

Determination of Heavy Metals in Fish and Water of White Nile During Watery Diarrhea Outbreak from June to July, 2017, Gezira Aba – Sudan

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Abstract: The objective of this study was to determine the concentrations of some heavy metal in fish (*Clarias gariepinus*) and water samples collected from White Nile at Gezira Aba. Heavy metals in fish and water samples were analyzed using Atomic Absorption Spectrophotometer (AAS) in accordance to standard analytical method. Data obtained were subjected to statistical analysis (ANOVA) to find out the significant difference of heavy metals in water body throughout the sampling period and in each organ of the sampled fish. The obtained results showed the average values Fe, Pb, Co, Cd in water samples were higher than WHO guide line limit for fresh water. The analysis of heavy metal in fish organs indicated that among eight heavy metals tested, Fe showed the highest concentration followed by Fe, Pb, Mn, Cu, Zn, Co, Cd and Cr. Results also showed that accumulation of heavy metals differed in the organs. Gill recorded high level of heavy metals followed by kidney, while liver contain lower level. It was concluded that levels of heavy metal in fish organs showed high concentration of detected heavy metals, while water samples give low heavy metals concentration. This implies that, the fish sample can be used to monitor heavy metals pollution level in the White Nile River. More safe and economic methods for elimination of heavy metals from contaminated waters are needed and continuous assessment of the level of pollution of Nile water and fish with heavy metals is also necessary.

Keywords: Environmental Pollution, Heavy Metals, Water Pollution, Fish

1. Introduction

The pollution of aquatic environment with heavy metal has been a worldwide problem during the recent years because they are indestructible and most of them have toxic effect to organism [1]. Among environmental pollutants, metals are of particular concern due to their toxic effect and ability to bioaccumulation in aquatic ecosystems [2]. Metals tend to accumulate in water and move up through the food chain; therefore, studies to quantify the level of heavy metals in environment and determine potentially hazardous levels for human are necessary [3].

The term heavy metal is applied to the metals and metalloids with atomic density greater than 4g/cm^3 or 5 time

than that of water, they are also known as trace elements because they occur in minute concentration in biological systems [4]. Heavy metals with high relative atomic weight are toxic at low concentration, they do not degrade or do not destroyed or generally they do not break down into less harmful constituents, but accumulate where they are released [3]. Pollution of the aquatic environment by inorganic chemical and heavy metals is a major threat to human health and to aquatic organisms [5]. They enter to the aquatic systems from different natural and human activities sources, including industrial or domestic wastewater, application of pesticides and inorganic fertilizers, leaching from landfills, shipping and harbor activities and atmospheric deposits and geological weathering of the earth crust [6]. Heavy metals

can be incorporated into food chains and absorbed by aquatic organisms to a level that might affect their physiological state. They are effective pollutants which have a drastic environmental impact on all organisms [7]. Some heavy metals such as Fe, Mn, Co, Cu and Zn are essential micronutrients for aquatic fauna and flora, but they may be dangerous at high levels [8]. Whereas Cadmium and lead are non-essential metals, as they are toxic even in trace amounts [9]. Fish are notorious for their ability to concentrate heavy metals in their muscles and thus play an important role in human's nutrition; they need to be carefully screened to ensure that an unnecessary high level of some toxic trace metals are not being transferred to humans through fish consumption [10]. Fish are often at the top of the aquatic food chain and many concentrate large amounts of heavy metals [11]. Fish samples can be considered as the most significant indicators in a fresh water system for estimation of metal pollution level [9].

The objective of this study is to provide a baseline study to the local authority and the enforcement body on the source of pollution in White Nile, hence assisting in the enforcement

process. The specific aims are to identify and quantify the presence of heavy metals in water and fish in the river. As water is the habitat of fish, there is significance to measure its quality to assess the possible source of contamination contributing to this problem.

