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Comparative Studies of Heavy Metals Accumulation in Kidneys and Gills of *Clariasgariepinus*in River Benue, Nigeria

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ABSTRACT---- ***The concentration of trace metals were determined in the waters, kidneys and gills ofClariasgariepinus(African catfish) from River Benue within Makurdi Metropolitan area using atomic absorption spectrophotometer. The trend of heavy metals accumulation in the kidney cells of the fish was in the order Cr > Ni >Pb> Cu > Al > Cd. Chromium (Cr) was the highest bio accumulated heavy metal while Cd was the lowest. Similarly, in the gills of the fish, trend of heavy metals was (Cr > Ni > Cu >Pb> Al > Cd). In the gills also Cr was the highest bio accumulatedheavy metal and Cd was the lowest. Cu was more accumulated in the gills than Pb as compared to kidneys.Among the two organs (kidneys and gills) of the fish there was no significant difference in the trend of metals accumulated in the organs of the fish. (ANOVA, p > 0.05). The heavy metals in the water are transferred to the kidneys and gills of the fish (Clariasgariepinus) which have an implication for public health due to the fact that fish is a rich source of protein for humans and is widely consumed within this area. River Benue within Makurdi is polluted with heavy metals. Regulatory authorities should ensure adequate treatment of water before consumption.***

Keywords--- Gills, kidneys, *Clariasgariepinus*, heavy metals

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1. INTRODUCTION

Among different pollutants, heavy metals are the most toxic, persistent and abundant pollutants that can accumulate in aquatic habitats and their concentration increases through biomagnifications (Oyewale and Musa, 2006). Therefore, high levels of heavy metals contents in fish may have significant impact on their health, reproduction and survival (Moore*et al.*, 2009). Fish has the potential to accumulate heavy metals in their organs, this can constitute health implications to consumers (Anim-Gyampo*et al.,* 2013).
Heavy metals absorption into fish organs in polluted aquatic environment depends on the nutritional and ecological requirements (Anim-Gyampo*et al.*, 2013).This may cause acute and chronic effect to humans (Nord *et al.*, 2004). The accumulation of heavy metals in the aquatic environment has direct consequences to man and to the ecosystem (Krishna *et al.,* 2014). There is serious severity in accumulation of heavy metals in aquatic life because of the non-degradability of the heavy metals that results to bioaccumulation and is transported along the successive food chain (Gesielski*et al.*, 2010). Research studies have established that fish are good indicators of chemical pollution and have long been used to monitor heavy metal pollution in coastal and marine environments (Krishna *et al.*, 2014). The development of industries has resulted to increased emission of pollutants into ecosystem (Wang *et al.*, 2013). Environmental degradation therefore result to poisoning, diseases and even death for fish (Zeitoun and Melana, 2014).

2. MATERIALS AND METHODS

Sampling Stations

Five (5) sampling stations at approximately 1km intervals were mapped out along the River within the Makurdi metropolitan area. At each station, three (3) samples were taken along transect across the River North – South axis. The sampling stations were as follows:

i. **Brewery Station I:** The brewery is located 5km away from Makurdi town along Makurdi-Gboko road. The brewery produce effluents from its daily routine production. The effluent are channeled into Ageba, a tributary of River Benue and if flows into the River.
ii. **New Bridge Station II**: It's about 5km from Wadata market. Its effluent flow from the Wurukum abattoir.
iii. **Old Bridge station III**: It is about 500 meters away from new bridge and 4.5km away from Wadata market. Effluents from New bridge flows directly into the old bridge station.

iv. **Saint Joseph Station IV**: It is about 1.5km away from Wadata market and about 200 meters away from Makurdi Water Works. It receives discharge from the Makurdi Water Works.
v. Wadata market Station V: Wadata market is located on the bank of River Benue. This station was designed as V and it receives municipal wastes that composed of solid wastes, abattoir effluents and domestic wastes generated from the market. A huge heap of refuse dump is found at this location where its wastes are leached directly into the river.
vi. Control Station IV: This was stationed out of River Benue. This station was at a special Science Secondary school fish farm Makurdi and was designed as VI.

Collection of Water Samples

At each sampling station, three (3) water samples were collected along the North-South transect of the River. Samples were taken 30cm below the water surface with the aid of a graduate rope with 500mL transparent glass bottles that was rinsed with acetone and sterilized at 105°C with hot air oven for an hour before use and transferred into 2.5 liter brown borosilicate glass bottles. The samples were transported to the laboratory in an ice parked cooler and kept in a freezer. In the laboratory the water samples for heavy metal analysis were digested and preserved prior to AAS analysis. Two hundred and fifty milliliters of each of the water samples were filtered through a whattmann filter paper of 0.45µm and then 2.0mL of concentrated trioxonitrate (V) acid of high purity was added to the 100ml of the sample to obtain a pH of approximately 1 (Cenci and Martin, 2004).

