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HEAVY METAL CONCENTRATIONS IN WATER AND SELECTED FISH SPECIES (TILAPIA, CAT FISH AND LUNG FISH) FROM LAKE BARINGO, KENYA

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Abstract: Elevated concentrations of heavy metals in water and sediments may be biomagnified along the aquatic food chains eventually affecting human health through the consumption of metal-contaminated water or fish from such water bodies. This study was carried out to assess the concentration levels of heavy metals in the tissues of Tilapia (Oreochromis niloticus), Cat fish (Clarias gariepinus) and Lung fish (Protopterus aethiopicus) from Lake Baringo, Kenya. Water samples were collected from four selected sites while the fish samples were purchased directly from the fishermen carrying out fishing activities within the lake. Analysis of the heavy metals (Cu, Zn, Fe, Cd and Pb) in water and fish samples was done using the flame atomic absorption Spectrophotometry (FAAS). From the results, the muscles always had lower concentration levels than the intestines in all the fish species for all the metals. In the muscles cat fish exhibited the highest levels of all the metals, followed by tilapia then lung fish. The pattern of the heavy metal concentration in tilapia muscles was Fe>Zn>Pb>Cu>Cd, that of cat fish muscles was Fe>Zn>Cu>Pb>Cd, while that of lung fish muscles was Fe>Zn>Pb>Cd. The heavy metal concentration patterns in the cat fish and lung fish muscles were almost similar except that copper was not detected in lung fish. The levels of Cu and Zn were below the WHO recommended limits for surface water while the mean concentration level of Fe was slightly above the WHO maximum permissible limit. On the hand, the concentration levels of Cd and Pb were above the WHO recommended limits. In the muscles, the concentrations of Zn and Fe were below the WHO recommended limits. Hence these metals have no immediate threat on the health of the consumers of fish and fish products from the lake. Cu, Pb and Cd concentration levels in the muscle tissues of the fish exceeded the WHO limits, exposing the consumers of fish from Lake Baringo to health risks.
Keywords: Bioaccumulation, Bio-magnification, Heavy metal, Intestines, Muscles, Toxicity.

I.0 Introduction

The continued increase in heavy metal concentration in the aquatic ecosystems is a global concern. Due to their bioaccumulation, ability to bio-magnify and toxicity even at low concentration, heavy metals pose potential negative impacts to the environment and human health. Heavy metals are released to the environment mainly from anthropogenic activities which include metal production, agricultural activities, mining, industrial development among others. They are also as a result of natural geochemical processes such as volcanic

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eruptions. The continued steady growth in human population has magnified the release of heavy metals into water bodies (Storelli, 2008). Heavy metals have a tendency to accumulate in selective tissues of living organisms (Bezuidehout *et al*., 1990). Heavy metals may bio-accumulate in various organs of aquatic organisms, particularly fish, which in turn may enter the human body through food chain causing serious health implications (Mozaffarian and Eric, 2006). Fish is a key source of proteins, minerals, vitamins and PUFAs (polyunsaturated fatty acids), particularly omega-3. Studies have shown that frequent consumption of fish reduces the risk of coronary heart disease, decreased mild hypertension and prevents certain cardiac illnesses (Mozaffarian and Eric, 2006). Consequently fish and fish products can be a key route of human exposure to heavy metals as fish may concentrate large amounts of heavy metals from food, water and sediments since it is often at the top of aquatic food chain (Storelli, 2008). Heavy metal exposure may lead to adverse health effects in humans including liver damage, renal failure cardiovascular diseases and even death (Javed and Usman, 2011).

