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Heavy Metal Bioaccumulation and Histopathological Studies of Fish Tissues from Ose River, Ondo State, Nigeria

Josephine O. Olayinka-Olagunju

ABSTRACT

Exposure of the aquatic ecosystem to heavy metals from both natural and anthropogenic activities are on the rise and have harmful health effects on all aquatic biota and human. This study assessed the concentrations of heavy metals (Fe, Pb, Cd, Cr, As, and Zn) in surface water, sediments, and fish tissues and also examined the histopathological changes in the tissues of two fish species (*Mormyrus rume* and *Clarias gariepinus*) from Ose River, Ondo State, Nigeria. Surface water and sediments were collected while fish species were procured from fishers on site from February to April 2021. Heavy metal digestions were done in the laboratory using HNO3/HCl while the concentrations were determined using Atomic Absorption Spectrometer. Histopathological alterations were observed in the kidney, liver, and gills of the fish. Bioaccumulation factor (BAF), ecological risk index, and potential ecological risk level were used to assess the investigated metal concentrations. In the surface water, the concentration of Cd (0.010–0.030 mg/l) and As (0.010–0.05 mg/l) exceeded the World Health Organization limits of 0.01mg/l while Fe, Pb, Cr, and Zn were within the limits. In the sediments, all metals except Pb and As exceeded the WHO limits. The concentrations of Pb (0.30±0.000–4.12±0.030 mg/l), Zn (9.970±0.010–30.77±0.023 mg/l), Cd (0.026±0.002–0.331±0.004 mg/l) and Cr (ND-0.331±0.004 mg/l) in the fish tissues were seen to be higher than the permissible limits of 0.5 mg/l, 5 mg/l, 0.005 mg/l and 0.05-0.15 mg/l respectively. The BAF showed no probability. The alterations observed in the kidneys of the fish were cholestasis, necrosis, loss of glomerui structure, and tubular necrosis. While the gills showed congestion of the central veins and interlamellae hyperplasia caused by the presence of a monogenean parasite. The livers however revealed loss of hepatocytes nuclei, necrosis in hepatocytes, and lymphocytic infiltrate. The study showed that the study site was polluted with heavy metals and may pose serious health issues to fishers, those using the water, and people feeding on fish from the river. This study, therefore, suggests good indicators for bio-monitoring of heavy metals in the Ose River. Seeing that the site was polluted with heavy metals hence, a more comprehensive assessment of the river is recommended.

Keywords: Bioaccumulation Factor, Heavy Metals, Histopathology, Hyperplasia, Necrosis, Ose River.

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I. Introduction

Exposure of the aquatic ecosystems to contaminants like heavy metals, microplastics, plastic additives, etc. from both natural and anthropogenic activities is on the rise across the globe. Heavy metals, for instance, may be essential and non-essential, however, at a higher concentration, both categories of metals may serve as contaminants [1], [2]. Heavy metals like zinc, copper, iron, nickel, and chromium are known as essential while cadmium and lead are referred to as non-essential heavy metals and are hazardous at low concentrations [2], [3]. Although the occurrence of heavy metals in the terrestrial and aquatic ecosystem may arise from some natural activities such as parent soils or rocks, flooding, and anthropogenic activities agriculture are however the primary cause of contamination in the aquatic environment [4], [5]. Heavy metal pollution may have injurious effects on the ecological balance because they are not biodegradable, and consequently may accumulate, persevere, and penetrate the aquatic food chains and cause threats to the aquatic lives and lead to health risks in the consumers, particularly in human [1], [6], [7]. Pollutants are able to accumulate along the aquatic food chain with severe risk to animal and human health. However, bioaccumulation of heavy metals in fish can give an understanding of the long-term status of the aquatic ecosystem [8].

Authman *et al*. [9] supported by Kock *et al*. [10] believed that fish is generally used as a biomarker to examine pollution in the aquatic ecosystem by assessing the biological organs. In addition, due to the various sensitive nature of fish to polluted water and their location at the top of the food chain, they are good bioindicators of pollution [11], [12]. Previous studies have shown that in different African countries, some heavy metals exceeded the permissible limits in water, fish, soils, edible vegetables, and food animals stipulated by the World Health Organization (WHO) [13]-[16]. Although reports of heavy metals build-up in fish in Nigeria are well documented, most of these studies have focused only on heavy metal assessment and bioaccumulation [7], [13], [14], [17], and only a few reported the relationships between heavy metals and histopathological alterations in fish [18]-[20]. More so, a few researchers have evaluated the health risks associated with the consumption of contaminated fish [2], [20].

Heavy metals, for instance, in the aquatic environment, may penetrate the fish organ through the gills, skin, or through their food chain and thereafter accumulate [9]. It should, however, be noted that in fish, the gill is the first target organ water from pollutants, while the liver is important for metabolism and excretion of xenobiotic substances with diverse morphological alterations due to noxious circumstances in the environment [21], and fish muscles, the most consumed part by human are the most poisonous part and when consumed the toxic substance may accumulate in the tissues of the human body. Furthermore, Boudou *et al.* argued that pollutants penetrate the aquatic environment through the tissues of the aquatic flora through absorption and enter the biological membrane that separates the internal medium of the organism from the external environment through the epithelium of gills [22].

