Journal of Aquatic Pollution and Toxicology
ISSN: 2581-804X

Open access Research Article

Comparative Assessment of Heavy Metals Bioaccumulation in the Tissues of African Catfish (*Clarias gariepinus*) Collected from Otin, Oba, Ogun and Agbabu Rivers, South-Western Nigeria

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ABSTRACT

Heavy metal contamination has devastating effects on the ecological balance of recipient water bodies and the diversity of aquatic organisms present therein. Fish are widely used to evaluate the health of aquatic ecosystems because pollutants build up in the food chain which results in adverse effects in the aquatic systems. African catfish (*Clarias gariepinus*) is of great commercial importance because it is the most widely consumed freshwater fish in Nigeria. In this research, heavy metal pollutants in the tissues of Clarias garienus collected from Otin, Oba, Ogun and Agbabu Rivers in the South-Western Nigeria were investigated to evaluate the bioaccumulation patterns of heavy metals. The fish were collected twice a month for six months from May to November. Concentrations of heavy metals were determined using Atomic Absorption Spectrophotometer (AAS). Results were compared using ANOVA and $P<0.05$ was considered to indicate statistical significance. Means of significant differences were separated using Duncan's multiple range test. The study indicated that the levels of heavy metals contamination in the analyzed water bodies are in the following order: Agbabu>Ogun>Otin>Oba. The mean concentration of the heavy metals in each organ and tissue sampled differed slightly and also conformed to the specifications of regulatory bodies.

Keywords: Heavy metals; Pollution; Concentration; Tissues; *C. gariepinus*

INTRODUCTION

The contamination of rivers with a wide range of pollutants has become a matter of great concern over the last few decades, not only because of the threat to public water supplies, but also with the damage caused to aquatic life. Heavy metal contamination may have devastating effects on the ecological balance of the recipient environment and a diversity of aquatic organisms [1]. This wide spread problem has ultimate effect on aquatic animals, among which fish are the most affected. Fish are widely used to evaluate the health of aquatic ecosystems because it can absorb heavy metals through epithelial or mucosal surface of their skin, gills and gastrointestinal tract, and since they play important role in human nutrition, they need to be carefully screened to ensure that unnecessary high levels of some toxic trace metals are not being transferred to man through fish consumption [2].

Heavy metals entering the aquatic ecosystem may not directly cause damage to organism but they can be deposited in aquatic organism through the effect of bioconcentration, bioaccumulation and other food chain process especially consumption of seafoods which poses threats to human health. Heavy metals in excess of the body needs of fish or man may constitute a major pollution source and pose a serious health risk [3]. The toxicity of iron (Fe) may lead to heamochromatosis, in severe

Received:	31-January-2020	**Manuscript No:**	IPJAPT-20-3292
Editor assigned:	05-February-2020	**PreQC No:**	IPJAPT-20-3292(PQ)
Reviewed:	19-February-2020	**QC No:**	IPJAPT-20-3292
Revised:	17-June-2022	**QI No.**	IPJAPT-20-32929
		Manuscript No:	IPJAPT-20-3292(R)
Published:	15-July-2022	**DOI:**	10.21767/2581-804X-6.4.46

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Citation Omosanya TA (2022) Comparative assessment of heavy metals bioaccumulation in the tissues of African catfish (*Clarias gariepinus*) collected from Otin, Oba, Ogun and Agbabu rivers, South-Western Nigeria. J Aquat Pollut Toxicol. 6:46.

cases, to thalassaemia while excessive intake of Zinc (Zn) may lead to diarrhea and vomiting in humans. Also, in man, the toxicity of Manganese (Mn) leads to a syndrome called manganism which involves both psychiatric symptoms and features of Parkinson disease.

African catfish (*Clarias gariepinus*) is of great commercial importance because it is the most widely consumed freshwater fish in Nigeria [4]. Therefore, it is a good choice of fish to study in respect to its response to environmental pollutants, particularly the heavy metals. In this research, heavy metal pollutants in fish collected from four water bodies in the South-Western Nigeria were investigated. The main aim of this research work was to evaluate the bioaccumulation patterns of heavy metals in Clarias garienus collected from Agbabu River, Ogun River, Otin River and Oba River in the South-Western Nigeria [5].

MATERIALS AND METHODS

Description of Site

The fish were collected from Otin river in Osun state, Oba river in Oyo state, Ogun river in Ogun state and Agbabu river in Ondo state in the South-Western Nigeria where fishing is predominant.

