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Accumulation of Heavy Metals In Water, Sediment and Fish Species In Ologe Lagoon

Ayoola S.O* and Agoro, T. O

Department of Marine Sciences, University of Lagos, Lagos State, Nigeria

**Corresponding Author: email: sayoola@unilag.edu.ng,soaayoola@yahoo.com,*

Tel: 234(80)34650102

Abstract

Fish inhabiting a polluted aquatic ecosystem tend to accumulate heavy metals in their tissues. Generally, accumulation depends on metal concentration, time of exposure, way of metal uptake, environmental conditions and intrinsic factors. This study was to investigate the metal accumulation in Sarotherodon melanotheron and Chrysichthys nigrodigitatus from the water and sediments at Ologe Lagoon for period of six months (April – September, 2014). The physicochemical parameters were determined according to AOAC and heavy metals such as zinc (Zn), copper (Cu), lead (Pb), Nickel (Ni) and chromium (Cr) were determined using Atomic Absorption Spectrometry. The sequence of Bioaccumulation factor (BAF) for Sarotherodon melanotheron: Cr > Zn > Cd > Pb > Cu; while for Chrysichthys nigrodigitatus: Cu > Cr > Pb > Cd > Zn. The study showed that generally the metal concentration in the water and sediments bio accumulated in Chrysichthys nigrodigitatus and Sarotherodon melanotheron are higher in Cr, Cu, Zn, and Cd. While the Ni and Pb are less in the tissues and are regarded to be safe by WHO and FEPA. Fish at the Ologe Lagoon are still consumable though partially contaminated with slight increase in heavy metals influenced by anthropogenic activities. However, it is quite evident that there was bioaccumulation of heavy metals in fish tissues and condition may get worse. Therefore, a regular monitoring of heavy metal levels in fishes is necessary.

***Key words**: Heavy Metals, Water, Sediment, Fish Species, Ologe Lagoon*

Introduction

Heavy metals have long been recognized as serious pollutants of the aquatic environment, they cause serious impairment in metabolic, physiological and structural system when present in high concentration as opined by Javed (2003). Heavy metals may affect organisms directly by accumulating in their body or indirectly by transferring to the next trophic level of the food chain. Metals are non-biodegradable and once they enter the environment, bio-concentration may occur in fish tissues by means of metabolic and bio-absorption processes (Hogstrand and Haux, 1991). Fish living in water bodies receiving high discharges of effluent from industries, a range of alterations related to physiological abnormalities have been observed (Vethaak *et al*., 2002).These effects have been attributed to various estrogenic chemicals known to be present within treated or/and untreated industrial effluents. Indeed, extensive laboratory-based studies have confirmed that chemicals contained in industrial effluents can induce many effects (Seki *et al*., 2002; Jobling *et al*., 2006). Furthermore, it has been shown that exposure to industrial effluents can inhibit the reproduction of fish (Seki *et al*., 2002; Thorpe *et al*., 2007). Although, the concentrations of chemicals typically measured in Waste water, treated or un-treated effluents may be low, compared to those required to affect fish reproduction in short-term laboratory studies, there are still major concerns about long-term exposures to effluents. This is because a prolonged exposure to some of these chemicals increases their level of effect (Thorpe *et al*., 2007). Specific studies that directly assess the effects of industrial effluents on population-relevant end-points, such as fish seed production (fingerlings/juveniles), are therefore, required to understand the consequence of exposure; relative to their histopathology, physiology, growth and survival.

As with other lagoons within the Lagos lagoon complex, Ologe lagoon is used for fishery, waste disposal, sand mining and transportation. It is also regarded as the 'large septic tank' in the region (Adeboyejo *et al*., 2009).

The level of heavy metals present in the sediments, the water body coupled with water quality criteria like Biological Oxygen Demand, Dissolved Oxygen, Suspended solids, and Dissolved solids need to be ascertained to determine the fitness of the water for fish. The objective of the study is to ascertain the degree of bio-accumulation and distribution of some heavy metals in fish, water and sediment at Ologe Lagoon in Badagry area of Lagos State.