2. Materials and Methods

2.1. Study Area Description

Gezira Aba (Aba Island) is considered the largest island in Sudan. It is located in White Nile State, approximately 280 KM South Khartoum with the length of 33 miles and width of 4 miles. Gezira Aba lies between coordinates of 32.62°E and 13.33°N. It is bordered by Nile in both sides. Nile main stream at the West and Jasser to the East, which is the only dust bridge in the area. Aba Island also is bordered by some cities such as Kosti city from the South Westside, Rabak city from the South East side and Asalaya sugar area from the East side (Figure 1).



Figure 1. Study Area and Sampling sites along White Nile in Gezira Aba.



Figure 2. Image of Asalaya industrial and agricultural waste water flow into White Nile.

2.2. Sample Collection

2.2.1. Water Samples

Water samples from different sites were collected using polyethylene sampling bottles. 500 ml of water were taken at each sampling site, immediately acidified with HNO_3 , then kept in an ice bath and transported to Veterinary Research Laboratory Center (Soba), Figure 3.



Figure 3. Images of water samples collected from three sites along White Nile.

2.2.2. Fish Samples

Three fish samples of species (*Clarias gariepinus*) with the same length and weight were collected from three different areas along the river. The fish was caught using gillnets, which were left over night in the river by local fishermen. They were dissected in the field using dissection kites, and the organs (gills, liver and kidney) were removed and put into small plastic tube, Figures 4 and 5. Organs were cut separately into small pieces and blended using blender in order to homogenize the sample of each organ. The homogenized samples were kept in an ice bath and transported to Veterinary Research Laboratory Center in Khartoum state for preparation and processing of heavy metals analysis.



Figure 4. Images of catfish (*C. gariepinus*) sample collected from White Nile water, Gezira Aba, Sudan.

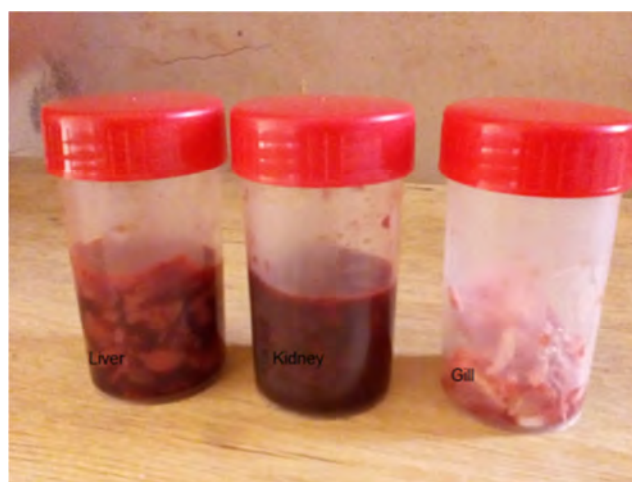


Figure 5. Image of Gill, Kidney and Live obtained from *C. gariepinus* sample.

2.2.3. Analysis of Water Samples

When the water samples have reached to the laboratory, they were acidified immediately by adding 1 ml of conc. HNO_3 acid to each bottle, then heavy metals concentration were determined by using Atomic Absorption Spectrophotometer (Phoenix-986), and results were given as mg/l

2.2.4. Analysis of Fish Samples

5g of each *Clarias gariepinus* organ (gill, liver and kidney) from different sites were taken into small beakers. 10 ml of conc. H_2SO_4 was added to each organ sample. Samples were covered and left for 16–24 hrs. Samples solutions were filtered in 50ml volumetric flask using filter paper, and then the volume was completed to 50ml with distilled water. The heavy metals were analyzed using Atomic Absorption Spectrophotometer.

2.3. Data Analysis

Data collected were subjected to one-way analysis of variance (ANOVA) to find out the significant differences of the metals in the water body, each fish organ and also standard deviation of heavy metals means was calculated. Possibilities less than 0.05 ($p < 0.05$) were considered statistically significant. All statistics was carried out using

Statistical Analysis program (SPSS, 20).

3. Results

Results of heavy metal concentrations in catfish (*Clarias*

gariepinus) and water White Nile at the three different sites were presented in Tables 1, 2 and graphically presented by Figures 6, 7. The results showed that there were highly significant differences ($P < 0.05$) in the *Clarias gariepinus* organs.