Additionally, histopathological changes may be used as indicators for the effects of different contaminants caused by humans in the aquatic organisms and are a replication of the entire health of the total population in the ecosystem [23], [24]. Wang *et al*. [25] and Koca *et al.* [26] reported that muscular tissue deterioration is an indicator of exposure to environmental pollutants such as insecticides or metals. Consequently, histological alterations in fish tissue might also serve as a consistent indicator of aquatic pollution. Chemical pollutant penetrates the aquatic biota's muscular tissue directly or indirectly by absorption through the membrane tissue. This research aimed to analyze the concentrations of heavy metals (Fe, Pb, Zn, Cd, Cr, As) in surface water, sediments, and in the tissues (gills, livers, hearts, and muscles) of *Mormyrus rume* and *Claria gariepinus* from Ose River. In addition, it examined the histopathological changes in the fish tissues.

II. Procedure

A. Study Site

Sampling was conducted in Ose River (Fig. 1). The river took it source from Apata Hills then flows through to the savannah and rainforest zones and released into the Atlantic Ocean [27]. The river is situated in the Northern zone of Ondo State with a rocky base and is slightly distant away from the community. The river is majorly used for commercial and agricultural purposes. The river takes its source from Ekiti State, southwestern Nigeria and according to [28] the river pollution index shows that the water is within the acceptable World Health Organization range.

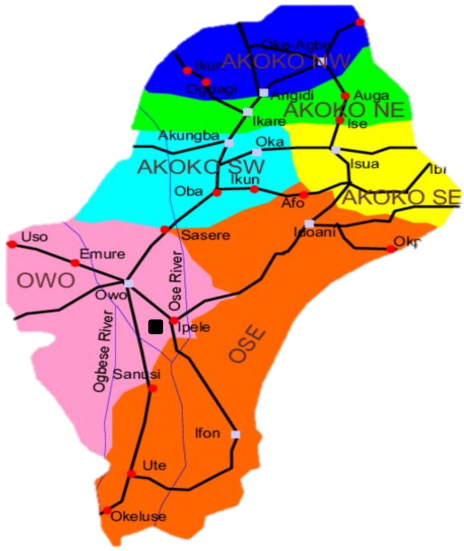


Fig. 1. Map of Ose River [27].

B. Sample Collection

Surface water and fish samples were collected between the months of February and April 2021. Fish samples were procured at the landing site and stored in an igloo cooler with ice and transported laboratory for identification and analysis. Surface water samples were collected from three different points monthly in the river [13], [29]. A total of twenty-seven (27) water samples and 11 fish samples were collected from the study site and taken to the Animal and Environmental Biology laboratory, Adekunle Ajasin University, Akungba-Akoko for identification, dissection, and analysis. A stainless-steel sediment grab was used to collect sediment samples in triplicate from the upper, lower, and middle reach of the river using the method described by Olayinka-Olagunju *et al.* [13] and Ali *et al.* [29]. The sediments collected were kept in Ziplock bags and a total of 27 samples were collected for the period of three months and transported to the laboratory.

C. Laboratory Analysis

The fish species were identified by a fish expert in the Department of Animal and Environmental Biology hatchery. The monthly water collections were kept in the refrigerator until the end of sample collections.

The fish samples were dissected from the anal opening to the head region. The gills, kidneys, muscles, heart and livers needed in this study were removed, rinsed with deionized water, and preserved in different sample bottles with 70% ethanol.

The sediment samples were air-dried in the laboratory, ground, and sieved using a 2 mm mesh sieve to fine homogenous samples before digestion.

D. Heavy Metals Sampling Digestion

The water samples were digested by adding 5.0 mL of HNO_3/HCl (3:2) to 100 mL of water and 2 g of sediments samples using a hot plate at 130 ºC. The solution was allowed to cool, and the digested samples were filtered with a 0.45 mm membrane filter. Using de-ionized water, the filtrate was made to 100 mL and stored in clean polyethylene bottles for heavy metal analysis in the atomic absorption spectrophotometer (N1100A model). All analyses were done in the laboratory using the standard method [30], [31]. The metals examined were Zinc (Zn), Lead (Pb), Chromium (Cr), Arsenic (As), Iron (Fe), Cadmium (Cd), and Chromium. The instrument was calibrated as follows (0, 2, 4, 6, 8, and 10 mg/L).

