

## Heavy Metals in organs and endoparasites of *Oreochromis niloticus*, Sediment and Water from River Ogun, Ogun State, Nigeria

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**Abstract:** Endoparasites have the ability to accumulate heavy metals and the capacity to detect even the lowest heavy metal concentrations. These have made them more suitable water pollution biomonitors than their fish hosts. Therefore, ninety Nile Tilapia, (*Oreochromis niloticus*), collected at 3 different points along River Ogun at Abeokuta were examined for presence of endoparasites. Fish muscle and organs, endoparasites, water and sediments samples collected at three sites were analysed for levels of Zn, Cu, Cd and Pb. Four trematodes species: *Allocreadiumghanensis*, *Phagicola longa*, *Clinostomumtilapiae*, and *Dipylidiumcaninum* and one acanthocephalan, *Acanthogyrustrilapiae* were identified from the fishes. There were variations in the heavy metal levels in sediment, water, fish tissues and parasites. The highest level of heavy metal accumulation was recorded in the parasites compared to fish tissues. Bioaccumulation levels of Pb, Cd and Cu were in the order: Parasites > Fish Muscle > Liver > Intestine. The highest concentrations of Cd (0.67±0.21), Pb (2.89±1.25) and Cu (4.16±1.04) were recorded in parasites while Zn (14.27±4.32) levels were highest in the liver. The higher heavy metal levels in endoparasites indicate the potential risks of metal accumulation from fish consumption and suggest parasite suitability as bioindicators of heavy-metal pollution in aquatic ecosystems.

**Keywords:** Bio indicator, fish parasites, Heavy metal, Nile Tilapia, water pollution.

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### I. Introduction

Heavy metal pollution in the aquatic ecosystem has attracted serious concerns in recent years and the persistent and accumulative nature of these pollutants makes them a major concern. Human activities such as increased industrialization and the discharge of wastes into the aquatic environment might be the main sources of contamination threatening bio-life particularly in developing countries [1][2].

There has also been increasing interest in the role of parasites as bioindicators of heavy metal pollution in aquatic habitats and especially in the interrelationship between parasitism and pollution [3][4][5]. This relationship is not simple and in essence involves a double edged phenomenon, in which parasitisation may increase host susceptibility to toxic pollutants or in which pollutants may result in increase or some decrease in the prevalence of certain parasites.

Parasites are an essential part of the aquatic environment and represent a significant proportion of the aquatic biomass. The relationship between environmental pollution and parasitism in aquatic organisms and the potential role of endoparasites as water quality indicators have received increasing attention during the past two decades [6][7]. Some parasites are sensitive to environmental change, others are more resistant than their hosts and tend to increase in number in polluted conditions [7]; these are now regarded as useful indicators of aquatic health. Fish parasite and metal interactions have generated a large pool of literature in Europe from environmental pollution monitoring perspectives [8][9][10][11][12][13][14][15]. Conclusions from these studies showed variations for different host-parasite associations. However, intestinal parasites generally accumulate some metals to concentrations several hundred times higher than the levels in host tissues [12][6][8][14] thus rendering parasites more sensitive metal accumulation biomonitors than their fish host. [16] Also indicated that parasites can also act as metal sinks for its fish host.

In spite of these, there is a dearth of information about the presence of heavy metals in Ogun River at Abeokuta and the accumulation of such heavy metals within resident fish fauna and their parasites. This study is therefore aimed at evaluating the metal concentration and accumulation in fish host and their parasites. This will ascertain the role of parasites as possible sentinel for monitoring increasing heavy-metal pollution in the aquatic environment and the suitability of such fish for human consumption.

## II. Materials And Methods

### 2.1 Study Area

This study was carried out in Ogun River at Abeokuta, Ogun State, Nigeria. Ogun State borders Lagos State to the South, Oyo and Osun States to the North, Ondo State to the east and the Republic of Benin to the west. Abeokuta is the state capital and largest city in the state [17].