Materials and Methods

Description of Study Station

Ologe lagoon, is in the southwestern part of Nigeria, along the border between Lagos state and Ogun State. It covers about 6354.71 km^2 in area and 285 km in perimeter, is a brackish coastal water bounding the city of Lagos, lying between 6º27'- 37'N and 3º02-3º09'E (Clarke *et al*., 2004). The lagoon cuts across the southern part of the Lagos metropolis, linking the Atlantic Ocean (in the west and south) and Lekki lagoon (in the east). It is fairly flat, approximately above sea level, swampy area to the south east. It serves severally as a place of abode, recreation, livelihood and transport for fisher folk and is a dumpsite for residence, industries, and for other wastewaters. It is bounded in the north by Agbara and Igbesa town (Ogun state) and Ijanikin town (Lagos state); in the west by Isepe Musin and ale; in the south by Gbanko and Badagry creeks and in the east by Egan, Ojoba, Idoluwo and other fishing villages.

Collection of Samples Methods of Analysis

Monthly surface water samples were collected for six months (April – September, 2014) at the study sites for analysis of physical and chemical parameters using well labeled 500ml plastic containers with screw caps. Collection of samples from each station was always between 09:00hrs–12:00hrs each time. The resultant solution was analyzed for heavy metals using atomic absorption spectrophotometer. Samples of the soil sediment were taken from the surface down to a depth of about 10cm at locations where water samples were taken. 10g of soil sample was taken from each

location and mixed together in a polythene bag. This was kept in a deep freezer prior to analysis for heavy metals. The sample was assayed for heavy metals using atomic absorption spectrophotometer.
Two species of fish (*Sarotherodon melanotheron* and *Chrysichthys nigrodigitatus)* were caught from the dam with net with the assistance of a fisherman. Each fish sample was briefly washed with distilled water to remove any adhering substances. Each fish sample was drained under folds of filter paper, wrapped in aluminum foil and deep frozen prior to analysis. Each solution was analyzed for heavy metals using Atomic Absorption Spectrophotometer. The method used for the determination of physic chemical parameters was standard methods described by A.O.A.C. (2005).

Statistical Analysis

Statistical analysis was carried out with the statistical package (SPSS). The data obtained in the study were subjected to one – way analysis of variance (ANOVA). Post.hoc analysis of the ANOVA result was done by using Duncan's Multiple Range Test at 5% level of significance.

Results

The results of the water quality parameters, heavy metal concentrations in water, sediments and in the tissue of the fish of *Chrysichthys nigrodigitatus* and *Sarotherodon melanotheron* evaluated at Ologe lagoon (April – September, 2014) were represented in Tables 1 to 5 and Figures 1and 2.

Table 1: The physio-chemical parameters of the water quality at Ologe lagoon (April – Sept., 2014).

	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
Temperature	25.50±0.5	26. 60 ± 0.5	25. 40 ± 0.5	27.40 ± 0.5	28. 60±0.5	25.50 ± 0.5
pH	5.38 ± 0.04	6.03 ± 0.02	5.11 ± 0.02	5.37 ± 0.02	6.41 ± 0.02	6.37 ± 0.01
Conductivity	419.33 ± 7.02	338.33 ± 1.15	433.00 ± 3.61	436.67 ± 2.08	391.33 ± 1.15	351.67 ± 2.89
Turbidity	28.2 ± 0.00	16.50 ± 1.31	22.57 ± 0.12	25.80 ± 0.70	15.60 ± 0.08	18.03 ± 0.06
Total Hardness	286.87 ± 3.96	248.67 ± 3.18	214.77 ± 1.11	202.40 ± 2.33	222.93 ± 2.71	210.40 ± 0.36
Chloride	77.73 ± 1.47	64.26 ± 0.06	82.47 ± 0.69	84.57 ± 0.25	71.20 ± 0.98	74.37 ± 0.12
Total Solid	250.67 ± 1.15	204.00 ± 3.61	255.33 ± 0.57	245.67 ± 1.15	235.00 ± 0.00	246.67 ± 1.15
TSS	10.33 ± 0.58	7.33 ± 1.15	8.00 ± 0.00	7.33 ± 0.58	12.67 ± 0.58	12.00 ± 1.00
BOD	75.93 ± 2.27	56.17 ± 1.89	65.93 ± 1.29	64.67 ± 1.52	60.90 ± 0.95	56.33 ± 0.57
DO	2.80 ± 0.00	3.11 ± 0.00	3.14 ± 0.00	3.56 ± 0.42	3.66 ± 0.00	3.48 ± 0.00
Pb	0.35 ± 0.03	0.18 ± 0.02	0.16 ± 0.02	0.15 ± 0.02	0.17 ± 0.01	0.11 ± 0.01
Cu	0	0	0.02 ± 0.01	0	0.01 ± 0.00	0.01 ± 0.01
Zn	0.87 ± 0.01	0.46 ± 0.02	0.65 ± 0.05	0.46 ± 0.02	0.35 ± 0.03	0.24 ± 0.00
Cd	0.08 ± 0.11	0.20 ± 0.00	0.01 ± 0.01	0.01 ± 0.00	0	0
Cr	0.08 ± 0.02	0.03 ± 0.01	0.04 ± 0.01	0.04 ± 0.05	0.01 ± 0.00	0.010 ± 0.00
Ni	0	0	0	0	0	0

