

ASSESSMENT OF HEAVY METAL POLLUTION IN *Clarias agboyiensis* and *Synodontis clarias* IN EPE AND LEKKI LAGOONS, NIGERIA

¹EITOKPAH, E. P., ²CHUKWU, L. O., ²LAWAL-ARE, A. O. & ¹BASSEY, O.B.

1 Nigerian Institute for Oceanography and Marine Research, Victoria Island Lagos

2. Marine Science Department, Faculty of Science, University Of Lagos, Akoka.

Corresponding author email: priscillaeit@gmail.com

ABSTRACT

Heavy metal pollution has generated serious concern across the globe. Fishes exposed to polluted water may induce physiological changes, which serve as a useful tool for assessing the health status of aquatic ecosystems. This study assessed the heavy metal pollution in *Clarias agboyiensis* and *Synodontis clarias* from Epe and Lekki lagoons. Samples were collected from pollution hotspots of the lagoons to evaluate the levels of heavy metals- lead (Pb), Zinc (Zn), Cadmium (Cd) and Iron (Fe) in liver, gills and gonads of *Clarias agboyiensis* and *Synodontis clarias* from Epe and Lekki Lagoons. Four sampling sites were established in each lagoon for four ecological seasons. The mean levels of heavy metals showed significant differences ($p < 0.05$) in the organs (gill, gonad and liver) and below permissible limit by WHO. The levels of heavy metals were in the order; $Fe > Zn > Pb > Cd$ as well as $liver > gill > gonad$ *Clarias agboyiensis* and *Synodontis clarias* from Epe and Lekki Lagoons. This is an indication that the gonad, gill and liver are good reflector of accumulated heavy metal pollutant from aquatic ecosystems. This study would serve as complimentary tools in the biomonitoring of the aquatic ecosystem.

Keywords: Heavy metals, Lagoons, Fish

INTRODUCTION

In the recent years, heavy metal pollution has become a serious concern all over the globe. These heavy metals are not readily degradable in the environment and thus accumulate in the animal and human tissues to a very high toxic level leading to undesirable effects (Kaur and Mehra, 2012).

The discharge of untreated or partially treated industrial waste water containing heavy metals into the water bodies, especially rivers get bioaccumulated along the food chain. Aquatic organisms have the ability to accumulate heavy metals from various sources including sediments, soil erosion and run off, air depositions of dust and aerosol and discharge of waste water (Godwin *et al.*, 2003, Hansel *et al.*, 2008). Fishes are often at the top of the aquatic food chain and may accumulate large amounts of metals prevalent in water (Mansour and Sidky, 2002).

The fish, as a bioindicator species plays an increasingly important role in the monitoring of water pollution because it responds with great sensitivity to changes in the aquatic environment (Mondon *et al.*, 2001). The exposure of fish to any stress induces a number of modifications in different organs, particularly gills, liver, gonad.

This organ plays a major role in metabolism and has a number of functions in the body, including glycogen storage, decomposition of red blood cells, plasma protein synthesis, hormone production, and detoxification (Kmiec, 2001). The gills are not only the prime organs for gaseous exchange, it also performs several other physiological functions including osmoregulation and excretion. Gills have a

large surface area in contact with the external environment; it is particularly sensitive to chemical and physical changes of the aquatic environment, thereby being the target organ in the fish for pollutants carried by water.

According to Nwankwo (2004), an important ecological ramification of increasing population pressure, poor sewage system, industrialization and poor waste management in Nigeria's coastal area is that pollutants freely find their way unabated into coastal waters through drains, canals, rivers, creeks and lagoons that act as conduits. Lagos State is within a low lying coastal zone of the south-western Nigeria sedimentary basin (Nwilo and Onuoha, 1993). This low lying position tends to influence the flow of other water towards the lagoons. Being a central receptacle of water bodies draining a large area of agricultural and industrial lands, the lagoons has been described as a sink to large amounts of aquatic pollutants resulting in severe consequences for the biota. These industrial effluents have impacts on the hydrochemistry of coastal ecosystems (Chukwu, 2006).

Heavy metals including both essential and non-essential elements have a particular significance in ecotoxicology, since they are highly persistent and all have the potential to be toxic to living organisms (Storeli *et al.*, 2005). The Lagos lagoon is the largest of the four lagoon systems of the Gulf of Guinea (Chukwu, 2002). The deficiency of an essential metal can therefore cause an adverse health effect, whereas its high concentration can also result in negative impacts which are equivalent to or worse

than those caused by non-essential metals (Kennedy, 2011).

