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Assessment of Some Heavy Metals in Oreochromis Niloticus and Bagrus Bayad, from River Nile and Swamp Water, Sudan

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ABSTRACT

Nile fish has an important role in food security and poverty alleviation in both rural and urban areas of the Sudan. The study was conducted to evaluate heavy metals Oreochromis niloticus and Bagrus bayad in River Nile at Khartoum state and Swamp water at north Kordofan State, Sudan. A total of 156 samples of Oreochromis niloticus and Bagrus bayad were collected from fish markets and the samples were subjected to analysis (cadmium (Cd), lead (Pb), Copper (Cu), Zinc (Zn), Iron (Fe) and Cobalt (Co). The data was subjected to SPSS by ANOVA. Heavy Metals accumulation in Oreochromis niloticus and Bagrus bayad from Nile River at Khartoum State and Swamp water at north Kordofan State were in International permissible levels. The findings of this study revealed that, in Nile River, at Khartoum State, there was no significant difference (P>0.05) for Cadmium (Cd), Lead (Pd) and Zinc (Zn) between Oreochromis niloticus and Bagrus bayad samples, but there was significant difference at (P≤0.05) for Copper (Cu) between Oreochromis niloticus and Bagrus bayad samples. There was a highly significant difference (P≤0.01) in Iron (Fe) and Cobalt (Co). Whereas in Swamp water, at North Kordofan State, there was significant difference (P≤0.05) for Cadmium (Cd), Copper (Cu) and Zinc (Zn) between Oreochromis niloticus and Bagrus bayad samples, but there was no significant difference at (P>0.05) for Lead (Pd) between Oreochromis niloticus and Bagrus bayad samples. There was a highly significant difference (P≤0.01) in Iron (Fe) and Cobalt (Co). According to the findings, the study recommended that, consumption of such fishes ought to be monitored to avoid the adverse effects led to by heavy metals.

Keywords: *Oreochromis niloticus, Bagrus bayad, Heavy Metal, River Nile, North Kordofan.*

INTRODUCTION

Fish occupies the highest trophic level in aquatic systems. Besides that, it has high economical value, thus fish are suitable as water quality indicator organism. Fish is a good bio-indicator because it has a potential to accumulate heavy metals and other organic pollutants (Ahmed and Shubami-Othman, 2010). When Fish is exposed to high concentrations of heavy metals in water it may take up substantial quantities of these metals. Heavy metals can enter from contaminated water and can accumulate into the fish's body by different routes. These metals concentrated at different contents in organs of fish body. Fish accumulates heavy metals in the tissue through absorption and humans can be exposed to heavy metals via food chain. This can cause acute and chronic effects in humans (Dogan and Yilmaz, 2007). Bioaccumulation of metals reflects the amount of heavy metals ingested by the organism, the way in which the

