Agricultural and Biological Sciences Journal

Vol. 1, No. 5, 2015, pp. 224-228 http://www.aiscience.org/journal/absj



Bioaccumulation and Histopathological Alterations of Heavy Metals in the Liver and Kidney of *Oreochromis niloticus* Fish Collected from the Blue Nile

Haram Hassan Abass Bakhiet*

Department of Fisheries and Wildlife Science, College of Animal Production Science and Technology, Sudan University of Science and Technology, Khartoum North, Sudan

Abstract

The study was conducted to investigate the occurrence and bioaccumulation of some heavy metals and histological structures of the liver and kidney of Oreochromis niloticus obtained from the blue Nile namely suba area, Khartoum during summer 2013 and winter 2014. There are two plants for municipal waste water treatment in Khartoum. Those treatments plants are located at Suba (south of Khartoum) and Elhaj Yousif - (east of Khartoum North). The treated sewage effluent is used in irrigation of trees and other fodder cultivations. This is the situation as planned for but in certain situations like rainy seasons the sewage effluents find an access to the river water. Copper, Chromium, lead, cadmium and iron concentrations were recorded in water and tissues of Oreochromis niloticus from the Blue Nile River. Histopathological alterations in fish tissues were also studied. The concentration of: Copper, Chromium, lead, and iron were highest in liver and lowest in kidney tissue, while cadmium (Cd) concentrations were highest in kidney, lowest in liver tissue. Several histopathological changes were noted in liver and kidney attributable to heavy metals exposure.

Keywords

Suba, Iron, Tilapia, Histopathology

Received: June 30, 2015 / Accepted: July 11, 2015 / Published online: July 27, 2015

@ 2015 The Authors. Published by American Institute of Science. This Open Access article is under the CC BY-NC license. http://creativecommons.org/licenses/by-nc/4.0/

1. Introduction

Pollution of the aquatic environment is a serious and growing problem. Increasing number and amount of industrial, agricultural and commercial chemicals discharged into the aquatic environment having led to various deleterious effects on the aquatic organisms (McGlashan, D.J. et al 2001)

Heavy-metal pollution is one of the five major types of common toxic pollutants in surface waters (Mason, 1991). Heavy metals are among the major contributors to the pollution of natural aquatic ecosystems (Sanders, 1997). Because of their chemical stability, heavy metals tend to accumulate into the tissues of different organisms (Hellawell,

1986; Sanders, 1997). Unfortunately, aquatic organisms can be exposed to extremely high levels of these heavy metals. Significant changes in external features and behavioral activities can be observed as a result of heavy metal pollution.

Aquatic organisms, including fish, accumulate pollutants directly from contaminated water and indirectly via the Histopathological alterations can be used as indicators for the effects of various anthropogenic pollutants on organisms and are reflections of the overall health of the entire population in the ecosystem.

These histopathological biomarkers are closely related to other biomarkers of stress since many pollutants have to undergo metabolic activation in order to be able to provoke

^{*} Corresponding author

cellular change in the affected organism. For example, the mechanism of action of several xenobiotics could initiate the formation of a specific enzyme that causes changes in the metabolism, further leading to cellular intoxication and death, at a cellular level, whereas this manifests as necrosis, i.e. histopathological biomarkers on a tissue level (Velkova-Jordanoska, L. et. al 2005)

The liver, as the major organ of metabolism, comes into close contact with xenobiotics absorbed from the environment and liver lesions are often associated with aquatic pollution. And it's one of the most susceptible organs to the harmful effects of heavy metals, because it is a detoxification organ and is essential for the metabolism and the excretion of toxic substances (Hinton and Lauren, 1990).

Several histopathological alterations were observed in the liver of Gymnocephalus cernua collected from Elbe Estuary contaminated by domestic, industrial and agricultural pollutants (Sakr, S. et. al 1985)

The objectives of this study is to investigate the impact of the environmental conditions of Suba industrial area on the bioaccumulation of some heavy metals and histological structures of the liver and kidney of the commercially important fish Tilapia niloticus

2. Materials and Methods

Study Area: Suba is located in south Khartoum near suba industrial area.