Table 2: Physico-chemical parameters of the sediment at the Ologe Lagoon

	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
pH	6.70 ± 0.00	6.83 ± 0.01	6.80 ± 0.00	6.34 ± 0.01	6.70 ± 0.00	6.63 ± 0.03
Conductivity	210	190	170	185	181.33 ± 1.15	161.67 ± 2.89
Sand	20	20	25	20	20	20
Silt	10	10	15	20	20	20
Clay	70	70	60	60	60	60
Pb	0.62 ± 0.03	0.39 ± 0.02	1.13 ± 0.02	1.15 ± 0.0	0.76 ± 0.01	0.53 ± 0.03
Cu	4.30 ± 0.26	3.88 ± 0.03	6.08 ± 0.11	6.3	4.12 ± 0.03	1.25
Zn	7.73 ± 0.12	11.1 ± 0.17	10.87 ± 0.30	10.47 ± 0.06	5.53 ± 3.97	9.11 ± 0.03
Cd	1.18 ± 0.03	1.5	0.04 ± 0.01	0.04 ± 0.01	0.06	0.04
Cr	0.28 ± 0.02	0.4	3.12 ± 0.03	4.14 ± 0.04	3.74 ± 0.14	3.28 ± 0.11
Ni	0.01	0.01	2.48 ± 0.03	1.28 ± 0.03	3.02 ± 0.02	2.88 ± 0.08

Table 3: Heavy metal concentrations of the *Chrysichthys nigroditatus* at the Ologe Lagoon.

	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
Pb	0.19 ± 0.04^{d}	0.09 ± 0.01^{c}	0.00 ± 0.00^{a}	0.06 ± 0.01^{b}	0.17 ± 0.01^{d}	0.17 ± 0.02^{d}
Cu	2.30 ± 0.12^{c}	0.01 ± 0.01^{a}	3.88 ± 0.12^{e}	3.06 ± 0.04^{d}	1.51 ± 0.04^{b}	2.17 ± 0.03^{c}
Zn	11.300 ± 0.17^{a}	23.20 ± 1.74^{b}	24.56 ± 0.16^{c}	10.34 ± 0.08^{a}	10.35 ± 0.03^{a}	10.24 ± 0.00^{a}
Cd	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.01 ± 0.01^{b}	0.00 ± 0.00^{a}	0.05 ± 0.005^{d}	0.03 ± 0.01^{c}
Cr	0.09 ± 0.02^{c}	0.04 ± 0.03^{a}	0.09 ± 0.02^{bc}	0.05 ± 0.01^{ab}	0.07 ± 0.01^{abc}	0.19 ± 0.04^{d}
Ni	0	0	0	0	0	0

The value in the same row and with the same superscript letters are not significantly ($p>0.05$) different; All values are expressed as Mean ± SD

Table 4: Heavy metal concentrations of the *Sarotherodon melanotheron* at Ologe Lagoon.

