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Lead and Zinc Concentrations in the Gill, Liver and Parasito-Fauna of *Sarotherodon melanotheron* iIn Makoko Lagoon, Lagos State, Nigeria

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Abstract

Morphometric and meristic features, metal accumulation and chemical composition of *Sarotherodon melanotheron* and its intestinal parasites were investigated in August, 2013. The Standard length of *Sarotherodon melanotheron* range between 13.10-21.50 cm with Mean ± SD of 16.15 ± 1.97, (p<0.001) and Head length range from 1.50-2.70 with Mean ± SD of 2.15 ± 0.28, (p<0.001). Heavy metal concentrations were determined in water, sediment, intestinal parasites, gills and liver of *Sarotherodon melanotheron* were analysed using Atomic Absorption Spectrophotometry to determine concentration of Pb and Zn. Metals in the water, sediment and parasites were above WHO level. The concentration of Lead and Zinc were higher in the sediment (Pb-18.82 and Zn-21.52) than the water (Pb-2.66 and Zn-15.41). The liver accumulated highest concentration of Lead and Zinc than the gill and parasite. The trend of lead accumulation was; gill (0.86)<parasite (0.98)<liver (3.54). This accumulation followed similar trend in zinc sampled, the mean concentrations for zinc; parasites; (Zn) (mg/l); 3.39, p<0.01, gill; (Zn)(mg/l); 0.72, p<0.01, liver; (Zn) (mg/l); 11.04, p<0.01. Fish parasites, particularly intestinal acanthocephalans and cestodes, accumulated heavy metals at concentrations significantly higher than those in fish tissues or the environment; hence, they could be used as bioindicators of heavy metal pollution. It is important to continue monitoring heavy metals concentration in waters, sediments and fish of Makoko lagoon so as to assess trends in heavy metal behavior in the area.

Keywords: Parasito-fauna • Sediment • Bioindicator • Bioaccumulated • Bioavailability • Pollution

Introduction

Lagos state, which is surrounded by water and through which the Atlantic Ocean passes is the industrial and commercial center of Nigeria, which implies that it has the highest number of industries and arguably people in a state in Nigeria and in Africa. As a commercial hub and the industrial nerve center of Nigeria with an estimated population of more than 20 million people, environmental concerns are normally focused on Lagos State. Over 70% of Nigeria's industries are cited in the state, each discharging its characteristic range of effluents containing heavy metals into the terrestrial and aquatic ecosystems within the state [1]. Expectedly therefore, studies have been conducted on fish which is a highly valued food that contains balanced level of amino acids, vitamin B12, cholesterol, high polyunsaturated fatty acids because it accounts for 40% of the animal protein in the diet of Nigerians [2].

According to a world bank's report published in March, 2020, over 80% of the industries worldwide discharge solid, liquid and gaseous effluents directly into the environment without adequate treatment [3]. This results in pollution. The pollution of the aquatic environment with heavy metals has become a worldwide problem during recent years because they are indestructible and most of them have toxic effects on organisms [4]. Aquatic animals (including fish) bioaccumulate trace metals in considerable amounts and stay over a long period. Fishes have been recognized as good accumulators of organic and inorganic pollutants [5]. As heavy metals cannot be degraded, they are deposited, assimilated or incorporated in water, sediment and aquatic animals thus, causing heavy metal pollution in water bodies. Therefore, heavy metals can be bioaccumulated and biomagnified *via* the food chain and finally assimilated by human consumers resulting in health risks [6]. The aim of this study is to investigate the accumulation of metals (Lead and Zinc) in the liver and gills of *Sarotherodon melanotheron* and its parasito-fauna.

Materials and Methods

This study was conducted in Makoko creek (latitude 6° 29' 46" N and longitude 3° 23' 16" E) in the Western part of Lagos, Nigeria. More than 150 specimens of live Black Jaw Tilapia-*Sarotherodon melanotheron* species were collected randomly from selected sites (60 29' 38.7" N, 30 23' 43" E, 6029' 41.9" N, 30 23' 42.8" E, 60 29' 44.2" N, 30 23' 51.7" E, 60 29' 38.3" N, 30 23' 52.6" E, and 60 29' 30.7" N, 30 23' 31" E) of the Makoko creek between 05:30 am-06:15 am using various fishing gears including hand nets and cast nets. Morphometric parameters were measured for each fish before dissection using a scalpel. Samples of parasites were picked with the scalpel and transferred into a micro test tube containing 70% alcohol as preservative. The liver and gill of each fish were carefully removed and transferred, each into separate test tubes, with corresponding labeling for each fish. The samples were digested in an open beaker on a hot plate, 5 g of each organ (wet weight) were weighed into a clean beaker and 10 ml of freshly prepared aqua regia (a mixture of concentrated nitric acid and concentrated hydrochloric acid in the ratio 1:3) was added to sample. The beaker was placed in a water bath on hot plate and heated until brown fumes disappeared. This solution was allowed to cool then transferred to a clean 25 ml standard flask and made up with distilled water to the mark. Filtration was essential to remove residue or unwanted materials. The filtrate was extracted and concentrations of lead and zinc were determined using Air Acetylene Flame Atomic Absorption Spectrophotometer.

