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RESEARCH PAPER

Heavy metals concentration and histopathological profile of some commercial fish species at Makoko Slum Neighbourhood Environment, Lagos, Nigeria

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ABSTRACT

Potentially harmful substances such as pesticides, heavy metals, and hydro chemicals are often released into the aquatic environment. The objective of the present study was to assess the concentration of lead, copper, cadmium, chromium, and nickel in water samples from two different points (Mid-stream and downstream), also determine the levels of Lead, Zinc, Manganese and copper in four commercially important fish species, *Pseudotolithus senegalensis* (croaker fish) and *Ethmalosa fimbriata* (bonga), *Oreochromis mossambicus* (Tilapia fish) and *Bagrus bayad* (silver catfish) from Makoko water body, Yaba, Lagos, Nigeria. Histopathological profile of the fish species selected was also examined. The results were compared to the World Health Organization (WHO) acceptable limit. The concentrations of the heavy metals were analyzed using Perkin Atomic Absorption Spectrophotometer (AAS). *Pseudotholithus senegalensis* had 3.01±0.02, 2.41±0.02, 3.48±0.01, 1.04±0.10 mg kg^{-1} as the mean concentration of lead, zinc, manganese, and copper respectively, while *E. fimbriata* had 1.06±0.02, 2.41±0.02, 4.14±0.01, 1.04±0.10 mg kg^{-1}, *O. mossambicus* had 2.09±0.02, 3.11±0.04, 2.48±0.02, 0.62±0.01 mg kg^{-1} and *B. bayad* had 1.53±0.12, 3.61±0.05, 2.44±0.03, 0.66±0.01 mg kg^{-1} as the mean concentration of these metals in the tissues of these fishes. The concentrations of heavy metals were higher in the gills compared to other organs. The mean concentration of each heavy metal were varied significantly ($p<0.05$) depending on the species of fish. In the histological analysis of the tissues, there was vacuolation of hepatocytes, inflammation, and necrosis. In the muscle, there was a mild lesion, necrosis, inflammation, and cellular degenerations. But the level of tissue and organ degeneration is more severe in the gills. The study showed that some levels of these metals were within the permissible recommended allowed limit for human consumption. It is concluded that Makoko Lagoon water body and fishes are heavily contaminated with heavy metals.

Keywords: Histopathology, Heavy metals, Fish species, Makoko, Lagos Lagoon, Pollutants

INTRODUCTION

Over the years, the aquatic environments have been influenced by contamination from multiple anthropogenic activities, for example industrial development, urbanization, and agricultural practices. The global concern of excessive contamination of aquatic ecosystems has resulted in major health and environment issues (Ayoola and Aina, 2017). The aquatic environment is the most recipient of pollutants produced by human and natural activities (Cavas, 2008; Sarong *et al.* 2013). Pollutants possibly accumulate in tissues of aquatic organisms at concentrations higher than that of the environment. The combinations of chemicals including parent compounds are exposed to organisms in an aquatic environment and these can have series of damages on the aquatic organisms (Ayoola and Aina, 2017). Among the pollutants, heavy metals are an interesting group of elements because this element has a strong impact on the aquatic ecosystems, toxicity persistence and accumulation in aquatic organisms (De *et al.,* 2010). The main impact to human is associated with exposure to cadmium, lead and mercury arsenic. The reduction in seedlings quantity and quality during the embryonic period of any biotic component may have been affected by heavy metals. (Ayoola and Aina, 2017).