	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
Pb	0.26 ± 0.03^{c}	0.14 ± 0.01^{b}	0.07 ± 0.00^{a}	0.14 ± 0.01^{b}	0.38 ± 0.034^{d}	0.17 ± 0.02^{b}
Cu	1.27 ± 0.12^{a}	1.26 ± 0.21^{a}	6.15 ± 0.04^{e}	3.76 ± 0.08^{c}	2.64 ± 0.06^{b}	4.12 ± 0.09^{d}
Zn	17.80 ± 0.53^{a}	0.24 ± 0.00^{b}	35.27 ± 0.45^{f}	16.46 ± 0.06^{d}	14.43 ± 0.15^{c}	11.67 ± 0.06^{b}
Cd	0	0	0	0.02 ± 0.00^{a}	0	0.02 ± 0.00^{a}
Cr	$0.23 \pm .012^{e}$	0.14 ± 0.01^{d}	0.12 ± 0.01^{c}	0.05 ± 0.01^{b}	0.03 ± 0.01^{a}	0.05 ± 0.00^{b}

The value in the same row and with the same superscript letters are not significantly ($p>0.05$) different; All values are expressed as Mean ± SD

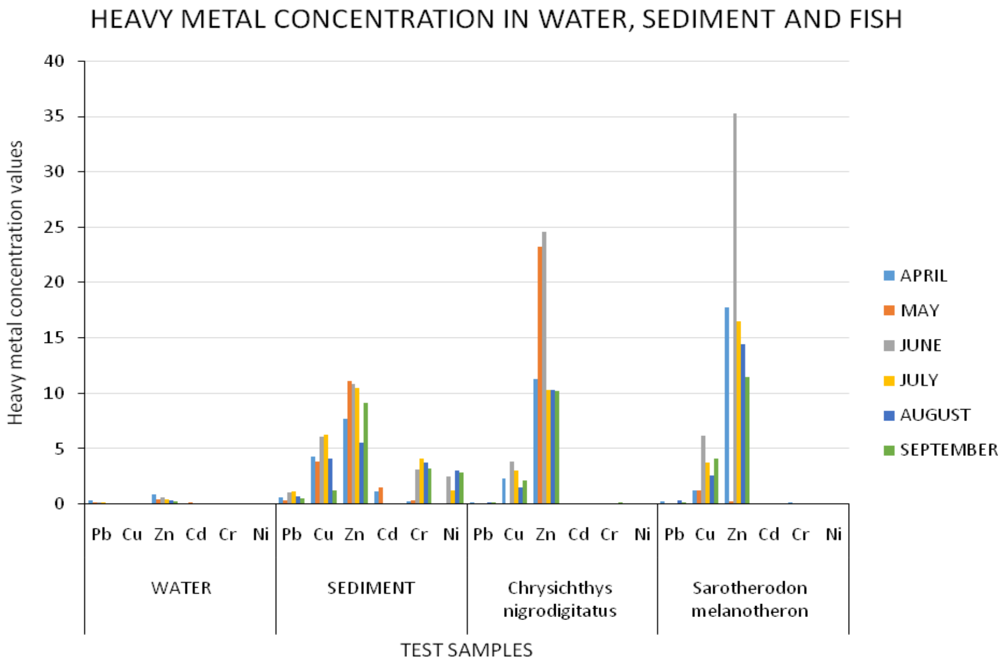

Figure 1: Heavy metal concentrations in water, sediments and fish species *Chrysichthys nigroditatus* and *Sarotherodon melanotheron* at the Ologe Lagoon.

Table 5: Bioaccumulation factor (BAF) of heavy metals in *Chrysichthys nigroditatus* at the Ologe Lagoon.

	Chrysichthys nigroditatus					
	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
Pb	3.25 ± 1.03	4.10 ± 2.22	0.00	20.28 ± 12.6	4.40 ± 2.51	3.20 ± 0.56
Cu	1.87 ± 0.05	291.98 ± 34.87	1.57 ± 0.36	2.06 ± 1.04	2.72 ± 1.12	0.58 ± 0.03
Zn	0.68 ± 0.04	0.48 ± 008	0.44 ± 0.03	1.01 ± 0.06	0.53 ± 0.32	0.89 ± 0.57
Cd	0.00	0.00	2.20 ± 1.34	0.00	1.28 ± 0.65	1.09 ± 0.76
Cr	3.04 ± 1.23	10.00 ± 3.98	34.67 ± 23.01	88.72 ± 34.42	51.07 ± 23.11	17.25 ± 5.02

Table 6: Bioaccumulation factor (BAF) of heavy metals in *Sarotherodon melanotheron* at the Ologe Lagoon.

