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Analysis of Transaminase and Phosphatase Levels in Lead (Pb)-Exposed Fish, Clarias gariepinus: Implications of Environmental Contamination

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Abstract
Sub-adults of the African catfish *Clariasgariepinus* were exposed to sublethal concentrations (0.0mg/l, 0.4mg/l and 0.8mg/l) of lead in a static bioassay for 96 hours to analyse the activities of Glutamic Oxaloactic Transaminase (GOT), Glutamic Pyruvate Transaminase (GPT), Acid Phosphatase (ACP) and Alkaline Phosphatase (ALP) in the serum, liver and kidney of the fish. The various biochemical enzymes were tested according to the reagent kit manufacturer's instructions. Results from statistical ANOVA at the 0.05 probability level revealed no significant difference (P>0.05) between the activities of the parameters under test and the control. GPT and ACP showed substantial evidence of enzyme reversibility, whereas GOT activity showed a dose-dependent impact, and ALP showed fragile evidence. The toxicant (Lead) caused organ dysfunction, enzyme inhibition, metabolic impairment, and organ damage, and it can be inferred from the results in general that these biochemical parameters show marked alterations. The reaction patterns of these organs to stress follow the order serum>liver>kidney. As a result, these biochemical measures can be handy instruments for monitoring biochemical pollution.

Keywords: Lead, *Clarias gariepinus*, Glutamic Oxaloacetic Transaminase (GOT), Glutamic Pyruvate Transaminase (GPT), Acid Phosphatase (ACP)

Introduction

Environmental contamination is one of the main issues facing modern society (Ali et al.,2019). This is a response to the last several decades of fast-growing enterprises, increasing energy demands, and inconsiderate exploitation of natural resources. Countless hazardous organic and inorganic compounds from a number of natural and man-made sources are ever-present in the soil and aquatic ecosystems. Among these, heavy metals pose the greatest threat to the ecosystem due to their poisonous nature and the propensity for bioaccumulation in the food chain (Briffa et al., 2020). The natural environment is mainly affected by releasing heavy metals from home and agricultural waste products, industrial waste materials, burning fossil fuels, mining, and wastewater treatment facilities. (Gheoghe et al., 2017). In general, heavy metals reach the aquatic environment through anthropogenic activities, including industrial effluents, residential sewage, mining, and agricultural wastes, as well as natural sources such as air deposition and geological matrix erosion (Ambreen & Javed, 2015). Among these, heavy metals pose the greatest threat to the ecosystem due to their poisonous nature and the propensity for bioaccumulation in the food chain (Briffa et al., 2020). The natural environment is mainly affected by releasing heavy metals from home and agricultural waste products, industrial waste materials, burning fossil fuels, mining, and wastewater treatment facilities. (Gheoghe et al., 2017). In general, heavy metals reach the aquatic environment through anthropogenic activities, including industrial effluents, residential sewage, mining, and agricultural wastes, as well as natural sources such as air deposition and geological matrix erosion (Ambreen & Javed, 2015). Since heavy metals persist in the natural ecosystem, they can accumulate inside living things. Plants exposed to contaminated soil may easily absorb heavy metals, which can lead to issues such as chlorosis, growth inhibition, defects in the water balance and photosynthetic processes, senescence, and death. Death results from diminished soil fertility and heavy metal pollution of the soil, which also affects microbial equilibrium.

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According to Authman et al. (2015), heavy metals can dissolve swiftly in an aquatic environment and subsequently enter the bodies of aquatic organisms. These metals then go up the food chain and into the bodies of larger animals. Animal health may be harmed due to the bioaccumulation of hazardous heavy metals in various tissues, compromising their regular physiological functions (Malik & Maurya, 2014). Heavy metal poisoning significantly impacts the rate of organism survival and reproductive capabilities. Certain substances have been shown to induce cancer, change genes, and interfere with the healthy creation and development of the embryo, depending on the species, dose, and length of exposure (Ngo et al., 2011). The main significant bio-indicators in aquatic environments for measuring metal contamination are thought to be fish. Since fish must live near dirty water, they are impacted by even the slightest changes in water contamination. The liver and kidneys of fish are essential organs for osmoregulation, detoxification as well as biotransformation, and xenobiotic excretion. (Vesey, 2010). Measuring the biochemical markers in fish liver and kidneys that uniquely respond to the level and kind of pollution allows researchers to assess the effects of heavy metals on aquatic ecosystems (Barhoumi et al., 2012. Among fish species, a useful species model for examining the effects of various environmental contaminants is the African catfish, *Clarias gariepinus*, which is one of the most prevalent freshwater fish in Nigeria and has significant nutritional value as an affordable source of protein. This species can adapt to different food types in the environment, is tolerant to environmental stress, and may be found day or night (Qu et al., 2014). Among these heavy metals, Lead (Pb) is one of the most dangerous pollutants in aquatic habitats compared to other heavy metals. The mining and smelting of lead ores, industrial effluents, fertilizers, pesticides, and municipal sewage wastes are the main causes of lead contamination (Needleman, 2006). Lead may enter a fish's body in several ways, including the gills, skins as well as the respiratory system. Once ingested, lead is dispersed throughout the fish's blood, gills, heart, liver, kidney, and gonads (ATSDR, 2005). Lead causes oxidative damage at greater doses, which might immediately impact the cell membrane. The naturally occurring element lead is greatly increased by various anthropogenic sources, including metal mining, the burning of coal, oil, and gasoline, the production of batteries, the use of lead-arsenate pesticides, lead-based paint and pigments, food cans, and others. Lead is also present in the environment in combination with other elements like PbS, PbSO4, and PbCO3. The liver, spleen, kidneys, and gills of fish are the primary sites of lead bioaccumulation. Transaminases, also known as aminotransferases, catalyze the transamination of an amino acid plus a -keto acid. They play a crucial role in producing amino acids used to make proteins. Analysis of biochemical parameters is recommended to offer early signals of essential alterations in stressed organisms. It is particularly effective for identifying target toxicity organs and general animal health. Therefore, the current study aims to examine how lead exposure affects the serum biochemical parameters of *Clarias gariepinus*.