Fish Sample Collection

The fish samples (*Clariasgariepinus*) were bought directly from the fishermen at the bank of River Benue at Wadata market fishing port site V. The *Clariasgariepinus* samples had mean weight 263 ± 4.6g and mean length 36.42 ± 1.25cm. The fish samples were still alive and stored in an ice parked box in order to maintain the freshness and later transported to the laboratory within one hour for the dissection of skin, bone, kidney, liver and gills. The organs of the fish dissected were oven dried separately for 24 hours to constant weight at 105°C.

Preparation of Standard and Working Solutions for the Heavy Metals

Preparation of standard and working solutions for heavy metals was carried out adopting the method of (APHA) 1999.

Fish Sample Preparation

The kidneys and gills of the cat fish were pooled according to the tissues type and milled with a mortar and pestle. They were put separately in a dry and properly labeled plastic containers and stored in a desiccator pending digestion.

Digestion of the Samples

0.200g of dry powdered fish sample was weighed into a 50ml tube and 2.5ml of selenium/teratoxosulphate (VI) acid mixture was added to each tube and to 5 blanks used as standards. This mixture was placed in an aluminum block on a hot plate, heat at approximately 200°C until sample fumes. The tubes were then removed from the hot plates and allowed to cool for about 45 minutes. 1ml of 30% of hydrogen peroxide, H_2O_2 was carefully added to the samples and standards. After the reaction subsides, then additional 2ml H_2O_2 was added.
The tubes were taken back to the hot plates and a 15ml glass vial was placed on top of each tube and the tubes were heated up to 330°C. This was left on the hot plates for about two hours until the solutions became clear. These samples were allowed to cool and 0.2mL, 0.4mL. 0.6mL and 0.8mL of stock solutions of each of the heavy metals to be analyzed was added to the standard solutions. The sample and standards were then diluted to the 50ml mark (Novozamsky*et al*., 1983).

Determination of Heavy Metals

Digested water and fish samples were poured into analyzer cups of the Atomic Absorption Spectrophotometer and concentration of heavy metals (cadmium, chromium, lead, nickel, copper and aluminium) in each of the samples was determined using atomic absorption spectrophotometer (AAS). The values of the heavy metal concentrations in the tissues were calculated based on dry weight as this discounts the variability due to inner parts difference in the moisture content of the organisms using the formula , Heavy metals mg/kg = $\frac{\text{AAS reading (mg/L) x Volume diluted}}{\text{Weight of sample digested}}$

Statistical Analysis

Results obtained were subjected to mean, standard deviation and standard error of means. ANOVA was determined and $p < 0.05$ was considered to indicate statistical significance. Means were separated using Duncan's multiple range Test. Microsoft excel 2013 version was used in the plotting of the graphs.
The transfer factor of metals in the water to the tissues of the fish was calculated using the formula

$$\text{Transfer factor (TF)} = \frac{\text{Metal in tissue}}{\text{Metals in water}}$$

(Rashed, 2001).

3. RESULTS AND DISCUSSION

Table1: Concentration of Heavy metals in River Benue at Makurdi

	Sampling Station Codes					
Parameter (mg/L)	**I**	**II**	**III**	**IV**	**V**	**VI**
Pb	0.33±0.16	0.54±0.53	0.33±0.08	0.46±0.59	0.68±0.81	0.17±0.39
Ni	0.22±0.30	0.44±0.61	0.30±0.25	0.50±0.68	0.35±0.35	0.56±0.66
Cu	0.21±0.28	0.22±0.09	0.41±0.52	0.05±0.04	0.64±0.89	0.57±0.73
Cr	1.08±0.47	0.12±0.08	1.46±0.91	2.67±3.62	1.66±0.57	2.50±0.64
Cd	0.21±0.007	0.19±0.007	0.15±0.06	0.19±0.04	0.15±0.08	0.27±0.03
Al	0.04±0.007	0.03±0.04	0.04±0.02	0.02±0.01	0.09±0.001	0.03±0.03

*values are means of triplicate readings.

Table2: Trace Element Concentration (mg/Kg) in Kidneys of *Clariasgariepinus*

Sample code	Pb	Ni	Cu	Cr	Cd	Al
A	0.69	0.28	0.5	3.03	0.15	0.57
B	1.21	0.95	0.44	0.04	0.003	0.05
C	0.78	0.14	0.49	0.55	0.09	0.07
D	1.27	0.3	0.43	0.92	0.05	0.02
E	0.73	0.2	0.23	1.06	0.09	0.03
F	0.83	0.52	0.68	0.67	0.15	0.02
G	0.97	2.07	0.51	1.64	0.08	0.01
H	0.24	1.93	0.15	1.66	0.14	0.07
I	0.33	1.26	0.6	0.05	0.29	0.02
J	0.66	1.12	0.08	0.62	0.005	0.03
K	0.61	0.83	0.83	0.38	0.43	0.007
L	0.76	1.65	0.25	3.28	0.11	0.04
Mean	0.76	0.94	0.43	1.16	0.13	0.08
Std	0.30	0.68	0.22	1.07	0.12	0.16
Min	0.24	0.14	0.08	0.04	0.00	0.01
Max	1.27	2.07	0.83	3.28	0.43	0.57