The toxic action of metals is particularly pronounced in the early stages of fish development (Vinodhini and Narayanan, 2008) and adversely affects various metabolic processes in developing fish (embryos in particular) resulting in developmental retardation, morphological and functional deformities. Heavy metals produce toxic effects at high concentrations, and thus could be considered as risk factors for several diseases (Medil *et al.*, 2010).

Study Area

The Lekki lagoon is one of the largest lagoons in West Africa and it supports a major fishery. The lagoon is located between Lagos and Ogun States of Nigeria and lies between longitude 003° 55' and 4° 15' E and between latitude 6° 25' and 6° 37' N. According to Kusemiju (1973), the lagoon has a surface area of about 247 km² and it is mostly

shallow (less than 3.0 m deep) the maximum depth being 6.4 m. Lekki lagoon is a freshwater environment fed by the river Oni in the North eastern part and by Rivers Oshun and Saga in the north western parts of the lagoon. It opens into the sea via the Lagos lagoon and Lagos harbour. Epe Lagoon is situated between latitudes 003°50' – 004°10'N and longitudes 06°35' – 06°40'E. The lagoon lies within the rainforest belt of southern Nigeria. Riparian vegetation at the bank of the lagoon consists mainly of grasses and secondary rainforest. The study area recognized some hotspots such as PVC factory, Oil depot/ storage facility, Dredgers, thermal plant, Wood-shaves canoe construction factory and rural setting with most of the population concentrated along the bank of the lagoon. Also, most inhabitants of the shore communities do not have toilet facilities hence defecation and release of other human wastes into the lagoon are common features in the study area. The map of Lekki and Epe lagoons are presented in Figure 1.

Table 1: Description of sampling stations at Epe and Lekki lagoons

Stations	Lagoons	Locations	Longitude	Latitude	Possible Pollution Sources
1	Lekki	Abejuoye	003°34'32.6"	6°30'56.2"	PVC Factory Generating Thermal Stress
2	Lekki	Okerakekere	03°34'53.1"	6°29'34.3"	Dredging activities
3	Epe	Oko-orisan	03°56'36.6"	6°34'37.1"	Oil Depot/Storage activities
4	Epe	Oju Alaro	03°58'44.9"	6°34'38.4"	Wood shaves deposition from Canoe Construction Factory, Dredging and domestic activities