Materials and Methods

Anhydrous lead chloride was utilized as the test substance in the experiment. Because it is less harmful than other forms of lead, the metal's chloride form was chosen. The concentrations for the experiment were 0.40 mg/l and 0.80 mg/l following a range-finding test. The molecular atomic weight of the lead chloride containing 1.0 g of lead was calculated thus:

$$\frac{\text{The molecular weight of Lead Chloride}}{\text{Atomic weight of Lead (Pb)}}$$

Below is the formula used to determine the requisite concentrations:

$$\frac{\text{Weight of lead needed X Molecular weight of lead}}{\text{Atomic weight of lead (Pb)}}$$

Sub-adults of the African catfish *Clarias gariepinus* were obtained from Toma's fish pond in Obiarukwu, Delta State, Nigeria. *Clarias gariepinus* was chosen because of its resilience to stress and significant commercial value in Nigeria. The fish were delivered to the laboratory in an oxygen-filled sack. The fish were kept in polypropylene bowls with a 60-litre capacity and bowl-hole water. To prevent malnutrition of the fish and any impacts on the fish's haematological parameters, the fish were given 14 days to acclimate while being fed commercial fish pellets (Rainbow Feeds). The condition of the fish was examined for sickness and signs of weakening. Every day, the water was changed, and dead fish were taken out immediately to prevent being eaten. The fish were fed twice a day, between 8:00 and 16:00. The fish had an average weight and length of 123.020±89 and 18.50±0.62, respectively. The water quality parameters of borehole water used were analyzed. Water quality determined were Temperature, Dissolved Oxygen (DO), Free Carbon IV Oxide (FCD), Total Alkalinity, pH, Hardness and Electrical Conductivity. A short-term static bioassay that lasts for 96 hours makes up the experimental setup. 50-litre plastic aquariums were employed. Three 50-litre plastic aquariums, each with a capacity of 0.40 mg/l, 0.80 mg/l, and a control of 0.0 mg/l, were used in a replicated experiment. Six

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sub-adult fish were put into each tank containing bore-hole water, and the toxicant was changed daily to maintain its potency and prevent the likelihood of the metal degrading. Feeding continued during the exposure period. Throughout the exposure phase, no mortality was recorded. Fish were collected at random, one per treatment, with the aid of a small scoop net, to study Glutamic Oxaloacetic Transaminase (GOT), Glutamic Pyruvate Transaminase (GPT) and Phosphatases like Acid Phosphatase (ACP) as well as Alkaline Phosphatase (ALP) levels in the fish's blood, liver, and kidney. The fish was then positioned with the back end up and cleaned with clean cotton wool to eliminate mucus secretions. Using a 21 gauge disposable syringe needle, caudal puncturing was used to obtain portions of blood from the caudal vasculature (Kori-Siakpere et al., 2005). When handling fish blood, it is imperative to use plastic syringes as contact with glass inhibits coagulation. The location of the puncture was selected to be around 3 to 4 cm distance from the genital opening. The syringe needle was placed at a right angle to the fish's spinal axis and gently aspirated throughout the process of penetration. It was thereafter carefully pressed until blood began to enter the syringe needle through a caudal arterial blood vessel. Blood samples were aspirated until 1.5cm3 was acquired, then the syringe needle was removed, and the blood was carefully placed into heparinized plastic containers. The samples were thoroughly yet gently mixed.