River Ogun is one of the main rivers in south-western Nigeria with a total area of 22.4 km<sup>2</sup> and a fairly large flow of about 393 m<sup>3</sup>/sec G1 during the wet season [18]. It has coordinates of 3°28'E and 8°41'N from its source in Oyo state to 3°25'E and 6°35'N in Lagos where it enters the Lagos lagoon [19]. The water from the river is used for agriculture, transportation, human consumption, various industrial activities and domestic purposes [18][19]. It also serves as raw water supply to the Ogun state water corporation which treats it before dispensing it to the public. Along its course, it constantly receives wastes from breweries, slaughterhouses, dyeing industries, tanneries, automobile workshops, agricultural and domestic wastewater before finally discharging into Lagos lagoon [20][18]. A 100 km<sup>2</sup> area around River Ogun has an approximate population of 3637013 (0.03637 persons per square meter) and an average elevation of 336 meters above the sea [21].

### 2.2 Fish Tissues and Parasite Collection

Ninety, live Nile Tilapia (*Oreochromis niloticus*) was randomly collected by fishermen from three sampling sites along River Ogun at Abeokuta from July-September 2014. Samples were collected between 0700 and 1000 hours as recommended by [22]. The fishes were caught using cast nets and transported to the laboratory in a container of river water. Fish sex was determined by the presence or absence of an intromittent organ on the ventral side just before the anal fin. This was later confirmed by the presence of testes or ovaries observed during dissection. Other morphometric indices were also determined. The fish specimens were examined for presence of parasites on the skin before dissection. Samples of muscle, intestine and liver were collected into clean labelled containers as recommended by [10]. The intestines were cut and opened in physiological saline to aid the emergence of the gastrointestinal parasites. The livers were carefully mashed in physiological saline and worm recognition was enhanced by the wriggling movements on emergence and thigmotropic nature of the parasite. The parasites collected were identified using standard key and the parasite prevalence and intensity were determined. The fish tissue samples and parasites collected were frozen at -26°C until further processing according to methods described by [13].

### 2.3 Water and Sediment collection

Water samples (500ml) were collected at the time of fish collection into pre-cleaned plastic containers. The samplings were done midstream by dipping each sample bottle at approximately 20-30 cm below the water surface, projecting the mouth of the container against the flow direction. In the laboratory, water samples were acidified with concentrated HCl and preserved in a refrigerator till analysis for Zn, Cu, Cd, and Pb. Sediments were also collected simultaneously with water samples using Ekman sediment grab sampler. Sediment samples were dried at 105 °C. The dried samples were ground in a porcelain mortar. In order to normalize variations in grain size distributions, the samples were sieved using 2mm mesh sieve into clean labelled plastic bottles and stored for heavy metal analysis.

### 2.4 Sample digestion and analysis

The frozen fish and parasite samples were allowed to thaw at room temperature and then dried at 80°C in a digestion microwave oven. The digestions of the samples were carried out using a modified method described by [9]. Briefly, 1.00g of the dried sample was digested using 15mL of concentrated HNO<sub>3</sub> and 5ml of concentrated HCl at 100°C for 20 minutes. The samples were then filtered through cotton wool, diluted to make 50 ml with deionized water and stored in sample bottles at room temperature. The clear colourless solution obtained was transferred into a 100mL volumetric glass flask and made up to 100mL with deionized water. Sample bottles and flasks were cleaned before use by rinsing three times with 1% HNO<sub>3</sub> and three times with deionized water. The digested sample solution was diluted (1:5) with deionized water prior to the analysis to reduce acid concentration. The heavy metal analysis was carried out on digested samples in the Buck scientific model 200A atomic absorption spectrophotometer.

The Bioaccumulation factors (BAF) were calculated according to [23] using the following formula:

$$\text{BAF} = \frac{\text{Metal concentration in fish tissue (mg/kg)}}{\text{Metal concentration in water (mg/l)}}$$

## 2.5 Statistical Analysis

Data were subjected to descriptive statistical analysis (95% confidence limit) using statistical package for social sciences (SPSS 17) to determine the mean and standard deviation values of metal concentration in the surface water, sediments and tissues of Nile tilapia.

