ISSN: 2347-5129
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.549
IJFAS 2016; 4(5): 284-286

www.fisheriesjournal.com
Received: 10-07-2016
Accepted: 11-08-2016

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Detection of the accumulation of heavy metals in *Oreochromis niloticus* fish flesh collected from three different Sudanese dams

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Abstract
The present study aimed to provide information for accumulation of heavy metals e.g. Pb, Cd, Zn and Cu in flesh of *Oreochromis niloticus* from three different Sudanese dams e.g. Jebel Aulia, Sennar and Marawi collected from upstream and downstream, respectively. A study of heavy metal concentrations in flesh of the studied fish showed that there were highly significant differences between the Pb, Cd, Zn and Cu, respectively. Heavy metal analysis from the *O. niloticus* muscles collected from Jebal Aulia, Sennar and Marawi dams showed that there were significant differences in Pb, Cd, Zn and Cu accumulated in *O. niloticus* muscles collected from the three different localities. All statistical analysis was carried out using Statistical Analysis program (SPSS,17) performed using one way analysis of variance (ANOVA) and Duncan's multiple Range Test, to determine differences between metals means at significance rate of $P<(0.05)$.

Keywords: Heavy metals, water quality, dams, oreochromis niloticus

1. Introduction
Bioaccumulation of heavy metals is capable of leading to toxic level on fish even when the exposure is low and the presence of heavy metals pollutant in freshwater environment is known to disturb the normal balance of the aquatic organism. A fish are notorious for their ability to concentrate heavy metals in their muscles and thus plays an important role in human's nutrition; they need to be carefully screened to ensure that unnecessary high level of some toxic trace metals are not being transferred to humans through fish consumption [1].
Anthropogenic activities continuously increase the amount of heavy metals in the environment, especially in aquatic ecosystem. Pollution of heavy metals in aquatic system is growing at an alarming rate and has become an important worldwide problem [6].
Increasing population, urbanization, industrialization and agriculture practices have further aggravated the situation [4]. As heavy metals cannot be degraded, they are deposited, assimilated or incorporated in water, sediment and aquatic animals and 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 associated risks [2].
As a consequence, fish are often used as indicators of heavy metals contamination in the aquatic ecosystem because they occupy high tropic levels and are important food source [2]. Fish are considered as one of the most indicative factors, in freshwater ecosystems, for the estimation of trace metals pollution [9]. Heavy metals like copper, iron and zinc are essential for fish metabolism, while some others such as mercury, cadmium and lead have no known role in biological systems. For normal metabolism, the essential metals must be taken up from water or food, but excessive intake of the essential metals can produce toxic effects [9].
Sudan is endowed with diversified surface and underground water resources, and arable lands that are suitable to support vigorous capture fishery activities which centered on the Nile River and its tributaries, and the territorial water of the Red Sea [3].
Recently, the demand for Tilapia *Oreochromis niloticus* consumption has increased continuously because *O. niloticus* is of low price with high nutritional value. The whole fish and fillet are admirable for consumers. Moreover, *O.niloticus* has many outstanding advantages such as easy to culture, high growth rate, easy breeding, high fibrillate protein,

cotton meat like sea bass fish, high nutrition and having more Omega-3 than other wild freshwater fishes and wild estuarine fishes. Therefore, the main objective of the present study is to provide information about the accumulation of heavy metals such as Pb, Cd, Zn and Cu in flesh of *O. niloticus* collected from upstream and downstream out of three different Sudanese dams as Jebel Aulia, Sennar and Marawi, respectively.

2. Materials and Methods

2.1 Study Area

The present study was conducted at the Central Laboratory of Fish Biology at Sudan University of Science and Technology, Sudan. Three fishing collection sites were designated; the first site includes two stations which their water supplies along White Nile River. The second site includes two stations that had their water supply along the Blue Nile River, and the third one includes two stations as which their water supply along Nile River main stream, respectively. The first site is Jebel Aulia Dam which is a dam on the White Nile River, South city of Khartoum; the second site is in city of Sennar located on the Blue Nile State, called Sennar Dam wherein was built in 1925 by the British engineer, desert explorer and adventurer, Stephen "Roy" Sherlock, under the direction of Weetman Pearson. The third site is Marawi Dam, which considered as the biggest dam in the country located near the city of Marawi in the State of Northern Sudan, about 350 km (220 mi) north Khartoum. It is situated on the River Nile main stream, close to the 4th Cataract wherein the river divides into multiple smaller branches with large islands in between.

2.2 Samples Preparation and Analysis

Ten fresh fish samples of O. niloticus were taken randomly from each station regularly every month for duration of one year sampling period. The samples were stored in ice containers and transferred to Soba Laboratory Center in Khartoum State for preparation and processing of heavy metal's analysis. Each sample was collected from each locality from up and down stream; dissection for its muscle tissues was made. The flash samples was dried using electric oven at 105 ºC for at least 9 hours till constant weight is achieved. Dry sample was grinded using manual porcelain mortar. All tools were made of stainless steel to avoid contamination with metal residues.

Further, about 5g from wet muscle was dried, ignited and digested with concentrated HNO_3 and HCL. The heavy metal Cu, Zn, Cd and Pb in water and flesh was measured using atomic absorption spectrophotometer (Thermo 6600, thermo electron corporation, Cambridge, UK).