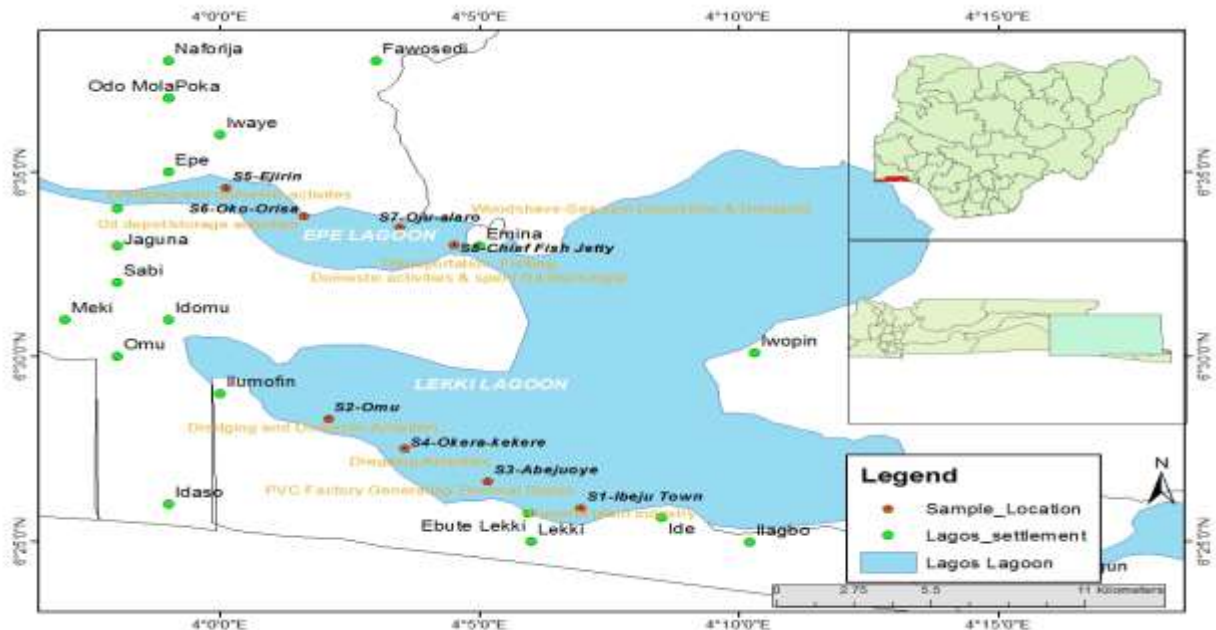


Fig. 1: Map of sampling stations at Epe and Lekki Lagoons
 Source: GIS Lab, Geography Department, University of Lagos

MATERIAL AND METHODS

Field sampling operations

A total of eight sampling stations were selected from each of two lagoons (Lekki and Epe) comprising of four stations on the basis of their accessibility and closeness to the hotspots where the pollutants are discharged into the lagoons alongside the coordinates in Table 1. Sampling durations was dictated by the two hydrological seasons (wet and dry) prevalent in the tropics (Oyewo, 1998). The fish samples used for this study were *Synodontis clarias* and *Clarias agboyiensis* (Figure 2).

The length and weight of *Synodontis clarias* were 27.25cm and 275.3g respectively. The Standard length and weight of *Clarias agboyiensis* were 30cm and 355.4g. Local fish samples were obtained from

fisher folks at the respective sampling stations. Collection of samples was carried out on ecological season.

Samples were collected and dissected to remove gills, liver and gonad samples. The gills were collected by opening the operculum of the fish samples. The liver and gonad samples were dissected out of the fish through the ventral side. The fish samples were bought from fish landing sites at Lekki and Epe and identified at the Marine Biology Section of the Institute of Oceanography. Ten specimens each of *Clarias agboyiensis* and *Synodontis clarias* were used for the study. Standard length of the samples was taken using a graduated ruler while body weight was measured using a balance. Fish specimens were sourced from four sampling stations.



Plate 1: *Synodontis clarias*



Plate 2: *Clarias agboyiensis*

Digestion of Fish Sample

Mixture of nitric acid and hydrochloric acid (1:3) was added to liver, gill and gonad sample and allowed to stand for five minutes. Sample mixture was then placed on a hot plate and heated at 120°C for 20-30 minutes and allowed to cool and filtered. The filtrate was transferred into 50mls standard flask, then made up to mark with distilled water.

Samples were poured into sample bottles and aspirated into an atomic absorption spectrophotometer for analysis (Agilent 200 AAS spectrometer).

RESULTS

The mean concentrations of heavy metals in the gill, gonad and liver of *Synodontis clarias* and *Clarias agboyiensis* are presented in Table 2. The

levels of heavy metal in the gill, gonad and liver of *Synodontis Clarias* and *Clarias agboyiensis* were generally below the WHO limits. The ANOVA showed that the heavy metal exhibited significant difference ($p < 0.05$) in the gill, gonad and liver of the fish species across the stations within Lekki and Epe lagoons. The Pearson correlation coefficient at Table 3 showed that the heavy metals concentrations indicated positively significant correlation ($p < 0.05$, $r = 0.983^*$) between cadmium and iron in gill as well as cadmium and zinc in gill ($p < 0.05$, $r = 0.984^*$).

Tables 2: The mean heavy metal concentrations in gonad, gill and liver of *Synodontis Clarias* and *Clarias agboyiensis* from Lekki and Epe Lagoons, South-Western Nigeria

GONAD					
Metals	Lekki Lagoon		Epe Lagoon		WHO limit($\mu\text{g/g}$)
	<i>Synodontis Clarias</i> ($\mu\text{g/g}$)	<i>Clarias agboyiensis</i> ($\mu\text{g/g}$)	<i>Synodontis Clarias</i> ($\mu\text{g/g}$)	<i>Clarias agboyiensis</i> ($\mu\text{g/g}$)	
Cd	0.06 \pm 0.01 ^{ab}	0.06 \pm 0.003 ^{ab}	0.05 \pm 0.004 ^{ab}	0.05 \pm 0.003 ^{bc}	2.0
Pb	0.03 \pm 0.004 ^b	0.03 \pm 0.004 ^{ab}	0.11 \pm 0.01 ^b	0.11 \pm 0.01 ^{ab}	2.0
Fe	3.14 \pm 0.33 ^{bc}	3.13 \pm 0.33 ^{ab}	3.92 \pm 0.51 ^{ab}	3.91 \pm 0.51 ^{ab}	100
Zn	1.05 \pm 0.07 ^c	1.05 \pm 0.07 ^{ab}	1.43 \pm 0.06 ^b	1.43 \pm 0.06 ^{ab}	75