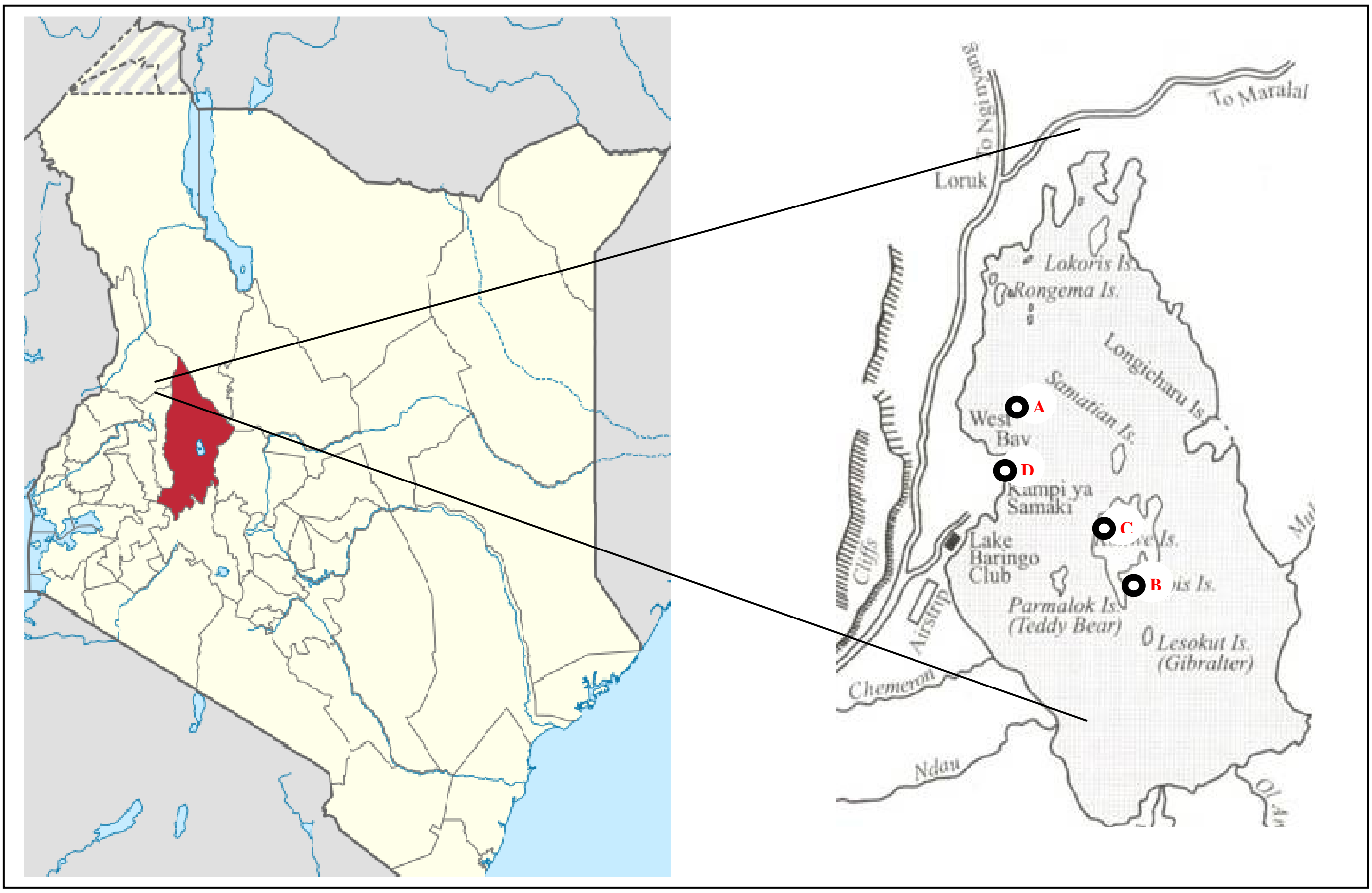
Human activities such as intensive agricultural activities, mining, increased use of leaded petrol, leather tanning and sludge dumping has led to massive increase in heavy metal content in the environment (Alo, 2006). According to previous studies heavy metals have been recorded in Lake Kariba, Zimbabwe (Berg *et al*., 1995), Lake Nasser (Rasheed, 2008) and Ogu River, Nigeria (Farkas and Adelowo, 2007). High concentration of heavy metals both in fish and water have been reported in Kenyan aquatic ecosystems as well (Mwashote, 2003) and (Muiruri *et al*., 2013). Due to the anthropogenic activities on the catchment areas, the water quality of the Feeder Rivers (Molo River and Perkerra River) may be impaired due to high concentrations of dissolved organic and inorganic substances which include heavy metals among others. This may lead to subsequent pollution of the lake. In the present study, concentration levels of heavy metals in water and selected fish species from Lake Baringo were determined and compared against the WHO maximum permissible limits to assess the quality of water and fish from the lake for human consumption.

2.0 Materials and Methods

2.1 Study Area

Lake Baringo is a fresh water Lake located in Baringo County within the Kenyan Rift Valley (fig. 1). The lake has a surface area of about 130 km^2 which may rise to 168 km^2 during the rainy seasons and an altitude of about 1100 m above sea level. There are two main and permanent tributaries which serve the lake, namely Molo river and Perkerra river and several seasonal rivers.