E. Preparation of Fish Gills, Liver, and Kidney for Histological Analysis

Histopathology tests were carried out on the gills, livers, and kidneys of the fish as follows: the organs of the fish were collected and fixed in 10 % formal saline to prevent decay. In addition, the organs were dehydrated into different percentages (50 %, 70 %, 80 %, and 100 %) of alcohol for 90 minutes each. After dehydration, they were cleared with 100 % xylene and left for 2 hours to remove any remnant alcohol and impregnated in liquid wax for 2 hours for embedding. The embedded organs were sectioned using a microtome and were stained with haematoxylin-Eosin [32]. The excess stain was removed under tap water. After clearing the xylene, DPX, Castor oil/xylene was added, and a cover slip was placed on each slide [33]. The preparations were left in the oven at 40 ºC and then histological structures and histopathological alterations of the gills, liver, and kidneys were viewed under the microscope with a digital camera connected to the computer system, recorded, and interpreted.

III. Data Analysis

A. Bioaccumulation Factor Determination

The bioaccumulation factors (BAF) of heavy metal concentrations in this study were calculated from the ratio of benthic fish (*Clarias gariepinus* & *M. rume*) species to sediments.

The BAF formula is expressed as:

$$BAF = Cn\ benthic\ fish/Cn\ sediments \quad (1)$$

where Cn pelagic fish is the concentration of heavy metals in pelagic fishes, Cn water is the concentration of heavy metals in surface water, Cn benthic is the concentration of heavy metals in benthic fish, and Cn sediments are the heavy metal concentrations in sediments [13].

B. Ecological Risk Index

Ecological Risk Index (ERI) consists of a single contamination coefficient, heavy metal toxicity response factor, a more elaborate pollution measure, and a potential ecological risk index.

The potential ecological risk index (Eif) for single heavy metal pollution is thus calculated as follows:

$$Eif = Tif\ x\ Cif \quad (2)$$

where Eif is the potential ecological risk index, Tif is the response coefficient for the toxicity of the single metal, and Cif is the pollution index and can be defined as follows:

$$Cif = Cis\ x\ Cin \quad (3)$$

where Cis = the concentration of heavy metal in the sediment and Cin is the background/reference value. The concentration of heavy background metal and the response coefficient for the toxicity of single metal described by [34]-[35] are presented in Table I.

TABLE I: Background Values of Heavy Metal and Response Coefficient For The Toxicity

Element	Background/Reference Value (B_n^i)	Coefficient for toxicity (T_f^i)
Cd	0.28	30.0
Cr	93.9	2.0
Pb	22.4	5.0
Zn	55.7	1.0

The range of potential ecological risk index and single-factor pollution of each metal examined in this study is presented in Table II.

TABLE II: Potential Ecological Risk Range and Risk Level

Range of potential ecological risk index (E^i_f)	Ecological risk level single-factor pollution
40	Low
$40 \leq E^i_f < 80$	Moderate
$80 \leq E_f{}^i < 160$	Higher
$160 \leq E_f{}^i < 320$	High
$320 \leq E_f{}^i$	Serious

C. Statistical Analysis

The data from the examined heavy metals were analyzed using the SPSS 24 statistical package. All data were also subjected to One Way Analysis of variance (ANOVA), the significance level at $p<0.05$ and was used to separate significant means. Microsoft Excel was used for all graphical presentations.

IV. Results

A. Heavy Metal Concentration in Surface Water

Table III presents the mean concentrations of heavy metals examined in surface water samples of River Ose. It can be seen from the data in Table III that Pb was not detected in the months of February and March.

However, in the month of April Pb was detected and ranged from 0.020–0.060 mg/l. When the results were compared to the WHO limit, the results were seen to be within the permissible limit. In addition, Cr was only detected in the surface water collected from the lower stream in February (0.010 mg/l) and the value was within the permissible limit of 0.05 mg/l. Iron and Zn range from 1.100–1.500 mg/l and 0.010–0.080 mg/l respectively. Furthermore, when the observed results were compared with the permissible limits, it was observed that the concentrations were within the limits. Arsenic (0.010 - 0.037 mg/l) and cadmium (0.010–0.060 kg/l) were seen to be above the WHO limits of 0.010 mg/l.

B. Heavy Metal Concentration in Sediment

The data in Table IV showed the mean concentrations of heavy metals observed in the sediments for the three months. The mean concentrations of Pb and As ranged from 0.146–0.196 mg/l and 0.020–0.270 mg/l, respectively. When the results were compared to the permissible limits of 5.0 mg/l (Pb) and 0.5–1.5 mg/l (As), it was seen that the mean concentrations were within the limits. Furthermore, the mean concentrations of Fe ranged from 28.210–29.470 mg/l, Zn 1.916–2.140 mg/l, Cr 0.020–0.310 mg/l, and Cd 0.180–0.216 mg/l, however, when these data were compared to WHO limits, it was observed that the results exceeded the limits in Table IV