Table 1. Heavy metals concentrations (mg/L) in fish (*Clarias gariepinus*) organs

Organs	Parameters of heavy metal (mg/L)							
	Cd	Pb	Cu	Zn	Fe	Mn	Co	Cr
Gill	0.054±0.003 ^a	0.379±0.012 ^a	0.171±0.007 ^a	0.135±0.003 ^a	1.300±0.004 ^a	0.297±0.003 ^a	0.126±0.003 ^a	0.0027±0.0003 ^b
Liver	0.035±0.003 ^c	0.136±0.004 ^c	0.136±0.004 ^b	0.095±0.003 ^c	1.076±0.013 ^c	0.251±0.013 ^c	0.088±0.039 ^c	0.0041±0.0004 ^a
Kidney	0.045±0.003 ^b	0.148±0.003 ^b	0.119±0.003 ^c	0.119±0.116 ^b	1.212±0.012 ^b	0.280±0.008 ^b	0.118±0.003 ^b	0.0024±0.0003 ^b

^{a,b,c}Means in the same column with superscript are significant different at the level ($p < 0.05$).

Table 2. Heavy metals concentrations (mg/L) in water from different areas

Areas	Parameters of heavy metal(mg/L)							
	Cd	Pb	Cu	Zn	Fe	Mn	Co	Cr
Area1	0.020 ^b	0.216 ^a	0.112 ^b	0.080 ^b	0.555 ^c	0.219 ^b	0.073 ^b	0.0009 ^a
Area2	0.025 ^a	0.215 ^a	0.121 ^a	0.085 ^a	0.613 ^a	0.226 ^a	0.080 ^a	0.0008 ^a
Area3	0.019 ^b	0.193 ^b	0.109 ^b	0.074 ^c	0.586 ^b	0.220 ^b	0.075 ^b	0.0010 ^a

^{a,b,c}Means in the same column with superscript are significant different at the level ($p < 0.05$).

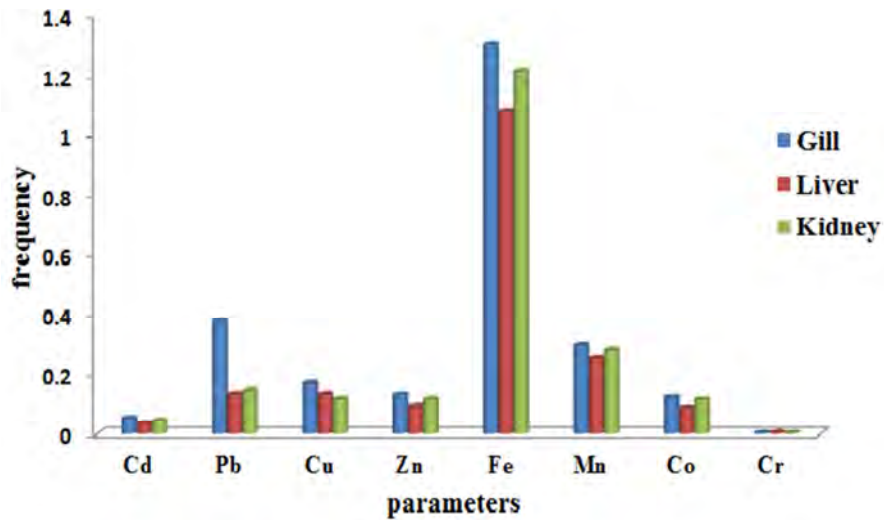


Figure 6. Distribution of heavy metal concentration in organs (gill, liver and kidney) in *Clarias gariepinus*.

