HEALTH RISK ASSESSMENT OF CHROMIUM IN ORGANS OF *Synodontis clarias* AND *Clarias agboyiensis* FROM EPE LAGOON, LAGOS, NIGERIA

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ABSTRACT

Pollution of the aquatic ecosystems with mixtures of organic and inorganic compounds remains a recurrent problem of global concern due to their toxicity, bioaccumulation, and potential for adverse effects in biological systems. This study investigated the seasonal variation of accumulated chromium (Cr) in the organs of Synodontis clarias and Clarias agboyiensis from Epe Lagoon, Lagos, Nigeria. The mean length and weight of Synodontis clarias collected during wet (33.52 ± 0.22 g and 28.40 ± 0.25 cm) and dry seasons (210.06 ± 3.67 g and 185.2 ± 2.54 cm) and Clarias agboyiensis collected during wet (33.52 ± 0.22 g and 28.40 ± 0.25 cm) and dry season (210.06 ± 3.67 g and 185.2 ± 2.54 cm)between June 2014 and April 2016 were reported herein. Statistical analysis showed a significant increase (p<0.05) in accumulated heavy metals by Synodontis clarias and Clarias agboyiensis in wet seasons. The calculated Hazard index (HI) in liver and gill was less than 1.0 which implied non-carcinogenic adverse effects from the consumption of these fish species. The HI was highest in the liver than the gill.

Keywords: Chromium, *Synodontis clarias, Clarias agboyiensis,* Epe Lagoons.

INTRODUCTION

Water resource plays a major role in the sustenance of life in various environment. Water has been described as a life-supporting universal solvent that is required by living things for metabolism (Agedah *et al.,* 2015). Water is also used for the nourishment of the body, food production, and development of the economy through its downstream applications, thus, exposure to these heavy metals has generated serious concern all over the globe, as it creates adverse effects on all forms of aquatic organisms in the water (Seiyaboh *et al*., 2017). Heavy metals are not readily degradable in the environment and thus, accumulate in animal and human tissues to a very high toxic level leading to undesirable effects (Kaur and Mehra, 2012).

Heavy metals are generated through a variety of natural and anthropogenic sources and activities. In aquatic environments, heavy metal pollution results from direct atmospheric deposition, geologic weathering, or through the discharges of agricultural, municipal, residential, or industrial waste products and wastewater treatment plants (WWTPs) (Bauvais *et al.,* 2015). The discharge of untreated or partially treated industrial wastewater containing heavy metals into the water bodies, especially lagoons facilitates the bioaccumulation of these heavy metals along the food chain. The presence of a metal pollutant in freshwater is known to alter the delicate balance of the aquatic ecosystem (Ogamba *et al.,* 2015). Studies from the field and laboratory have shown that accumulation of heavy metals in tissues of exposed organisms is mainly dependent on concentrations of the metals in water and the exposure period; although, some other environmental factors such as water temperature, oxygen concentration, pH, hardness, salinity, alkalinity and dissolved organic carbon may play significant roles in the accumulation of metal accumulation and toxicity to fish (Jitar *et al.*, 2014).

Synodontis clarias and *Clarias agboyiensis* belong to the family Mochokidae from Africa; namely Cameroon, Chad, Egypt, Ethiopia, Gambia, Ghana, Mali, Niger, Nigeria, Nile, Senegal, and Sudan and is documented as being found in lakes and rivers (Durmaz *et al.,* 2006). Structurally, *Synodontis clarias* and *Clarias agboyiensis* usually have elongated bodies, large heads, depressed and bony with small eyes. Narrow and angular occipital processes; gill openings wide; air-breathing labyrinthic organ arising from gill arches; first gill arch with 24 to 110-gill rakers; cleithrum pointed, narrow with longitudinal ridges with sharpness. These species are bentho-pelagic (bottom feeder), omnivorous feeders that occasionally feed at the surface, hence, are highly susceptible to water pollution, due to their ecological niche some of their physiological and biochemical processes may be interrupted by pollutants when they are assimilated by fish tissues (Durmaz*et al.,* 2006). Exposure to the fish may lead to alterations in different organs, particularly the gills, liver, and spleen. Hence, this study evaluated the seasonal variations in the levels of chromium (Cr) in the gills, liver, and gonad of *Synodontis clarias* and *Clarias agboyiensis* from Epe Lagoons, Lagos, Nigeria.