Sample Collection

Clarias gariepinus were collected from the four rivers twice a month i.e. every second and last week of the month for six months, from May to November. The collected samples were kept in plastic container containing iced block and taken to the laboratory where they were washed with running tap water to remove dirt and immediately dissected with sterile scissors to remove gills, liver, muscles and gut which were transferred into sterile sample bottles, labeled and kept for digestion and analysis of heavy metals.

Sample Preparation

Prior to digestion, samples were separately dried in a laboratory oven to obtain a constant dry weight of 0.5 g from each sample. The dried samples were each ground to powder, using laboratory ceramic mortar and pestle, and sieved with 2 mm sieve.

Digestion of Sample

The powdered samples were digested using the procedure described by Novozamsky.

Determination of Heavy Metals

Samples were then poured into auto analyser cups and concentrations of heavy metals (cadmium, iron, manganese, copper, chromium, zinc and lead) in each sample were determined using Atomic Absorption Spectrophotometer (AAS). The values of the heavy metal concentrations in the tissues were calculated based on dry weights as this discounts the variability due to inner parts differences in the moisture content of organisms [6].

Statistical Analysis

Results were presented as means ± SE, where n equals the number of fish samples from which tissues were isolated [6]. Results from all the specimens were compared using ANOVA and $P<0.05$ were considered to indicate statistical significance. Means of significant differences were separated using Duncan's Multiple Range Test [7].

RESULTS AND DISCUSSION

The Mean (± SE) concentration of heavy metals in the tissues of *Clarias gariepinus* collected from Otin, Oba, Ogun and Agbabu Rivers respectively. The Mean (± SE) concentrations of the heavy metals in the tissues of *Clarias gariepinus* collected from the four different rivers were not significantly different ($P<0.05$). The trend of heavy metals concentration in the tissues of *Clarias gariepinus* in this study fluctuates between locations of the rivers [8]. This trend is in agreement with the study, who reported variation in the trend of heavy metals concentration in selected rivers in South-Western Nigeria while Aghoghovwia also observed fluctuation trend in heavy metals between location and fish species **(Figures 1-4)**.

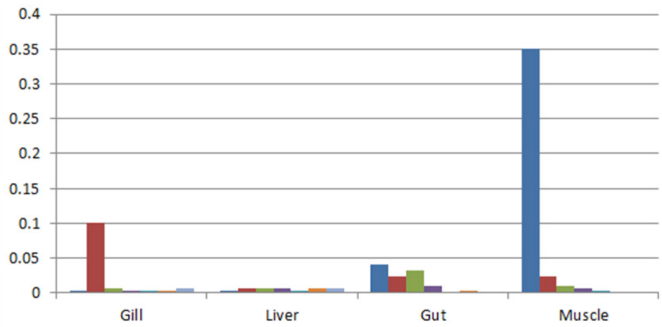

Figure 1: Mean concentration (mg/kg) plot of heavy metals in the tissues of *C. gariepinus* collected from Otin river. Note: ( ) Zn, ( ) Mn, ( ) Fe, ( ) Pb, ( ) Cu, ( ) Cd, ( ) Cr

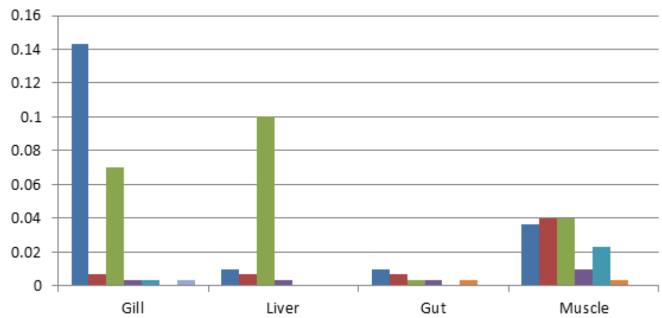

Figure 2: Mean concentration (mg/kg) plot of heavy metals in the organ and tissues of *C. gariepinus* collected from Oba river. Note: ( ) Zn, ( ) Mn, ( ) Fe, ( ) Pb, ( ) Cu, ( ) Cd, ( ) Cr