Figure 1: The study area map showing the sampling sites



.2.2 Sample Collection

Sites receiving effluents were chosen except for the southern sampling point which was far from the areas within the lake receiving direct effluents. Three replicate water samples were collected from each of the four sampling points. The samples were collected in polyethylene bottles and acidified with concentrated HNO_3. Fish samples were purchased directly from fishermen at landing sites on the shores of Lake Baringo. The samples were then put in a cool box filled with ice and transported to the laboratory for the analysis.

2.3 Determination of Heavy Metal in Water Samples

In the laboratory, the samples were filtered using filter papers and stored below 8^oC prior to the heavy metal analysis. 50 ml of each sample was evaporated to 20 ml to concentrate the metal ions. Heavy metal concentrations were then determined by flame atomic absorption Spectrophotometry (APHA, 1998).

2.4 Determination of heavy metals in fish

Heavy metals in fish were determined by separately digesting 1.0 g of intestines and 1.0 g of the muscle of each sample in 10 ml of a mixture of Nitric acid and Perchloric acid in the ratio 3:1 (v/v). The digested fish samples were then run in the AAS machine for heavy metal analysis.

3.0 Results and Discussion

3.1 Heavy Metal Concentration in Surface Water of Lake Baringo

Concentrations of the metals of interest varied with different sampling points as shown in table 3.1.

Table 3.1: Concentrations of Cu, Zn, Fe Cd and Pb in surface water from Lake Baringo

Sampling point	Copper in μ/ml	Zinc in μ/ml	Iron in μ/ml	Cadmium in μ/ml	Lead in μ/ml
Northern	0.15±0.02	0.04±0.01	0.40±0.01	0.04±0.01	0.25±0.03
Southern	0.02±0.01	$0.01\pm0.00_2$	0.05±0.01	$0.03\pm0.00_2$	BDL
Central	0.07±0.02	0.18±0.03	0.26±0.02	$0.19\pm0.00_3$	0.11±0.02
Landing	0.08±0.03	0.31±0.02	0.28±0.02	$0.01\pm0.00_1$	0.31±0.04
WHO	1	3	0.1	0.005	0.01

At the northern point, Fe recorded the highest concentration (0.40±0.01 μ/ml) while Zn and Cd recorded the lowest concentration levels (0.04±0.01 μ/ml). The Southern point gave the lowest concentration for all metals with iron being the most abundant (0.05±0.01 μ/ml) followed by cadmium ($0.03\pm0.00_2$ μ/ml), copper (0.02±0.01 μ/ml) and zinc ($0.01\pm0.00_2$ μ/ml). Lead was, however, not detected at the point. Fe had the highest concentration at the central point while Cu levels were lowest at the point. The landing point had the concentration levels for Zn and Pb being the highest while Cd had the lowest concentration. The mean concentration levels recorded for Cu and Zn were below the WHO recommended limits while the Fe concentrations recorded were slightly above the WHO maximum permissible limit. The mean concentration levels for Cd and Pb recorded were however above the WHO recommended values. Similar studies done in Lake Victoria, Kenya also recorded high zinc concentration levels (Lalah *et al*., 2008 and Mwamburi, 2009).

3.2 Heavy Metal Concentration in Selected fish species

Heavy metals can enter into fish through the skin, gills and orally through food and water (Al-Kahtani, 2009). In the fish body, the metal is transported through the blood stream and either stored, transformed or excreted (Ozturk *et al*., 2009). The muscles always had lower concentration levels than the intestines in all the fish species for all the metals. In the muscles cat fish exhibited the highest levels of all the metals, followed by tilapia then lung fish (table 3.2)

Table 3.2: Mean concentrations Cu, Zn, Fe, Cd and Pb in fish samples

sample	part	Copper (mg/Kg)	Zinc (mg/kg)	Iron (mg/kg)	Cadmium (mg/Kg)	Lead (mg/Kg)
Tilapia	Intestines	12.2±3.64	85.7±4.07	5154.4±95.35	3.1±0.07	7.42±2.00$_1$
	muscle	5.8±1.26	17.1±4.36	63.9±8.57	0.1±0.04	6.11±1.02
Cat fish	Intestines	21.0±2.57	49.4±3.5	2226.8±16.5	2.5±0.13	6.55±1.336
	muscle	8.5±0.47	29.5±4.28	125.6±55.07	1.9±0.30	5.75±1.57
Lung fish	Intestines	8.5±0.41	78.8±1.45	209.7±4.29	2.1±0.22	5.47±0.196
	muscle	BDL	25.7±1.47	53.0±2.14	0.7±0.19	4.17±0.39