Exposure of substances can influence to abnormal physiological responses and cause negative effects on reproduction, growth, behaviour, and development. (Ayoola and Aina, 2017). The contaminants such as heavy metals can directly or indirectly affect DNA. (Omogoriola and Ayoola, 2017). Fish may accumulate metals in their tissues (McCarthy and Shugart, 1990), this accumulation is varies from metal to metal, and it is also species and organ depending of aquatic organisms (Mirzaei *et al.,* 2007). The accumulation process is going to the gill, intestine, or skin to the circulatory system and then proceeds to the organs of detoxification (kidney, liver, and spleen,) either for long-term storage or excretion (Ayoola *et al.*, 2017)). Besides, these heavy metals could also be transferred to human beings that feed on the fish or other contaminated aquatic biotas (Yusni and Sinaga, 2018). According to Ayoola *et al.* (2017), there can be deleterious to human health as a result of heavy metals accumulate in the human body over a long period of time. Food contamination by heavy metals is considered one of the most significant sources of human health risk. Globally and in developing counties like Nigeria, health risk result from consumption of food from aquatic ecosystems contaminated with hazardous chemicals like heavy metals. The frequent use of heavy metals in industries has led to the increasing discharge of harmful heavy metals into the aquatic environment thus, increasing pollution, which is a significant environmental hazard for aquatic organisms, fish, and humans (Omogoriola and Ayoola, 2017).

According to Omogoriola *et al.* (2018), majority of aquatic organisms have the capability of concentrating metals through feeding which can lead to the accumulation of high concentrations of metals in their tissues. Fish is an important sources of energy, proteins, vitamins, and different nutrients. Studies also showed that dietary intake is the main route of exposure to heavy metals for most people. Hence, the aim of the present study was evaluate the level of metallic contamination of Makoko water body, investigate histopathological changes in the gills, livers, kidney, and muscles of some fish species.

MATERIALS AND METHODS

Time and Site

The study was done in Makoko, Lagos Mainland, Lagos, Nigeria, West Africa, and its geographical coordinates are located at latitude 6° 29' 46" (6.4961°) north and longitude 3° 23' 16" (3.3878°) east and it is situated at elevation 4 meters above sea level (as shown in Figure 1). The water system in Makoko is polluted by household wastes and industrial effluents such as petroleum hydrocarbon, sawmill wastes, and faecal matters. Fishing is the main occupation of Makoko people.

Collection of Water and Fish Specimens

The water samples from the lagoon at Makoko were collected into clean 150cl PET bottles from the two selected points (down-stream and mid-stream) respectively according to USEPA procedure for the sampling of wastewater. The water samples meant for physical and chemical analysis were collected into 150cl PET bottles fully while water samples for the determination of heavy metals were collected into PET bottle and nitric acid added to prevented oxidation of organic matters. The temperature and pH values of the water samples were taken at the point of sampling using a calibrated pocket pH meter (model no?) and a digital thermometer. Simultaneously, four different speciesof fish freshly caught from Lagoon through the assistance of fishermen were identified as croaker *(Pseudolithus senegalensis*), silver catfish (*Bagrus bayad*), bonga (*Ethmalosa fimbriata*) and tilapia *(Oreochromis mossambicus*). Water samples were also collected in order to determine metals using the standard method of sampling techniques (APHA, 1999). They were immediately taken to the laboratory.