The serum of blood was produced by centrifuging it for 5 minutes at 3000rpm in a motor centrifuge. Two sections of the blood samples were visible. The serum was visible on top, while the plasma was visible on the bottom. The serum was then placed in an anticoagulant plastic container and was ready for use. The serum was tested for Transaminases (GOT and GPT) and Phosphatases (ACP and ALP). When the blood sample was extracted from the fish, they were sacrificed and dissected to collect the liver and the kidney of the fish. The posterior of the fish was placed upwards, and a careful cut was done from the genital opening up to the head of the fish. The kidney and liver were carefully removed from the fish and homogenized. The purpose of homogenizing the liver and kidney is to prepare the supernatant for analysis. The liver and kidney after ground using a ceramic mortar and pestle, were rinsed with 8.0ml of normal saline and centrifuged to access the supernatants. The fish samples were thus taken from the various aquaria, including the control. The function of acid phosphatase was calculated using the Tenniswood et al. (1976) technique. The liver's tissue was blended in a glass homogenizer by applying 10 ml of distilled water and centrifuged for 10 minutes at 3000 rpm. In a freshly sterilized test tube, 0.5 ml of the supernatant was added, followed by 0.5 ml of the substrate solution (i.e. p-nitrophenyl phosphate) and 0.5 ml of 0.1N citrate buffer. As mentioned earlier, the test tube containing the solution was immersed in a 37ºC water bath for 30 minutes. After 30 minutes, the reaction in the extracts was stopped by adding 3.8 ml of 0.1N sodium hydroxide. The final colour was measured at 415 nm using a UV-visible spectrophotometer (Spectronic-20 Bausch and Lamb). The values obtained were given in µ moles of phenol liberated per min per 100 mg protein. Alkaline phosphatase activity was determined using Tenniswood et al.'s (1976) technique. The liver's tissue was homogenized in a glass homogenizer with 10 ml of distilled water. Centrifugation was for 10 minutes at 3000 rpm. In a freshly sterilized test tube, 0.5 mL of the supernatant was mixed with 0.5 mL of the substrate solution i.e. p-nitrophenyl phosphate alongside 0.5 mL of glycine buffer. The test tube holding the abovementioned solution was immersed in a 37ºC water bath and left for 30 minutes. After 30 minutes, the reaction in the extract was stopped using 10 ml of 0.2N sodium hydroxide. The resultant colour was measured at 415 nm using a UV spectrophotometer (Spectronic-20, Bausch and Lamb). The values were given in phenol liberated per min per 100 mg protein moles.

Using King (1965) technique, GOT and GPT's actions were ascertained. The liver tissue was mashed in 5 ml of phosphate buffer and centrifuged for 10 minutes at 3000 rpm. 1.33 g of L-aspartic acid and 15 mg of -keto glutaric acid were mixed together in 20.5 ml of buffer and 1N of sodium hydroxide to adjust the pH to 7.5 and combined with the phosphate buffer to make up to 50 ml for GOT activities. For GPT activities, in 20 ml of buffer, 1.78 g of DL-alanine and 30 mg of -keto glutaric acid were dissolved. The pH was corrected to 7.5 using 1N of sodium hydroxide and made up to 100 ml with buffer before adding a few drops of chloroform. The content was transferred to clean test tubes and incubated for 5 minutes at 37ºC. The test tubes were then filled with 0.2 ml of tissue homogenate and set for 1 hour in the case of GOT and 30 minutes in the case of GPT. The tubes were kept at room temperature for 20 minutes after the reaction was stopped with 1.0 ml of DNPH reagent. The colour obtained in the UV spectrophotometer (Spectronic-20, Bausch and Lamb) was read at 520 nm against the reagent blank after adding 10 ml of 0.4 N sodium hydroxide solution. A set of pyruvic acid was also processed in the same way as the standard. Results of GOT and GPT activities were expressed in U/L. The mean values of the numerous tissues tested and the toxicant concentrations in the experimental fish were subjected to statistical analysis using the Analysis of Variance (ANOVA) at the 0.05 level of significance. SPSS 11.5 for Windows 98 and Microsoft Excel 2000 were used to help with the calculations.

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Results

Table 1 shows the physicochemical properties of the test water measured during the sublethal toxicity bioassay with lead concentrations. The Temperature (T) was 26^{o}C, Hydrogen ion concentration (pH) was between 6.89, Electrical Conductivity (EC) (µS/cm) 195, Total Dissolved Solids (TDS) (mg/L) was 119 mg/L, Free Carbon IV Oxide (FCD) (mg/l) was 1.67, Alkalinity (mg/l) was 38.65. Dissolved Oxygen (DO) (mg/L) was 6.57 mg/L.