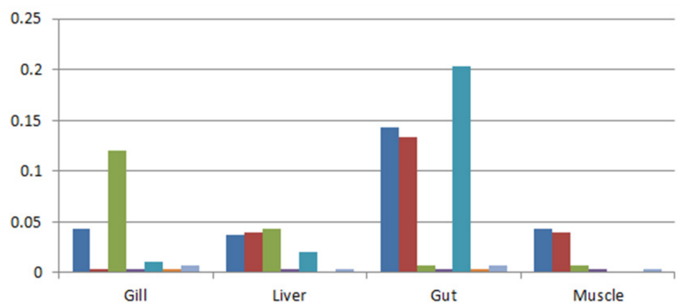

Figure 3: Mean concentration (mg/kg) plot of heavy metals in the organ and tissues of *C. gariepinus* collected from Ogun river. Note: ( ) Zn, ( ) Mn, ( ) Fe, ( ) Pb, ( ) Cu, ( ) Cd, ( ) Cr

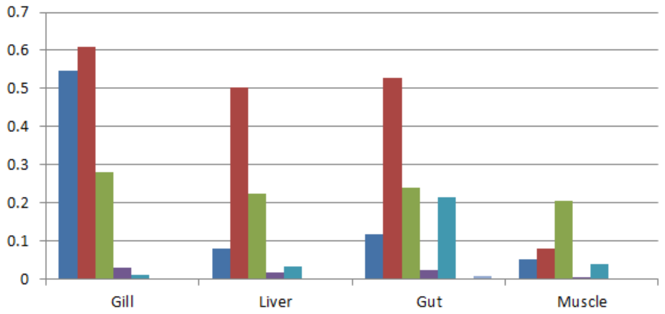

Figure 4: Mean concentration (mg/kg) plot of heavy metals in the organ and tissues of *C. gariepinus* collected from Agbabu river. Note: ( ) Zn, ( ) Mn, ( ) Fe, ( ) Pb, ( ) Cu, ( ) Cd, ( ) Cr

The heavy metals investigated were found in varying concentration. The result showed that the highest concentration sites of Zinc (Zn) in the fish samples from the different water bodies were as follows: Muscle (0.3500 mg/kg ± 0.2762 mg/kg) at Otin river, Gill (0.1433 mg/kg ± 0.1284 mg/kg) at Oba river, Gut (0.1433 mg/kg ± 0.0689 mg/kg) at Ogun river and Gill (0.5467 mg/kg ± 0.0145 mg/kg) at Agbabu river. The trend of Zn concentration in the tissue sampled at Otin river was observed to be in the following sequence: Muscle>Gut>Liver>Gill, at Oba river it was: Gill>Muscle>Liver ≥ Gut, at Ogun river was recorded to be: Gut>Muscle ≥ Gill ≥ Liver while at Agbabu river, it was found to be: Gill>Gut>Liver>Muscle. This conformed to the study who reported that Zn are found in measureable quantities in the fish tissues and also within safe limits for consumption [9,10].

The highest concentration sites of Manganese (Mn) for the rivers are as follows: Gill (0.1000 mg/kg ± 0.0058 mg/kg) at Otin River, Muscle (0.0400 mg/kg ± 0.0306 mg/kg) at Oba river, Gut (0.1333 mg/kg ± 0.0667 mg/kg) at Ogun river and Gill (0.6100 mg/kg ± 0.0306 mg/kg) at Agbabu river. The trend of Mn concentration in the organ and tissue sampled at Otin river was observed to be in the following sequence: Gill>Liver>Gut>Muscle, at Oba river it was: Muscle>Liver>Gill> Gut, at Ogun river is observed to be: Gut>Liver ≥ Muscle>Gill while at Agbabu river, it was found to be: Gill>Gut>Liver>Muscle. The concentration of Mn in the tissues of the sampled fish were lower than the recommended concentration limit [11,12].

The highest concentration sites of Iron (Fe) for the water bodies are as follows: Muscle (0.0100 mg/kg ± 0.0058 mg/kg) at Otin river, Liver (0.1000 mg/kg ± 0.0404 mg/kg) at Oba river, Gill (0.1200 mg/kg ± 0.0693 mg/kg) at Ogun river and Gill (0.2800 mg/kg ± 0.0173 mg/kg) at Agbabu river. The trend of Fe concentration in the tissue sampled at Otin river was observed to be in the following sequence: Muscle>Gill ≥ Liver>Gut, at Oba river it was: Liver>Gill>Muscle>Gut, at Ogun river is observed to be: Gill>Liver>Muscle ≥ Gut while at Agbabu river, it was found to be: Gill>Gut>Liver>Muscle. The highest concentration obtained in this study was below the high residue concentrations of Fe in fish samples [13,14].

