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HUMAN HEALTH AND ECOLOGICAL RISKS OF SOME HEAVY METALS IN *Sarotherodon melanotheron* FROM A TROPICAL LAGOON

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Abstract
Increasing contamination of aquatic environment as a result of indiscriminate discharge of solid wastes and effluents has become a global issue of environmental concern. There are harmful substances contained in the wastes and effluents which create a major problem on the quality of the Nigerian coastal water. This study evaluated the human health and ecological risks of Cu, Pb, Zn and Hg in Sarotherodon melanotheron from Lagos Lagoon, South-Western Nigeria. The metals' concentrations were determined in the fish, using atomic absorption spectrophotometer. Health risk assessment of consumers from the intake of metals in the fish was evaluated by Health Risk Index (HRI) and Health Quotient (HQ). Ecological Risk Quotient (ERQ) was also calculated. The metal levels in the fish are in decreasing order Zn (0.026±0.04mg/kg) > Cu (0.011±0.01mg/kg) > Pb (0.0008±0.00mg/kg) > Hg (0.000±0.00mg/kg) and fell below the recommended limit by Environmental Protection Agencies. HRI and HQ of each metal was less than one, indicating that there was no potential health risk associated with the consumption of S. melanotheron from Lagos Lagoon. The Ecological Risk Quotient (ERQ) was also found to be less than one (ERQ<1). This indicated that S. melanotheron did not constitute any ecological threat to the Lagos lagoon.

Key Words: *Food Safety and Security; Environmental Pollution; Heavy metals, Lagoon*

Introduction

Accelerated growth of industry and agriculture has led to the release of heavy metals into the aquatic environment, which has constituted significant environmental hazard for invertebrates, fish, and humans (Uluturhan and Kucuksezgin, 2007). Metals are reported to be well concentrated in the water (Abdul *et al*., 2019) and sediments (Kormoker *et al*., 2019) and fish (Yi *et al*., 2017). Health risk assessment is known to be a useful tool for detecting health risks of human activities (Deventer *et al.,* 2004). It involves identifying the potential of a risk source to introduce risk agents into the environment, estimating the amount of risk agents that come in contact with the human environment boundaries (Yi *et al*., 2011), and quantifying the health consequences of exposure (Haung *et al.,* 2008).

A number of methods have been offered for estimation of the possible risks to human health of heavy metals in fishes. The risks may be grouped into non-carcinogenic and carcinogenic effects. The

threshold for adverse effects, are compared with the observed or predicted exposure concentration, as determined by dose-effect relationship, in the case of carcinogenic contaminants. Researchers have employed the probability risk assessment technique to wholly exploit available exposure and toxicity data. However, these methods have been utilized to evaluate the health risks of carcinogenic pollutants (Cardwell *et al*., 1999; Hall *et al*., 2000; Wang *et al*., 2002).

In the case of non-cancer risk assessment methods, quantitative estimate of the probability of experiencing non-cancer effect from contaminant exposure are not provided (Yi *et al.,* 2011). However, either carcinogenic on non - carcinogenic methods can be used to evaluate health risk initiated by heavy metals (Agneta *et al*., 2006).

Fish are one of the most important and the largest groups of vertebrates in the aquatic system. Trace metals can be accumulated via both food chain and water in fish (Zheng *et al*., 2007). Fish have been considered good indicators for heavy metal contamination in aquatic systems because they occupy different trophic levels with different sizes and ages (Burger *et al*., 2002). The objective evaluated the metal concentration, potential health and ecological risks associated with heavy metals through consumption of fish from the Lagos lagoon using the Hazard quotient (HQ), health risk index (HRI) and ecological risk quotient (ERQ) using *Sarotherodon melanotheron* as indicator species.