Water samples were collected in plastic bottles previously cleaned with detergent and soaked overnight in 5% nitric acid. Water samples for heavy metal analysis were fixed, using 5% nitric acid and stored frozen at -10oC. 5 ml of concentrated hydrochloric acid was added to 250 ml of water sample and evaporated to 25 ml. The concentrate was transferred to 50 ml flask and diluted to 100 ml distilled water. Cd and Pb were determined with the aid of Atomic Absorption Spectrophotometer. Aquatic organisms can

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accumulate chemical compounds both directly from the environment (*via* skin or respiratory surface) and indirectly (by collecting and concentrating a chemical compound from food). This process is called bioaccumulation, and is measured with the Bioaccumulation Factor (BAF) which is defined as the ratio of the concentration of a chemical accumulated inside an organism (from food and direct exposure) to the concentration in the surrounding environment [7].

$BAF=C_{org}/C_m$

C_{org}=Concentration of the heavy metals in the organism (gill or liver)

C_m=concentration of the heavy metals in the aqueous environment of the organism

Statistical analysis

Relevant data were cleaned, coded and exported into SPSS version 20.0 (SPSS 2011 IBM Corp, New York, United States) for statistical analysis. Comparisons were assessed using Mean ± Standard deviation and one-way Analysis of Variance (ANOVA). A p-value of ≤ 0.05 was considered statistically significant in all statistical comparison.

Results

More than 150 specimens of live Black Jaw Tilapia-*Sarotherodon melanotheron* species were collected randomly from selected sites of the Makoko creek between 05:30 am-06:15 am using various fishing gears including hand nets and cast nets. Some of the parameter observed at the creek are as shown in Table 1 below.

Parameters	Values	WHO Limit
Air Temp (°C)	28.5	37
H2O Temp (°C)	26.5	30
Conductivity (µs/cm)	1.1	8-10,000
Turbidity (NTU)	72	5
Salinity (o/oo)		0.5
Dissolved oxygen (mg/l)	5.2	5
pH	7.96	6.5-8.9

Table 1. Physico-chemical parameters of Makoko Creek.

There was no correlation in various absolute morphometric features of *Sarotherodon melanotheron* on analysis. Caudal peduncle length had no correlation with eye diameter and pre-anal length. The eye diameter had no correlation with caudal peduncle length and pre-anal length. The head width had no correlation with the pre-anal length. The dorsal fin length had no correlation with pre-anal length. Also, the pre-anal length had no correlation with the caudal peduncle length, eye diameter, dorsal fin length and head width (Table 2).

Parameter	Parameter	% Correlation	Pearson correlation (R)	Parameter not correlated
Total length	13	100%	0.429-0.872	None
Standard length	13	100%	0.412-0.872	None
Caudal peduncle length	13	84.62%	0.209-0.728	ED, PAL
Head length	13	100%	0.436-0.884	None
Snout length	13	100%	0.343-0.811	None
Head width	13	92.31%	-0.199-0.670	PAL
Eye diameter	13	84.62%	0.156-0.436	CPL PAL
Pre-anal length	13	100%	-0321-0.531	CPL, ED, DFL, HW
Pre-pelvic length	13	92.31%	-321.54	None
Dorsal fin length	13	100%	0.219-0.613	PAL
Pelvic fin length	13	100%	0.381-0.836	None
Anal fin length	13	100%	0.253-0.690	None
Pectoral fin length	13	100%	0.416-0.836	None
Body depth	13	100%	0.301-0.816	None

Table 2. Relationship between the various morphometric features of *Sarotherodon melanotheron* in Makoko lagoon using pearson correlation.

From our analysis, the concentration of Lead and Zinc were higher in the sediment (Pb-18.82 mg/l and Zn-21.52 mg/l) than the water (Pb-2.66 mg/l and Zn-15.41 mg/l). It was also observed that the liver accumulated highest concentration of Lead and Zinc than the gill and parasite. The trend of lead accumulation was; liver (3.54 mg/l)>parasite (0.98 mg/l)>gill (0.86 mg/l). This accumulation followed similar trend in zinc sampled, the mean concentrations for zinc; parasites; (Zn) (mg/l); 3.39, p<0.01, gill; (Zn) (mg/l); 0.72, p<0.01, liver; (Zn)(mg/l); 11.04, p<0.01. Table 3 below, showed heavy metals concentrations in the water, sediment and liver of *Sarotherodon melanotheron*. The metal concentrations accumulated in the fish's liver were more than that found in the water but not higher than concentrations in the sediment; Liver (Pb-3.54 ± 7.64 mg/l, Zn-11.04 ± 3.08 mg/l), Water (Pb-2.66 ± 0.68 mg/l, Zn-15.41 ± 6.88 mg/l), Sediment (Pb-18.82 ± 8.69 mg/l, Zn-21.52 ± 6.15 mg/l).