MATERIALS AND METHOD

Study Area

Epe Lagoon is situated between latitudes 003º50′ – 004º10′N and longitudes 06º35′ – 06º40′E (Figure 1). The lagoon is located within the rainforest belt of southern Nigeria. The riparian vegetation at the bank of the lagoon consists mainly of grasses and secondary rainforests. Land use in the area includes agriculture, human activities like sand mining, artisanal fisheries, and transportation (using motorized boats). A major feature of the lagoon is the overwhelming presence of water hyacinth (*Eichhornia crassipes*), a phenomenon that has been linked to pollution (Nwankwo and Onitiri, 1992).

Collection and Analysis of Fish samples

Collection of Fish samples

The fish samples used for the study were *Synodontis clarias* and *Clarias agboyiensis.* The choice of the organisms was made based on their availability, ecological niche (bentho-pelagic fish species) and sensitive response to pollutants from hotspots. The fish samples were caught using a trap net set at the bottom of the lagoon. The mean length and weight of *Synodontis clarias* collected during wet (33.52 ± 0.22 g and 28.40 ± 0.25 cm) and dry seasons (210.06 ± 3.67 g and 185.2 ± 2.54 cm) and *Clarias agboyiensis* collected during wet (33.52 ± 0.22 g and 28.40 ± 0.25 cm) and dry season (210.06 ± 3.67 g and 185.2 ± 2.54 cm)between June 2014 and April 2016.