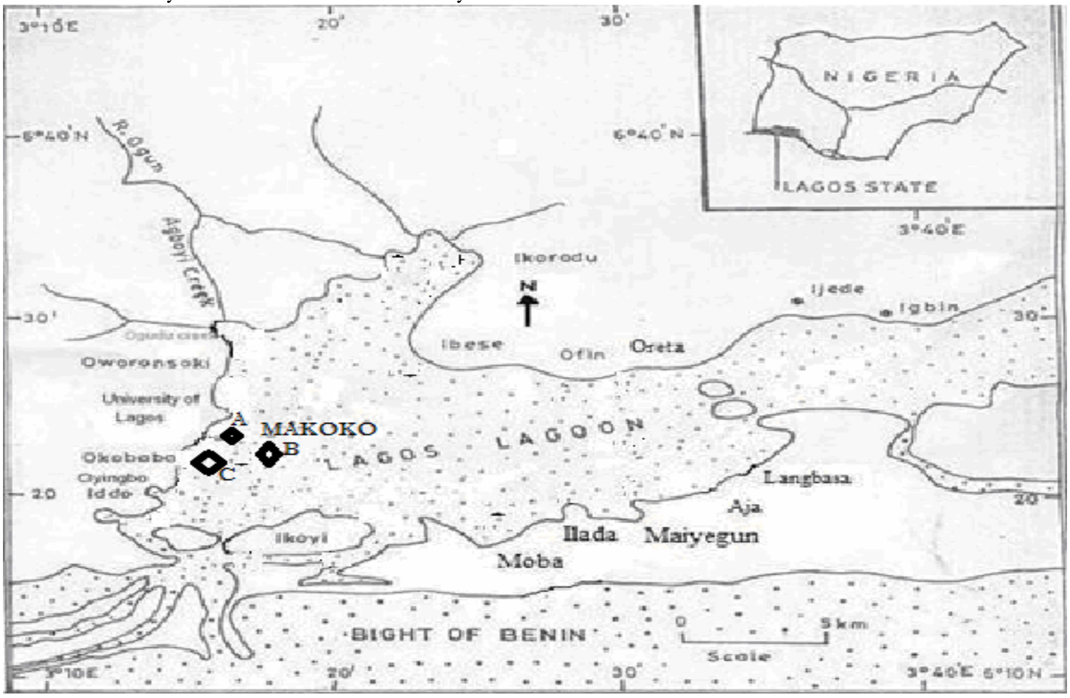

Figure 1: Makoko Lagoon map showing site of sampling

Analysis of the water sample

Water samples from Makoko water body were analyzed for alkalinity using acid-based titrimetric and pH by electrometric method, chloride and Mercuric Nitrate by colorimetric method. The total hardness, calcium, and magnesium were analyzed by using EDTA Titrimetric method. The dissolved oxygen was analyzed by Winkler titrimetric method while chemical oxygen demand was analyzed by Reflux Oxidation and Titrimetric method. The total dissolved solids and total solids were analyzed by gravimetric method. The biochemical oxygen demand was analyzed using dilution nitrate Phenoldisulphonic Acid Colorimetric method while phosphate was analyzed by using Phosphomolybdate colorimetric method. The turbid metric method was used to analyze sulphate while Nessler's Colorimetric method was used for ammonia. The metals such as Pb, Cd, Cr, Cu, Co, and Ni were analyzed by using Atomic Absorption Spectrophotometry (AAS) as detailed in the standard procedures of the AOAC (1990) and the APHA-AWWA-WPCF (1985) manuals.

Determination of Residual Heavy Metals in some selected commercially important fishes

Residual concentrations of heavy metals were measured using a Flame atomic absorption spectrophotometer (Perkin Elmer-2280, USA) in fish tissues (liver, kidney, gill, skin, and muscle) according to the APHA (2005).

Statistical analysis

Data were subjected to Student *t*-test, analyses of variance (*F* test) followed by the Duncan's multiple range test to evaluate the difference in means, at $p < 0.05$ using SAS version 9.1(SAS,2018).

RESULTS

The pH values of the two samples (downstream and midstream) of water from Makoko waterbody were 7.11 and 7.13 (Table 1). There was no significant difference (p>0.05) between the pH value of water taken at the downstream and midstream. The pH values of water samples were found to be within the permissible value specified by the World Health Organization (WHO, 2005) for Water. The temperatures of Makoko waterbody taken at two different points were 27.0°C and 27.2°C. There was no significant difference in the temperature of the water. The temperature of the water plays a major role in the quality of aquatic life and habitats. As the fluctuation of temperature determines what species will live and thrive in a body of water. At this temperature ranges, the fishes can still live and thrive in a body of water.

The total dissolved solids of water samples from two different points were 344 mg L^{-1} and 365 mg L^{-1} respectively. These values were still found within the desirable limit as the maximum permissible value of 500 mg L^{-1} as specified by WHO (2005). However, the values were considered high as they were tending towards the permissible limit by WHO (2005). The reason for this could be attributed to pollution where wastewaters are discharged into the river. The levels of salinity of water were between 60.1 to 69.1 (mg L^{-1}). These values were still in the desirable limit. As the salinity of the water is related to the total dissolved solids. The value of dissolved oxygen, biochemical oxygen demand and chemical oxygen demand of the water samples were in the range of 2.14- 2.37 (mg L^{-1}), 38.0-39.2 (mg L^{-1}) and 43.5- 46.6 (mg L^{-1}). The dissolved oxygen of down-stream was higher than that of the mid-stream. The values of BOD and COD for both down-stream and mid-stream were high. When BOD levels are high, dissolved oxygen levels decrease because the oxygen that is available in the water is being used by bacteria.