metals are distributed among the different tissues and extent to which the metal is retained in each tissue type (Sultana and Rao, 1998). Fish consumption has increased in importance among health-conscious because it provides a healthy, low cholesterol source of protein and other nutrients including omega-3 (n-3) fatty acid that reduce cholesterol levels and the incidence of heart disease, stroke, and preterm delivery (Anderson and Wiener 1995 and Knuth *et al*., 2003). In Sudan, Nile tilapia, *Oreochromis niloticus* is the main species of freshwater fishes that inhabit Nile River, and it is one of the most popular, cheapest, and available fish for all Sudanese. *O. niloticus* can survive in bad environmental conditions because their resistance to disease is physically powerful, and their respiratory demands are slight so that they can accept low oxygen and high ammonia levels (Zhou *et al*., 1998). Fish may concentrate large amounts of some metals from the water (Mansour and Sidky, 2002) and transfer throughout the web chain into humans. Metals of major interest in bioavailability studies, as listed by the U.S. Environmental Protection Agency are Al, As, Be, Cd, Cr, Cu, Hg, Ni, Pb, Se, and Sb (McKinney and Rogers, 1992). These metals were selected because of their potential for human exposure and increased health risk (Birungi *et al*., 2007). The contamination of aquatic scheme one among the intense drawback in previous few decades (Vutukuru, 2005; Dirilgen, 2001). A good vary of contamination by inorganic and chemical compound includes serious metals think about as natural trace parts of the aquatic ecosystems (Langston, W. J. 1990; Bryan *et al*., 1992). Serious metals are typically divided in two kind essential and non-essential serious metals. Necessities metals are Zn, Cu, Cr, Se, Ni, Al and non- essential serious metals are Hg, Cd, Pb. serious metals are non deadly at this time in low concentration once their multiplied the concentration their deadly and cause adverse health effects as a result of these metals aren't simply metabolized by body which metals will simply accumulate in soft tissue and that they are long persistence and bio accumulation and bio magnifications within the organic phenomenon (Even *et al*., 2011; Henry M. Robert *et al*., 2009). Al is a harmful metal to the aquatic ecosystem, being responsible for events of toxicity with serious ecological consequences (Correia *et al*., 2010). Different physiological alterations frequently observed in different fish species exposed to Al as cardiovascular, hematologic, respiratory, ionoregulatory, reproductive, metabolic, endocrine and gill damage (Brodeur *et al*., 2001 and Vuorinen *et al*., 2003). Few studies evaluated Al concentration in edible tissues of aquatic organisms in Sudan. The accumulation levels vary considerably among tissues, organs (Canli and Kalay 1998), metals and species (Heath 1995). Toxic effects of the heavy metals occur when excretory metabolic, storage and detoxification mechanisms are no longer able to counter uptake (Kalay and Canli 2000). The accumulation of heavy metals in tissues of fish is dependent upon of exposure concentration and duration as well as other factors as temperature, salinity, hardness and metabolism of the animals (Grobler *et al*., 1989, Heath 1995). So, the heavy metal concentration in tissues reflects past exposure via water and/or food (Velcheva, 2006).

Research Problem

Fish, a source of protein with pronounced placement on local food menu is now considered an important dietary threat of heavy metal toxicity via consumptions. The study on heavy metals contamination in fish is vital to assess the current status of heavy metal in fish and threats to human health from heavy metals pollution of water environment.

Objective of this research

The assessment of some heavy metals as cadmium (Cd), lead (Pb), Copper (Cu), Zinc (Zn), Iron (Fe) and Cobalt (Co), in muscle of two fresh water fish species: *Oreochromis niloticus* and *Bagrus bayad* at Khartoum and North Kordofan States to assess its possible hazards on fish and consumers.

Material and Methods

Study Area

This research was conducted in River Nile at Khartoum and Swamp water at North Kordofan States.

General Experimental Strategy

The similarities and differences in Heavy Metals of *Oreochromis niloticus* and *Bagrus bayad* fish species in River Nile at Khartoum and Swamp water at North Kordofan States were investigated via laboratory analysis through this study.

Fish Sampling

A total of 156 samples of *Oreochromis niloticus* and *Bagrus bayad* were collected from Nile

River at Khartoum State and Swamp water at North Kordofan State, 39 representative samples were randomly collected from each fish species.

Preparation of Fish Samples

Collected fish were cut into three parts horizontally and in the middle. Each one was gutted, scaled, fins removed and washed with clean, cold potable water, after that 30 grams muscles were taken from this part and transferred to sterilized container (50 ml size).

Preservation of Samples

All collected samples were put into sterilized containers and preserved immediately in minced ice preservative container by means of layers (first minced ice layer then samples layer and ice layer and so on and so for).

Fish Samples Analysis

Heavy Metals in Fish Tissues

A total of 156 fish from both fish species: *Oreochromis niloticus* and *Bagrus bayad* were collected from River Nile at Khartoum State and Swamp water from North Kordofan State. Heavy metal concentrations were determined using an atomic absorption spectrophotometer according to (Olaifa *et al*., 2004).

$$\text{Heavy metal concentration (µg/g)} = \frac{\text{Reading of atomic absorption X volume of diluted solution}}{\text{Weight of sample (g.)}}$$

Statistical Analysis

The data was analysed by using statistical package for Social Studies (SPSS version 20). One way analysis of variance (ANOVA) was used for means separation between fish types. A P-value of ≤ 0.05 was considered indicative of a statistically significant difference.

