocarditis (inflammation of the heart muscle), or acute coronary syndrome. However, these enzyme levels alone are not specific indicators of cardiovascular diseases (Wang *et al.,* 2017 and Ahmed *et al.,* 2022). Also monitoring of heavy metals is important in diagnosing the structural and functional status of fish exposed to toxicants. It also has considerable diagnostic value that acts as pathophysiological reflector of the general well-being of the body (Fagbuaro *et al.,* 2016, Corredor-Santamaría *et al.,* 2016, Mourad *et al.* 2017 and Nagaran *et al.,* 2023).

Tilapias have many attributes (fast growth, tolerance to a wide range of environmental conditions, resistance to stress and disease, ability to breed in captivity, feeding on low trophic levels and good sensorial proprieties of flesh) that make them a perfect candidate for promoting aquaculture and supply sustainable development in Nigeria (Fagbuaro *et al.,* 2016; Loto *et al.,* 2021). Tilapia guineensis is one of the fish species of great economic importance around the world. It is usually a native fish species of high commercial value in lakes and rivers where they are found.

Many work had been done on the serum biochemical profile of some fish species around the globe. Amazingly, there is dearth of information on the serum biochemical profile of T. guineensis in Nigeria (Fagbuaro, *et al.*, 2016, Corredor-Santamaría *et al.*, 2016, Mourad *et al.* 2017, Oluwalola *et al.*, 2020, Owolabi *et al.*, 2021, Nareed *et al.*, 2022, Nagaran *et al.*, 2023 and Hana *et al.*, 2023). Hence, this research is designed to investigate the serum biochemical profile as well as bio-concentration of Cu, Pb, Zn and Hg in Tilapia guineensis inhabiting Lagos lagoon, Nigeria.

2. Materials and Methods

2.1 Study Area

The Lagos lagoon (being one among the nine South-western lagoons) is an open, shallow and tidal lagoon, with a surface area of 208km^2 and a mean depth of less than two meters (Fajemila *et al.*, 2020). The lagoon (Latitude N 06° 31. 048' and Longitude E 003° 24. 473') which is found within the heart of the Lagos Mega City, experiences both dry and wet seasons. The proliferation of urban settlements and slum in the city of Lagos has also meant increased human pressure and the generation of domestic effluents, which eventually find their way into the lagoon. The lagoon receives a complex mixture of domestic and industrial waste and has served as the ultimate sink for the disposal of domestic sewage since the latter part of the 19th century. However, the lagoon has received an excellent attention due to its environmental and economic importance for being a big source of fish production in Lagos, Nigeria (Loto *et al*., 2021).

2.2 Collection and Identification of Samples

Thirty six (36) samples of *Tilapia guineensis* were collected monthly from June to August, 2021 using cast net with the assistants of artisanal fishermen. *Tilapia guineensis* samples were identified according to Olaosebikan and Raji (2013) and Auta *et al.,* (2021).

2.3 Biochemical Analysis

The livers were carefully removed after being dissected. For the enzyme assay, 0.5g of the liver were macerated and added to 5 mL of physiological saline (Edori *et al*., 2013). De-ionized water was added to an additional 0.5g of the homogenate sample, which was then centrifuged at 3000 rpm for 10 min (Loto *et al.* 2021). The supernatant was poured into plain bottles and refrigerated (-4°C) for storage. The activities of Alanine aminotransferase (ALT) and Aspartate aminotransferase (AST) in the liver tissue were measured using calorimetric assay, while the activities of Alkaline Phosphatase (ALP) in the liver were estimated using the phenolphthalein monophosphate method (Edori *et al*., 2013 and Loto *et al*., 2021).