Table 1. Physical and Chemical Properties of Water Samples from Makoko waterbody (Down and Mid-stream)

Parameters/units	**Average of *D.S**	**Average of *M.S**
pH	7.13 ±0.01*	7.11 ±0.06
Temperature, °C	27.2 ±0.01	27.0 ±0.00
*TDS, mg/l	365 ±1.00	344 ±0.03
Salinity, $^0/_{00}$	60.1 ±0.02	69.1 ±0.25
*DO, mg/l	2.37 ±0.03	2.14 ±0.45
*BOD, mg/l	38.0 ±1.00	39.2 ±1.02
*COD, mg/l	46.6 ±5.00	43.5 ±1.55
Nitrate, mg/l	3.31 ±0.06	3.69 ±0.05
Phosphate, mg/l	2.09 ±0.06	2.05 ±0.06
Oil & Grease, mg/l	0.01 ±0.01	0.63 ±0.01

* D.S: Down Stream and M.S: Mid-Stream

Table 2 shows the average mean of concentration of heavy metals in the water sample from down-stream and mid-stream of Makoko waterbody which are cadmium (0.64 ±0.02 and 0.72±0.04), chromium(0.02 ±0.01 and0.03±0.01), copper (0.54±0.10 and 0.49 ±0.01), lead(0.31

±0.02 and 1.42 ±0.02) and nickel (2.01 ±0.01 and 1.65 ±0.01). The maximum limit of the concentration of lead, nickel, and cadmium in the water body is higher than the maximum limits (0.01, 0.02 and 0.003 mg L^{-1}) by WHO, (1990). But the accumulation of the copper was found to be within maximum permissible of WHO, (1990). The high concentration of heavy metals in the water body was due to industrial waste and domestic waste which have a high level of these heavy metals.

Table 2. Concentrations of selected heavy metals in Makoko Lagoon (Down- & Mid-stream)

Parameters	Average of *H.M in D.S (mg kg^{-1})	Average of H.M in M.S	WHO Limit
Cadmium	0.64 ±0.02	0.72 ±0.04	0.5
Chromium	0.02 ±0.01	0.03 ±0.01	0.5
Copper	0.54 ±0.10	0.49 ±0.01	0.3
Lead	0.31 ±0.02	1.42 ±0.02	0.3
Nickel	2.01 ±0.01	1.65 ±0.01	80

*H.M: Heavy metals, D.S: Down -Stream, M.S: Midstream

Heavy Metal Concentration

The table 3a-3d showed the concentration of heavy metals in extracted organs of four selected fishes. The concentration of lead in tilapia fish (gill: 2.09±0.02, kidney: 0.59±0.02, liver: 0.55±0.01 and muscle: 0.06±0.01 mg kg^{-1}). The concentration of lead in the organs of tilapia fish are higher in gill in order of 2.09>0.59>0.55>0.06 (gill>kidney>liver>muscle). The levels of lead present in organs of tilapia have all exceeded the maximum permissible limits given by WHO (2005). The concentration of zinc in tilapia fish (gill: 3.11±0.04, kidney: 2.28±0.02, liver: 1.20±0.06 and muscle: 0.20±0.04 mg kg^{-1}). The concentration of zinc in the organs of tilapia fish are higher in gill in order of 3.11>2.28>0.1.20>0.20 (gill>kidney>liver>muscle). The levels of zinc present in organs of tilapia all exceed the maximum permissible limits given by WHO (2005). The concentration of manganese in Tilapia fish (gill: 2.48±0.02, kidney: 1.23±0.01, liver: 1.05±0.01and muscle: 0.22±0.01). The concentration of manganese in the organs of tilapia fish are higher in gill in order of 2.48>1.23>1.05>0.22 (gill>kidney>liver>muscle). The levels of manganese present in organs of tilapia all exceed the maximum permissible limits given by WHO (2005).