RESULTS

Table1. *Heavy metal concentration (µg/g) (mean ± SE) of Oreochromis niloticus and Bagrus bayad were collected from Nile River at Khartoum State, Sudan:*

Element	Fish Species	Mean ± SE	Significance level
cadmium (Cd)	*O. niloticus*	0.01 ± 0.00	NS
	B. bayad	0.01 ± 0.00	
Lead (Pb)	*O. niloticus*	0.14 ± 0.01	NS
	B. bayad	0.15 ± 0.00	
Copper (Cu)	*O. niloticus*	0.12 ± 0.00	*
	B. bayad	0.11 ± 0.01	
Zinc (Zn)	*O. niloticus*	0.11 ± 0.01	NS
	B. bayad	0.11 ± 0.00	
Iron (Fe)	*O. niloticus*	1.10 ± 0.05	**
	B. bayad	1.14 ± 0.01	
Cobalt (Co)	*O. niloticus*	0.10 ± 0.00	**
	B. bayad	0.12 ± 0.01	

NS ≡ not significant, *≡ significant at (P ≤ 0.05), **≡ significant at (P ≤ 0.01), SE ≡ Standard Error

Table2. *Heavy metal concentration (µg/g) (mean ± SE) of Oreochromis niloticus and Bagrus bayad were collected from Swamp water at North Kordofan State, Sudan*

Element	Fish Species	Mean ± SE	Significance level
cadmium (Cd)	*O. niloticus*	0.01 ± 0.00	*
	B. bayad	0.03 ± 0.00	
Lead (Pb)	*O. niloticus*	0.15 ± 0.01	NS
	B. bayad	0.17 ± 0.00	
Copper (Cu)	*O. niloticus*	0.11 ± 0.00	*
	B. bayad	0.09 ± 0.01	
Zinc (Zn)	*O. niloticus*	0.10 ± 0.01	*
	B. bayad	0.12 ± 0.00	
Iron (Fe)	*O. niloticus*	1.12 ± 0.05	**
	B. bayad	1.16 ± 0.01	
Cobalt (Co)	*O. niloticus*	0.10 ± 0.00	**
	B. bayad	0.13 ± 0.01	

NS ≡ not significant, *≡ significant at (P ≤ 0.05), **≡ significant at (P ≤ 0.01), SE ≡ Standard Error

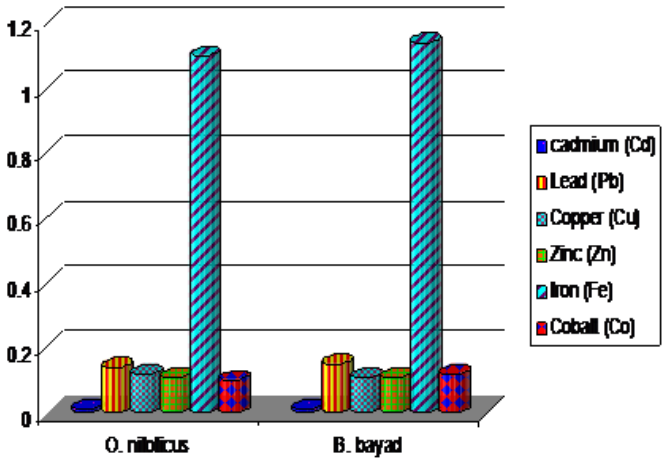

Figure1. *Heavy metal concentration S (µg/g) of Oreochromis niloticus and Bagrus bayad were collected from Nile River at Khartoum state, Sudan*