Materials and Methods

Study Area

The Lagos lagoon is an open, shallow and tidal lagoon, with a surface area of 208km^2 and an average depth of less than two meters. The lagoon is located in Lagos State, Nigeria and is one of the nine lagoons in South-western Nigeria (Nwankwo, 2004; Onyema, 2008). The Lagos lagoon experiences brackish condition which is more noticed in dry season, due to the dynamics of river inflow and sea water incursion. Increased river inflow creates low brackish and freshwater condition in various parts of the lagoon. Hence, the parts of the lagoon closer to the harbor experience more marine influences than the parts farther inland (Onyema, 2008). The study area (Latitude 6° 31.048' N and Longitude 3° 24.473' E) is in front of the University of Lagos where cage culture is practiced.

Collection and Identification of Samples

Thirty six (36) samples of Tilapia fish, *Sarotherodon melanotheron* were collected forth nightly from June to August, 2011 using cast net. Samples were identified according to Adesulu and Syndenham (2007) and Olaosebikan and Raji (2013) and transported in ice chest to the Marine Science Laboratory of the University of Lagos for determination of heavy metals.

Determination of Heavy metals

Concentrations of Cu, Hg, Pb and Zn in the fish tissues were determined using a standard scientific model of flame atomic absorption spectrophotometer (FAAS) according to Zhang *et al.* (2007) and Lawson (2011).

Statistical Analysis

The concentration of heavy metals obtained in this study was subjected to descriptive statistics to determine the means and standard deviations using SPSS 20.0. The health risk index, health quotient, and ecological risk quotient were determined as follow:

Health Risk Index (HRI) (which gives quantitative information on risk posed by each contaminant to the health of the fish consumers) was calculated as:

$$\textbf{Health Risk Index} = \frac{Daily\ Intake\ of\ Metal\ (DIM)}{Reference\ Oral\ Dose\ (RfD)}$$ (Isibor and Imoobe, 2017)

Where, $$\textbf{DIM} = \frac{M \times CF \times Daily\ intake\ of\ fish}{Average\ body\ weight}$$ (Isibor and Imoobe, 2017)

and M is the concentration of metal in fish (mg/kg), CF (Conversion Factor) = 0.085. (Note that 60 kg was adopted as the average body weight of the fish consumers. Daily intake of fish was also estimated as 48g/person/day according to FAO, 2007).

Health quotient (which estimates the hazard heavy metal could have on the human population in their later life) was determined as:

$$HQ = \frac{Wfish \times Mfish}{RfD \times B_o}$$ (Omobepade *et al.,* 2020)

Where: W_{fish} is the dry weight of the fish consumed per/day,
M_{fish} is the concentration of heavy metal in the species in mg/kg,
RfD is the reference oral dose.

Ecological Risk Quotient (ERQ) (which numerically evaluates the associated risks in quantification and interpretation of the concentration of chemicals in aquatic environment) was calculated as: $$\textbf{ERQ} = \frac{Environmental\ Concentration\ (mg/kg)}{Recommended\ Limit\ (mg/kg)}$$ (Olawusi-Peters *et al.,* 2019)

Results

Concentration of Heavy metals

The concentration of heavy metals as presented in Table 1 showed that it was in the decreasing order of Zn (0.026±0.04mg/kg) > Cu (0.011±0.01mg/kg) > Pb (0.0008±0.00mg/kg) > Hg (0.000±0.00mg/kg). All the observed concentrations were below the Federal Environmental Protection Agency (FEPA, 2003) and World Health Organisation (WHO, 2003) permissible limits for fish in the aquatic medium and as food respectively.

Table 1: Heavy metals (Cu, Pb, Hg and Zn) in *S. melanotheron* from Lagos Lagoon

Copper (mg/kg)	Lead (mg/kg)	Mercury (mg/kg)	Zinc (mg/kg)
0.011±0.01	0.0008±0.00	0.000±0.00	0.026±0.04

Health Risk Index (HRI)

The HRI of *S. melanotheron* from Lagos Lagoon as determined in this study is presented in Figure 1 which shows that Pb (0.057) had the highest HRI while Cu (0.018) and Zn (0.006) had the second and third highest values respectively. The HRI of Hg was 0.000 due to the 0.000±0.00mg/kg recorded in Table 1. The implication of the values of HRI recorded for all the metals was that they

constituted no health risk for the consumers of the fish.