2.1. Sampling

30 water samples and 30 Samples of T. niloticus were obtained from the Blue Nile River at Khartoum Suba area, during 2013 - 2014, measuring about 36 - 26. cm in total length and 732 - 109g in weight. After dissection of fish samples, parts of liver and kidney were carefully removed and prepared for heavy metal measure and histological studies.

2.2. Water Analysis

The water samples were preserved by the addition of one ml of concentrated nitric acid per liter until the time of analysis. The water samples were filtered through $0.45\mu l$ membrane filter. The required volume (100 ml) of the filtrate was collected to measure Copper, Chromium, leads, cadmium and iron levels in water samples by using Flame Atomic Absorption Spectrophotometer

2.3. Analysis of Fish Samples

Approximately 2.0 gm of each kidney and liver sample were weighed and ached in the furnace at 550 oC for 90 min. The

ash was dissolved in 5 ml concentrated nitric acid and made up to 25 ml volume. The elements Cu, Cr, Pb, Cd and Fe were assayed using Atomic Absorption Spectrophotometer (Perkin–Elmer 2880) and the results were given as mg/g dw.

Histological Investigations: Specimens from liver and kidney were fixed in 10% neutral buffered formalin, dehydrated, embedded in paraffin wax and sectioned at 4-6 μ m then stained with haematoxylin and eosin and examined microscopically (Bernet, D., H et.al.1999)

2.4. Statistical Analysis

Data were analyzed by SPSS 16 ANOVA test

3. Results

Results of the main types of histopathological change detected are shown in Table (1) and Heavy metal concentrations in water of the Blue Nile are shown in table (2) and the Concentration of heavy metals in fresh Nile tilapia liver and kidney tissues are shown in Table (3) Figure (1): (A) to(E) and (2): (A) to(E) are shown The histopathological alterations in Tilapia tissues)

Table 1. Showing the main types of histopathological changes detected.

Organ	Histopathological changes	%of fish in which the effect was detected
	Lymphocytic infiltration	19%
	Cell rupture	10%
liver	focal areas of necrosis	16%
	Vaculation and degeneration in the hepatocytes	14%
Kidney	Blood congestion	11%
	Tubule rupture	7%
	Shrinking of glumeruli	12%
	Vacuolation in glomerulus	13%

Table 2. Heavy metal concentrations in water samples (mg/L) of Blue Nile.

metal	Mean ± SE	Occurrence %
Copper	$\textit{0.045} \pm \textit{013}$	77%
Chromium	0.120 ± 0.041	77%
lead	0.180 ± 0.05	80%
cadmium	0.169 ± 0.05	64%
IRON	0.076 ± 0.023	87%

Sections from the liver and kidney were prepared from fish and were examined under the light microscope. The microscopic observations were reported for each organ and the intensity of changes were tabulated in table (1) and are presented by figure (1 & 2) (from A to E)

Liver: Figure 1 (A) shows the normal histological structures of the liver. (B) The most common lesions in the liver of

226

studied fish were Cell damage (CD), (C) Lymphocytic infiltration& dead nuclei (LI&DN), (D) focal areas of necrosis (FN) and (E) ruptured hepatocytes and vacuolar degeneration in the hepatocytes (RH&V)

Kidney: Figure 2 (A) shows the normal histological

structures of the kidney. The histopathological alterations in the kidney of the fish included (B) rupture of glumeruli(R). (C) Blood congestion (BC). (D) Shrinking of glumeruli (SH G) and (E) Vaculation in glomerulus. (V).

Table 3. Concentration of heavy metals (ppm) in fresh Nile Tilapia liver and kidney. Mean ±SD.

Metal Tissue	Copper	Chromium	lead	cadmium	IRON
liver	0.052 ± 0.033	0.212±0.020	0.232±0.36	0.137 ± 0.047	0.322±0.414
kidnev	0.051 ± 0.078	0.130 ± 0.104	0.102 ± 0.075	0.149 ± 0.242	0.275±0.589