C. Heavy Metal Concentrations in Fish Tissues

The concentrations of heavy metals in fish tissues are presented in Table VI. The result suggests that Fe ranged from 59.80 mg/l to 100.67 mg/l in the tissues of *M. rume* and 54.30–123.00 mg/l in *C. gariepinus*. The result, therefore, revealed that Fe was within the permissible WHO limits of 123.5 mg/l shown in Table VI. On the other hand, the concentrations of Pb were seen in the hearts (0.30–3.16 mg/l), gills (0.91–4.12 mg/l), livers (1.03–1.48 mg/l), and kidneys (0.66–2.20 mg/l) of the two species. Lead's concentration in the muscles of the two species was seen to be below the WHO limit of 0.5 mg/l while those observed in the heart, liver, kidney, and gills were above the permissible limits. Furthermore, Zn ranged from 9.970–30.77 mg/l in both fish. From the data, the concentrations of zinc were higher than the permissible limit of WHO. Arsenic concentrations ranged from 0.036–0.203 mg/l and when compared with the WHO limit, the concentrations were within the permissible limits. The concentrations of cadmium range from 0.026–0.331 mg/l and when the result was compared to the WHO limit, it was seen that all concentrations in the fish tissues were greater than the values stipulated by the regulatory agency. Chromium ranged from ND - 2.103 mg/l in all the tissues however, the table showed that Cr was not detected in the muscle of *C. gariepinus*, while the concentration of Cr in *M. rume* tissues were greater than the WHO limit of 0.05–0.15 mg/l.

TABLE III: MEAN HEAVY METAL CONCENTRATIONS OF OSE RIVER

Heavy metals / Months	Iron (Fe)	Lead (Pb)	Zinc (Zn)	Chromium (Cr)	Cadmium (Cd)	Arsenic (As)
February (US)	1.100 ± 0.006	ND	0.017 ± 0.003	ND	0.020 ± 0.000	0.027 ± 0.003
February (MS)	1.120 ± 0.000	ND	0.010 ± 0.000	ND	0.013 ± 0.003	0.050 ± 0.006
February (LS)	1.490 ± 0.040	ND	0.053 ± 0.009	0.010 ± 0.000	0.037 ± 0.003	0.060 ± 0.000
March (US)	1.100 ± 0.000	ND	0.030 ± 0.000	ND	ND	0.010 ± 0.001
March (MS)	1.497 ± 0.136	ND	0.030 ± 0.000	ND	ND	0.020 ± 0.000
March (LS)	1.500 ± 0.000	ND	0.010 ± 0.006	ND	0.020 ± 0.000	0.040 ± 0.000
April (US)	1.143 ± 0.009	0.020 ± 0.000	0.080 ± 0.060	ND	0.010 ± 0.000	0.010 ± 0.000
April (MS)	1.207 ± 0.003	0.030 ± 0.006	0.0267 ± 0.003	ND	0.010 ± 0.000	0.020 ± 0.000
April (LS)	1.410 ± 0.017	0.060 ± 0.000	0.043 ± 0.009	ND	0.030 ± 0.000	0.040 ± 0.000
WHO limit	5.000 mg/l	0.1 mg/l	5 mg/l	0.05 mg/l	0.01 mg/l	0.01 mg/l

Note: ND - Not Detected; US - Upper Stream; MS – Mid Stream; LS – Lower Stream Sources: Field data (2021).

TABLE IV: MEAN HEAVY METAL CONCENTRATIONS IN SEDIMENTS

Heavy metals / Months	Iron (Fe)	Lead (Pb)	Zinc (Zn)	Chromium (Cr)	Cadmium (Cd)	Arsenic (As)
February (US)	28.210 ± 0.057	0.160 ± 0.000	2.000 ± 0.000	0.020 ± 0.000	0.180 ± 0.057	0.220 ± 0.000
February (MS)	29.130 ± 0.318	0.186 ± 0.033	1.916 ± 0.491	0.026 ± 0.033	0.200 ± 0.000	0.186 ± 0.033
February (LS)	29.470 ± 0.230	0.180 ± 0.000	2.090 ± 0.404	0.030 ± 0.000	0.2067 ± 0.088	0.270 ± 0.057
March (US)	29.040 ± 0.159	0.196 ± 0.014	1.940 ± 0.023	0.190 ± 0.005	0.160 ± 0.005	0.036 ± 0.033
March (MS)	29.200 ± 0.000	0.150 ± 0.011	2.066 ± 0.020	0.230 ± 0.003	0.200 ± 0.000	0.020 ± 0.000
March (LS)	29.266 ± 0.036	0.190 ± 0.057	2.140 ± 0.000	0.280 ± 0.000	0.206 ± 0.008	0.056 ± 0.003
April (US)	29.246 ± 0.164	0.180 ± 0.000	2.066 ± 0.003	0.210 ± 0.005	0.160 ± 0.115	0.040 ± 0.000
April (MS)	29.326 ± 0.014	0.146 ± 0.003	2.000 ± 0.000	0.236 ± 0.003	0.190 ± 0.000	0.026 ± 0.003
April (LS)	29.043 ± 0.333	0.180 ± 0.005	2.066 ± 0.011	0.310 ± 0.000	0.216 ± 0.008	0.066 ± 0.003
WHO	5.00 0 mg/l	5.00 mg/l	≤ 1 mg/l	0.1 mg/l	0.1 mg/l	0.5–1.5 mg/l

Note: ND - Not Detected; US - Upper Stream; MS – Middle Stream; LS – Lower Stream Sources: Field data (2021),