2.4 Determination of heavy metals

The samples were uniformly ground after being oven-dried at 60°C for 48 h. 50 mL digestion tubes containing 0.2 g of powdered weight and 2.5 mL of an H_2SO_4 and selenium solution were placed in an aluminum block on a heated plate (Esilaba *et al*., 2020). The tubes were heated at ~200°C until the solution fumed. Each tube was removed from the hot plate and allowed to cool for 10 min. One millilitre of 30% H_2O_2 was added to each tube. After the reaction subsided, an additional 2 mL H_2O_2 was added to each tube, which was then placed on a hot plate and heated to 330°C until clear (~2 h). The yellow tint of the solution disappeared as the digest was completed. The solution was poured into a centrifuge tube and made up to 30 mL mark with distilled water. This was centrifuged at 3000 rpm for 10 min. The supernatant was decanted into sample vials for analysis. The concentrations of heavy metals were determined using a PG990 atomic absorption spectrophotometer. Analytical blanks were run in the same way as the samples and concentrations were determined using standard solutions prepared in the same acid matrix (Ajibare *et al*., 2018). The accuracy of application of the analytical procedure was evaluated using certified reference material for Hg, Zn, Cu, and Pb (Esilaba *et al*., 2020). All of the glassware underwent a 24 h soak in dilute nitric acid after which they were properly cleaned with distilled water. Analytical-grade reagents were utilized throughout. The United States Environmental Protection Agency's (USEPA, 2011) quality control (QC)/assurance (QA) protocol for metal analysis was applied.

2.5 Determination of Bio-Concentration Factor (BCF)

Bio-concentration factor (BCF) is the ratio of the steady-state metal ion concentrations in the fish tissue to the concentration in water (Orata and Birgen, 2016). The higher the ratio, the more severe the bio-concentration of pollutants. Bio-Concentration factor was determined according to (Orata and Birgen, 2016) as:

$$BCF = \frac{\text{Concentrations of metal in fish tissue (mg/kg)}}{\text{(Concentrationc of metal in water (mg/L)}}$$

2.6 Statistical Analysis

Data were statistically analyzed with the aid of descriptive statistics to establish means and standard deviations while Pearson correlation was used to identify the relationship among the parameters (at P=0.05) using IBM SPSS Statistics 20.

3. Results and Discussion

The concentration of AST, ALT and ALP in *T. guineensis* is presented in Table 1. The table showed that the biochemical enzymes were in the order of ALP > AST > ALT. The table further revealed that AST ranged from 59.20 ± 21.03IU/L (July) to 108.33 ± 30.48IU/L (June) with mean of 88.56 ± 33.38IU/L. ALT also ranged from 21.87 ± 7.49IU/L (July) to 81.44 ± 37.09IU/L (June) with an average of 48.94 ± 33.48IU/L while the mean ALP recorded in the fish was 113.55 ± 82.33IU/L with a minimum and maximum value of 43.47 ± 17.50IU/L (August) and 183.09 ± 91.16IU/L (June) respectively.

Table 1 Biochemical enzyme in *T. guineensis*

Month	AST (IU/L)	ALT (IU/L)	ALP (IU/L)
JUNE	108.33 ± 30.48^{b}	81.44 ± 37.09^{b}	183.09 ± 91.16^{b}
JULY	59.20 ± 21.03^{a}	21.87 ± 7.49^{a}	114.08 ± 48.16^{b}
AUGUST	98.16 ± 26.57^{b}	43.50 ± 12.30^{ab}	43.47 ± 17.50^{a}
MEAN	88.56 ± 33.38	48.94 ± 33.48	113.55 ± 82.33

Means±std in the same column with different superscripts are significantly different at P<0.05

The concentration of heavy metal in water of Lagos lagoon is presented in Table 2. The table revealed that the concentration of Cu was as high as 5.50 ± 1.96mg/L in the month of June but was as low as 0.07 ± 0.01mg/L in the months of July and August. The table showed that the mean concentration of Cu (1.88 ± 2.94) was slightly above the World Health Organization (2022) and Federal Environmental Protection Agency (2003) recommended limits of < 1mg/L and 1mg/L respectively. Similarly, the concentration of Zn (25.49 ± 44.27mg/L) was higher than the 20.0mg/L and 5.0mg/L stipulated by WHO (2022) and FEPA (2021) respectively. However, the mean concentrations of Hg (0.00 ± 0.00mg/L) and Pb (0.25 ± 0.49mg/L) were lower than the permissible limits of 0.1mg/L (WHO, 2022) and <1mg/L (FEPA, 2021) for Hg and Pb respectively. Also, the concentration of Cu, Pb, Hg and Zn in *T. guineensis* of Lagos lagoon is presented in Table 3 which showed that the concentration of Cu (0.0093 ± 0.01mg/kg), Hg (0.0000 ± 0.00mg/kg), Zn (0.0248 ± 0.04mg/kg) and Pb (0.0005 ± 0.00mg/kg) were lower than the 3.0mg/kg, 0.1mg/kg, 30.0mg/kg and 2.0mg/kg recommended by WHO (2022).