## III. Results

### 3.1 Prevalence and Distribution of Endoparasites of Fishes from River Ogun

Five parasite species were identified in this study: *Phagicola longa*, *Acanthogyrostilapiae*, *Dipylidiumcaninum*, *Clinostomumtilapiae*, and *Allocreadiumghanensis*. A total of 45(50%) of the 90 *O. niloticus* examined were infected with these parasites (Table 1) and a total of 80 parasites were collected from the infected fishes. At sampling station 1, 43.3% of the fish examined had parasites. *Phagicola longa* (16.7%), *Acanthogyrostilapiae*(23.3%) and *Dipylidiumcaninum*(3.3%) were identified in fishes at this station. Parasites were identified from 56.6% of fishes from station 2; *Clinostomumtilapiae*(13.3%), *Phagicola longa* (10%), *Acanthogyrostilapiae*(26.7%) and *Allocreadiumghanensis*(100%). Station 3 had infection in 15(50%) of the 30 fishes examined (Table 1). The highest parasite occurrence (75%) was in the GIT while 25% of parasites identified were from the gills.

**Table 1: Prevalence of Endoparasites of Fish Collected from three Sampling Stations on River Ogun**

Site	Parasites occurrence			No of fish infected	GIT	Gill	Total
	NoExami ned	Parasites	Taxa of parasite identified				
Station 1	30	Dc	Trem	1(3.3%)	4(100%)	-	4
		Pl	Trem	5(16.7%)	3(75%)	1(25%)	4
		At	Acant	7(23.3%)	8(61.5%)	5(38.5%)	13
		<b>Total</b>		13(43.3%)			
Station 2	30	Ct	Trem	4(13.3%)	9 (81.8%)	2 (18.2%)	11
		Pl	Trem	3(10%)	5(83.3%)	1(16.7%)	6
		Ag	Trem	2(6.6%)	3(100%)	-	3
		At	Acant	8(26.7%)	9(75%)	5(25%)	14
		<b>Total</b>		17(56.6%)			
Station 3	30	Ct	Trem	11(36.7%)	11(64.7%)	6(35.3%)	17
		Ag	Trem	4(13.3%)	8(100%)	-	8
		<b>Total</b>		15(50%)			
<b>Total</b>	90		<b>Grand total</b>	45 (50%)	60 (75%)	20 (25%)	80(100%)

**Note:** Trem- Trematode, Acanth- Acanthocephala, Ag-*Allocreadiumghanensis*, Pl-*Phagicolalonga*, Ct-*Clinostomumtilapiae*, At-*Acanthogyrostilapiae*, Dc-*Dipylidiumcaninum*

### 3.2 Heavy Metal Analysis

There were variations in the heavy metal concentrations recorded for water, sediment, fish tissues and endoparasite samples collected (Table 2). The heavy metal level recorded in sediment and water samples were higher than the WHO (2003) and FEPA (2003) recommendations (Table 3). The heavy metal levels in the water and sediment samples from Station 2 were significantly ( $P < 0.05$ ) higher than the concentrations at Stations 1 and 3. The levels in water and sediments from the three sampling stations were in decreasing concentrations as follows:  $Zn > Cu > Pb > Cd$ . The Pb levels in water ( $9.60 \pm 4.70 \text{ mg/l}$ ) and sediment ( $28.90 \pm 20.20 \text{ mg/kg}$ ) at Station 2 were significantly ( $P > 0.05$ ) higher than the levels recorded for Stations 1 and 3. Although, the Cu and Cd concentrations at the three sampling stations were not significantly ( $P < 0.05$ ) different, the highest concentrations of Cu (Water:  $10.90 \pm 4.50 \text{ mg/l}$ ; sediment:  $37.40 \pm 10.90 \text{ mg/kg}$ ) and Cd (water:  $0.63 \pm 0.20 \text{ mg/l}$ ; sediment:  $2.10 \pm 0.80 \text{ mg/kg}$ ) were recorded at Station 2 (Table 2). The levels of Zinc recorded in the three sampling stations were significantly ( $P > 0.05$ ) higher than the levels of other heavy metals analysed in this study. The highest concentrations of Zn were recorded in water ( $20.90 \pm 9.10 \text{ mg/l}$ ) and sediment ( $222.90 \pm 73.00 \text{ mg/kg}$ ) samples collected from Station 2.