TABLE V: HEAVY METALS CONCENTRATIONS IN FISH ORGANS AND MUSCLES

Heavy metals / Months	Organ	Iron (Fe)	Lead (Pb)	Zinc (Zn)	Chromium (Cr)	Cadmium (Cd)	Arsenic (As)
Mormyrus rume	Hearts	69.510±0.004	3.16±0.023	30.77±0.023	0.701±0.000	0.331±0.004	0.081±0.002
	Gills	100.67±0.008	4.12±0.030	19.20±0.000	0.510±0.030	0.075±0.003	0.036±0.004
	Liver	88.310±0.004	1.48± 0.14	17.27±0.080	0.387±0.008	0.101±0.002	0.080±0.003
	Kidney	64.800±0.000	0.66±0.037	19.40±0.030	1.021±0.020	0.090±0.003	0.061±0.004
	Muscle	64.467±0.058	0.41±0.020	16.10±0.006	0.634±0.020	0.291±0.000	0.043±0.003
Clarias gariepinus	Hearts	59.800±0.000	0.30±0.000	23.56±0.3200	0.323±0.030	0.303±0.003	0.103±0.008
	Gill	123.0±0.000	0.91±0.030	29.01±0.057	0.410±0.013	0.064±0.006	0.091±0.021
	Liver	54.30±0.003	1.03±0.020	20.04±0.020	0.401±0.000	0.180±0.030	0.073±0.006
	Kidney	69.91±0.182	2.20±0.025	27.60±0.030	2.103±0.020	0.078±0.000	0.079±0.004
	Muscle	61.10±0.012	0.40±0.030	9.970±0.010	ND	0.026±0.002	0.203±0.303
WHO limit		123.5 mg/l	0.5 mg/l	5 mg/l	0.05–0.15 mg/l	0.005 mg/l	5 mg/l

Source; Field Data (2021).

D. Bioaccumulation Factor

Bioaccumulation factors (BAF) of heavy metals in *M rume* tissues (heart, gill, liver, and muscle) showed that the highest BAF value (16.1958) was recorded in the metal zinc from the heart of *M rume* recorded the highest value while the BAF least was seen in muscle, as with 0.3425. Furthermore, in *C. gariepinus*, the highest BAF was observed in the kidney (Zn = 850.150) while the least was seen in the muscle (Cd =1.500). When the results were compared to the limits described, they showed no probability as all the values were below 1000.

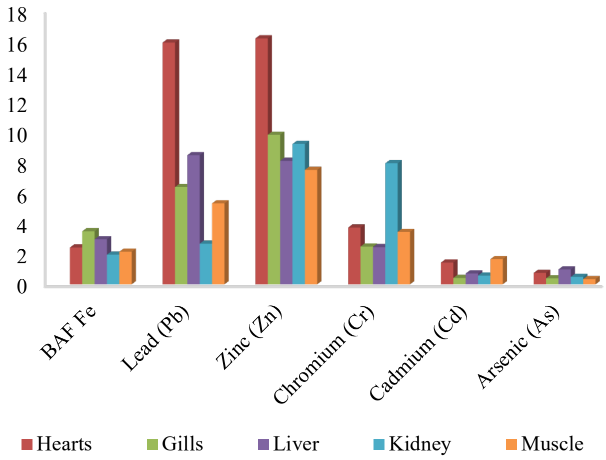


Fig. 2. BAFs of heavy from *M. rume* to sediments. Fieldwork data.

E. Potential Ecological Risk Index

The potential ecological risk index of the heavy metals in surface water and sediments is revealed in Table VI. The potential ecological risks of Pb, Zn, Cr, and Cd in the surface water were below 40, indicating low risk as shown in Table II. Furthermore, in the sediment, Cd was below 40 meaning low risk, the values of PERI of Cr and Pb in the sediments were above 160 suggesting they were a considerable amount of risk of heavy metals while the value of Zn showed that it was seriously at risk.

TABLE VI: POTENTIAL ECOLOGICAL RISK INDEX OF SURFACE WATER AND SEDIMENTS

Element	Potential ecological risk index in surface water	Potential ecological risk index in sediment
Cd	1.176	14.437
Cr	1.878	287.71
Pb	12.32	175.62
Zn	16.69	1018.42

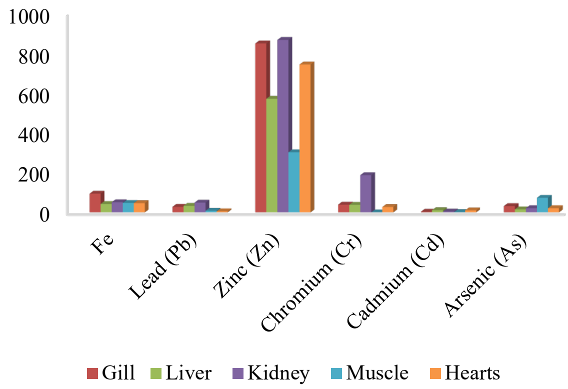
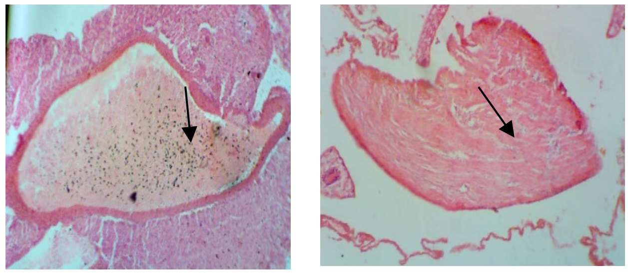


Fig. 3. BAFs of heavy from *C. gariepinus* to sediments.