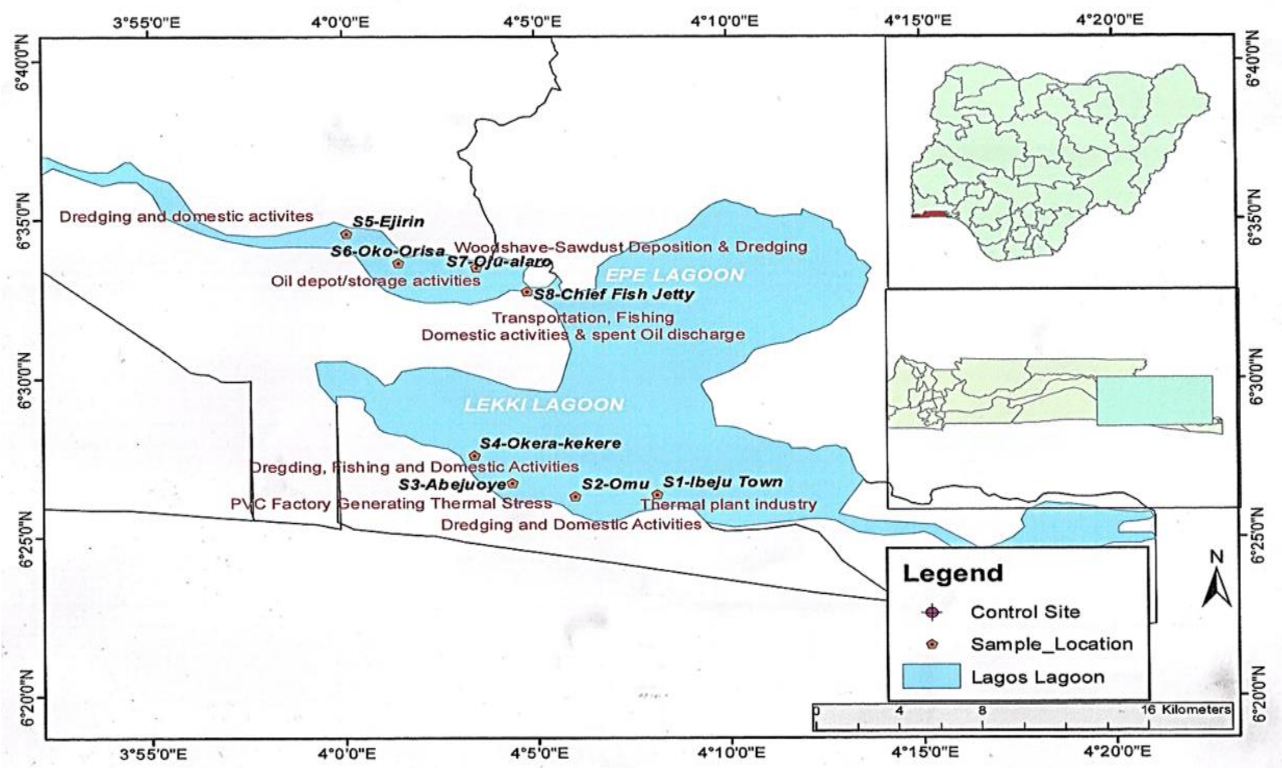

Figure 1: Map of Sampling Stations at Epe Lagoons
(Source: Field Survey, Department of Geography, University of Lagos**)**

Fish Samples Preparation and Analysis

Blood samples were collected from the selected specimens using a sterile syringe (5ml) and were immediately transferred into EDTA bottles for laboratory analysis. The gills, liver, and gonads were excised from these samples. The liver and gonad were rinsed in with a normal saline solution, placed in a small plastic container with a tight cover, and preserved in a freezer with a temperature of 20°C until analysis (Ejimadu *et al.*, 2015). The gills, gonads, and liver tissues were fixed in 10% formalin. The samples were then analysed at the Anatomic and Molecular Pathology Laboratory of College of Medicine, University of Lagos, Idi-Araba, Lagos State.

Hazard Index

The dosage of the exposures may be estimated by the expected quantities of toxicants (in this case, chromium) in the ingested fish. The average daily dose (ADD) of the contaminant via the identified pathways (i.e., fish ingestion pathways) indicates the quantity of chemical substances, ingested per kilogram of body weight per day (Paustenbac and Reilly, 2002) that:

$$ADD = \frac{C \times IR \times ED \times EF}{Bw \times AT}$$

Where: C is the concentration of the contaminant in the environmental media (mg/kg); IR, the ingestion rate per unit time (0.028 mg/day); ED, the exposure duration (30 years); EF, the exposure frequency (days/year- 365); BW, the body weight of the receptor (60kgfor Adults); AT, the average time (years) equal to the life expectancy; and 365, the year-to-day conversion factor.

Hazard Quotient (HQ)

Exposure to harmful chemicals can result in toxic risks also referred to as non-carcinogenic harms. The extent of the harm is indicated in terms of ~~a~~ hazard quotient (HQ):

$$HQ = \frac{ADD}{RfD}$$

Where: the RfD is the reference dose (the estimate of the highest dose that can be taken every day over a prolonged period without causing an adverse non-cancer effect). The RfD value for chromium was 0.003 mg/kg/day, derived from USEPA-IRIS (2010) database.

RESULTS

The mean concentrations of Chromium (Cr) in the tissues of sampled fish with season from Epe Lagoon are shown in Table 1.

Table 1: Mean Concentrations of Chromium (mg/kg) in the Tissues of Sampled Fish Species with Season

Organs	***Synodontis clarias***		***Clarias agboyiensis***	
	Chromium Concentration (mg/kg)			
	Wet	Dry	Wet	Dry
Gill	0.04	0.04	0.02	0.025
Liver	0.04	0.05	0.017	0.023

The results obtained indicated that the values of Cr were within the same range in the gill of the sampled fish species in both seasons. Whereas in the liver, the values of Cr were slightly higher in the dry season than in the wet season. The mean concentrations of average daily dose (ADD) of Chromium (mg/kg) in the fish tissues with season are presented in Table 2.