GILL					
Metals	Lekki Lagoon		Epe Lagoon		WHO limit($\mu\text{g/g}$)
	<i>Synodontis Clarias</i> ($\mu\text{g/g}$)	<i>Clarias agboyiensis</i> ($\mu\text{g/g}$)	<i>Synodontis Clarias</i> ($\mu\text{g/g}$)	<i>Clarias agboyiensis</i> ($\mu\text{g/g}$)	
Cd	0.01 \pm 0.002 ^b	0.01 \pm 0.002 ^b	0.04 \pm 0.01 ^b	0.04 \pm 0.01 ^{ab}	2.0
Pb	0.01 \pm 0.003 ^b	0.01 \pm 0.002 ^{ab}	0.01 \pm 0.002 ^{ab}	0.01 \pm 0.002 ^{ab}	2.0
Fe	31.83 \pm 3.01 ^b	31.83 \pm 3.01 ^b	47.11 \pm 2.13 ^{ab}	47.11 \pm 2.13 ^{ab}	100
Zn	2.39 \pm 0.11 ^{bc}	2.38 \pm 0.11 ^{ab}	2.81 \pm 0.81 ^{ab}	2.81 \pm 0.03 ^{ab}	75

LIVER					
Metals	Lekki Lagoon		Epe Lagoon		WHO limit($\mu\text{g/g}$)
	<i>Synodontis Clarias</i> ($\mu\text{g/g}$)	<i>Clarias agboyiensis</i> ($\mu\text{g/g}$)	<i>Synodontis Clarias</i> ($\mu\text{g/g}$)	<i>Clarias agboyiensis</i> ($\mu\text{g/g}$)	
Cd	0.08 \pm 0.01 ^b	0.08 \pm 0.005 ^b	0.15 \pm 0.01 ^{ab}	0.15 \pm 0.01 ^b	2.0
Pb	0.05 \pm 0.01 ^{bc}	0.004 \pm 0.001 ^{bc}	0.16 \pm 0.02 ^b	0.004 \pm 0.001 ^b	2.0
Fe	55.76 \pm 3.04 ^b	55.76 \pm 3.04 ^{ab}	34.54 \pm 1.57 ^b	34.54 \pm 1.57 ^b	100
Zn	6.81 \pm 0.31 ^{bc}	6.80 \pm 0.31 ^{ab}	23.51 \pm 5.27 ^{bc}	23.50 \pm 5.27 ^b	75

Mean \pm S.E (Standard error) with $p < 0.05$ indicating significant difference in the spatial variations across the stations and seasons.

Table 3: Pearson correlation coefficient of heavy metals in gill, gonad and liver of *Clarias agboyiensis* and *Synodontis clarias* from Lekki and Epe lagoons

	Cd_GO	Pb_GO	Fe_GO	Zn_GO	Cd_GI	Pb_GI	Fe_GI	Zn_GI	Cd_LI	Pb-LI	Fe_LI	Zn_GI
Cd_GO	1											
Pb_GO	-1.000**	1										
Fe_GO	-1.000**	1.000**	1									
Zn_GO	-1.000**	1.000**	1.000**	1								
Cd_GI	0.151	-0.151	-0.163	-0.151	1							
Pb_GI	0.944	-0.944	-0.947	-0.944	0.399	1						
Fe_GI	0	0	-0.013	0	-983*	0.28	1					
Zn_GI	0.007	-0.007	-0.02	-0.007	-984*	0.287	1.000**	1				
Cd_LI	-1.000**	-1.000**	1.000**	1.000**	-0.151	-0.944	0	-0.007	1			
Pb_LI	-0.431	0.431	0.442	0.431	-0.799	-0.705	-0.792	-0.796	0.431	1		
Fe_LI	1.000**	-	-1.000**	-1.000**	0.151	0.944	0	0.007	-	-0.431	-1	
		1.000**							1.000*			
									*			
Ze_LI	-1.000**	1.000**	1.000**	1.000**	0.151	-0.944	-0.001	-0.008	1.000*	0.432	1.000	1
									*		**	

** Correlation is significant at the 0.01 level (2-tailed), * Correlation is significant at the 0.05 level (2-tailed). GO- Gonad, GI- Gill and LI - Liver

DISCUSSION

In recent years, lagoons have been subjected to anthropogenic pollutants capable of impairing the healthy status of an ecosystem. Heavy metals were assessed in the gill, gonad and liver of *Clarias agboyiensis* and *Synodontis clarias* for four ecological seasons in Epe and Lekki Lagoons.