F. Histopathological Analysis

Fig. 4 and Fig. 6 showed the histological alterations observed in the liver, kidney, and gill tissues of *M. rume*. In Fig. 4a cholestasis presence was observed in the kidney of the fish while 4(b) revealed necrosis and loss of glomeruli structure in the kidney of *M rume*. However, Fig. 5a and 5b showed the congestion of the central vein and hyperplasia in the gills respectively. In the liver, Fig. 6a and 6b, lymphocytic infiltrate and congested vessels were seen in the liver of *M. rume*.

The kidney of *C. gaiepinus* on the other hand, (Fig. 7a, 7b) exhibited healthy kidney and tubular necrosis. While the gill in Fig. 8a and 8b, reveals fish congestion of blood and interlamellar hyperplasia respectively caused by presence of a monogenean parasite. The livers revealed loss of nuclei of hepatocytes and necrosis in hepatocytes (Fig. 9a, 9b).



a b

Fig. 4. Photomicrograph of sections (a) showing the presences of cholestasis (b) necrosis and loss of glomeruli structure found in the kidney of M rume.

a b

Fig. 5. Photomicrograph of sections (a)shows congestion of the central vein and (b) hyperplasia in gills of M rume.

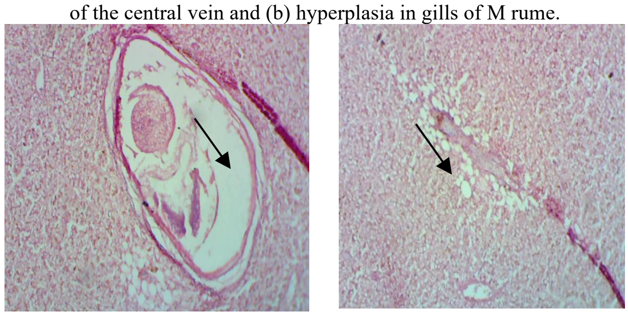


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Fig. 6. Photomicrograph of sections (a) shows lymphocytic infiltrate (b) congested vessel in the liver of M. rume.

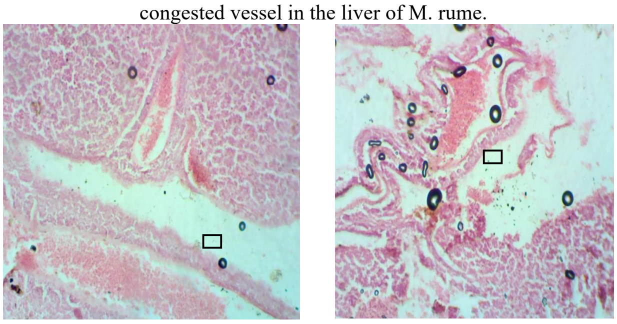

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Fig. 7. Photomicrograph of sections (a) shows healthy kidney (b) tubular necrosis in the kidney of C. gariepinus.

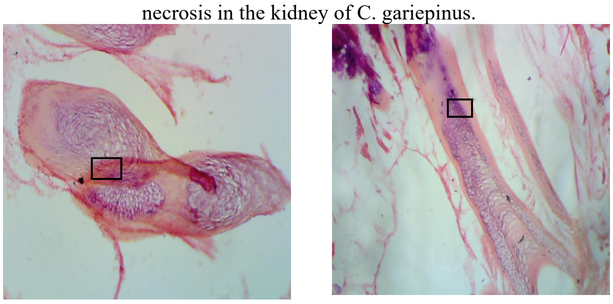

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Fig. 8. Photomicrograph of sections (a) shows congestion of blood (b) interlamellar hyperplasia caused by presence of a monogenean parasite in the gills of C. gariepinus.

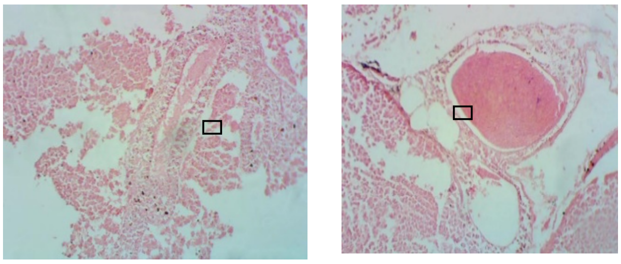

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Fig. 9. Photomicrograph of sections (a) loss of nuclei of hepatocytes (b) necrosis in hepatocytes in liver of C. gariepinus.