	Sarotherodon melanotheron					
	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
Pb	2.40 ± 0.52	2.91 ± 0.11	15.90 ± 4.51	8.03 ± 0.12	2.01 ± 1.05	3.19 ± 1.01
Cu	3.32 ± 1.05	3.09 ± 0.05	0.99 ± 0.02	1.67 ± 0.05	1.56 ± 0.32	0.30 ± 0.01
Zn	0.43 ± 0.21	46.25 ± 23.1	0.31 ± 0.01	0.64 ± 0.03	0.38 ± 0.21	0.79 ± 0.26
Cd	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	1.84 ± 0.02	0.0 ± 0.0	2.00 ± 0.05
Cr	1.39 ± 0.24	2.79 ± 0.52	26.74 ± 11.01	77.74 ± 21.12	112.41 ± 87.21	65.53 ± 32.10

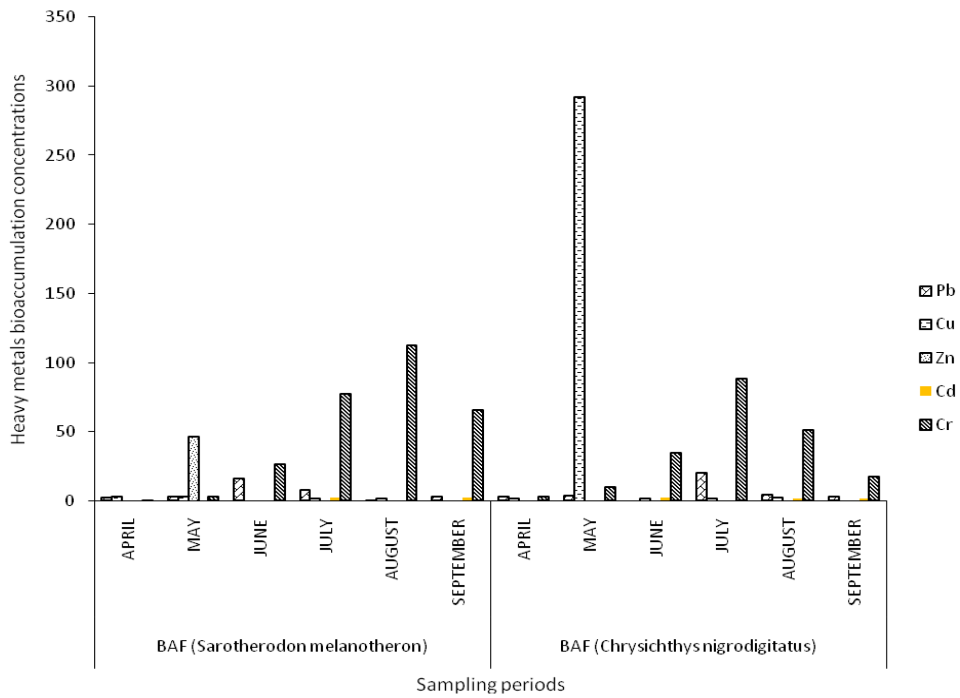

Figure 2: Bioaccumulation Factor of heavy metal concentrations in fish species *Chrysichthys nigroditatus* and *Sarotherodon melanotheron* at the Ologe Lagoon

Discussion

The study was carried out to determine heavy metals concentration (Zn, Pb, Cd, Cu, Ni and Cr) in water, sediments and tissues of two (2) different species of fish (*Chrysichthys nigrodigitatus* and *Sarotherodon melanotheron*) collected from Ologe Lagoon for a period of six months (April – Sept., 2014). The pH value range from 5.11 to 6.41with a mean pH

value of 5.78 which was slightly acidic in the water and fell below the FEPA and WHO standard limits of 6 – 9. The mean conductivity value ranges from 338.33 to 436.67µS/cm with a mean total value of 395.06 µS/cm which are far higher than 70µS/cm. The turbidity recorded a mean value of 21.12NTU which fell below the statutory limits of 25 or (<40) NTU, while the Biological Oxygen Demand was 63.32mg/L which was higher than FEPA/ WHO limits of 10 or 50 and Dissolved Oxygen (DO) was 3.29mg/L which fell below FEPA/ WHO limits of 6 mg/L. The physico-chemical parameters of the water and sediment qualities indicated that there was a significant difference in the water and sediments, as well as the heavy metal concentrations in the fish species at Ologe Lagoon, which are reflections of the level of heavy metal contamination. Obasohan (2006) also reported significantly differences in Cr, Pb, Cu and Zn levels in water and sediments in the study stretch of Ogba River and Ekpo *et al.,* (2013) also reported that the concentrations of heavy metals in bottom sediment were significantly higher (p<0.05) than those recorded in water samples.
Sediments act as the most important reservoir or sink of metals and other pollutants in the aquatic environment (Gupta *et al.*, 2009). 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 (Fernandes *et al.,* 2007).The sediments recorded more clay than silt and sand with a large fluctuations in the months. Hamed (1998) attributed the high concentrations of trace metals in the Imo river sediments to high clay content of sediment and industrial activities. Comparing the concentrations of trace metals in sandy sediments and clay sediments in aquatic environment, Udoessien (2004) reported that sandy sediments showed low concentrations of heavy metals than clayey sediments.