Hazard Quotient

The hazard quotient of *S. melanotheron* from Lagos Lagoon as presented in Figure 2 revealed an order of Pb (0.6667) > Cu (0.2100) > Zn >(0.0702) > Hg (0.000). The figure revealed that all the minerals had HQ of less than one (HQ<1), indicating that Pb, Cu, Zn and Hg did not have any hazard/ health related risks for the consumers of the fish in later life.

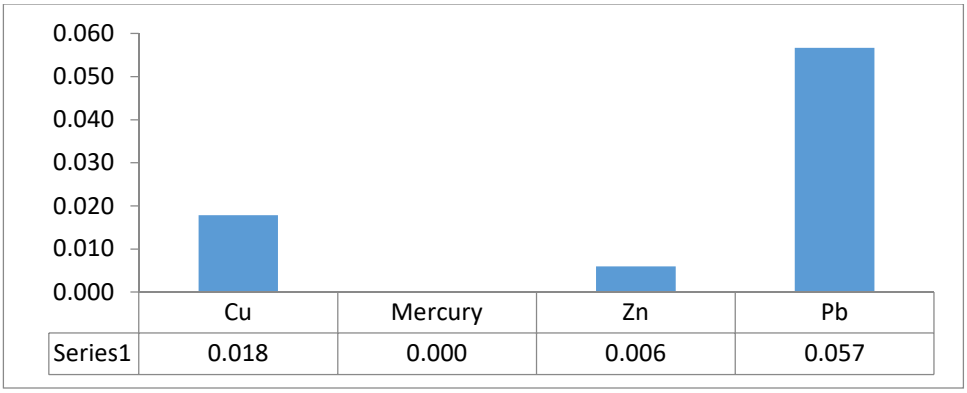

Fig. 1: Health Risk Index (HRI) of *S. melanotheron* from Lagos Lagoon

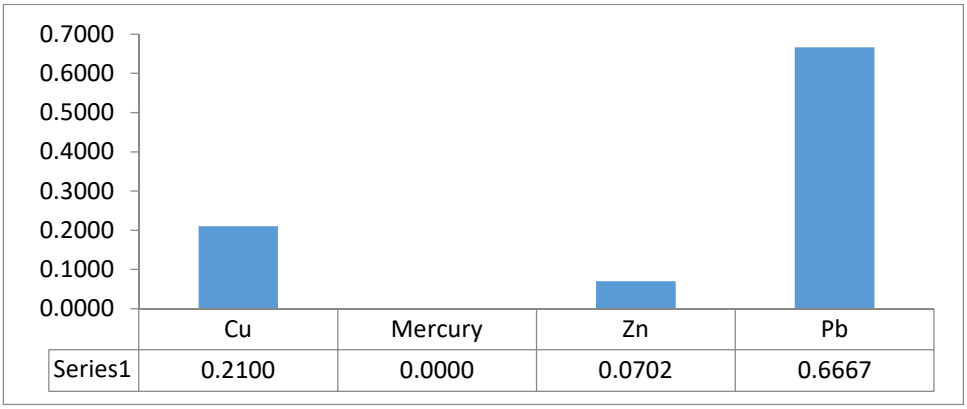

Fig. 2: Hazard Quotient (HQ) of *S. melanotheron* from Lagos Lagoon

Ecological Risk Quotient (ERQ)

The Ecological Risk Quotient (Figure 3) was in the decreasing order of Cu (0.0035) > Zn (0.0009) > Pb (0.0004) >Hg (0.000). This indicated that *S. melanotheron* did not constitute any ecological threat to the Lagos lagoon since all the values of ERQ were less than one (ERQ<1).

