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RESEARCH ARTICLE

HEAVY METALS CONCENTRATIONS IN NILE TILAPIA FISH (OREOCHROMIS NILOTICUS) IN DONGOLA AND MEROWE, NORTHERN STATE, SUDAN

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ABSTRACT

The contamination of metals is a major environmental problem and, especially in the aquatic environment. This study aims to identify and determine the levels the heavy metals (HMs) in the tilapia fish tissue in two localities in the Northern State, Sudan. The tilapia fish tissue was analyzed in the Central Petroleum Laboratories, Khartoum, Sudan, using Inductively Coupled Plasma– Optical Emission Spectrometer ICP-OES 725 E) instrument to determine Zn, Pb, Cu, Co, Ni, Cd, Mo, Cr, Fe, Li, and Hg levels and compare their concentrations with the permissible levels (PLs), using the Complete Randomized Design (CRD) with three replications. The results from two localities reflects the presence of high amounts of HMs, the two types of tissue (muscular & liver) from Tilapia fish demonstrated the presence of high quantities of Lead and Nickel in muscle tissue more than the permissible limits (0.214 and 0.5 -0.6 ppm) according to FAO/WHO1999 EPA2003. Similar in the Liver tissue also demonstrated high quantities of Lead more than the permissible limits according to FAO/WHO (1999) EPA (2003). It is concluded that the accumulation of Heavy metals in the aquatic environment in the northern state requires more attention from the authorities.

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INTRODUCTION

Fish are used as bio-indicators of aquatic ecosystems for estimation of HM pollution and potential risk for human consumption (Agarwal *et al.,* 2007). Bioaccumulation of metals in fish takes place directly, from the water by gills and indirectly from food (Barron, 1990). The metals such as Cu, Zn, Fe, and Co are essential and have important biochemical functions in the organism as opposed to non-essential metals like Pb, Cd, Hg, and As. Essential metals are used either as an electron donor system or function as ligands in complex enzymatic compounds. The essential trace metals are only used in trace amount by the organism and usually they are found in small concentrations in the environment. The amount of heavy metals (HMs) in the organism does not exceed the level, which allows the enzyme system to function without interference. The excess amount of HM in the organism can be regulated by homeostasis. However, if the HM concentration at the source of supply, e.g. water and food, is too high, the homeostasis mechanism ceases to function and the HMs act in either an acutely or chronically toxic manner (Bryan and Hummerstone, 1973).The function of uptake and excretion in fish determine the accumulation of metal in fish. The gills are likely sites of metal uptake from water, due to their large surface area and the close proximity of the internal constituent of the body and external environment (Wepener, 1997). Within the body, the degree of accumulation in different tissues is dependent on the binding of the metal to specific ligands. Dallinger *et al*. (1987) stated that, as far as fish is concerned, there are three possible ways, by which metals may enter the body: (i) the body surface, (ii) the gill, and (iii) the alimentary tract. However, little is known about the uptake of HMs through the skin. It can be assumed that the body surface of fish more or less, impervious to harmful substances in the surrounding water. HMs have an effect on different aquatic organisms, but its effect is often complex and difficult to interpret. Dissolved oxygen, pH, salinity, temperature and hardness of water proved to be factors that influence the physiology of an organism and the rate of uptake of HMs. According to Chaudhari *et al*. (1996), the main factors concerned in determining the seasonal variation of HM levels in aquatic biota are the extent of pollutant delivery into the aquatic

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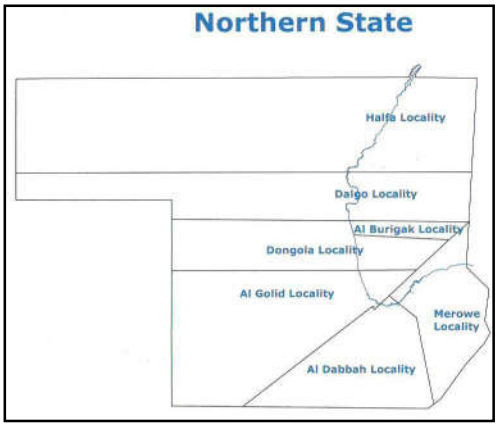
environment, the weight change occurring in the organisms and the direct effects of salinity, temperature and other water qualities, which vary seasonally.

MATERIALS AND METHODS

Site of experiment: The study was carried out in Dongola and Merowe localities, Northern State, Sudan. The state population is *ca*.699,065). Map of the River Nile State showing the River, Dongola and Merowe is shown below.



Methods: The laboratory work was meant to determine Zn, Pb, Cu, Co, Ni, Cd, Mo, Cr, Fe, Li, and Hg levels in tilapia fish *(Oreochromis niloticus)* tissue in Dongola and Merowe administrativelocalities and compared with the permissible levels (PLs), using the Complete Randomized Designed (CRD) with three replications.

Samples collection: Nile tilapia samples were collected from commercial catch, three times every year, from the two localities with total 18 samples. The fresh fish samples were kept in clean white polyethylene bags previously washed with a detergent, rinsed with de-ionized water and nitric acid, in order to reduce or remove HMs residues, then stored in cool containers and transported to the Veterinary Research Laboratory, Soba, Khartoum, for surgical removal of the liver and the muscles before they were analyzed for HMs at the Central Petroleum Laboratories (CPL), Khartoum, using Inductively Coupled Plasma– Optical Emission Spectrometer ICP-OES 725 E)ICP-OES.