The concentration of copper in Tilapia fish (gill: 0.62±0.01, kidney: 0.55±0.01, liver: 0.39±0.03 and muscle: 0.23±0.10). The concentration of copper in the organs of tilapia fish are higher in gill in order of 0.62>0.55>0.39>0.23 (gill>kidney>liver>muscle). The levels of copper present in organs of tilapia all exceed the maximum permissible given by WHO (2005). The concentration of lead in croaker fish (gill: 3.01±0.02, kidney: 0.58±0.03, liver: 0.44±0.01and muscle: 0.13±0.03). The concentration of lead in the organs of croaker fish are higher in gill in order of 3.01>0.58>0.44>0.13 (gill>kidney>liver>muscle). The levels of lead present in organs of tilapia are all exceeded the maximum permissible given by WHO (2005). The concentration of zinc in Crocker fish (gill: 2.41±0.02, kidney: 2.18±0.02, liver: 1.14±0.10and muscle: 0.20±0.01). The concentration of zinc in the organs of tilapia fish are higher in gill in order of

2.41>2.18>1.14>0.20 (gill>kidney>liver>muscle). The levels of zinc present in organs of tilapia are all exceeded the maximum permissible given by WHO (2005).

The concentration of manganese in croaker fish (gill: 3.48±0.01, kidney: 2.66±0.05, liver: 2.01±0.05and muscle: 0.12±0.01). The concentration of manganese in the organs of croaker fish are higher in gill in order of 3.48 >2.66>2.01>0.12 (gill>kidney>liver>muscle). The levels of manganese present in organs of tilapia all exceed the maximum permissible given by WHO (2005). The concentration of copper in croaker fish (gill: 1.04±0.10, kidney: 0.28±0.01, liver: 0.44±0.01and muscle: 0.33±0.03). The concentration of copper in the organs of tilapia fish are higher in gill in order of 1.04>0.44>0.33>0.28 (gill>liver>muscle>kidney). The levels of copper present in organs of croaker all exceed the maximum permissible given by WHO (2005).

Table 3. Mean concentrations of heavy metals in several fish species

Bonga Fish (*Ethmalosa fimbriata*)

Heavy metals	Mean (±SD) Concentration of heavy metals (mg/kg)			
	Gill	Kidney	Liver	Muscle
Lead	1.06 ±0.02	0.70±0.02	0.57±0.01	0.22±0.01
Zinc	2.41±0.02	2.28±0.02	1.20±0.04	0.51±0.02
Manganese	4.14±0.01	3.37±0.05	1.62±0.01	0.21±0.01
Copper	1.04±0.10	0.46±0.10	0.34±0.01	0.22±0.02

Croaker Fish (*Pseudolithus senegalensis*)

Heavy metals	Mean (±SD) Concentration of heavy metals (mg/kg)			
	Gill	Kidney	Liver	Muscle
Lead	3.01±0.02	0.58±0.03	0.44±0.01	0.13±0.03
Zinc	2.41±0.02	2.18±0.02	1.14±0.10	0.20±0.01
Manganese	3.48±0.01	2.66±0.05	2.01±0.05	0.12±0.01
Copper	1.04±0.10	0.28±0.01	0.44±0.01	0.33±0.03

Tilapia Fish (*Oreochromis mossambicus*)

Heavy metals	Mean (±SD) Concentration of heavy metals (mg/kg)			
	Gill	Kidney	Liver	Muscle
Lead	2.09±0.02	0.59±0.02	0.55±0.01	0.06±0.01
Zinc	3.11±0.04	2.28±0.02	1.20±0.06	0.20±0.04
Manganese	2.48±0.02	1.23±0.01	1.05±0.01	0.22±0.01
Copper	0.62±0.01	0.55±0.01	0.39±0.03	0.23±0.10