The highest concentration sites of Lead (Pb) for the water bodies are as follows: Gut (0.0100 mg/kg ± 0.0058 mg/kg) at Otin river, Muscle (0.0100 mg/kg ± 0.0058 mg/kg) at Oba river, Gill (0.0300 mg/kg ± 0.0116 mg/kg) at Agbabu river while all the tissue have the same concentration at Ogun river. The trend of Pb concentration in the organ and tissue sampled at Otin river was observed to be in the following sequence: Gut>Muscle ≥ Liver>Gill, at Oba river it was: Muscle>Gill ≥ Liver ≥ Gut while at Agbabu river, it was found to be: Gill>Gut>Liver>Muscle [15,16].

The highest concentration sites of Copper (Cu) for the water bodies are as follows: Gut (0.2033 mg/kg ± 0.1984 mg/kg) at Ogun river, Muscle (0.0233 mg/kg ± 0.0145 mg/kg) at Oba river, all the tissue have the same concentration (0.0033 mg/kg ± 0.0033 mg/kg) except Gut (0.0000 mg/kg ± 0.0000 mg/kg) at Otin river and Gut (0.2167 mg/kg ± 0.1917 mg/kg) at Agbabu river. The trend of Cu concentration in the tissue sampled at Ogun river was observed to be in the following sequence: Gut>Liver>Gill>Muscle, at Oba river it was: Muscle>Gill>Liver ≥ Gut, at Otin river is observed to all be of the concentration except Gut (0.0000 mg/kg ± 0.0000 mg/kg) while at Agbabu river, it was found to be: Gut>Muscle> Liver>Gill. Copper is an essential element which promotes the activity of certain enzyme systems in the body and this study revealed that the concentration of Cu in fish tissues does not exceed the standard limits [17,18].

The highest concentration sites of Cadmium (Cd) for the water bodies are as follows: Liver (0.0067 mg/kg ± 0.0033 mg/kg) at Otin river, Muscle and Gut (0.0033 mg/kg ± 0.0033 mg/kg) at Oba river, Gill and Gut (0.0033 mg/kg ± 0.0033 mg/kg) at Ogun river and all the tissue have the same concentration (0.0033 mg/kg ± 0.0033 mg/kg) except Liver (0.0000 mg/kg ± 0.0000 mg/kg) at Agbabu river. The trend of Cd concentration in the organ and tissue sampled at Otin river was observed to be in the following sequence: Liver>Gill ≥ Gut>Muscle, at Oba river it was: Muscle ≥ Gut>Liver ≥ Gill, at Ogun river it was found to be Gill ≥ Gut>Liver ≥ Muscle while at Agbabu river, it was observed to be: Gill ≥ Gut ≥ Muscle>Liver. The concentration of Cd is low in sampled fish tissues and also within acceptable standard limits [19,20].

The highest concentration sites of Chromium (Cr) for the water bodies are as follows: Liver and Gill (0.0067 mg/kg ± 0.0033 mg/kg) at Otin river, Gill (0.0033 mg/kg ± 0.0033 mg/kg) at Oba river, Gill and Gut (0.0067 mg/kg ± 0.0067 mg/kg) at Ogun river and Gut (0.0100 ± 0.0058) at Agbabu river. The trend of Cr concentration in the tissue sampled at Otin river was observed to be in the following sequence: Liver ≥ Gill>Gut ≥ Muscle, at Oba river it was: Gill>Gut ≥ Liver ≥ Gill, at Ogun river it was found to be Gill ≥ Gut>Liver ≥ Muscle while at Agbabu river, it was observed to be: Gut>Liver>Muscle ≥ Gill. The result of this investigation showed that the highest concentration of Cd was below the maximum standard limits while concentration of Chromium is higher than maximum recommended limits [21,22].

The Mean (± SE) concentration of the heavy metals in the tissues of the fish were compared using ANOVA and it was determined that they are not significantly different ($P<0.05$). The mean concentrations of the heavy metals in each tissue sampled differed slightly. The study indicated that the levels of heavy metals contamination in the analyzed water bodies followed the trend; Agbabu>Ogun>Otin>Oba. The recorded trend could be attributed to the high rate of anthropogenic activities around the water bodies hence the concentration increases the discharge of the pollutants into the nearby water. Generally, the concentrations of the heavy metals observed in this study revealed that they are found in measurable quantities and still within safe limits [23,24].

CONCLUSION

The result of this investigation showed that the concentration of heavy metals deposition into Otin, Oba, Ogun and Agbabu rivers, South-Western Nigeria is within the acceptable limit. Hence, fish harvested from the rivers are safe for human consumption. However, proper monitoring and management policies of the activities in riverine areas should be established and/or enforced to prevent environmental pollution of the rivers.

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