Table 2: Mean Concentrations of Average Daily Dose (ADD) of Chromium (mg/kg) in the Fish Tissues with Season

Organs	***Synodontis clarias***		***Clarias agboyiensis***	
	Average Daily Dose (ADD			
	Wet	Dry	Wet	Dry
Gill	1.87×10^{-5}	1.87×10^{-5}	9.33×10^{-6}	1.17×10^{-5}
Liver	1.87×10^{-5}	2.33×10^{-5}	7.93×10^{-6}	1.07×10^{-5}

In the specie *Synodontis clarias*, the values of ADD were the same in the gill for both season, while in the liver, the values of ADD were higher in the dry season than in the wet season. On the other hand, in the specie *Clarias agboyiensis,* the values of ADD were higher in the wet season than that in the dry season in both organs. The Hazard Quotient (HQ) of chromium (mg/kg) in the organs of sampled fish (Table 3), revealed that the values of HQ were within the same range in the organs of both sampled fish in the two season.

Table 3: Mean Concentrations of Hazard Quotient (HQ) of Chromium (mg/kg) in the Fish Tissues with Season

Organs	***Synodontis clarias***		***Clarias agboyiensis***	
	Hazard Quotient (HQ)			
	Wet	Dry	Wet	Dry
Gill	0.04	0.04	0.02	0.025
Liver	0.04	0.05	0.017	0.023

DISCUSSION

Escalating human populations and economic development have significantly contributed to the current worldwide deterioration in water quality, including seasonal accumulation of heavy metals such as Cr, in lagoons and estuary (Ademoroti, 1996). Essential metals and non-essential metals have been demonstrated to accumulate along the trophic chain in marine ecosystems (Pande and Sharma, 1999). Non-essential metals are not known to play any metabolic function although, as a consequence of their bioaccumulation in fish, these metals can be toxic for humans, even at a very low concentration (Santos *et al.,* 2005). Assessment of the heavy metal concentration in fish is important both for nature management and human consumption. The present study documents the bioaccumulation of heavy metals in two fish species from Epe Lagoon, Lagos State, Nigeria. The presence of Cr recorded in these two species was generally low, and was within the permissible limits approved for fish food suitable for human consumption. According to the reports of FAO/WHO and FEPA or Federal Environmental Protection Agency, the maximum allowable limit of chromium (Cr) in fish food is 0.05–0.15 mg/kg body weight (FAO/WHO, 1984; WHO, 1999; FEPA, 2003). The low levels of Cr observed in this study are similar to the report of Canli and Atli (2003) on some fish species in the Mediterranean estuary. This would imply that the accumulations of these metals in the tissues of *Synodontis clarias* and *Clarias agboyiensis* from Epe lagoon are gradual, although the bioavailability of the metals is attributed to the continuous release of pollutants from several anthropogenic activities within the study area.

Also, the two fish species had different mean concentrations of Cr in their different organs. This observation agrees with the findings of Adedeji and Okocha (2011) on some fish species from Epe Lagoons. Heavy metal bioaccumulation in fish is species-dependent. and habitats, where the species dwell, are also linked to heavy metal accumulation in fish organs (Obasohan *et al.,* 2007). The variations of heavy metal concentrations in the different fish species could also be attributed to size (body weight and length), gender, age and growth rates, types of tissues analysed, and physiological conditions (Clark *et al.,* 1997). In this study, the results obtained indicated that the values of Cr were within the same range in the gill of the sampled fish species in both seasons. However, in the liver, the values of Cr were slightly higher in the dry season than in the wet season. This result was compared favourably with previous studies that found heavy metal concentrations in fish to be higher in the dry season than in the wet season (Okoronkwo, 1992; Ismail and Saleh, 2012; Kumar *et al.,* 2013). This is because higher concentrations of metals in fish during the dry season were due to high temperatures, which increased the activity, ventilation, metabolic rate, and feeding sessions (Adeyeye *et al.,* 1996). The low heavy metal concentrations in the wet season were due to the dilution of metal levels associated with heavy rains (Obasohan, 2007).