Silver Catfish (*Bagrus bayad*)

Heavy metals	Mean (±SD) Concentration of heavy metals(mg/kg)			
	Gill	Kidney	Liver	Muscle
Lead	1.53±0.12	0.66±0.05	0.50±0.01	0.02±0.01
Zinc	3.16±0.05	2.32±0.04	1.11±0.05	0.16±0.01
Maganese	2.44±0.03	1.28±0.02	1.39±0.03	0.26±0.01
Copper	0.66±0.01	0.58±0.01	0.62±0.10	0.28±0.01

The concentration of lead in Silver catfish (gill: 1.53±0.12, kidney: 0.66±0.05, liver: 0.50±0.01and muscle: 0.02±0.01). The concentration of lead in the organs of silver catfish are higher in gill in order of 1.53>0.66>0.50>0.02 (gill>kidney>liver>muscle). The levels of lead present in organs of silver catfish all exceed the maximum permissible given by WHO (2005). The concentration of zinc in Silver catfish (gill: 3.16±0.05, kidney: 2.32±0.04, liver: 1.11±0.05 and muscle: 0.16±0.01).The concentration of zinc in the organs of silver catfish are higher in gill in order of 3.16>2.32>1.11>0.16 (gill>kidney>liver>muscle). The levels of zinc present in organs of silver catfish all exceed the maximum permissible given by WHO (2005). The concentration of manganese in Silver catfish (gill: 2.44±0.03, kidney: 1.28±0.02, liver: 1.39±0.03and muscle: 0.26±0.01). The concentration of manganese in the organs of tilapia fish are higher in gill in order of 2.44>1.39>1.28>0.26 (gill>liver>kidney>muscle). The levels of manganese present in organs of tilapia all exceeded the maximum permissible limits given by WHO (1999). The concentration of copper in Silver catfish (gill: 0.66±0.01, kidney: 0.58±0.01, liver: 0.62±0.10 and muscle: 0.28±0.01) while concentration of copper in the organs of tilapia fish are higher in gill in order of 0.66>0.62>0.58>0.28 (gill>liver>kidney>muscle). The levels of lead present in organs of silver catfish all exceeded the maximum permissible limits given by WHO (1999).

The concentration of lead in Bonga fish (gill: 1.06 ±0.02, kidney: 0.70±0.02, liver: 0.57±0.01and muscle: 0.22±0.01). The concentration of lead in the organs of tilapia fish are higher in gill in order of 1.06>0.70>0.57>0.22 (gill>kidney>liver>muscle). The levels of lead present in organs of Bonga all exceeded the maximum permissible limits given by WHO (1999). The concentration of zinc in Bonga fish (gill: 2.41±0.02, kidney: 2.28±0.02, liver: 1.20±0.04 and muscle: 0.51±0.02). The concentration of zinc in the organs of tilapia fish are higher in gill in order of 2.41>2.28>1.20>0.51 (gill>kidney>liver>muscle). The levels of lead present in organs of Bonga fish all exceed the maximum permissible given by WHO (1999).

The concentration of manganese in Bonga fish (gill: 4.14±0.01, kidney: 3.37±0.05, liver: 1.62±0.01and muscle: 0.21±0.01).The concentration of manganese in the organs of Bonga fish are higher in gill in order of 4.14>3.37>1.62>0.21 (gill>kidney>liver>muscle). The levels of manganese present in organs of tilapia all exceeded the maximum permissible limits given by WHO (1999). The concentration of copper in Bonga fish (gill: 1.04±0.10, kidney: 0.46±0.10, liver: 0.34±0.01and muscle: 0.22±0.02). The concentration of lead in the organs of tilapia fish are higher in gill in order of 1.04>0.46>0.34>0.22 (gill>kidney>liver>muscle). The levels of copper present in organs of Bonga fish all exceeded the maximum permissible limits given by WHO (1999).