Table 1: The physicochemical properties of the test water measured during the sublethal toxicity bioassay with lead concentrations

Parameters	Results
Temperature (^{0}C)	26.00
pH	6.89
Electrical Conductivity (EC) (µS/cm)	195.00
Total Dissolved Solids (TDS) (mg/l)	195
Total Dissolved Solids (TDS) (mg/l)	119
FCD (mg/l)	1.67
Alkalinity (mg/l)	38.65

Changes in blood biochemical levels frequently indicate changes in the physiological status of fish. Although there was no mortality in the current investigation, we did find physiological abnormalities in the fish following lead exposure. Tables 2, 3, and 4 reveal the results of quantitative estimations of serum, liver, and kidney GOT, GPT, ACP, and ALP.

Results of Glutamic Oxaloacetic Transaminase (GOT) (u/l) activity

The effects of lead on the GOT activity in selected organs are shown in Table 2 and Figure 1, respectively. In the serum, 0.4mgPb/l concentration recorded the highest value of GOT activity as 35.59±0.02U/L. The lowest value of GOT activity was recorded in the control (0.0mgPb/l) as 29.63±0.05U/L after 96 hours of exposure. The levels of GOT recorded in the liver had the highest value in the control at 35.39±0.16U/L, while the lowest level obtained for GOT in the liver was recorded at 0.8mgPb/l as 33.64±1.10U/L after 96 hours of exposure. In the kidney, the highest level of GOT obtained was in the control at 35.58±0.31U/L, while the lowest level was at 0.8mbPb/l at 32.17±0.55U/L. The serum reveals a fluctuating pattern in the activities of GOT, while the values obtained in the liver and kidney show a decreasing trend as concentration increases. In all tissues and organs, the highest value was obtained in the serum, while the lowest was in the serum. Therefore, from statistical analysis, there was an insignificant difference (P>0.05) in treatment means used during the exposure to lead for 96 hours.

Table 2: Mean Value of GOT activity in selected organs of *Clarias gariepinus* exposed to sublethal concentrations of lead (Pb) for 96 hours.

	Mean Values of GOT (U/l)		
Conc. (mgPb/l)	Serum	Liver	Kidney
0.0	29.63±0.05	35.39±0.16	35.58±0.31
0.4	35.59±0.02	33.85±1.02	34.71±0.88
0.8	34.47±0.77	33.64±1.10	32.17±0.55

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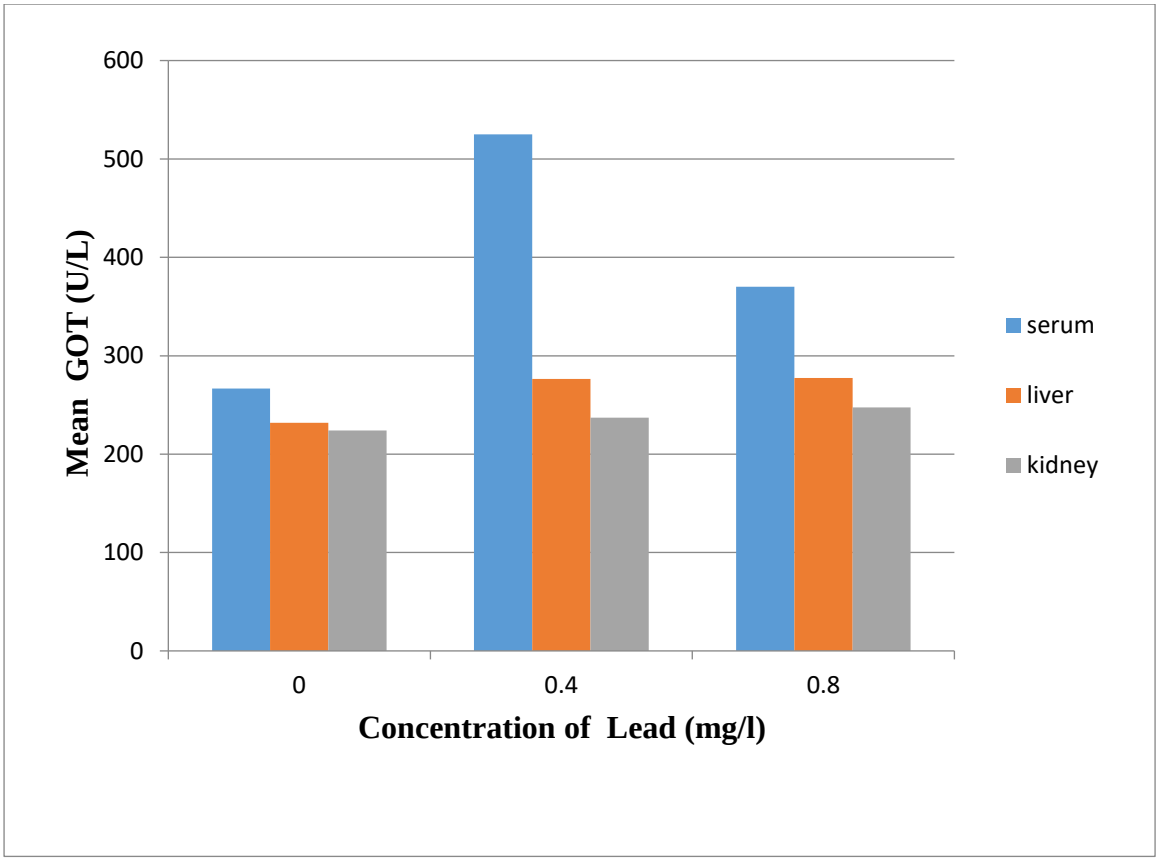