The values of Average Daily Dose (ADD**)** were the same in the gill in both season in the specie *Synodontis clarias*, while in the liver, the values of ADD were higher in the dry season than in the wet season. On the other hand, in the specie *Clarias agboyiensis,* the values of ADD were higher in the wet season than in the dry season in both organs. Generally, the values were low in both species, which implies that fish species from Epe Lagoons are safe for human consumption, although may have the probability of adding metals and bioaccumulating them over a long time. The HI values obtained in the organs of sampled fishes in this study for both seasons are less than 1 (HI < 1) and thus implies minimal non-carcinogenic risk exposure with no significant health risk to consumers of *Synodontis clarias* and *Clarias agboyiensis* from Epe Lagoon. Conversely, studies by Chan *et al*. (2018) and El-Kattan et al. (2019) also showed that HI values greater than 1 should trigger public health concerns for consumers of fishery products

CONCLUSION

From the findings of this study, there were low levels of chromium in the gills, liver, and gonads of *Synodontis clarias* and *Clarias agboyiensis* from Epe lagoon, the levels were also low with seasonal variation. Generally, the results showed a low level of accumulated Cr in the organs of both *Synodontis clarias* and *Clarias agboyiensis* and were within the permissible limit of WHO/FEPA. It is important to constantly monitor the presence and levels of heavy metals in this Lagoon, irrespective of the present low level because continuous deposition might pose threat with time.

REFERENCES

Adedeji, O.B. and Okocha R.C. (2011). Bio-concentration of heavy metals in prawns and water from Epe Lagoon and Asejire River in Southwest Nigeria, *Journal of Applied Science, Environment and Sanitation,* 6 (3):377-384

Ademoroti, C.M.A. (1996). Environmental Chemistry and Toxicology. Fodulex Press Ibadan 215 pp.

Adeyeye, E.I., Akinyugha, R.J., Febosi, M.E. and Tenabe, V.O. 1996. Determination of some metals in *Clarias gariepinus* (Cuvier and Valenciemes), *Cyprinus carpio* (L), and *Oreochromis niloticus* (L) fishes in a polyculture freshwater pond and their environment. *Aquaculture,* 47: 205-214.

Agedah, E. C., Ineyougha, E. R., Izah, S. C., Orutugu, L. A. (2015). Enumeration of total heterotrophic bacteria and some physico-chemical characteristics of surface water used for drinking sources in Wilberforce Island, Nigeria. *Journal of*

Environmental Treatment Techniques, 3 (1): 28 – 34.

Bauvais, C., Zirah, S., Piette, L., Chaspoul, F. And Coulon, I.D. (2015). Sponging up metals: Bacteria associated with the marine sponge *Spongia officinalis*. *Marine Environmental Research,* 104: 20-30.

Canli, M. and Atli G., (2003). The relationships between heavy metal (Cd, Cr, Cu, Fe, Pb, Zn) levels and the size of six Mediterranean fish species, *Turkish Journal of Fisheries and Aquatic Sciences,* 121: 129-136.

Chan H. M., Trifonopoulos M., Ing A., Receveur O., Johnson E. (1999), Consumption of freshwater fish in Kahnawake: risks and benefits, *Environmental Research*, 80(2): 213– 222.

Clark, R.B., Frid, C. and Attril, M. 1997. Marine Pollution 4th eds. Oxford University Inc. New York. 161 pp.

Durmaz, H., Sagun, E., Tarakci, Z. and Ozgokce, F. (2006). Antibacterial activities of *Allium vineale, Chaerophyllummacropodum*and *Prangos ferulacea*. *African Journal of Biotechnology*, 5: 1795-1798

Ejimadu, C. U, Chukwu L. O. and Amaeze, H. N. (2015). Cellular biomarker responses of Bagrid catfish, *Chrysichthys nigrodigitatus* in a contaminated coastal ecosystem. *African Journal of Biotechnology,* 14(25): 2114-2123.

El-Kattan, Y.A., Nahla, A. Abo-El Roos. (2008), Levels of some heavy metals in River Nile water and Oreochromis niloticus fish at Menoufia Governorate. *Egyptian Journal of Comparative Pathology & Clinical Pathology,* 21(1): 64–75.

FAO/WHO (1984), List of maximum levels recommended for contaminants by the Joint FAO/WHO Codex Alimentarius Commission. Second Series CAC/FAL, Rome, pp. 1–8. 16.

FEPA (Federal Environmental Protection Agency) (2003), Guidelines and standards for Environmental Pollution Control in Nigeria, pp. 238. 17.