The level of Cd recorded in fish samples from the different stations in River Ogun was higher than the WHO and FEPA (2003) recommendations (Table 3), however the values recorded for Zn, Cu and Pb were within the limits. The levels of Pb, Cd, Cu and Zn in the liver, intestine and muscles were highest from *O. niloticus* collected from Station 2. Significantly higher concentrations of the Pb, Cd, Cu and Zn were recorded in the muscles *O. niloticus* and the lowest levels were from the intestine (Table 2). The heavy metal concentrations

in the liver, intestine and muscles of *O. niloticus* collected from the three sampling stations were in the decreasing order: Zn>Cu>Pb>Cd. The levels of these metals in the fish organs were significantly lower than the concentration recorded for sediment and water samples.

The heavy metal levels in endoparasites of *O. niloticus* collected from Station 2 were significantly ( $P<0.05$ ) higher than the concentrations in fish harvested at Stations 1 and 3. The lowest levels of heavy metals were recorded in endoparasites of fish collected from station 1. The levels of Pb, Cd and Cu recorded in the endoparasites were however, higher than the levels in the fish tissues (liver, muscle and intestine) with the metal concentrations in the parasites from the three sampling stations in the pattern: Zn>Cu>Pb>Cd.

**Table 2: Heavy Metal Levels in Water, Sediment, Fish (liver, intestine and muscle) and Fish Endoparasites from Sampling Stations on River Ogun**

Station	Sample examined	Lead(Pb)	Cadmium(Cd)	Copper(Cu)	Zinc(Zn)
Station 1	Water	7.90±3.10 <sup>a</sup>	0.41±0.10 <sup>a</sup>	10.10±5.90 <sup>a</sup>	19.70±7.50 <sup>a</sup>
	Sediment	24.00±10.70 <sup>b</sup>	1.60±0.40 <sup>a</sup>	26.40±11.60 <sup>a</sup>	144.90±48.40 <sup>a</sup>
	Fish				
	Liver	2.59±2.07 <sup>a</sup>	0.79±0.25 <sup>a</sup>	2.81±1.55 <sup>a</sup>	13.01±6.43 <sup>a</sup>
	Intestine	1.45±1.26 <sup>a</sup>	0.47±0.36 <sup>a</sup>	2.32±1.92 <sup>a</sup>	8.26±4.03 <sup>a</sup>
	Muscle	2.04±1.47 <sup>a</sup>	0.90±0.47 <sup>a</sup>	3.33±1.03 <sup>a</sup>	12.08±7.79 <sup>a</sup>
Station 2	Parasite	2.17±1.57 <sup>a</sup>	0.48±0.77 <sup>a</sup>	3.37±2.91 <sup>a</sup>	11.16±4.08 <sup>a</sup>
	Water	9.60±4.70 <sup>b</sup>	0.63±0.20 <sup>b</sup>	10.90±4.50 <sup>a</sup>	20.90±9.10 <sup>b</sup>
	Sediment	28.90±20.20 <sup>b</sup>	2.10±0.80 <sup>b</sup>	37.40±10.90 <sup>b</sup>	222.90±73.00 <sup>b</sup>
	Fish				
	Liver	1.73±1.13 <sup>b</sup>	0.63±0.37 <sup>a</sup>	4.05±1.53 <sup>b</sup>	15.12±5.92 <sup>b</sup>
	Intestine	1.04±0.78 <sup>b</sup>	0.25±0.16 <sup>ab</sup>	2.46±0.58 <sup>a</sup>	14.18±3.75 <sup>b</sup>
Station 3	Muscle	2.83±1.03 <sup>b</sup>	0.74±0.39 <sup>ab</sup>	4.26±1.30 <sup>b</sup>	19.90±5.26 <sup>b</sup>
	Parasite	3.32±1.05 <sup>b</sup>	0.75±0.67 <sup>b</sup>	4.87±0.56 <sup>b</sup>	12.54±1.67 <sup>ab</sup>
	Water	7.50±6.60 <sup>a</sup>	0.42±0.20 <sup>a</sup>	10.50±7.20 <sup>a</sup>	20.80±8.70 <sup>b</sup>
	Sediment	24.90±16.90 <sup>a</sup>	2.10±1.40 <sup>b</sup>	32.70±7.70 <sup>ab</sup>	158.30±59.70 <sup>c</sup>
	Fish				
	Liver	1.20±0.60 <sup>c</sup>	0.20±0.10 <sup>b</sup>	1.25±0.50 <sup>c</sup>	14.70±4.81 <sup>ab</sup>
	Intestine	1.30±0.50 <sup>a</sup>	0.20±0.72 <sup>b</sup>	1.24±0.22 <sup>b</sup>	13.52±1.80 <sup>b</sup>
	Muscle	2.56±1.25 <sup>b</sup>	0.59±0.21 <sup>b</sup>	4.24±1.28 <sup>b</sup>	19.45±4.47 <sup>b</sup>
	Parasite	3.20±1.20 <sup>b</sup>	0.50±0.24 <sup>a</sup>	4.25±0.32 <sup>b</sup>	10.38±1.58 <sup>b</sup>