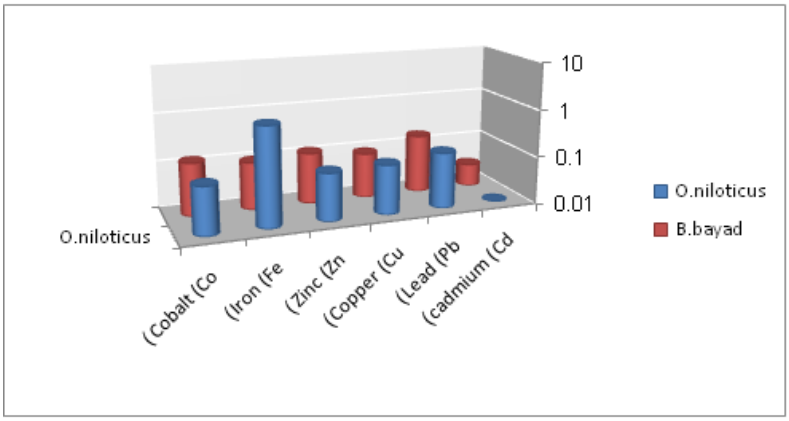

Figure2. *Heavy metal concentration (µg/g) of Oreochromis niloticus and Bagrus bayad were collected from Swamp water at North Kordofan*

DISCUSSION

Due to the toxicity of heavy metals and their accumulation in fish body, the assessment and determination of the concentration levels of heavy metals in freshwater fish species have not reached a considerable level of attention in different developing countries. This interesting study was aimed to assess some heavy metals as cadmium (Cd), lead (Pb), Copper (Cu), Zinc (Zn), Iron (Fe) and Cobalt (Co), in muscle of two fresh water fish species: *Oreochromis niloticus* and *Bagrus bayad* in River Nile at Khartoum State and Swamp water at North Kordofan State to assess its possible hazards on fish and consumers in Sudan.

Heavy Metals Contents of Oreochromis Niloticus and Bagrus Bayad in Nile River at Khartoum State

Cadmium (Cd)

The results showed in table (1) that, the level of Cd (µg/g /g) of *O. niloticus* and *B. bayad* fish in Nile River at Khartoum State. The levels were found Cd to be 0.01 µg/g /g for the all studied fish species. There were no significant differences recorded (P>0.05) in Cd between *O. niloticus* and *B. bayad* fish. However, the findings were lower than FAO/WHO limit (1989), European Community (2005) and England (1997) were reported that, the Maximum permissible limit of Cd in fish muscle (µg/g dry. wt.) is 1.67, 0.17 and 0.67, respectively.

Lead (Pb)

The results showed in table (1) that, the level of Pd (µg/g /g) of *O. niloticus* and *B. bayad* fish Nile River at Khartoum State. The levels were found Pd to be 0.14 and 0.15 (µg/g /g) for *O. niloticus* and *B. bayad* fish species, respectively. There were no significant differences (p>0.05) recorded in Pd between *O. niloticus* and *B. bayad* fish. However, the findings were lower than El-Sayed et al., (2011) were figured out that, the Pd concentrations in fish muscle (µg/g)

were range from 4.20 to 5.69 and 3.11 to 5.02 for *O. niloticus* and *B. bayad*, respectively.

Copper (Cu)

The results showed in table (1) that, the level of Cu (µg/g /g) of *O. niloticus* and *B. bayad* fish Nile River at Khartoum State. The levels were found Cu to be 0.12 and 0.11 (µg/g /g) for *O. niloticus* and *B. bayad* fish species, respectively. There was significant difference (P≤0.05) in Cu concentration between *O. niloticus* and *B. bayad* fish species. However, the findings were lower than FAO/WHO limit (1989), WHO (2009) and England (1997) were reported that, the Maximum permissible limit of Cu in fish muscle (µg/g dry. wt.) is 1.67, 100 and 66.67, respectively. The results were lower than **El-Sayed et al., (2011)** were reported that, the Cu concentrations in fish muscle (µg/g) were range from 0.27 to 0.67 and 0.39 to 0.63 for *O. niloticus* and *B. bayad*, respectively.

Zinc (Zn)

The results showed in table (1) that, the level of Zn (µg/g) of *O. niloticus* and *B. bayad* fish Nile River at Khartoum State. The levels were found Zn to be 0.11 (mg/g) for *O. niloticus* and *B. bayad* fish species. There was no significant difference (P>0.05) in Zn concentration between *O. niloticus* and *B. bayad* fish species. However, the findings were lower than El-Sayed et al., (2011) were stated out that, the Zn concentrations in fish muscle (µg/g) were range from 4.14 to 4.84 and 3.03 to 4.71 for *O. niloticus* and *B. bayad*, respectively.