Table 2 Heavy metal in water

Month	Copper(mg/L)	Mercury(mg/L)	Zinc(mg/L)	Lead(mg/L)
JUNE	5.50 ± 1.96^{b}	0.01 ± 0.00^{a}	67.08 ± 67.88^{b}	0.75 ± 0.66^{b}
JULY	0.07 ± 0.01^{a}	0.00 ± 0.00^{a}	4.18 ± 1.33^{a}	0.00 ± 0.00^{a}
AUGUST	0.07 ± 0.01^{a}	0.00 ± 0.00^{a}	5.23 ± 1.51^{a}	0.00 ± 0.00^{a}
MEAN	1.88 ± 2.94	0.00 ± 0.00	25.49 ± 44.27	0.25 ± 0.49
WHO, 2022	<1	0.1	20	<1
FEPA, 2021	1	-	5	0.05

Means±std in the same column with different superscripts are significantly different at P<0.05

Table 3 Heavy metals in *T. guineensis*

Month	Cu (mg/kg)	Hg (mg/kg)	Zn (mg/kg)	Pb (mg/kg)
JUNE	0.0075 ± 0.00^{a}	0.0000 ± 0.00^{a}	0.0060 ± 0.00^{a}	0.0000 ± 0.00^{a}
JULY	0.0070 ± 0.00^{a}	0.0000 ± 0.00^{a}	0.0110 ± 0.00^{a}	0.0000 ± 0.00^{a}
AUGUST	0.0135 ± 0.01^{b}	0.0000 ± 0.00^{a}	0.0575 ± 0.07^{b}	0.0015 ± 0.00^{b}
Mean	0.0093 ± 0.01	0.0000 ± 0.00	0.0248 ± 0.04	0.0005 ± 0.00
WHO, 2022	3	0.05	30	2

Means±std in the same column with different superscripts are significantly different at P<0.05

The Bio-Concentration factor is presented in Table 4 which revealed that bio-concentration was highest in Cu in August (0.203) while highest bio-concentration of Zn was in July (0.003). Summarily, the concentration of minerals bio-concentrated by the fish from the water was as low as 0.00 (Hg), 0.005 (Cu), 0.002 (Pb) and 0.001 (Zn).

Table 4 Bio-Concentration factor of Heavy metals in *T. guineensis*

Month	Cu	Mercury	Zn	Pb
June	0.001	0.000	0.000	0.000
July	0.103	0.000	0.003	0.000
August	0.203	0.000	0.011	0.000
Mean	0.005	0.000	0.001	0.002

The relationship between heavy metals and biochemical parameters of *T. guineensis* is presented in Table 5. The result shows that Cu and Zn had strong and significant correlation (r=0.96; P= 0.00). the table also revealed significant correlations between AST and ALT (r=0.47, P=0.00), AST and ALP (r=0.25, P=0.03), ALT and ALP (r=0.43, P=0.00). The table also revealed negative (but not significant) correlation between AST and Cu (r= -0.06, P=0.85) and Cu and Pb (r= -0.27, p=0.39). Similarly, the relationship between heavy metals in water and biochemical parameters of *T. guineensis* is presented in Table 6 which shows that ALT was significantly correlated with Cu (r=0.66, P=0.02), Pb (r= -0.59, P=0.05), Hg (r= -0.63, P=0.03) and AST (r=0.47, P=0.00). Also, ALP was significantly correlated with AST (r=0.25, P=0.03) and ALT (r=0.43, P=0.00). for the heavy metals, Cu had significant correlation with Pb (r= 0.94, P=0.00), Hg (r= 0.99, P=0.020) and Zn (r= 0.90, P=0.00) while Zn had significant correlation with Pb (r=0.99, P=0.00) and Hg (r=0.96, P=0.00). the table also revealed that Hg and Pb were significantly correlated (r=0.98, P=0.00).