Sample types	Number	Heavy metal			
		Min-Max	Lead (mg/l)	Min-Max	Zinc (mg/l)
Water medium	-	1.98-3.14	2.66 ± 0.68	7.42-20.27	15.41 ± 6.88
Sediment	-	12.67-24.96	18.82 ± 8.69	19.82-26.91	21.52 ± 6.15
Liver of *Sarotherodon melanotheron*	50	0.89-4.56	3.54 ± 7.64*	3.69-14.04	11.04 ± 3.08**
Gill of *Sarotherodon melanotheron*	50	0.07-1.76	0.86 ± 1.15**	0.12-1.48	0.72 ± 1.06**
Parasite of *Sarotherodon melanotheron*	50	0.13-2.18	0.98 ± 1.84*	0.82-4.48	3.39 ± 3.08**
WHO Standard, 1993			0.01		3

*Above WHO Food and Water Safety Standard, 1993; * means values significant at P<0.01 level; ** means values significant at P<0.05 level

Table 3. Heavy metal concentrations in the liver of *Sarotherodon melanotheron* in relation to water and sediment concentrations.

Discussion

This Makoko creek has been under the stress of human activities because of its accessibility to man. Major stressors include garbage overload arising from indiscriminate dumping of litter from the inhabitants of the community, burning of fuels. The prominent features of the study area are the presence of bamboo-built houses on the river and canoes scattered all over the shoreline and on the creek. This area was chosen for this study because of the high biological activities that can be observed in this area.

The present investigations have revealed the concentration of two heavy metals of public health importance, Lead (Pb) and Zinc (Zn), and these were generally higher with mean values of 2.0 and 11.08 mg/l respectively when compared with recommended values for marine waters. Sediment concentration also revealed generally high mean values of 17.08 and 24.75 mg/l of Pb and Zn respectively, compared with recommended values for marine waters [8]. Heavy metal contamination in sediment can affect the water quality and bioaccumulation of metals in aquatic organisms, resulting in potential long-term implication on human health and ecosystem [9]. These values in the surface water could be adduced to anthropogenic activities going on around the lagoon because of its closeness to urban area and high population of people around the place rather than by natural enrichment [1].

Studies have shown that the abundance of available element forms in water and/or food at different sites in addition to some water characteristics can affect metal intake and accumulation [10]. The heavy metals accumulation inside the tissues of different parasites and their hosts is affected by many external and internal factors [11]. Many authors reported that the variability in the rate of accumulation may be attributed to the proximity of tissues to toxic medium, structure and function of organs and the presence of ligands in tissues of organs having an affinity to the heavy metal.

The highest concentrations of Pb and Zn were recorded in the liver compared to the gills and parasites. The gills are directly in contact with water; therefore, the concentration of metals in the gills reflects their immediate concentration in water where the fish lives, whereas the concentrations in liver represent storage of metals over time [12]. The relatively higher Zn concentration in the liver may also be due to the role of the liver as an activator of numerous enzymes [13]. The liver is considered a good monitor of water pollution with metals since their concentrations accumulated in this organ are often proportional to those present in the environment. The accumulation of metals in the gills may be due to adsorption to the gill surfaces and dependent on the availability of proteins to which these metals may bind. Water hardness (mainly calcium concentration) considerably affects uptake of metals across the gill epithelium) [14]. The low accumulation of these heavy metals in gills may be due to development of some defensive mechanism such as excessive mucous secretion and clogging of the gills [15].

A similar study carried out at Old Netim River, Akamkpa, Cross River State by Ekpo et al., in 2013 showed a higher concentration of Lead (mean value of 6.5 mg/l) as compared with the present investigation at Makoko Lagoon (mean value of 2.0 mg/l) in water. However, the Zinc concentration was lower (mean value of 9.8 mg/l) compared with that observed at Makoko Lagoon (mean value of 11.08 mg/l). In sediment, the concentration of Lead reported by Ekpo et al., was 15.0 mg/l which is about the same concentration in Makoko Lagoon. Zinc concentration in Old Netim River was 43.5 mg/l which is higher than 24.75 mg/l recorded for Makoko Lagoon. The concentration of metals in the liver and gill of samples from Makoko Lagoon (Pb-3.54 mg/l, Zn-11.04 mg/l and Pb-0.86 mg/l, Zn-0.72 mg/l respectively) were lower than those recorded in samples from Old Netim River (Pb-9.12 mg/l, Zn-23.51 mg/l and Pb-4.27 mg/l, Zn-18.18 mg/l respectively).

Generally, the host-parasite accumulation had shown that increase in host tissue metal concentration resulted to subsequent increase in the parasite concentration. This agrees with the work of Olojo and Oluberu [16].

Conclusion

Studies of occurrences of metals in the various environmental components are crucial to understanding the metals, and also the exchange between sediments and the water column, as well as bioavailability of the metals. It is important to continue monitoring heavy metals concentration in waters, sediments and fish of Makoko lagoon so as to assess trends in heavy metal behaviour in the area. Such studies should use methods that are agreed upon and standardized.

In July 2012, the Nigerian government officials destroyed dozens of residences in Makoko after giving residents 72 hours' notice of eviction. Lagos may have to continue the destruction of this historically-obnoxious community in order to redevelop what is now seen as prime waterfront.

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