This study revealed that the measured concentrations of all metals in the target organs of the fish species in Epe and Lekki lagoons were below standard guidelines of WHO (2011). The Pearson's correlation coefficient showed significant correlation between Cd and Fe as well as Cd and Zn in the gill shows a relationship of similar discharge source and impact in the gill which is an indication of anoxic water quality thus impairs respiration of the fish species. However, the highly significant positive correlations between heavy metals suggest the possibility of common sources of origins which may be anthropogenic in both lagoons (Armah *et al.*, 2010).

Although the levels of heavy metal in the organs of the fish species in both lagoons were below permissible standards, but metals showed significant differences ($p < 0.05$) in the organs of *Clarias agboyiensis*, except Cr and Pb showed no significant difference ($p > 0.05$) in the organs *Synodontis clarias* across the stations and seasons. Hence, the metals used in this study have posed no threat for consumption of the fish from the coastal water. Copper and Zinc are essential element and are regulated by physiological mechanisms in most organism. However, occurrence of excessive levels of them is regarded as potential hazard which can endanger both animal and human health (Wright and Welbourn, 2002).

The slight increase in the concentration of Zinc in this study could be associated with human activities and vehicular movement that occur in the environment. Human activities such as the use of chemicals and Zinc-based fertilizers by farmers and spent engine oil wastes and petrochemicals from the nearby welder and automobile mechanic workshops could also enhance a high concentration of this metal in sediment and surrounding aquatic ecosystems. The highest mean values of Zn level were observed in 1.43 µg/g in gonad, 2.81 µg/g in gill and 23.51 µg/g in liver of *Synodontis clarias* from Epe lagoon, Lagos Nigeria and similar to the zinc level reported by Obasohan (2007), who recorded (10.18 - 15.28 mg/100g) in *Parachanna obscura* from Ogba River, Benin City, Nigeria.

However at high concentrations, zinc exerts adverse effects in fish accumulating structural damage, which affects the growth, improvement and survival of fish. Zinc accumulates in the gills of fish and this designates a depressing effect on tissue respiration leading to death by hypoxia. Although

humans can handle proportionally large concentrations of zinc, too much zinc can still cause renowned health problems, such as stomach cramps, skin annoyances, vomiting, nausea and anemia.

Very high levels of zinc can damage the pancreas and disturb the protein metabolism, and cause arteriosclerosis (Afshan *et al.*, 2014). Although the levels of Heavy metal in the organs of the fish species in both lagoons were below permissible standard but metals showed significant differences ($P < 0.05$) in the organs of *Clarias agboyiensis*. Target organs such as the liver and gills are metabolically active tissues that accumulate metals at high level. Accumulation of heavy metals in fish can be probably attributed to presence of these pollutants in the ecosystem. Occurrence of excessive levels of the heavy metal is regarded as potential hazard which can endanger both animal and human health.

CONCLUSION

The identified hotspots with anthropogenic activities around Lekki and Epe lagoons contribute significantly to the pollution of these water bodies. The results of this finding present a valuable baseline data on the heavy metals in the organs of fish from Lekki and Epe lagoons. The metals – Cd, Pb, Fe and Zn in gonad, gill and liver were below the limits by WHO. The decreasing order of heavy metals profile in the organs are; Liver > Gill > Gonad in both fish species from both lagoons. Despite the low concentrations of cadmium and lead compared to the 2 µg/g recommended as maximum limit for fish (WHO, 2011), the frequent accumulation of the metals as recorded in this study raises concern for consumers of these fish species from the lagoons as it could pose health implications.

RECOMMENDATION

As a good and popular source of protein, consumers of fish should be protected by carrying out the types of exercise described in this study regularly and proffer measures for mitigation of these metals before discharge from the hotspots. This would go a long way to protect human by ensuring food safety and security, and promote good health and livelihood. Constant monitoring of these aquatic environments is thereby recommended.

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