Values are expressed as Mean of the triplicate samples ± standard deviation  
 Mean with the same letters within a column are not significantly different ( $P>0.05$ )

**Table 3: Heavy metals levels in water, sediment and fish**

Heavy Metals	Water		Sediment		Fish	
	Means of total concentration in present study(mg/L)	Maximum Limit WHO/ FEPA (mg/L)	Means of total concentration in present study(mg/kg)	Maximum Limit WHO/ FEPA(mg/kg)	Means of total concentration in present study(mg/kg)	Maximum limit WHO/ FEPA (mg/kg)
Zn	20.46	3.000	175.36	0.0123	14.42	30 (FAO,1983)
Cu	10.50	1.000	32.16	0.025	2.88	3.0
Pb	8.33	0.010	25.93	0.040	1.86	2.0
Cd	0.49	0.003	2.90	0.006	0.53	0.5

### 3.3 Bioaccumulation of Heavy Metal in Fish tissues and Parasite

The bioaccumulation data showed that the analysed metals (Pb, Cd, Cu and Zn) were bioaccumulated in the following order: Parasites>Fish Muscle> Liver > Intestine (Fig 1.2.3). In station 1, bioaccumulation of Cd, Cu and Zn are in the following order: parasite>liver>muscle>intestine (fig 1), Pb however showed highest bioaccumulation in the liver. In Stations 2 the metal bioaccumulation was in the following order: Parasites>Muscle> Liver > Intestine (fig 2). Station 3 followed the same pattern as in Station 2 though Zn bioaccumulation levels (fig 3) were highest in muscle and lowest in the parasite. Cd had the highest bioaccumulation value amongst all the heavy metals studied.

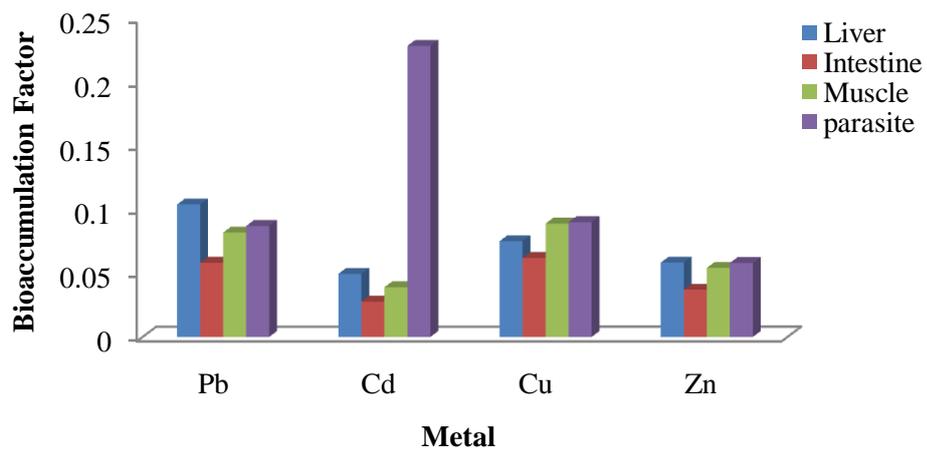


Figure 1: Heavy Metal Bioaccumulation Factor in the Fish Tissues and Endoparasites from Sampling Station 1