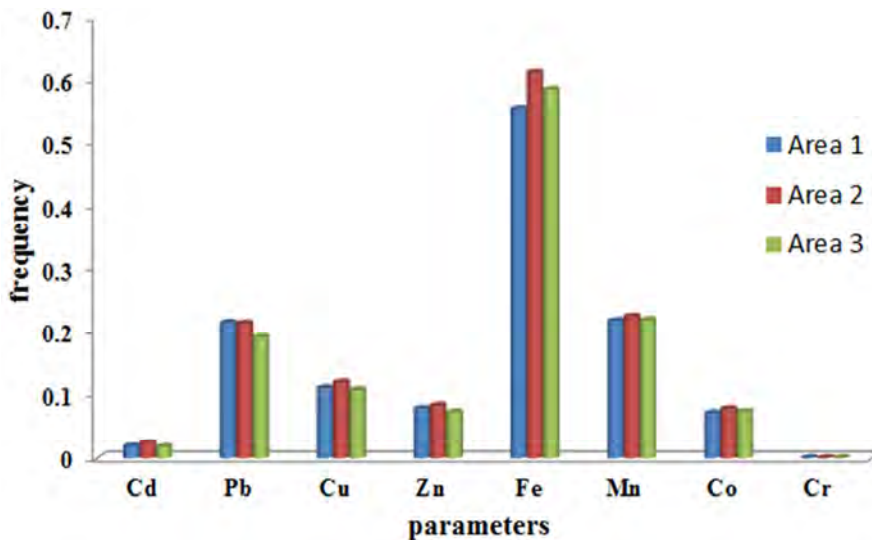


Figure 7. Distribution of heavy metal concentration in water from three different areas in Gezira Aba.

4. Discussion

The accumulation of heavy metal in gill fish organs of *Clarias gariepinus* were 0.054 ± 0.003 , 0.379 ± 0.012 , 0.171 ± 0.007 , 0.135 ± 0.003 , 1.300 ± 0.004 , 0.297 ± 0.003 , 0.126 ± 0.003 and 0.0027 ± 0.0003 respectively were less than world health organizations (WHO) international standard. The accumulation of this heavy metal in gill, liver, and kidney were various with gill higher accumulation of metal following kidney and less in liver in different parameters has shown in Table 1. Meant analysis of one way (ANOVA) there is different significant at level ($p < 0.05$), and also between gill, liver and kidney. This study is in agreement with [12, 13] who reported that accumulation of heavy metal is varied at different levels in difference organs of the fish tissues. Metal concentration in fish organs depends on pollution and many different for various fish species living in the same water body also [14].

The trends of heavy metal concentration were in the decrease order $Fe < Mn < Pb < Cu < Co < Zn < Cd < Cr$ this trend in agree with trends reported by several authors [15]. Also the trends decrease in different organs of *Clarias gariepinus* from gill > kidney > liver and show that the gill and kidney more heavy metal following liver may be due to adsorption to the gill surface and dependent on the availability of protein to which these metal may bind [16,17].

Heavy metals in aquatic environment and aquatic biota pose a risk to fish consumers and other wildlife. Heavy metals may enter aquatic ecosystem from different natural and anthropogenic sources including industrial or domestic sewage, storm run-off, leaching from landfills-/dump sites and atmospheric deposit [18, 19, 20].

Data in Table 2 showed the heavy metals concentrations of water samples collected from three different three areas in Gazira Aba. The results showed that there were significant differences ($P < 0.05$) in the heavy metals in water samples collected from the three observed areas. The accumulation of Fe and Mn were very high in all samples of the three areas as shown in Table 1, the Fe was (0.613, 0.555, 0.586), in areas (2,3,1) respectively, these results were agreed with [21, 22].

5. Conclusion

From the above observations, it is clear that the concentration of heavy metals in drinking water were below the WHO guideline limit, except Cd, Co, Fe and Pb which are of higher value than WHO value. The highest concentration of heavy metals in water was recorded for Fe followed by Pb, Co and Cd, while the lowest concentration was recorded for Cr. Fe showed the highest concentration of all the detected heavy metals, followed by Pb, while the Cr had the lowest metal concentration. Concentration of heavy metals in the gill was recorded very high, followed by kidney organ, while liver organ recorded the least level of concentration. This implies that, the fish samples can be used to monitor heavy metals pollution level in the White Nile

River. This may be due to Asalaya industrial and agricultural waste water flow into White Nile, Figure 2. More safe and economic methods for elimination of heavy metals from contaminated waters are needed and continuous assessment of the level of pollution of Nile water and fish with heavy metals is also necessary.

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