Concentrations of Cu in the muscles showed a slight variation ranging from 5.80±1.26 mg/kg wet mass (tilapia) to 8.5±0.47 mg/kg wet mass (cat fish). Cu, however, was not detected in the muscles of lung fish. The concentration levels of copper recorded in the muscles were slightly above the WHO maximum permissible limit of 3.0 mg/kg in fish and fish products. (WHO, 2004).

As shown in table 3.2, the highest concentration levels of Zn in the fish muscle were recorded in cat fish (29.5±4.28 mg/kg) while tilapia recorded the lowest concentration in muscles (17.10±4.36 mg/kg) wet mass. The mean zinc concentration levels in the fish muscles studied were below the recommended limit of 75 mg/kg in fish and fish products (FAO/WHO 1984). Njogu *et al*. (2011) recorded comparable results in Lake Naivasha, Kenya. The muscles recorded Fe concentration levels ranging from 53.03±2.14 mg/kg (lung fish) to 125.6±55.07 mg/kg wet mass in cat fish. Akan *et al*. (2010) recorded similar results in which the concentration level of iron was high in tilapia in a study carried out in river Benue in Adamawa state, Nigeria. High mean iron concentration values were also recorded by Aharamwa and Umunnakwe (2014) in the assessment of heavy metal content in fish muscle in Lake Oguta, Imo State Nigeria. The mean iron concentration levels recorded in the fish muscles during the study were below the recommended limit of 100 mg/kg in fish and fish products except for the cat fish which recorded mean Fe concentration levels of 125.6±55.07 mg/kg wet mass in the muscle.

Cadmium concentrations in the muscles ranged from 0.1±0.04 mg/kg wet mass (tilapia) to 1.9±0.30 mg/kg wet mass in cat fish. This was slightly above the WHO maximum permissible limit of 1.0 mg/kg. Similar results were reported by Mbuthia *et al. (*2014) on a study in Lake Baringo, Kenya. The concentration level of cadmium in tilapia muscles, however, was below the WHO maximum permissible limit (MPL).

Lead is a well known toxicant that has several deleterious effects even at low concentrations. The concentrations of lead obtained in the fish muscle of each of the species were relatively high considering the acute toxicity of the metal. Tilapia recorded the highest concentration (6.11±1.02 mg/kg) in the muscle followed by cat fish (5.75±1.57 mg/kg) while lung fish recorded the lowest concentration level (4.17±.39 mg/kg). The mean concentration levels of Pb in the fish muscle recorded during the study were above the WHO guideline value of 2.0 mg/kg in fish and fish products (WHO, 2000). The results are in line with the findings of Tole and Shitsama (2003) on heavy metal concentration in fish from Winam Gulf of Lake Victoria, Kenya which can be attributed to industrial effluents running into the lake.

3.3 Conclusion

The most dominant metal in the water samples was Fe while the least abundant one was Cu. The mean concentration levels of Cu and Zn were below the WHO guideline value in surface water. The mean concentration level of Fe was however slightly above the WHO maximum permissible limit. On the contrary, the concentration levels of Cd and Pb were above the WHO recommended limits. This shows that Lake Baringo may be polluted with Pb and Cd. The results also showed that metal accumulation varied between fish species depending on species-specific factors like age, feeding behavior and swimming patterns. The concentration levels of all the metals of interest in the muscles were remarkably lower than in the intestines. Cat fish accumulated the highest levels of all the metals in the muscles compared to the rest of the species. The concentrations of Zn and Fe were below the WHO recommended limits for fish and fish products. Hence these metals have no immediate threat on the health of the consumers of fish and fish products from Lake Baringo. However, the levels of Cu, Pb and Cd in the muscle tissues of the fish exceeded the WHO maximum permissible limit. This exposes the consumers of fish and fish products from Lake Baringo to health risks.

The study recommends

1. Further research on other heavy metals not covered in the study.
2. Further research should be carried out to determine the concentration levels of the studied metals in different fish organs such as the gills, scales and the liver.