Results of glutamic pyruvate transaminase (gpt) activity

The effect of lead on the GPT activity in selected organs is shown in Table 3 and Figure 2, respectively. In the serum, the control (0.0mgPb/l) recorded the highest value of 35.81±1.25u/l, while the lowest value of GPT activity was recorded at 0.4mgpb/l concentration as 31.63±1.57u/l. Also, in the liver, the highest level of GPT obtained was at 0.8mgpb/l at 35.63±0.28u/l, while the lowest value of GPT was recorded at the control as 34.95±0.14u/l. The levels of GPT obtained in the kidney recorded the highest level at 35.66±0.20u/l while the lowest value recorded was at the 0.4mgpb/l concentration with 33.33±1.23u/l. As shown in the graph in Figure 2, the serum and the kidney showed a fluctuating pattern in the activity of GPT obtained, while only in the liver were the results obtained decreased with increased concentrations. In the selected organs analyzed, the highest level of GPT was obtained in the serum as 35.81±1.25u/l in the control, while the lowest value was obtained in the serum also at 0.0mgPb/l as 31.63±1.57u/l. Therefore, statistical analysis showed an insignificant difference in the treatment means used during the exposure to lead for 96 hours.

Table 3: Mean value (X±S.E) of GPT activity in selected organs of *Clarias gariepinus* exposed to sublethal concentrations of lead (Pb) for 96 hours.

	Mean Values of GOT (U/l)		
Conc. (mgPb/l)	Serum	Liver	Kidney
0.0	35.81±1.25	34.95±0.14	34.24±0.24
0.4	31.63±1.57	34.96±0.51	33.33±1.23
0.8	35.64±0.09	35.63±0.28	32.17±0.20

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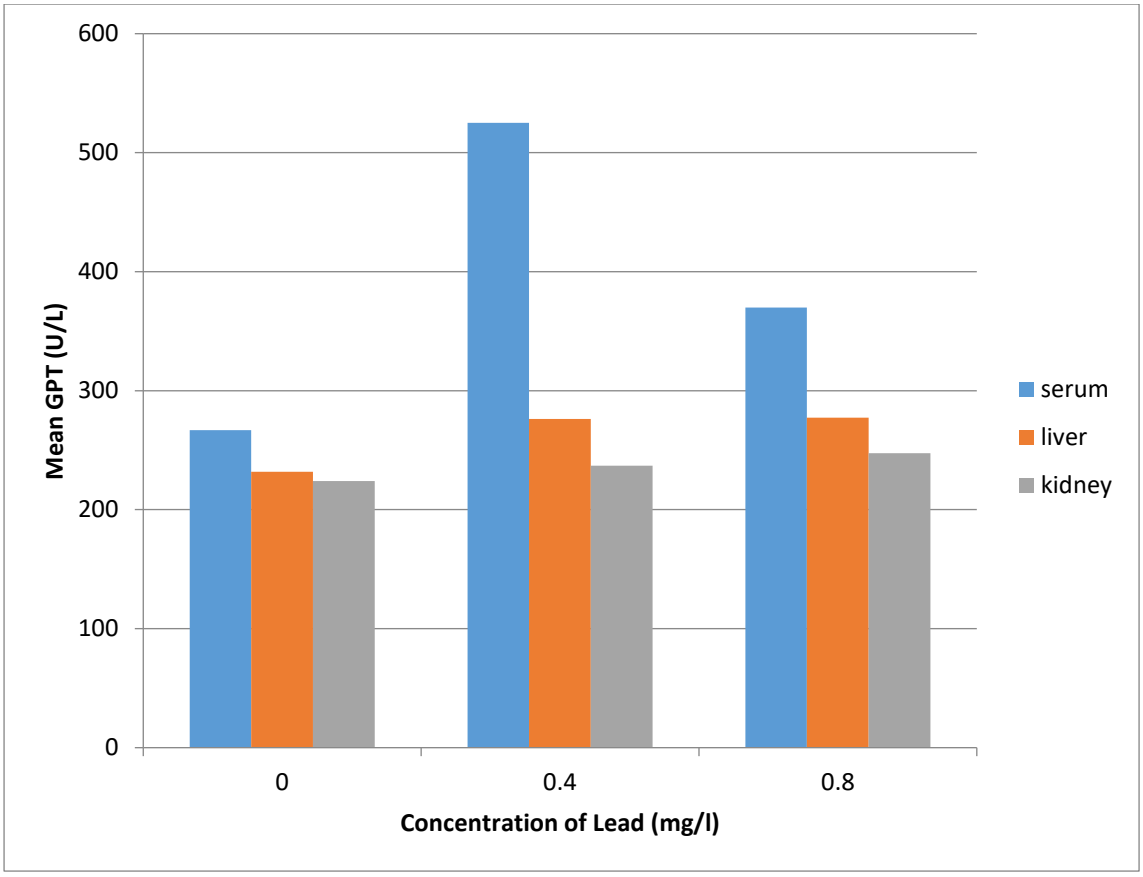