The result of histopathological examination of organs of four fish species shows some histopathological alteration resulting from the accumulation of heavy metals in these organs. The research is pertinent as it attempts to assess the histopathological effect of commercial importance in Makoko landing site of Lagos state. Based on the analysis of results to establish the level of metallic contamination of the fishes and its histopathological examination of extracted organs, it was discovered that the concentration of heavy metals was higher and histopathological examination of the organs show alteration resulting from heavy metal contamination.

DISCUSSION

In this study, the Makoko landing site is highly contaminated with heavy metals attributed to chemical waste from various activities including automobile servicing, dumps, pesticides that discharge effluents into the site. The water and fish samples taken in this vicinity and analyzed were found to contain an elevated concentration of heavy metals. The concentration of heavy metals in fish samples correlate well with the metal concentration observed in the water samples and the result of analyses provided valuable quantitative information as reported by Ayoola and Aina (2017), that heavy metals and their salts constitute the most widely distributed group of highly toxic and long retained pollutants and exposure to them even at low concentration is associated with diverse health effect, (Omogoriola and Ayoola, 2017). This study establishes the significant pollution index of the Makoko landing site, as it clearly shows the stress exposure of fish resident in this location and seems to adequately explain the preponderance of observed lesions and these are attributable to the measurable levels of heavy metals as reported in the Ologe Lagoon by Ayoola and Aina (2017).

More realistically, it could be presumed that the levels of contaminations in the test waters are significant and the exposure of resident fish population could lead to the destruction of vital organs. The water quality information shows that the differences in habitat quality and shows that the maximum limit of the concentration of Cadmium in Mid-stream is higher in comparison to Down-stream. The accumulation of heavy metals in Croaker Fish (*Pseudolithus senegalensis*), Bonga Fish (*Ethmalosa fimbriata*) and Silver catfish (*Bagrus bayad*) were relatively high when compared with maximum allowed limit of 0.5mg/kg in fish food as stated in FAO (1997); thus, corresponding with the metallic toxicity of three aquatic components through water, plankton and sediments while Tilapia Fish (*Oreochromis mossambicus*) and Silver catfish (*Bagrus bayad*) showed low concentration of heavy metals. High metal concentration is low in muscles and relatively highest in the liver and gill which can combine with other contaminants such as Ammonia and Mercury to produce an addictive toxic effect on fish as proved by Cengiz and Unlu, (2002) on the histopathological changes in gills of different fish species exposed to pollutants.

In this analysis, Manganese bioaccumulation in Bonga fish (*Ethmalosa fimbriata*) gill was the highest; this is an indication that the ability of fish tissue to either regulate or accumulate metals and this is directly related to the amount of metal accumulated in the specific tissue, physiological difference and the position of each tissue in the fish as supported by Mallat (1985) that accumulation of heavy metals in a tissue is primarily a reflection of concentrations of metals in water and exposure time. It depends on the sources, uptake, diet or waterborne exposure. Also, the liver is the main organ for detoxification that suffers serious morphological alterations in fish exposed to pesticides (Dutta *et al.*, 1993). The changes and Alterations in the tissues may be useful as markers that indicate prior exposure to environmental stressors (Ayoola and Alajabo, 2012).

All the histopathological observations indicated a destructive effect in the gill and liver tissues of fishes. In the histological analysis of the tissues, there was vacuolation of hepatocytes, inflammation, and necrosis. In the muscle, there was a mild lesion, necrosis, inflammation, and cellular degenerations. But the level of tissue and organ degeneration was more severe in the gills.

This is in agreement with the finding of Bradl, (2002). Gill and liver histopathological alterations, such as those observed in this study and findings from previous studies, could result in severe physiological problems, ultimately leading to the death of fish. Histopathological results indicated that gill was the primary target tissue affected by pollutants. Rankin *et al*. (1982) reported that gills are generally considered a good indicator of water quality, being models for studies of environmental impact.

CONCLUSION

This research work clearly revealed that Makoko Lagoon water body and fishes are heavily contaminated with heavy metals due to large and small-scale industrial activities in the area and the neighbouring cities.

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