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References

[1] Aharamwa, B.C. and Umunnakwe, J. E. (2014). Assessment of water quality and heavy metal levels of fish species in Oguta lake, Imo state Nigeria. *Journal of Natural Sciences Research*, 4: 103-111.

[2] Akan, J.C., Abdulrahman, F.I., Sodipo, O.A., Ochanya.A.E. and Askira, Y.K. (2010): Heavy metals in sediments from river Ngada, Maiduguri Metropolis, Borno state, Nigeria. *Journal of Environmental Chemistry,* 3:1-8.

[3] Al-Kahtani, M. A. (2009). Accumulation of heavy metal in Tilapia fish (Oreochromis niloticus) from Al-Khadoud Spring Al-Hassa, Saudi Arabia. *American Journal of Applied Sciences* , 1: 2024-2029.

[4] Alo, B. (2006). Heavy metal pollution in different environmental media in africa. problems and prospects(with case studies from Nigeria). Abuja: *University of Lagos Centre for Environmental Human Resources Development Department of Chemistry*, 1: 6-9

[5] APHA, (1998). Standard methods for the examination of waste water. Washington DC.

[6] Berg, H., Kiibus., M. and Kautsky, N. (1995). Heavy metals in a tropical Lake Kariba Zimbabwe. *Water and Soil Pollution*, 2: 237-252.

[7] Bezuidehout, L., Schoonbee., H. and Dewet, L. (1990). Heavy metal content in organs of the African Sharptooth Catfish, Clarias gariepinus; Burchel from a transvaal lake affected by mine and industrial effluents. *Water South Africa*, 4: 125-128.

[8] FAO/WHO (1984). List of maximum levels recommended for contaminants by the joint FAO/WHO *Codex Alimentarius Commission,* 3:1-8

[9] Farkas, E. and Adelowo, O. (2007). Biomarkers of oxidative stress and heavy metal levels as indicators of environmental pollution in African Cat fish (Clarias gariepinus) from Nigeria Ogu river. *International journal of environmental resources and public health*, 2: 158-165.

[10] Mbuthia, J.W., Ogendi, G.M., Moturi, W.N. and Maina, G.M. (2014). Heavy Metal Concentration in Tissues of Commercially Exploited Fish from Lake Baringo, Kenya. *Journal of Environmental Science, Toxicology and Food Technology.* 8(3): 55-63.

[11] Mozaffarian, D. and Eric, B. (2006). Fish intake, contaminants and human health: Evaluating the Risks and the Benefits. *Journal of American Medical Association*. 296: 1885-1900.

[12] Muiruri, J., Nyambaka, H. and Nawiri, M. (2013). Heavy metals in Water and Tilapia fish from Athi-Galana-Sabaki tributaries, Nairobi. *International Food Research Journal*, 23:891-896.

[13] Mwashote, B. (2003). Levels of Cadmium and Lead in water, sediments and selected fish species in Mombasa, Kenya. *Western Indian Ocean Journal*, 1: 25-34.

[14] Njogu, P., Keriko, J.M., Wanjau, R.N. and Kitetu, J.J. (2011). Distribution of heavy metals in various lake matrices: water, soil, fish and sediments: A case study of the Lake Naivasha basin, Kenya. *Jomo Kenyatta University of Agriculture Science and Technology*, 13(1): 23-47.

[15] Ozturk, M., Ozozen, G., Minareshi, O. and Minareshi, E. (2009). Determination of heavy metals in fish, water and sediments of Avsar Dam Lake. Iran. *Journal of Environmental Health, Science and Engineering*, 1: 73-80.

[16] Rasheed, M. (2008). Monitoring of Heavy metals in fish from Nasser Lake. *Environmental International Journal*, 7:168-175.

[17] Storelli, M. (2008). Potential human health risks from metals (Hg, Cd, and Pb) and polychlorinated biphenyls (PCBs) via seafood consumption: Estimation of target hazard quotients (THQs) and toxic equivalents (TEQs). *Pharmacological-Biological Department, University of Bari*, 1:2782-2788

[18] Tole, M. P. and Shitsama, J. M. (2003). Concentrations of heavy metals in water, fish and sediments of the Winam Gulf, Lake Victoria, Kenya. *Aquatic Ecosystem Health and Management Society*, 1:1-9.

[19] WHO (2000). Hazardous Chemicals in human and environmental health, Geneva, pp. 564

[20] WHO (2004). Copper in drinking water. Background Document for the Development of WHO Guidelines for Drinking Water Quality. Geneva, pp. 516.