In this study, there were significant difference in the heavy metal concentration in the fish species at different months at the Ologe Lagoon. Obasohan *et al.*, (2006) also reported significantly differences in Cr, Pb, Cu and Zn levels in water and sediments in the study stretch of Ogba River. Chromium (Cr) bioaccumulation in fish has been reported to cause impaired respiratory and osmoregulatory functions through structural damage to gill epithelium (Heath, 1991). The values of Cr (0.04 – 0.19mg/kg) recorded in *Chrysichthys nigrodigitatus* and (0.03 – 0.20) in *Sarotherodon melanotheron* in this study were above WHO and FEPA limiting standards of 0.15mg/kg for food fish. Based on the above finding, the consumption of fish at Ologe Lagoon could presumably lead to Cr induced health stressor of ailments.The Copper concentrations accumulated in *Chrysichthys nigrodigitatus* in this study, ranged from 0.01±0.01 to 3.88±0.12mg/kg and 1.20±0.21 to 6.15±0.04 mg/kg in *Sarotherodon melanotheron*. These levels exceeded WHO and FEPA recommended limit (3.0mg/kg) in inland freshwater fish. The implication is that the fish from Ologe Lagoon, based on the recorded Copper (Cu) concentrations, may not be suitable for consumption. Copper (Cu) is an essential element that serves as a cofactor in a number of enzyme systems for most living organisms. Cu bioaccumulation has been reported to be related to copper toxicity and the pH of water is a determinant factor in the process (Carvalho *et al*, 2004). Fish are known to accumulate Ni in different tissues when exposed to elevated levels in their environment (Nussey *et al*, 2000; Obasohan and Oronsaye, 2004).The high level of Ni (<0.01mg/kg) recorded in both fish species (*Chrysichthys nigrodigitatus* and *Sarotherodon melanotheron*) in this study was low. The levels are below the WHO and FEPA recommended limits of 0.5 and 0.6mg/kg respectively in fish, indicating that the fish of the Ologe lagoon is less contaminated with nickel.

Lead (Pb) accumulation levels in *Chrysichthys nigrodigitatus* recorded in this study also varied significantly among the months. Oguzie (2003) also reported lower levels (0.007-0.022mg/kg) for fishes of Ikpoba River in the same locality. Lead (Pb) levels accumulated *Chrysichthys nigrodigitatus* in this study recorded a value range of 0 – 0.19mg/kg and 0.07 – 0.38mg/kg in *Sarotherodon melanotheron* which were, however, lower than WHO and FEPA standard limit of 2.0mg/kg for fish. This implies that the consumption of Ologe Lagoon fish as far as Pb contamination is concerned is safe for now.

Conclusion

The study showed that generally the metal concentration in the water and sediments bio accumulated in *Chrysichthys nigrodigitatus* and *Sarotherodon melanotheron* which are higher in Cr, Cu, Zn, and Cd. While the Ni and Pb are less in the tissues and are regarded to be safe.

Fish absorb metals through ingestion of water or contaminated food. Heavy metals have been shown to undergo bioaccumulation in the tissue of aquatic organisms. On consumption of fish and other aquatic organisms these metals become transferred to man. Although the results do not explicitly indicate a manifestation of toxic effects, the possibility that deleterious effects could manifest after a long period of consumption of fish caught in Ologe lagoon with metal contamination cannot be ruled out.

Recommendation

This study indicates that, fish at the Ologe Lagoon are still consumable though partially contaminated with slight increase in heavy metals influenced by anthropogenic activities. However, it is quite evident that there was bioaccumulation of heavy metals in fish tissues and condition may get worse. Therefore, regular monitoring of heavy metal levels in fishes is necessary.

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