Table 5 Relationship between Heavy metals and Biochemical Parameters of *T. guineensis*

	Cu	Hg	Zn	Pb	AST	ALT	ALP
Cu	1.00						
Hg	NA	NA					
Zn	0.96* (0.00)	NA	1.00				
Pb	-0.27 (0.39)	NA	-0.21 (0.50)	1.00			
AST	-0.06 (0.85)	NA	0.03 (0.92)	0.22 (0.50)	1.00		
ALT	0.43 (0.17)	NA	0.46 (0.13)	0.29 (0.37)	0.47* (0.00)	1.00	
ALP	0.22 (0.48)	NA	0.17 (0.59)	0.18 (0.58)	0.25* (0.03)	0.43* (0.00)	1.00

NA means 'Cannot be computed' because at least one of the variables was constant; *Correlation is significant at P≤0.05; P in bracket

Table 6 Relationship between Heavy Metals in water and Biochemical Parameters of *T. guineensis*

	Cu	Pb	Hg	Zn	AST	ALT	ALP
Cu	1.00						
Pb	0.94* (0.00)	1.00					
Hg	0.99* (0.00)	0.98* (0.00)	1.00				
Zn	0.90* (0.00)	0.99* (0.00)	0.96* (0.00)	1.00			
AST	-0.23 (0.47)	-0.31 (0.33)	-0.27 (0.39)	-0.32 (0.31)	1.00		
ALT	-0.66* (0.02)	-0.59* (0.05)	-0.63* (0.03)	-0.55 (0.06)	0.47* (0.00)	1.00	
ALP	-0.28 (0.38)	-0.25 (0.43)	-0.27 (0.39)	-0.24 (0.45)	0.25* (0.03)	0.43* (0.00)	1.00

*Correlation is significant at P≤0.05; P in bracket

The biochemical enzymes observed in this study were in the order of ALT<AST<ALP. The range of ALT (21.87 ± 7.49IU/L - 81.44 ± 37.09 IU/L), AST (59.20 ± 21.03 IU/L - 108.33 ± 30.48 IU/L) and ALP (43.47 ± 17.50 IU/L - 183.09 ± 91.16 IU/L) observed in this study was similar to the observations of Gabriel *et al.* (2012) who stated that cellular damage, cardiovascular diseases, tissue necrosis, liver damage and cancer are symptoms of high levels (>500IU/L) of ALP activity while Wang *et al*. (2017) reported that phosphate ingestion may cause its increase in fish. Likewise, ALP may also increase if excretion of bile is inhibited by damage of liver (Mourad *et al.,* 2017). Therefore, the value of ALP (113.55 ± 82.33 IU/L) observed in this study compared to previous studies (Gabriel *et al.,* 2012; Fagbuaro *et al*., 2016, Mourad *et al*., 2017, Özdemir *et al.,* 2022, and Nareed *et al*., 2022) may indicate healthier state of the plasma membranes. The amount of AST, ALP, and ALT is used as an indicator of liver function and the enzymes are considered important to evaluate health status in fish because the activities of serum ALT and AST vary with species (Gabriel *et al*., 2012). Increase in plasma AST and ALT might be related to stress condition, cell damages in liver, and cell degradation in liver, heart, or muscles caused by heavy metals (Fagbuaro *et al*., 2016 and Nagaran *et al.,* 2023).

The acceptable or tolerable limits of ALT (5-100 IU/L), AST (10-200 IU/L), and ALP (10-500 IU/L) in fish can vary depending on several factors, including the fish species, environmental conditions, and regulatory guidelines of the country or region. These parameters are often used as indicators of liver health and function in fish. It is important to note that these ranges can vary depending on the species, life stage (e.g., fry, juvenile, adult), and the type of fish farming (e.g., aquaculture, wild capture). Additionally, different guidelines may exist for different countries or regions. These guidelines typically take into account factors such as species physiology, environmental conditions, and potential exposure to contaminants (Loto *et al*., 2021).

In this study, AST ranged from 59.20 ± 21.03IU/L to 108.33 ± 30.48IU/L with mean of 88.56 ± 33.38IU/L while ALT ranged from 21.87 ± 7.49IU/L to 81.44 ± 37.09IU/L with an average of 48.94 ± 33.48IU/L. The obtained values were within the acceptable range of 10-200IU/L and 5-100IU/L for AST and ALP respectively (Wang *et al.,* 2017). According to Özdemir *et al.* (2022), AST and ALT have been useful biomarkers in liver toxicological studies. The values recorded in this study is higher than the observation of Nareed *et al*. (2022) who reported a decrease in the levels of AST and ALT in fish exposed to pesticides. The observed low values were linked to liver damage without any regeneration, reduction in the permeability of hepatic cells membrane by toxicants, thereby forcing the enzymes to accumulate in the cells (Özdemir *et al.,* 2022 and Ahmed *et al*., 2022).