Results of acid phosphatase (acp) (u/l) activity

The effect of lead on Acid Phosphatase (ACP) activities in selected organs is shown in Table 4 and Figure 3, respectively. In the serum, the highest level of ACP was recorded at 0.8mgPb/l as 221.92±51.48u/l, while the lowest, as obtained in the control, was 67.66±3.64u/l. Correspondingly, in the liver, the highest value obtained at 0.4mgpb/l was 178.16±59.65u/l, while the most reduced level of ACP was recorded as 53.90±3.11u/l in the control. Consequently, in the kidney, the highest level of ACP activity was recorded as 103.17±8.40u/l in the 0.4mgpb/l concentration. In contrast, the lowest level of ACP in the kidney was recorded as 33.68±5.84u/l, surprisingly in the 0.8mgpb/l concentration. As shown in the graph in Figure 4, the liver and kidney revealed a fluctuating pattern in the values obtained for ACP, while only the serum had values that increased as the concentration increased. In all the selected organs analyzed, the highest level of ACP was recorded as 221.92±51.48u/l in the serum at 0.8mgpb/l, while the lowest value was at 0.8mgpb/l also as 33.68±5.84 in the kidney. Therefore, statistical analysis showed an insignificant difference (P>0.05) in treatment means used during the exposure to lead for 96 hours.

Table 4: Mean value (X±S.E) of ACP activity in selected organs of *Clarias gariepinus* exposed to sublethal concentrations of lead (Pb) for 96 hours.

	Mean Values of ACP (U/l)		
Conc. (mgPb/l)	Serum	Liver	Kidney
0.0	67.66±3.64	53.90±3.11	42.12±0.70
0.4	218.54±65.20	178.16±59.65	103.17±48.40
0.8	221.92±51.48	79.81±22.04	33.68±5.84

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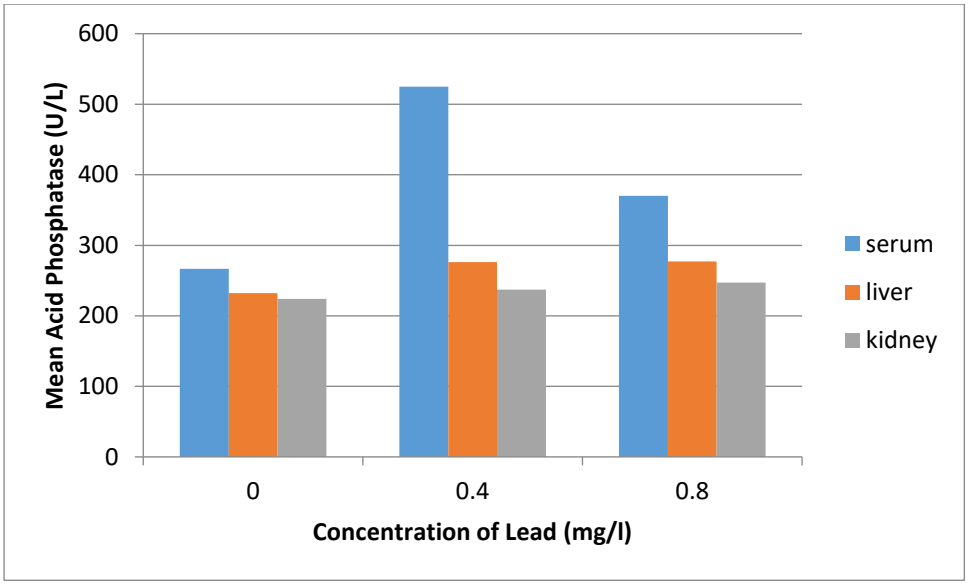