V. Discussion

The obtained heavy metal concentration results from surface water showed that Pb was not detected in the first two months of surface water collection while Fe, Zn, and Cr were below the permissible limits of WHO [36], [37]. This may be due to the fact that the river was almost dried up at the time this study was conducted and also, the dry season was at its peak in Nigeria. Another reason for these results might be that most of the heavy metals have accumulated in the benthic or bottom region or the sediments of the river [14], [15]. These results are however in agreement with those obtained by Olayinka-Olagunju who suggested that the concentration of heavy metals examined in Owena River was within permissible limits of WHO [14].

On the other hand, Cd was seen to exceed the standard acceptable levels set by WHO [36] in water, sediment, and all fish organs. Cadmium is not an essential metal; however, it is very poisonous to fish even at low concentrations [20], [38]. The highest concentration of Cd was seen in the fish tissue muscle of *M. rume* followed by sediments and lastly in the surface water. Cadmium according to [39] was reported to be an impurity in zinc as it is usually found around zinc ores. In addition, Cd is referred to as a toxic trace metal and may be found in some rocks, fertilizers, galvanized plumbing, industrial waste, coal, and petroleum [40]. Though no past or recent studies have revealed any valuable benefit of Cd, most of the previous studies have revealed negative effects of the metals. The bioaccumulation of Cd may affect human and animal organs such as kidneys, hearts, liver, and muscles, and exposure to high or low concentrations may result in cardiovascular diseases fatigue, headaches, nausea, vomiting, abdominal cramps, diarrhea, and fever [41].

Arsenic exceeded the permissible limits of WHO in surface water only but was within the standard in the sediments and fish organs. Results from this study were similar to what was reported by [13] however it differs from the high concentration reported by [42]. Arsenic like cadmium is a trace metal that occurs naturally in rocks, and soil and may also be used by different industries for various purposes. In addition, As can be combined with other metals to make a chemical that can be used as insecticides or agricultural products. However, long-term exposure to inorganic arsenic in water may cause health-related issues like cancer, skin discoloration, high blood pressure, and cardiovascular diseases in humans [43].

In this study, Fe concentration was found to be higher in sediments but was within the limit in water and fish tissues. Although Fe is an essential metal, however at higher or large quantities, it will increase the growth of algae in the river which will prevent sunlight from reaching the surface of the river and also disrupt the aquatic food chain. on the other hand, the presence of algae in freshwater reduces the quality of water and results in stagnation. The results from this study are similar to the findings of [14] and [16] who observed high concentrations of Fe in sediment from different rivers in Ondo State. The reason for the high concentration in the sediment may be due to the parent soil of Nigeria [13].

The element Cr was only detected in the lower stream in the month of February and the concentration was within the limits. However, in the sediments and fish organs, Cr was higher than WHO standards. The highest concentration of Cr was observed in the kidney of the fish species (1.356 kg/l and 1.870 kg/l) and the least was seen in the water samples. Chromium as a metal exists in two stable oxidation states and may come across in biological systems [44], [45]. Cr (III) compounds, for example, are predominantly non-hazardous and are sometimes referred to as essential trace element nutrients in humans, taking important parts in sugar and fat metabolism [45], [46]. On the other hand, Cr (VI) compounds, are more soluble and are very hazardous since they are effective oxidizing compounds that have been suggested to pass through cells by an active transport process in place of phosphate anions, which they structurally resemble [47]. Previous studies have shown that when the skin comes in contact with a low concentration of Cr, it may result in skin irritation and lead ulceration. However, long-term exposure may result in kidney and liver damage as well as interruptions of circulatory and nerve issues [48]. Bioaccumulation of Cr in aquatic life is dangerous and may affect the consumption of fish. Results from this study are similar to those [14] that reported high concentrations in Owena River, Ondo State, Nigeria.

These concentrations of Pb in surface water and sediments suggests that the samples were not contaminated with lead as at the time of this study. However, in the fish organs, Pb was more contaminated in M. rume than in *C. gariepinus*, this may be because the former is a benthic fish while the former is pelagic. This may be because benthic sediments have a more complex holding capacity to retain heavy metals than any other segment in the waterbody [15], [49]. Lead (Pb) has been shown to be linked to anthropogenic activities such as cement production, battery, e-waste, etc. [50]. Previous studies have shown that Pb has numerous detrimental effects on human and animal health even at low concentrations. In addition, long-term exposure to Pb may cause death or impairment to the central nervous system, the brain, kidneys, and liver and could be genotoxic [14]. On the other hand, in children, Pb has a poisonous effect. Results of this study corroborate the findings of [13], [14], [51].