Iron (Fe)

The results showed in table (1) that, the level of Fe (µg/g /g) of *O. niloticus* and *B. bayad* fish Nile River at Khartoum State. The levels were found Fe to be 1.10 and 1.14 (µg/g) for *O. niloticus* and *B. bayad* fish species. There was a highly significant difference (P≤0.01) in Fe concentration between *O. niloticus* and *B. bayad* fish species. The findings were lower than WHO (2009) reported that, the Maximum permissible limit of Fe in fish muscle (µg/g dry. wt.) is 3.33. However, the findings were in agreement with Okafor and Opuene (2006) they were figured out that, the Bioaccumulation of Fe in fish muscle (µg/g) of *B. bayad* was 1.30.

Cobalt (Co)

The results appeared in table (1) that, the level of Co (µg/g /g) of *O. niloticus* and *B. bayad* fish Nile River at Khartoum State. The levels were found Co to be 0.10 and 0.12 (µg/g) for *O. niloticus* and *B. bayad* fish species. There was a highly significant difference (P≤0.01) in Co concentration between *O. niloticus* and *B. bayad* fish species. The results were lower than El-Sayed et al., (2011) were reported that, the Co concentrations in fish muscle (µg/g) were range from 3.35 to 5.33 and 4.40 to 7.96 for *O. niloticus* and *B. bayad*, respectively. These variations may be attributed to the differences among the fish locations, fish sizes, fish ages and types sources of nutrition from an area to another.

Heavy Metals Contents of Oreochromis niloticus and Bagrus bayad in Swamp water at Kordofan State

Cadmium (Cd)

The results showed in table (2) that, the level of Cd (µg/g /g) of *O. niloticus* and *B. bayad* fish in Swamp water at Kordofan State. The levels were found Cd to be 0.01 and 0.03 µg/g/g for *O. niloticus* and *B. bayad* fish, respectively. There were significant differences recorded (P≤0.05) in Cd between *O. niloticus* and *B. bayad* fish. However, the findings were lower than FAO/WHO limit (1989), European Community (2005) and England (1997) were reported that, the Maximum permissible limit of Cd in fish muscle (µg/g dry. wt.) is 1.67, 0.17 and 0.67, respectively.

Lead (Pb)

As shown in table (2) that, the level of Pd (µg/g /g) of *O. niloticus* and *B. bayad* fish in Swamp water at Kordofan State. The levels were found Pd to be 0.15 and 0.17 (µg/g /g) for *O. niloticus* and *B. bayad* fish species, respectively. There were no significant differences (p>0.05) recorded in Pd between *O. niloticus* and *B. bayad* fish. However, the findings were lower than El-Sayed et al., (2011) were mentioned that, the Pd concentrations in fish muscle (µg/g) were range from 4.20 to 5.69 and 3.11 to 5.02 for *O. niloticus* and *B. bayad*, respectively.

Copper (Cu)

As shown in table (2) that, the level of Cu (µg/g /g) of *O. niloticus* and *B. bayad* fish in Swamp water at Kordofan State. The levels were found Cu to be 0.11 and 0.09 (µg/g /g) for *O. niloticus* and *B. bayad* fish species, respectively. There was significant difference (P≤0.05) in Cu concentration between *O. niloticus* and *B. bayad* fish species. However, the findings were lower

than FAO/WHO limit (1989), WHO (2009) and England (1997) were reported that, the Maximum permissible limit of Cu in fish muscle (µg/g dry. wt.) is 1.67, 100 and 66.67, respectively. The results were lower than El-Sayed et al., (2011) were reported that, the Cu concentrations in fish muscle (µg/g) were range from 0.27 to 0.67 and 0.39 to 0.63 for *O. niloticus* and *B. bayad*, respectively.

Zinc (Zn)

The results showed in table (2) that, the level of Zn (µg/g) of *O. niloticus* and *B. bayad* fish in Swamp water at Kordofan State. The levels were found Zn to be 0.10 and 0.12 (mg/g) for *O. niloticus* and *B. bayad* fish species. There was significant difference ($P \leq 0.05$) in Zn concentration between *O. niloticus* and *B. bayad* fish species. However, the findings were lower than El-Sayed et al., (2011) were figured-out that, the Zn concentrations in fish muscle (µg/g) were range from 4.14 to 4.84 and 3.03 to 4.71 for *O. niloticus* and *B. bayad*, respectively.