Table 3: Trace Element Concentration (mg/Kg) in the Gills of *Clariasgariepinus*

Sample code	Pb	Ni	Cu	Cr	Cd	Al
A	0.67	0.56	0.21	4.89	0.12	0.09
B	1.2	0.31	0.35	1.09	0.03	0.03
C	0.91	0.23	0.29	0.33	0.09	0.02
D	1.1	1.33	0.34	1.76	0.009	0.02
E	0.64	0.16	0.36	0.15	0.13	0.03
F	1.24	1.54	0.3	4.08	0.07	0.01
G	0.97	2.33	1.75	2.2	0.04	0.42
H	0.55	1.36	0.09	0.59	0.28	0.01
I	0.35	0.24	0.79	0.27	0.06	0.42
J	1.09	1.71	0.39	0.62	0.009	0.03
K	0.69	0.52	0.82	0.55	0.39	0.02
L	0.48	1.55	0.93	4.12	0.1	0.01
Mean	0.82	0.98	0.55	1.72	0.11	0.09
Std	0.30	0.73	0.46	1.71	0.11	0.15
Min	0.35	0.16	0.09	0.15	0.01	0.01
Max	1.24	2.33	1.75	4.89	0.39	0.42

4. DISCUSSION

Heavy metals such asPb, Ni, Cu, Cr, Cd and Al were detected in River Benue at different concentration at the studied locations. Heavy metals have the ability to bio accumulate in the organs of the fish. In the course of this study heavy metals were found to accumulate in the kidney and gills of *Clariasgariepinus* (African catfish). The heavy metals that were found in the water were transferred into the body organs of the fish where they became bio-accumulated. This result is consistent with the findings of Anim-Gyampo*et al*. (2013) who reported that heavy metal concentrations in water samples are usually less than what is obtained in the organs of the aquatic organisms. Results from this study revealed that Cr was the highest accumulated heavy metal and Cd the lowest in the kidneys of *Clariasgariepinus*. This could be as result of physiological processesin cellular composition.The trend of heavy metals accumulation in the kidney cells of the fish was in the order Cr > Ni >Pb> Cu > Al > Cd.

Cr was the highest bio accumulated heavy metal while Cd was the lowest in the gills of the fish(Cr > Ni > Cu >Pb> Al > Cd). This findings is consistent with an earlier study in River Benue that showed Cu was more accumulated in the gills than Pb (Eneji*et al*., 2011). However the findings of this study differs significantly from the result of an earlier study where Cu was the highest metal accumulated in the gills of the fish (Akan *et al*., 2012).

Among the two organs of the fish there was no significant difference in the trend of metals accumulated in the organs of the fish. (ANOVA, $p > 0.05$). This may be attributed to the fact that the bio accumulation is a time event that occurred over time.

Generally in this study, different metals accumulated at different concentration in the two organs of the fish. This observation is consistent with the report of an earlier study in River Benue at Makurdi on *Clariasgariepinus* (Eneji*et al*., 2011). The difference in the levels of bio accumulation in the kidneys and gills of the fish may be linked to the different physiological function of kidneys and gills of the fish. Other plausible reasons may be the behavior of the fish and feeding habits of the fish that may be significant in the bioaccumulation differences of the heavy metals in the kidneys and gills of the fish (Eneji*et al*., 2011). The result of this study that reported Cr as the most accumulated heavy metals among the metals examined in the kidneys and gills of the fish is consistent with the findings of an earlier study that reported Cr as the most accumulated metal among the other metals examined (Akan*et al*., 2012). Similarly the findings of this study that Cd is the lowest heavy metal accumulated in the kidneys and gills of the fish is consistent with the findings of (Bashir*et al*., 2013). The low accumulation of Cd in thetwo organs of the catfish is attributed to the findings that the solubility of Cd is influence by large degree of acidity (Ros and Slooff, 1987).

5. CONCLUSION

It was concluded from the findings of this study that, the concentration of the metals like Pb, Ni, Cr, Cd, and Al in the waters of River Benue have been transferred to the fish which lives in the water and derives it nourishment in the water of the River. This is evident in the bioaccumulation of heavy metals in the kidneys and gills of *Clariasgariepinus* in River Benue at Makurdi. This situation has a negative consequence on the public health of the residents of Makurdi and its environs that consume the fish as the most prevalent rich source of protein. However, the high level of bioaccumulation of Cr in kidneys and gills of the fish is a good bio indicator and bio maker for the monitoring of pollution in the aquatic ecosystem.

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