The concentration of Zn was seen to be within the WHO limit in the water samples but exceeded the standard in sediments and fish organs. The element zinc has been classified as an essential metal and it is regulated by many aquatic organisms and cannot be biomagnified. Although Zn is essential, it should, however, not exceed the permissible limits of WHO [36]. Vardi and Chenji [52] are of the opinion that aquatic organisms absorb Zn from their environment and not from their feeds. The results from this present study support the views of [52] as the highest concentrations of zinc were observed in the fish tissues and organs. Ana *et al.* [53] for instance, suggested that the availability of zinc in the environment depends on physicochemical factors such as pH, hardness, and dissolved oxygen. [54] further argued that alloys like brass and bronze, fungicide, and batteries may be the sources of Zn in sediment. This present study is also similar to the results obtained by [13] and [54] whose Zn mean concentrations were higher than the permissible limits in fish organs.

The order of metals in surface water Fe>Zn>As>Cd>Pb>Cr, in sediments Fe>Zn>Pb>Cd>Cr>As and in fish tissues Fe>Zn>Pb>Cr>Cd>As. The most striking thing in the order of heavy metals is that Fe was the most abundant metal in the three samples. This may be due to Nigeria's parent materials. These results are consistent with those of [13], [55], [56].

The bioaccumulation factor in *M. rume* heart though the highest but it suggested no probability also, in *C. gariepinus*, the highest BAF seen in kidney implied no probability too. The interpretation of BAFs metals was described by [57] and the categories are as follows: BAF < 1000: no probability of accumulation; 1000 < BAF < 5000: bio-accumulative; BAF > 5000: extremely bioaccumulative. Therefore, from this study, according to the categories, all the heavy metal BAFs were less than 1000 (BAF < 1000), indicating no probability. The BAF pattern in *M. rume* was heart>gills>liver>kidney>muscle.

The result implied that the heart was the most polluted organ with Zn of M. rume, thus, high concentrations of metals in humans or animals have been reported to cause cardiovascular issues. The results, however, corroborate the findings of [58] who observed a high concentration of Zn in the heart of *Epinephelu microdon* collected from Saudi Arabia. In addition, *C. garieinus* order was as follows: kidney>gill>heart>liver>muscle. The kidney of *C. gariepinus* had the highest concentration of zinc and may have adverse effects at a very high probability. This result, however, differs from the results obtained by [13], however, it is similar to the result of [58]. The BAF order of both *M. rume* and *C. gariepinus* are reported respectively as follows: Zn>Pb>Cr>Fe>Cd>As and Zn>Cr>Fe>As>Pb>Cd. The result implied that zinc, an essential element was the most abundant metal BAF in both fish.

The potential ecological risk index of the heavy metals in surface water suggested low risk implying that the surface water sample were not hazardous. On the other hand, results from the sediments, suggested that the PERI ranged from considerable amount of hazard to a very serious hazard suggesting that the sediments were extremely contaminated with Cr, Pb and Zn. This study therefore suggest that the PERI of the water was less than the sediments, implying that the sediments were more toxicity than the water sample. This study implied that all benthic organism in this site might be affected by Cr, Pb and Zn. This study differs from the opinion of [13] who reported moderate risk in the samples examined at Ogbese River.

Histopathological alteration in the affected livers resulted to cholestasis, a condition that affects bile flow, and leads to the accumulation of bile fluid in the liver. The condition may further cause serious disease or death due to pruritus, malnourishment and difficulties from portal hypertension secondary to biliary cirrhosis. However, according to [59] histopathological alterations were not metal-specific and may not be associated with hepatic responses to toxicant exposures. More so, the presence of pollutants may alter cellular changes that are sometimes seen in the liver as a result of their continuous metabolic detoxification and biotransformational activities [2].

Similarly, necrosis, a kidney disorder was observed to have caused changes in the fish. Necrosis causes damage to the tubule cells of the kidneys and may result in acute kidney failure. The tubules are tiny ducts in the kidneys, which aid blood filtration when passes through the kidneys [60]. The major causes of necrosis include low blood supply to the kidney resulting from chemical medications that disrupt the kidney and serious body infections. The observed alterations in the gills showed shows congestion of blood in the central vein, hyperplasia, and interlamellar hyperplasia caused by presence of a monogenean parasite. Hyperplasia and hypertrophy of epithelial cells are the most common histopathological damages associated with fish gills in freshwater environments [2]. These alterations are usually associated with fat, surrounding, and intermingling to the primary and secondary lamellae [61]. This result corroborates the findings of [2] and [18] who reported similar gill alterations and stated that the alteration is associated with heavy metal contamination in the aquatic environment. However, the alteration in this study could be linked to the presence of parasites which could be a result of defaecation from human subjects into the aquatic ecosystem which were seen during the sample collection.

VI. Conclusion

Even though some heavy metals concentrations exceeded the permissible limits in the water, sediments and organs in the sampled fish species, these fish may cause some severe health threats diversity of the fish in their habitat and injurious to human health after consumption. Thus, the bioaccumation of heavy metals need to be reduce through constant monitoring of Ose River as well as educating the populace on the danger of the nature of their activities due to ability of heavy metals to up and biomagnify over time. Lastly, effective implementation and enforcement of legislation on appropriate disposal of domestic and industrial waste measures may help to decrease heavy metal exposure in the aquatic environment.

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Conflict of Interest

The author declares that no conflict of interest.

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