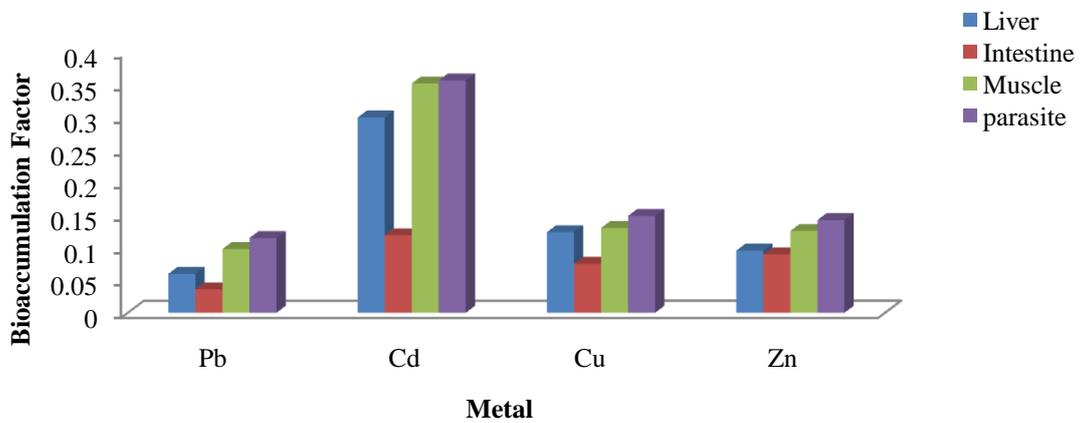


Figure 2: Heavy Metal Bioaccumulation Factor in the Fish Tissues and Endoparasites from Sampling Station 2

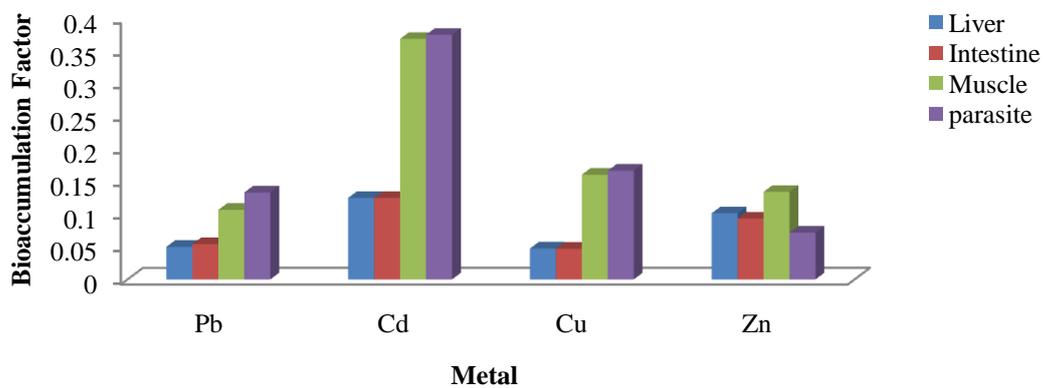


Figure 3: Heavy Metal Bioaccumulation Factor in the Fish Tissues and Endoparasites from Sampling Station 3