Ismail I., and Saleh M. I., (2012), Analysis of Heavy Metals In Water And Fish (Tilapia Sp.) Samples from Tasik Mutiara, Puchong. *The Malaysian Journal of Analytical Sciences*, 16 (3):346–352.

Jitar, O., Teodosiu, C., Oros, A., Plavan, G. and Nicoara, M. (2014). Bioaccumulation of heavy metals in marine organisms from the Romanian sector of the Black Sea. *Northern Biotechnology*, 84(14): 2-19.

Kaur, S. and Mehra, P. (2012). Assessment of Heavy Metals in Summer and Winter Seasons in River Yamuna Segment Flowing through Delhi, India. *Journal of Environment and Ecology*, 3(1): 88-91.

Kumar C.S., Jaikumar M., Robin R.S., Karthikeyan P., Kumar C.S., (2013), Heavy Metal Concentration of Sea Water and Marine Organisms in Ennore Creek, Southeast Coast of India, The Journal of Toxicology and Health, 103, pp. 192–201.

Nwankwo, D.I., and Onitiri (1992). Periphyton (Aufuschs) community on submerged aquatic macrophytes in Epe Lagoon, Nigeria. *Journal of Agriculture and Science Technology,* 3: 153 – 141.

Obasohan, E.E. 2007. Heavy metals concentrations in the offal, gill, muscles, and liver of a freshwater mudfish (*Parachanna obscura*) from Ogba River, Benin City Nigeria. *African Journal of Biotechnology* 6 (22): 2620- 2627.

Obasohan, E.E., Ovonsaye, J.A.O. and Obano, E.E. 2006. Heavy metal concentration in *Malapterurus electricus* and *Chrysichthys nigrodigitatus* from Ogba River, Benin city. *African Journal of Biotechnology.* 5 (10): 974 - 982.

Ogamba, E. N.; Seiyaboh, E. I.; Izah, S. C.; Ogbugo, I.; Demedongha, F. K. (2015).Water quality, phytochemistry, and proximate constituents of Eichhornia crassipes from Kolo creek, Niger Delta, Nigeria. International Journal of Applied Research and Technology, 4 (9):77 – 84.

Oguzie, F.A. (2003). Heavy metals in fish, water, and effluents of lower Ikpoba River Benin City. *Parkistan Journal of Science and Industrial Research,* 46 (3): 156-160.

Okoronkwo, I.P. (1992). Heavy Metals Content in Water and Fish of River Niger at Yelwa-Yauri. Msc. Thesis, University of Benin, Benin-City, Nigeria.

Oze, G., Oze, R. Anunuso, C., Ogukve, C. Nuvanjo, H and Okone, K (2006). Heavy metal pollution of fish of Qua Iboe River Estuary: Possible Implications for Neurotoxicity. *The Internet Journal of Toxicity*. 3 (1): 1-6.

Pande, K.S. and Sharma, S.D. (1999). Distribution of Organic Matter and toxic metals in the sediments of Ramgang River at Moradabad, India. *Pollution Research,* 18 (1): 43-47.

Santos, I. R., Silva-Filho E. V., Schaefer C. E., Albuquerque- Filho M. R., Campos. L. S. (2005). Heavy metals contamination in coastal sediments and soils near the Brazilian Antarctic Station, King George Island. *Marine Pollution Bulletin*, 50: 85–194.

Seiyaboh, E. I.; Izah, S. C.; Oweibi, S. (2017) Assessment of Water Quality from

Sagbama Creek, Niger Delta, Nigeria. *Biotechnology Research*, 3 (1): 3 (1):20-24.

USEPA-IRIS, (2010). USEPA's Integrated Risk Information System (IRIS) Program: Progress Report and Report to Congress. November 2015. Available at. https://www.epa.gov/sites/ production/files/2015-12/documents/iris_report_to_congress_nov2015.pdf Accessed 30 March 2021

WHO, (1999), Food safety issues associated with products from aquaculture, Report of a Joint FAO/NACA/WHO Study Group, World Health Organization Technical Report Series 883, pp. 1–55.