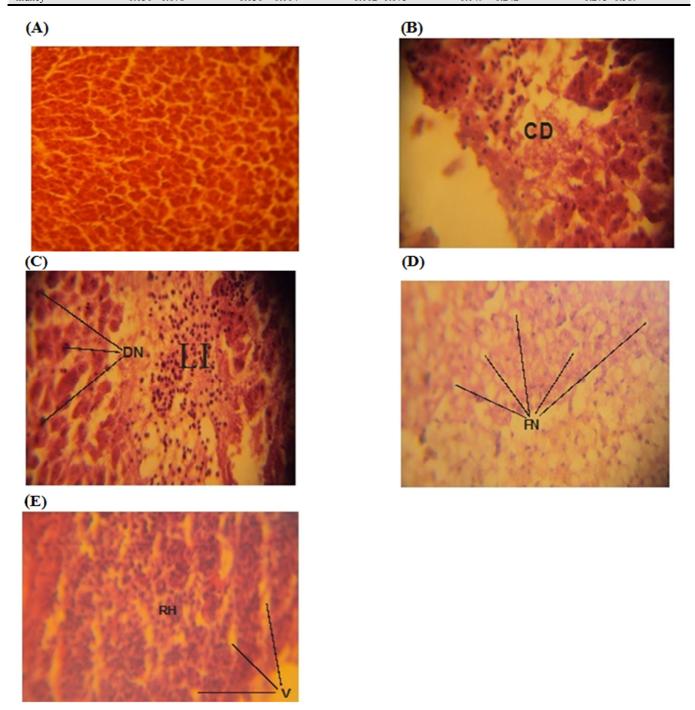


Figure (1). Liver.

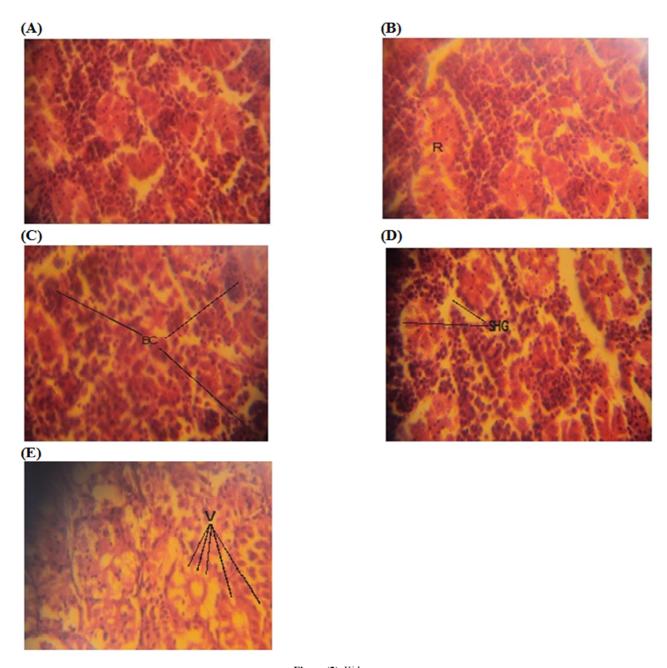


Figure (2). Kidney.

4. Discussion

The histopathological alterations attributed to the prolonged exposure to heavy metals resulted in respiratory, osmoregulatory and circulatory impairment. These findings were demonstrated by Fernandes et al., (2008)

The liver showed degeneration of the hepatocytes, congestion of central vein and nuclear pyknosis in the majority of hepatic cells. These findings were apparent as the liver considered the organ of detoxification, excretion and binding proteins such as metallothionein (MTs). The metal-binding proteins were present in the nuclei of hepatocytes suggested

that the increase in the cell damages (De Smet and Blust 2001). Similar results were observed by Van Dyk (2003) Liver of fish is sensitive to environmental contaminants because many contaminants tend to accumulate in the liver and exposing it to a much higher levels than in the environment, or in other organs (Heath 1995).

Pandey et al., (1994) described the alterations in liver of Liza parsia exposed to Hg Cl2 (0.2 mg Hg l– 1) for 15 days.