Reagents, Instruments and Glassware: The reagents required for this work were as follows: HNO3 and deionized water. The materials and glassware used were sterile water, measuring cylinders of different sizes, pipettes, test tubes, volumetric flasks and ICP-OES 725 E).

Sample Preparation: The fish samples were oven dried at 105 °C until they reached a constant weight (Jackson, 1992). Each dried sample was then ground into a fine powder, using porcelain mortar and pestle, and thereafter all powdered tissues were kept in desiccators prior to further chemical analysis. The fish powder samples were thoroughly homogenized, before subjecting them to digestion, and were digested using concentrated $HNO_3$and H_2O_2 (1:1, v/v) according to FAO methods (Daziel and Baker, 1983). Dried and powdered fish samples (1 g) was weighed and transferred into 250 ml round bottled flask, and the mixture of 10 ml of concentrated HNO_3 (65%) and 10 ml of H_2O_2 (30%) was added . The flask was covered with a watch glass and left aside until the initial vigorous reactions occur. The samples were heated on a Heating Mantle to 130 °C until dissolution inside a fume-hood to reduce the volume to 3-4 ml. The samples were allowed to cool, filtered and diluted to 50 ml in volumetric flask with de-ionized water. Digested tissue samples were analyzed to determine the concentration of HMs by ICP-OES.

RESULTS AND DISCUSSION

All metals, however, can be toxic to aquatic organism where present at high levels, causing direct effects, *e.g*. histological damage or a reduction in survival, growth and reproduction of the species it influences (Heath, 1987). Tables (1 and 2) showed that the fish collected from the River Nile of the two localities indicted the presence of high levels of HMs in both muscles and liver, *viz*. Pb and Ni; more than the permissible limits (0.214 and 0.5 -0.6 ppm) according to FAO/WHO (1999) and US EPA (2003). In the Liver, Pb was higher than the PLs of the two above-mentioned agencies. In Lake Manzala, Egypt, Muiruri *et al.* (2013) reported that the concentration of Pb, Mn, Cd and Cr in water, and Pb, Ni and Mn in Tilapia fish gills were found to be higher than the WHO recommended limit. However, the present study confirmed the results obtained by Samir and Ibrahim(2008) as they found that the edible part of tilapia fish showed higher levels of Cd and Pb, in the lakes Edku and Manzala, Egypt

Table 1. Concentration of heavy metals (ppm; mean±SE) in the Tilapia fish tissues from Dongola Locality, determined by ICP method

HM	Zn	Pb	Cu	Co	Ni	Cd	Mo	Cr	Fe	Li	Hg
MUSCLE	0.166 ± 0.007	0.481 ±0.055	0.229 ± 0.004	0.0024 ±0.001	4.023 ± 0.180	00.085 ± 0.003	0.075 ± 0.006	0.406 ± 0.006	0.0345 ± 0.002	0.093 ± 0.005	0.006 ± 0.001
CV%	1.60	6.20	2.50	2.40	1.50	1.00	4.70	6.70	1.70	1.80	6.00
LIVER	0.160 ± 0.001	0.467 ± 0.016	0.412 ± 0.030	0.034 ± 0.002	0.340 ± 0.010	0.098 ± 0.000	0.092 ± 0.002	0.053 ± 0.046	0.397 ± 0.016	0.097 ± 0.001	0.008 ± 0.000
CV%	1.60	2.90	1.70	1.10	3.40	9.80	3.06	1.15	2.48	9.70	8.00
PLs FAO/WHO(1999), EPA(2003)	60	0.214	3.0	NF	0.5 -0.6	0.1	NF	0.15-1.0	43	NF	NF

NF= Not Found

Table 2. Concentrations of heavy metals (ppm; mean±SE)) in the Tilapia fish tissues from Merowe Locality, determined by ICP method

HM	Zn	Pb	Cu	Co	Ni	Cd	Mo	Cr	Fe	Li	Hg
MUSCLE	0.131 ±0.002	0.399 ± 0.003	0.229± 0.008	0.021 ± 0.002	3.577 ± 0.112	0.083 ± 0.003	0.071 ± 0.001	0.362± 0.004	0.341 ± 0.003	0.094 ± 0.002	0.04 ± 0.001
C.V.%	4.30	9.90	2.81	1.05	2.26	2.07	7.10	6.03	8.52	3.13	4.00
LIVER	0.139 ± 0.001	0.466 ± 0.006	0.241 ± 0.002	0.027 ± 0.002	0.285 ± 0.085	0.097 ± 0.001	0.080 ± 0.000	0.051 ± 0.046	0.353 ± 0.001	0.097 ± 0.001	0.006 ± 0.000
C.V.%	1.39	5.82	1.20	1.35	3.35	9.70	8.00	7.72	1.76	9.70	0
PLs FAO/WHO (1999), EPA (2003)	60.0	0.214	3.0	NF	0.5 -0.6	0.1	NF	0.15-1.0	43.0	NF	NF

NF= Not Found

Conclusion

The Tilapia fish tissue from both localities demonstrated the presence of high amounts of HMs, more than the permissible limits. It is, therefore, recommended that HMs pollution in the Northern State of Sudan requires more efforts from the authorities.

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