Results of alkaline phosphatase (alp) (u/l) activity

The effect of lead on Alkaline Phosphatase (ALP) activity in selected organs is shown in Table 5 and Figure 4, respectively. In the serum, the 0.4mgpb/l concentration recorded the highest value at 525.03±108.01u/l, while the lowest value was obtained at the control as 266.71±6.14u/l. Consequently, in the liver, the highest value obtained for ALP was recorded in the 0.8mgpb/ul concentration as 277.25±31.23u/l, while the lowest value was obtained in the control as 231.99±4.36u/l. Similarly, in the kidney, the highest level of ALP present is recorded at 0.8mgpb/l as 247.33±18.45u/l, while the lowest value obtained as 224.00±3.66u/l in the control, respectively. As shown in the graph in Figure 4, the liver and kidney show a trend in which their values increase with an increase in concentration in contrast to the values obtained in the serum with a fluctuating pattern. In the serum, liver and kidney analyzed, the highest level of ALP was recorded at 0.4mgpb/l in the serum as 525.03±108.01u/l, while the lowest value was obtained in the kidney as 224.00±3.66u/l in the control. Therefore, from statistical analysis, there was an insignificant difference (P>0.05) in treatment means used during the exposure to lead.

Table 5: Mean value (X±S.E) of ALP activity in selected organs of *Clarias gariepinus* exposed to sublethal concentrations of lead (Pb) for 96 hours.

	Mean Values of ALP (U/l)		
Conc. (mgPb/l)	Serum	Liver	Kidney
0.0	266.71±6.14	231.99±4.36	224.00±3.66
0.4	525.03±108.01	276.37±28.76	237.10±6.26
0.8	369.98±102.22	277.25±31.23	247.33±18.45

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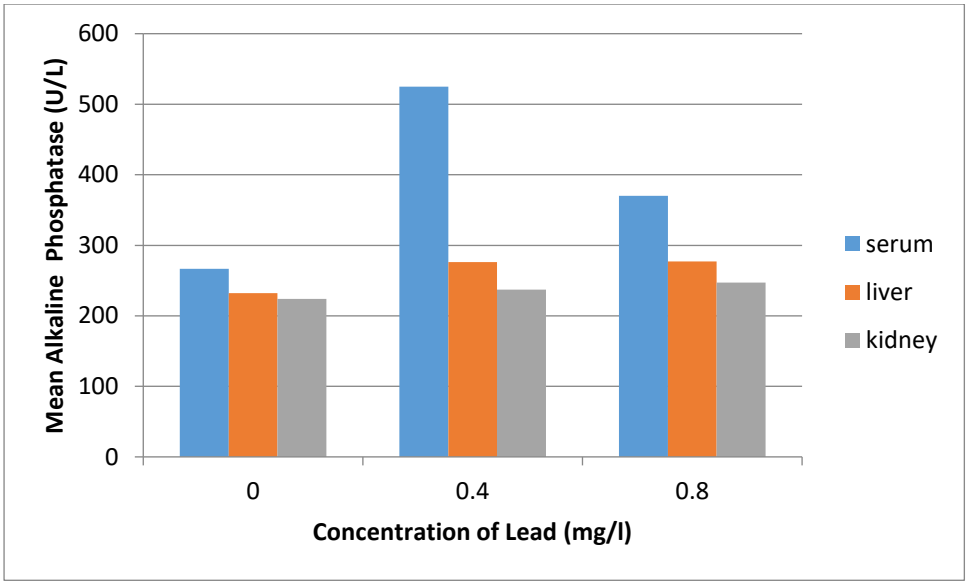

Discussion

Sublethal concentrations of various toxicants, especially heavy metals in the aquatic environment, may not result in the swift death of aquatic species, though Omoregie et al. (1990) did report that they offer substantial impacts and can cause a number of physiological dysfunctions in fish. Increased rate of opercular beats, surfacing rate, jerking movements, quick and erratic swimming, and vertical positioning when undisturbed are some of the physiological and behavioural seen in this study. When statistical differences between the activities of GOT, GPT, ACP, and ALP in the serum, liver, and kidney of the freshwater *Clarias gariepinus* at three varying concentrations (0.0 mg/l, 0.4 mg/l, and 0.8 mg/l) were examined, they were found to be significant ($P>0.05$). The results that have been shown highlight the significance of biochemical parameters as "early warning indicators" of water contamination despite arguments that such a method for monitoring pollution is complicated. The serum in this experiment exhibits a shifting pattern in the values obtained at the various concentrations of GOT activity, with the value obtained for the 0.4mgPb/l concentration having the highest value at 35.59±0.02U/l. This is most likely caused by the fact that the levels of GOT activity achieved rise not only when compared to the control but also decrease as concentration increases. This is consistent with research by Oluah (1998), who found that when *Clarias albopunctatus* was exposed to serial Copper II salt dilution for 21 days, GOT activity reduced with increasing concentration. In research on fish blood, similar examinations by Balint et al. (1997), Luskova et al. (2002), and David et al. (2004) revealed higher levels of GOT activity compared to the control fish. When the freshwater fish *Oreochromis mossambicus* was exposed for 30 days to sublethal quantities of cypermethrin. The GOT levels in the liver and kidney were surprisingly lower in the control group compared to the serum level, and they continue to decline as the toxicant's concentration increases. Similar increases were seen in the gill, liver, and blood of juvenile *Clarias gariepinus* subjected to sublethal Glyphosate and Propanil toxicity by (Rashida et al., 2022). Similar increases in these enzymes' activity were also noted by Atamaniuket al. (2013) in goldfish subjected to 2, 4-dichlorophenoxyacetic acid. Similarly, increases in transaminases were seen in fish exposed to zinc (Srivastava & Prakash, 2018; Srivastava et al., 2012).