## IV. Discussion

### 4.1 Prevalence of Endoparasites of *O. niloticus*

The higher number of trematode parasite species recorded compared to acanthocephalans in this study is similar to results obtained by [24] where higher numbers of flukes were recorded in Cichlids compared to Acanthocephalans. The fewer number of parasites identified in the gills compared to the GIT of study specimen may most probably be a result of the benthic feeding habit of *O. niloticus* where the fish feeds mostly on plankton, diatoms and detritus. The fact that most benthic fauna acts as intermediate hosts for many parasite groups [25] might also aid transmission. In the sampling stations, the diverse parasite fauna and higher prevalence rates recorded in fishes from Station 2 might be attributable to the higher pollution level at this site. This result compares well with findings of [26] where increases in the prevalence and intensity of the acanthocephalan infection in *Tautoglabrus adspersus* were recorded with increased levels of municipal and industrial effluents. *Dipylidium caninum*, a parasite primarily of dogs and cats recorded in station 1, might be from the run offs into the river from soil contaminated by animal waste or from direct dumping of animal waste into the river by surrounding communities. The difference in parasite fauna observed in the fishes at the 3 sites may be due to the differences in the pollution levels at the sites. Effluents including heavy metals could alter the distribution, abundance and viability of invertebrate intermediate hosts, such as molluscs and crustaceans, of the identified parasites. These hosts are necessary to complete the life cycles of these parasites and their reduction will invariably affect parasites population dynamics.

### 4.2 Heavy metals concentrations at the three investigated sites

The high heavy metal concentrations recorded in River Ogun at Abeokuta suggests impairment of the water quality due to these contaminating materials, Effluent discharges from manufacturing industries and motor car mechanic workshops located around sampling point 2 may be responsible for the higher level of zinc, copper, lead and cadmium recorded at the site. The closeness of the river to urban areas and the anthropogenic activities around the river because of high human population may also have contributed to the heavy metal levels recorded.

Metals are reported to interact with organic matter in the aqueous phase, settle and results in the high concentration of metals in sediments [27]. The high concentrations of heavy metals in sediments, which were higher than those in the surface water and the organisms, at the three sampling stations were similar to observations of [28] who reported that the fine silt particles in sediment provide large surface areas and intermolecular forces that adsorb and accumulate heavy metals, making sediment a sink for the metals which may remain there for long periods. Sediments therefore constitute possible sources of continuous contaminants in aquatic systems. Precipitation of these metals may also occur in the form of insoluble hydroxides, oxides and bicarbonates whenever alkaline pH is recorded. [27] Noted that metal mobilization in the sediment environment is dependent on physicochemical changes in the water at the sediment-water interface.

The information about heavy metal content of fish is important for the appropriate management of rivers and the safety of such fish for human consumption. Several studies show a wide variation in heavy metal concentrations in fish and the differences in metal concentrations, chemical characteristics of water from which fish were sampled, ecological needs, metabolism and feeding patterns of fish are responsible for such variations. Fish absorb metals through ingestion of water or contaminated food and heavy metals have been shown to undergo bioaccumulation in the tissue of aquatic organisms. In rivers, fish are often at the top of the food chain with a tendency for concentration and accumulation of heavy metals [29]. Therefore, [30] suggested that bioaccumulation of metals in fish may be an index of metal pollution in the aquatic body. This could also be a useful tool for the study of the physiological role of high metals concentrations in aquatic organisms. The variability in the rate of accumulation may be attributed to the proximity of tissues to toxic medium, physiological state of the tissues, structure and function of organs and the presence of ligands in tissues of organs having an affinity for heavy metal [31]. [32] Noted that the concentration of metals in whole body tissues is often correlated with ambient metal levels in the contaminated habitat.

The higher heavy metal concentration in *O. niloticus* muscle recorded could be attributed to the metals being lipophilic; they reside and accumulate in fatty tissues and these metals may also enter fishes not only by ingestion but also through dermal absorption, which will invariably increase the concentration level in the muscle. [33] Stated that because muscle is not an active tissue for bioaccumulation of metals, accumulation in the muscular tissue of fish, are pointers to the danger of its biomagnifications into humans, being the last level of the trophic chain consuming such contaminated fish. [34] Reported that higher metal concentrations in muscle than in the liver of smelt *Osmerus eperlanus* and perch *Perca fluviatilis*, were due to the characteristics of the fish habitat. The higher concentration of metals recorded in the liver compared to the intestine in this study can be related to the binding of metal to metallothionein in the liver, which serves as a detoxification mechanism. Thus the difference in accumulation pattern of metals in different tissues in the present study was presumably due to the differences in their physiological roles in maintaining homeostasis. [35] Reported that organisms have the

ability to develop a defence mechanism against the harmful effects of metals and other xenobiotics that produces degenerative changes in the aquatic organisms including fish.