Iron (Fe)

The results showed in table (2) that, the level of Fe (µg/g /g) of *O. niloticus* and *B. bayad* fish in Swamp water at Kordofan State. The levels were found Fe to be 1.12 and 1.16 (µg/g) for *O. niloticus* and *B. bayad* fish species. There was a highly significant difference ($P \leq 0.01$) in Fe concentration between *O. niloticus* and *B. bayad* fish species. The findings were lower than WHO (2009) mentioned that, the Maximum permissible limit of Fe in fish muscle (µg/g dry. wt.) is 3.33. However, the findings were in agreement with Okafor and Opuene (2006) they were reported that, the Bioaccumulation of Fe in fish muscle (µg/g) of *B. bayad* was 1.30.

Cobalt (Co)

As shown in table (2) that, the level of Co (µg/g /g) of *O. niloticus* and *B. bayad* fish in Swamp water at Kordofan State. The levels were found Co to be 0.10 and 0.13 (µg/g) for *O. niloticus* and *B. bayad* fish species. There was a highly significant difference ($P \leq 0.01$) in Co concentration between *O. niloticus* and *B. bayad* fish species in Swamp water at Kordofan State. The results were lower than El-Sayed et al., (2011) were reported that, the Co concentrations in fish muscle (µg/g) were range from 3.35 to 5.33 and 4.40 to 7.96 for *O. niloticus* and *B. bayad*, respectively.

However, these variations may be attributed to the differences among the fish locations, Sources of water, fish sizes, fish ages and types, and sources of nutrition from an area to another.

CONCLUSION

Fish has an important role in food security and poverty alleviation in both rural and urban areas of Sudan, but little is known about the nutritional value of the Nile fish that are normally utilized either fresh or preserved dried, salted or smoked. After conducting the study, it showed that variety of the heavy metals concentrations were no exceeded the quality limits set for the serious metals. The study was conducted to evaluate heavy metals *Oreochromis niloticus* and *Bagrus bayad* in River Nile at Khartoum state and Swamp water at Kordofan State, Sudan. A total of 156 samples of *Oreochromis niloticus* and *Bagrus bayad* were collected from fish markets and the samples were subjected to analysis (cadmium (Cd), lead (Pb), Copper (Cu), Zinc (Zn), Iron (Fe) and Cobalt (Co). The data was subjected to SPSS by ANOVA. Heavy Metals accumulation in *Oreochromis niloticus* and *Bagrus bayad* from Nile River at Khartoum State and Swamp water at Kordofan State were in International permissible levels. The findings of this study revealed that, in Nile River, at Khartoum State, there was no significant difference ($P > 0.05$) for Cadmium (Cd), Lead (Pd) and Zinc (Zn) between *Oreochromis niloticus* and *Bagrus bayad* samples, but there was significant difference at ($P \leq 0.05$) for Copper (Cu) between *Oreochromis niloticus* and *Bagrus bayad* samples. There was a highly significant difference ($P \leq 0.01$) in Iron (Fe) and Cobalt (Co). Whereas in Swamp water, at North Kordofan State, there was significant difference ($P \leq 0.05$) for Cadmium (Cd), Copper (Cu) and Zinc (Zn) between *Oreochromis niloticus* and *Bagrus bayad* samples, but there was no significant difference at ($P > 0.05$) for Lead (Pd) between *Oreochromis niloticus* and *Bagrus bayad* samples. There was a highly significant difference ($P \leq 0.01$) in Iron (Fe) and Cobalt (Co).

RECOMMENDATION

- Serious metal stuff features a potential to bio-accumulate within the fish muscle. Therefore, consumption of such fishes ought to be monitored to avoid the adverse effects led to by heavy metals.
- Consumers should eat *Oreochromis niloticus* and *Bagrus bayad* from Nile River

and Swamp water because their Heavy Metals within International permissible levels.

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