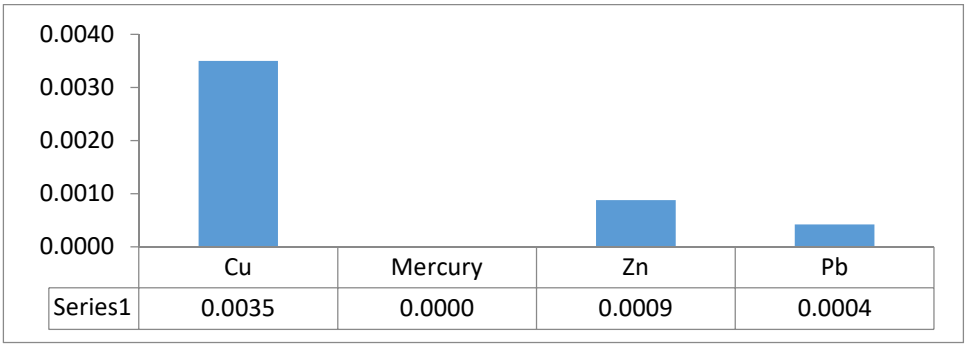

Fig. 3: Ecological Risk Quotient (ERQ) of *S. melanotheron* from Lagos Lagoon

Discussion

The study evaluated the potential health and ecological risks associated with heavy metals through consumption of *Sarotherodon melanotheron* from the Lagos lagoon as indicator of aquatic pollution.

The mean concentration of copper in the fish samples was 0.011 mg/kg, which fell below all 30ppm permissible guidelines of WHO and FEPA (2003). High concentration of Cu can be harmful to the body. Its excessive consumption may cause neurological disorder, liver cirrhosis and dermatitis (Giri and Singh, 2015). Zinc was observed to be low in concentration across all the fish samples with a mean value of 0.026mg/kg. This mean concentration of Zn was below the WHO maximum guideline of 40mg/kg for safe human consumption (WHO, 2003). Excessive intake of Zn has been reported to be toxic and caused lethargy, nausea, anemia and electrolyte imbalance (Prasad, 1984; Plum *et al*., 2010). Although, in this study the values for Zn suggested that the consumption of the fish possesses no health risk. The concentrations of Pb in this study were very low in all the fish samples, with mean value of 0.0008 mg/kg, which was below the recommended mean concentration value for lead (WHO/FAO, 2007). The study showed that the concentrations of Pb were very low and will not have any health risk on the consumers of the fish. However, the United States Environmental Protection Agency (2000b) has classified Pb as being potentially hazardous and toxic to most forms of life. It has been found to be responsible for chronic neurological disorders in foetuses and children especially when it is greater than 0.1 mg/kg. Hence, the fish in the study area are safe for consumption since all the values were far lower than 0.1mg/kg. The concentrations of Hg in this study were also very low in all the fish samples, with a mean value of 0.000±0.00mg/kg, below the detectable level (BDL).

The Ecological Risk Quotient of the present study also indicated that *S. melanotheron* did not constitute any ecological threat to the Lagos lagoon since all the values of ERQ were less than one (ERQ<1), which agreed with the findings of Olawusi-Peters *et al*. (2019), where ecological risk of heavy metals exposure to fish was reported to be less than one. The health risk assessments (HRI) and hazard quotient of the heavy metals considered in this study indicated that there was no human health risk due to consumption of *S. melanotheron* from Lagos Lagoon. The human health risk assessment in this study was quite lower compared to the values obtained in studies reported by Akoto *et al*. (2014); Enuneku

et al. (2014) and Enuneku *et al*. (2018) of heavy metals assessed in fish tissues. However, this study was in agreement with the findings of Alipour *et al*. (2015) and Küpeli *et al*. (2014) who reported that the health risk of some metallic elements associated with the consumption of fish was less than one.

Conclusion

Despite the level of contamination as from anthropogenic activities within the lagoon, this study still showed that the heavy metals content in the muscle of *S. melanotheron* from the Lagos Lagoon were below the maximum recommended values by the EU and FAO/WHO. From the food safety and security point of view, the HRI values for the individual metals showed that there was no health risk for humans due to the intake of heavy metals in the fish from the Lagos Lagoon. The hazard quotient revealed that all the metals (Pb, Cu, Zn and Hg) do not possess any health related risks to the consumers.

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