The kidney is a vital organ of body and proper kidney function is to maintain the homeostasis. It is not only involved in removal wastes from blood but it is also responsible for selective reabsorbtion, which helps in Maintaining volume and pH of blood and body fluids and

erythropoieses (Iqbal, et. al 2004) The kidney is one of the first organs to be affected by contaminants in the water (Thophon, S., M. et al 2003) The common alterations found in the kidney of studied fish were severe rupture of hepatocytes, Blood congestion, Shrinking of glumeruli, Vacuolation in glomerulus. The present results are in agreement with those observed in C. carpio exposed to sewage (Kakuta, I. et al.1997) P. lineatus exposed trichlorfon (Veiga, M., E. et al 2002) and L. calcarifer exposed to cadmium (Thophon, S., M. et al. 2003). Similar alterations in kidney of Tilapia were observed in several species of fish exposed to heavy metals and these alterations were described by Oliveira Ribeiro et al. (2002),

5. Conclusion and Recommendations

It can be conclusively deduced from this study that fish has the tendency to bioaccumulate heavy Metals in a polluted environment. Since virtually all metals investigated were found in higher concentration, so government should intact laws that will ensure that industries make use of standard waste treatment plants for the treatment of their wastes before they are being discharged into water bodies

The result indicates that the heavy metal contamination definitely affects the aquatic life of the fresh water fish. Hence, a scientific method of detoxification is essential to improve the health of This economic fish in any stressed environmental conditions. However, the high concentrations of the analyzed metals in the whole body tissues investigated could be due to the storage role played by these tissues.

Fish contaminated by heavy metals suffers pathological alterations, with consequent inhibition of metabolic processes

References

Bernet, D., H. Schmidt, W. Meier, P. Burkhardt-Holm and T. Wahli, 1999. Histopathology in fish: Proposal for a protocol to assess aquatic pollution. J. Fish Disease, 22:25-34.

- HELLAWELL, J. M., 1986. Biological indicators of freshwater pollution and environmental management. Elsevier, London, pp. 546.
- HINTON, D.E. AND LAURE'N, D.J., 1990. Integrative histopathological effects of environmental stressors on fishes. Am. Fish. Soc. Symp., 8: 51–66.
- Iqbal, F., I. Z. Qureshi and M. Ali, 2004 Histopathological changes in the kidney of common carp, Cyprinus carpio following nitrate exposure. J. Res. Sci., 15: 411-418.
- Kakuta, I. and S. Murachi, 1997. Physiological response of carp, Cyprinus carpio, exposed to raw sewage containing fish processing wastewater. Environ. Toxicol. Water Quality, 12: 1-
- MASON, C.F., 1991. Biology of fresh water pollution, second. Longman, New York, pp. 351.
- McGlashan, D.J. and J.M. Hughies, 2001. Genetic evidence for historical continuity between populations of the Australian freshwater fish Craterocephalus stercusmuscarum (Atherinidae) east and west of the Great Diving Range. J. Fish Biol., 59: 55-67.
- Oliveira-Ribeiro CA, Belger L, Pelletiter E, Rouleau C. 2002. Histopathological evidence of inorganic mercury and methylmercury toxicity in the arctic charr (Salvelinus alpinus). Environmental Research 90: 217-225.
- Sakr, S. and S. Gabr, 1985. Ultrastructural changes induced by diazinon and neopybuthrin in skeletal muscles of Tilapia nilotica. Proceed. Zool. Soc. A.R.E., 21: 1-14.
- [10] SANDERS, M.J., 1997. A field evaluation of the freshwater river crab, Potamonauteswarreni, as a bioaccumulative indicator of metal pollution. M.Sc. thesis, Rand Afrikaans University, South Africa
- [11] Thophon, S., M. Kruatrachuc, E. Upathau, P. Pokethitiyook, S. Sahaphong and S. Jarikhuan, 2003. Histopathological alterations of white seabass, Lates calcarifer in acute and subchronic cadmium exposure. Environ. Pollut., 121: 307-320.
- [12] Veiga, M., E. Rodrigues, F. Pacheco and M. Ranzani- Paiva, 2002. Histopathologic changes in the kidney tissue of Prochilodus lineatus, 1836 (Characiformes, Prochilodontidae) induced by sublethal concentration of Trichlorfon exposure. Brazilian Arch. Biol. Technol., 45: 171-175.
- [13] Velkova-Jordanoska, L. G. Kostoski, 2005. and Histopathological analysis of liver in fresh (Barbus meridionalis petenyi Hekel) in reservoir Trebenista. Natura Croatica, 14: 147-153.