To ensure the health and well-being of fish populations, it is crucial to monitor these liver enzymes regularly, especially in aquaculture settings. Monitoring can help detect potential diseases, stressors, or environmental changes that may impact the liver function of fish (Wang *et al.,* 2017). The result revealed that the concentrations of the biochemical enzymes (AST, ALT and ALP) and heavy metals (Cu, Pb and Zn) were highest in the month of June. This may be as a result of the disposal of wastes into the lagoon. Fejemila *et al.* (2020) reported that urban wastes (which contain heavy metals, organic compounds, PCBs, PAHs and organotins) are being carried into the lagoon by Ogun and Osun rivers.

In this study, the concentrations of heavy metals were compared with World Health Organisation (WHO, 2022) and Federal Environmental Protection Agency (FEPA, 2021) to ascertain the level of toxicity of the heavy metals in the fish. The results showed that the concentration of mercury in the fish was not detected. Also, Cu, Pb and Zn in the fish were all below the permissible limits of WHO (2022). However, the concentration of Cu, Pb and Zn in water were above the permissible limits of WHO (2022) and FEPA (2021) as presented in Table 2. Since Lagos lagoon is considered to be affected by several pollution sources, the high levels of Cu, Pb and Zn in the water could therefore be due to its release from sediments as well as anthropogenic activities (El-Batrawy *et al*., 2018). Zn is deleterious at lower sub-lethal concentrations, especially after prolonged exposure (Ajibare *et al.,* 2018; Loto *et al.,* 2021). The observed concentration of Pb in water may have resulted from gasoline containing lead (Pb) from the fishery boats or from agricultural runoff containing agrochemicals such as pesticides and fertilizers (Ajibare *et al.,* 2018; El-Batrawy *et al*., 2018) or from the wastes coming from oil and textile industry as well as urban sewage carried by the Ogun and Osun rivers (Fajemila *et al*., 2020).

The values obtained as bio-concentration factors in this study were very low (0.00–0.005). This showed that the metal concentrations bioaccumulated from the water was low. Olusegun *et al.* (2021) stated that high bio-concentration factors of heavy metals in the fish may reflect the release of heavy metals in large quantities to the environment as a result of industrial and domestic runoff. Although the BCFs were low (indicating low bioaccumulation from the water), the slight increment from June to August may be due to several natural and anthropogenic factors. Ajibare *et al.* (2018) and Adegbola *et al.* (2021) stated that different uptake, excretion rates and affinity of metals to fish tissues are responsible for the differences in the concentrations of metal ion accumulated in fish. Moreover, Younis *et al.* (2015) reported that BCF values are influenced by the extent of pollution in the environment, types of chemical as well as metabolite properties of the tissues.

This study revealed negative correlation between AST and Cu in fish. A similar observation was reported by Mourad *et al.* (2017) who stated that metal accumulation in fish can cause high mortality or serious histological and biochemical alterations in the survived fish. Moreover, Wang *et al.* (2017) reported that significant elevation in AST levels can indicate tissue necrosis (cell death) in various organs, including the liver, heart, skeletal muscles, and kidneys while the degree of elevation depends on the extent and location of tissue damage (Javed and Usmani, 2015 and Ahmed *et al*., 2022). This study also revealed that ALT was significantly correlated with Cu, Pb and Hg in water. This corroboates El-Batrawy *et al*. (2018) who observed that 0.25mg of Cu substantially increased the activities of ALT and AST in *Heteropneustes fossilis* after prolonged exposure. Similarly, Younis *et al.* (2015) observed increased AST in *Clariaalbo punctatus* exposed to Hg and Zn and attributed the increase to impairment of metabolism imbalances in the anatomy and physiology of the reservoir tissues. The specific effects of heavy metals on enzyme activities can vary depending on the fish species, the type and concentration of heavy metal, the duration of exposure, and other factors (Loto *et al.,* 2021).

4. Conclusion

The concentration of metals observed in the fish and water indicated that the bioaccumulation of heavy metals from water was low. Also, since the values recorded for the metals, ALP, AST and ALT in *T. guineensis* were within the acceptable range, the fish should therefore be safe for human consumption. However, this study established that the concentration of metals in the study area imposed some negative impacts on the activities of the liver enzymes; thus, there is an urgent need to prevent the entrance of hazardous substances (especially heavy metals) into aquatic ecosystems. Moreover, the concentrations of metals in water and fish should be continuously monitored in order to keep it safe, and to protect the biodiversity of the Lagos lagoon.

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