2.3 Determination of Heavy Metals

Following the procedure by [7] Weighing 2.0g of powder sample in to a silica evaporating crucible of known Weight, place and then transfer the crucible on a hot plate and allow smoking until completely charred; transfer crucible to muffle furnace at of 470 ºC and the ash left at this temperature for three hours. When completed; cool and extract with minimum amount of hydrochloric acid. Evaporate to dryness, extract again with 10ml of 25% HCL, boil and filter in to 100ml calibrated flask, wash the filter with warm 1% HCL solution and make up to 100ml with water and mix. This solution is used for the determination of heavy metals.

Readings of Targeted Elements

The instrument which was adopted for the readings to the two trace elements was the atomic Absorption Spectrometer (AAS) A Analyst 700.

2.4 Statistical Analysis

Statistical analysis was performed using one way Analysis of variance (ANOVA) and Duncan's multiple Range Test to determine the differences between heavy metals means at significance rate of $P<0.05$. The standard deviation of heavy metals means was also estimated. All statistics was carrying out using Statistical Analysis program (SPSS, 17).

3. Results

The heavy mantel concentration in O.niloticus flesh collected from three Sudanese Dams is presented in table (1, 2 and 3). The results showed that there were highly significant differences at ($P>0.05$) in the heavy metals in O.niloticus samples collected from upstream and downstream in all seasons.

Table 1: Mean Heavy Metals Data in *Oreochromis niloticus* During Summer.

Habitats (Dam)		Heavy metals (mg/L)			
		Pb	Cd	Cu	Zn
Jebel Aulia	Upstream	0.215±0.156[a]	0.217±0.003[a]	0.127±0.003[a]	0.105±0.004[a]
	Downstream	0.295±0.054[a]	0.032±0.003[a]	0.133±0.005[a]	0.105±0.005[a]
Sennar	Upstream	0.184±0.008[b]	0.021±0.002[b]	0.115±0.006[b]	0.102±0.005[a]
	Downstream	0.216±0.010[b]	0.028±0.003[a]	0.128±0.004[b]	0.106±0.004[a]
Marawi	Upstream	0.184±0.013[b]	0.080±0.001[b]	0.120±0.003[b]	0.101±0.004[a]
	Downstream	0.227±0.019[b]	0.020±0.002[b]	0.128±0.002[b]	0.079±0.054[b]

[a,b,c]: Means in the same raw with superscript are significant differences at ($p\leq0.05$).

Table 2: Mean Heavy Metals Data in *Oreochromis niloticus* During Winter.

Habitats (Dam)		Heavy metals (mg/L)			
		Pb	Cd	Cu	Zn
Jebel Aulia	Upstream	0.253±0.008[b]	0.037±0.005[a]	0.127±0.007[b]	0.109±0.011[a]
	Downstream	0.257±0.012[b]	0.050±0.010[b]	0.137±0.009[b]	0.115±0.005[b]
Sennar	Upstream	0.283±0.009[a]	0.032±0.003[a]	0.119±0.004[c]	0.101±0.004[a]
	Downstream	0.314±0.017[a]	0.360±0.001[a]	0.123±0.003[c]	0.124±0.003[a]
Marawi	Upstream	0.219±0.004[c]	0.032±0.005[a]	0.130±0.004[a]	0.107±0.005[a]
	Downstream	0.229±0.003[c]	0.049±0.008[b]	0.145±0.004[a]	0.123±0.005[b]

[a,b,c]: Means in the same raw with superscript are significant differences at ($p\leq0.05$).

Table 3: Mean Heavy Metals Data in Oreochromis niloticus During Autumn.

Habitats		Heavy metals (mg/L)			
		Pb	Cd	Cu	Zn
Jebel Aulia	Upstream	0.174±0.006[a]	0.014±0.001[a]	0.118±0.003[b]	0.096±0.005[a]
	Downstream	0.209±0.011[b]	0.021±0.001[a]	0.124±0.004[b]	0.103±0.003[b]
Sennar	Upstream	0.182±0.106[a]	0.019±0.001[a]	0.123±0.004[a]	0.095±0.006[a]
	Downstream	0.208±0.007[b]	0.023±0.002[a]	0.128±0.003[a]	0.108±0.008[a]
Marawi	Upstream	0.172±0.007[b]	0.015±0.002[a]	0.121±0.004[a]	0.096±0.006[a]
	Downstream	0.215±0.023[a]	0.018±0.002[b]	0.126±0.006[a]	0.110±0.004[a]

[a,b,c]: Means in the same raw with superscript are significant differences at ($p \leq 0.05$).

4. Discussion

The amounts of Pb, Cd, Zn and Cu in O. niloticus muscle are summarized in Table 1. 2 and 3. Various studies found that metal uptake by fish performed via water and food which constitutes the major pathway for accumulation in liver and muscle. However, when contamination occurs, concentration of metals in certain tissues increases in proportion with that of fresh water. A study of heavy metal concentrations in O. niloticus flesh collected from three different locations up and down stream throughout the year showed that there are highly significant differences among Pb, Cd, Zn and Cu, respectively. These findings in the same line with [5] who reported that 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. Heavy metal analysis of the O. niloticus muscle collected from Jebel Aulia, Sennar and Marawi dams showed that there is significant concentration of Pb, Cd, Zn and Cu accumulated in O. niloticus muscle from the three localities, wherein this results are agreed with [9] who reported that heavy metals like copper, iron and zinc are essential for fish metabolism, while some others such as mercury, cadmium and lead have no known role in biological systems. For normal metabolism the essential metals must be taken up from water or food, but excessive intake of the essential metals can produce toxic effects.

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