Transaminases like GOT and GPT, serve as valuable biomarkers to detect chemical pollutants in aquatic animals, and changed transaminase levels reveal makeup strategies for decreased metabolic functions. (Sathya et al., 2012; Ramesh et al., 2014; Khan et al., 2020). Differences in the functions of these enzymes also signify harm to hepatic tissues and cells, which is equivalent to the liver degrading and failing, releasing serum enzymes into the blood serum (Firatet al., 2011). Increases in GOT and GPT activity in lead-exposed fish show that lead invasion has caused necrotic damage to the liver. The decrease in GOT activity levels in the liver and kidney may be attributed to higher lead concentrations, which cause excessive metabolism, dysfunction, and organ damage. This causes the toxicant effect to be transferred to the blood, raising the GOT level in the serum. The phosphatases (both the acid and the alkaline) are typically referred to as phosphomonoesterases and are known to be active in acidic and alkaline pH ranges, respectively. The findings of this study's analysis of acid phosphatases provide a clear indicator that the environment is disturbed. Changes in acid and alkaline phosphatase activity are reliable signs of stress brought on by fish exposure to any toxin (Gupta & Sharma, 2023). Shivani et al. (2023) found that the activity of ACP and ALP enzymes rose in the serum, liver, and

kidney of *Clarias batrachus* exposed to fluoride in the early periods of exposure but reduced in the later phases, showed similar increases after 12 days of exposing *Clarias gariepinus* to cadmium chloride. Our study's increased ALP activity confirms past findings. The *Cyprinus carpio* gills exposed to the greatest concentration of copper sulphate showed the most dramatic rise in ALP activity (Karan et al., 1998). When exposed to mercuric chloride, the air-breathing fish *Clarias batrachus* has increased ALP activity in its dendritic organs. The freshwater catfish, *Heteropneustes fossilis*, exposed to Cadmium, showed elevated ALP levels in its ovaries and muscles (Sastry & Subhadra, 1985). When Rosy barbs (*Puntius conchonius*) subjected to mercuric chloride were studied, the ALP activity increased in all the liver, gills, stomach, and gonads (Gill et al., 1990). However, Gupta and Sharma (2023) reported that when *Channa punctatus* was exposed to the pesticide Lindane, the activity of the enzymes acid phosphatase (ACP) and alkaline phosphatase (ALP) decreased in the following order: gills>liver>muscle>heart>brain>kidney>liver, respectively.

Conclusion

The examination into the sublethal effects of lead revealed various changes in the GOT, GPT, ACP, and ALP activities found in serum, liver, and kidney with very harmful consequences ranging from enzyme suppression to organ and metabolic impairment. The results showed that although the phosphatases had the highest degree of involvement, the biochemical parameters (GOT, GPT, ACP, and ALP) were very much involved in environmental monitoring since they were sensitive to the environment and dose-dependent in their response. Alkaline phosphatase did not indicate enzyme reversibility in the liver or kidney despite its slower rate in the serum in all the biochemical parameters and organs analyzed. It can also be inferred that sera had maximum values than liver and kidney with a trend thus serum>liver>kidney, indicating that when pollution becomes harmful, the liver and kidney become more vulnerable. To describe dysfunction and illness states in fish exposed to heavy metals (lead), this study effort has been able to offer baseline information on the participation of these biochemical parameters in pollution assessment of the aquatic system.

Recommendations

Based on the findings of this study, the following are thus recommended:

1. The transaminase and phosphatase levels should be regularly monitored to determine the degree of lead pollution.
2. More stringent controls on lead emissions and runoff should be implemented.
3. The Government should create and implement remediation strategies to purify Pb-contaminated water bodies. Such methods may involve the application of absorbent materials or phytoremediation. Through biological and environmental monitoring, the success of cleanup operations can be regularly evaluated.
4. To comprehend the long-term implications, additional research on the sub-lethal effects of lead exposure on fish health and development should be encouraged. Stakeholders and the general public should be informed about the dangers of lead poisoning and the value of preserving clean water supplies.

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