The higher concentration of Zinc in this study could be associated with high human activities such as the use of chemicals and Zinc-based fertilizers, discharge of spent engine oil wastes and petrochemicals from the nearby automobile mechanic workshops and high vehicular movement around the study environment. These activities could enhance the high concentration of this metal in soils and waters entering the river. The high Zn level in the *O. niloticus* from this study is similar to the levels reported by [36] in *Parachanna obscura* from Ogba River, Benin City, Nigeria. Such reports are of public health importance since excessive intake of Zn by humans may result in vomiting, dehydration, abdominal pain, nausea, lethargy and dizziness [37].

Copper (Cu) is one of the essential metals necessary for human health in small quantities. Its presence in aquatic environment may be due to accumulation from domestic and agricultural wastes. Copper combines with certain proteins (e.g. Ferritin, Transferrin, plastocyanin.) to produce enzymes that act as catalyst for physiological and metabolic functions. It is also necessary for the synthesis of haemoglobin [38]. However, high quantities may have deleterious effects on most organisms. The high Cu values recorded in water and sediment may have adverse health effects on fish living in such environments after long periods of exposure as with most living organisms. However, the optimal levels recorded in fish muscle, suggests a detoxification mechanism by the fish thereby reducing accumulation from its environmental.

Pb and Cd are toxic elements which have no significant biological functions but show carcinogenic effects on aquatic biota and humans even at low exposures. The high Pb level recorded in water and sediment may be resultant effects of contaminants from the activities of car wash operators and automobile repair workshops located in the area. The Cd levels recorded in fish samples from the study sites which were higher than WHO/FEPA [39] maximum permissible limit of 0.5mg/kg in fish food were also similar to the values recorded in fishes of Olomoro water body [40]. High values were also recorded in fishes from the River Niger [41]. In man, Cd poisoning could lead to anaemia, renal damage, bone disorder and cancer of the lungs [42]. Pb values recorded in fish were within the recommended limits of 2.0mg/kg for fish food. Pb exposure is known to cause musculo-skeletal, renal, ocular, neurological, immunological, reproductive and developmental disorders [37].

Bioaccumulation factors are of particularly great importance denoting much higher detection ability in parasites than fish tissues. The bioaccumulation factors obtained for the analysed metals suggest a higher capacity of parasites to accumulate these metals compared to fish tissues. This suggests an uptake of metal by parasites from the fish tissues. Similar study by [43] reported that nematodes from the liver of *C. gariepinus* have a higher concentration of heavy metals than the tissue. [9] Reported that cadmium was significantly higher in isolated acanthocephalan parasite than in any organ (muscles, intestine and liver) of infected perch. [44][15] Also concluded from their studies that heavy metal concentrations in endoparasites were higher than the concentrations observed in the fish organs.

The increase in the heavy metal concentrations in parasite following an increase in fish host can be interpreted as elemental competition for essential element. Parasites and fish host have been shown to compete for several elements such as Ca, Cu, Fe, Zn and Sr [6]. It is probable that competition for elements between host and parasites for essential elements could lead to increased absorption of heavy metals by the fish parasites thus rendering parasites sensitive metal accumulation bio-monitors than their fish host.

## V. Conclusion

Generally, high level of metals recorded in this study may be attributed to the discharge of effluents by the industries, automobile workshops, domestic and agricultural wastes in river Ogun at Abeokuta. Since parasites from *O. niloticus* accumulated higher levels of heavy metals than water and fish tissues, the fish muscle as well as fish parasites can serve as good bioindicators for heavy metal pollution in aquatic ecosystem. This is however of public health importance because of human consumption of fish harbouring parasites with high heavy metal levels. Protective mechanisms are required to prevent continuous pollution of the river and protection of consumers of its fisheries products.

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