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Determination of heavy metals in water, sediments and tissues of *Clarias garipienus* and *Oreochromis niloticus* from Kpata River, Lokoja, Nigeria

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Abstract
The pollution of aquatic ecosystems by heavy metals is an important environmental problem as heavy metals constitute some of the most hazardous substances that can bioaccumulate in various biotic systems. This study was aimed at assessing the levels of some heavy metals (Lead, Cadmium, Chromium and Copper) in water, sediment and fish samples from Kpata River in Lokoja metropolis, Kogi State. A total of three samples each of water, sediment, fishes (*Clarias garipienus* and *Oreochromis niloticus*) were collected and analyzed for heavy metals using Atomic Absorption Spectrophotometer (AAS). Data obtained were subjected to statistical evaluation using simple statistics. Parameters evaluated were grand mean, standard deviation and coefficient of variance percentage. Result showed that concentration of Lead in the different tissues of the Catfish were higher ($P<0.05$) than Tilapia fish. Whereas, the concentrations of Copper in the different tissues of Tilapia were higher ($P<0.05$) than Catfish. Moreover, the concentration of all the metals determined in water, sediment and fish samples were below allowable limit of World Health Organization (WHO). This finding indicates that the water is safe for both aquatic life and man and consumption of fish from this river does not pose any risk of heavy metal contamination to consumers. However, there is need for continual assessment of the level of pollution of this river with a view to reducing the level of pollution via education and public enlightenment.

Keywords: Heavy metals, pollution, Kpata, sediments, fish

1. Introduction

Heavy metal is any metallic chemical element that has a relatively high density and is toxic or poisonous at low concentrations. As trace elements, some heavy metals (e.g. copper, iron, zinc, manganese and selenium) are essential to maintain the metabolism of the human body. However, at higher concentrations they can lead to poisoning [1].

For many decades, the pollution of aquatic environment with heavy metals has become a worldwide problem because of their potential toxic effect and also most of them accumulate in tissues and organs of aquatic organism [2]. However, the amount of absorption and bioaccumulation of the heavy metals depends on ecological, physical, chemical and biological condition and the kind of element and physiology of organisms [3]. Research on heavy metals alongside monitoring programmes in aquatic environment have become important due to concerns of over accumulation and toxic effects to aquatic organisms and to humans through the food chain since contaminants can persist for many years in sediments where they hold the potential to affect human health and the environment [4,5]

Fish as an important component of the human diet, is generally appreciated as one of the healthiest and often times referred to as the “cheapest” source of protein, as its amino acid compositions are richer in Cysteine than most of the other sources of protein [6]. However, they also possess bio-accumulative property, which can cause a build-up of metals within their tissues. This accumulation of metals may occur through contamination of water bodies which serve as habitat to the fish as well as from elemental heavy metals, which is mainly caused by anthropogenic activities and processing methods [7].

Sediments are an important sink of a variety heavy metals and may serve as an enriched source of these contaminants for benthic organisms [8]. Metals may be present as as free ions, dissolved species, or forming organic complexes with fulvic and humic acid. Lead may associate readily with particulates and become absorbed or co-precipitated with carbonates, oxyhydroxides, sulphides and clay minerals. The aim of this study was to determine the levels of some heavy metals in water, sediments and some tissues of *Oreochromis niloticus* and *Clarias gariepinus* collected from Kpata river, Lokoja, Kogi State.

2. Materials and Methods

2.1 Description of the Study Area

Kpata River is a river that flows into the river Niger within Lokoja metropolis. For many years, it has been a major source of water for Kogi State Water Board, Lokoja. This river is located close to a market in Lokoja. Toxic wastes are most often times washed into this water body.

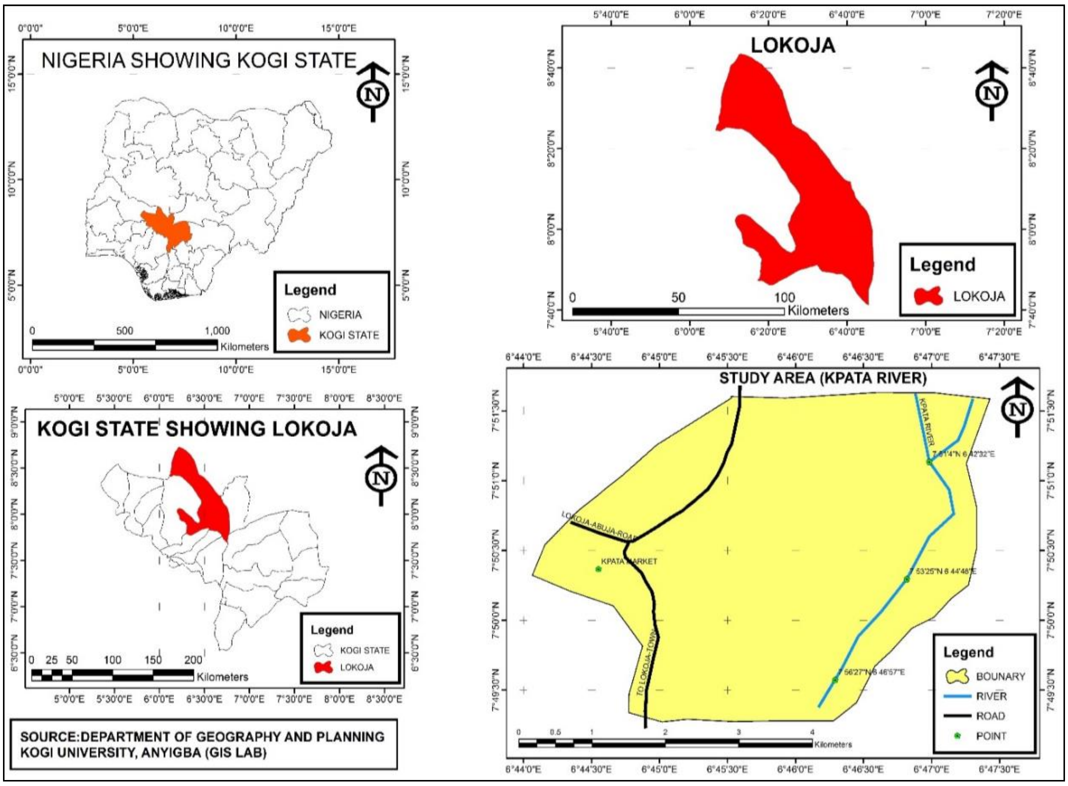

Fig 1: Map showing study area

2.2 Samples Collection

Water samples were collected using plastic containers to fetch water below the surface of designated points, mixed properly and stored in a plastic container rinsed with 0.01N nitric acid and kept in deep freezer prior to the time of analysis [9].

The sediment samples were collected by scooping with a plastic spoon from the points where the water sample were taken, air dried and kept awaiting analysis. The samples of available fish species (*Oreochromis nilocticus* and *Clarias gariepinus*) in the stream were purchased from fishermen at the stream site. The fish samples were properly washed and stored at 4 ^{0}C pending analysis. These samples were collected at 8.00 am local time while the temperature (27 ^{0}C) of the water was taken at the point of collection.

2.3 Sample Treatment

Five centimeter cube of concentrated hydrochloric acid were added to 250.0cm^3 of water sample and evaporated to 25.0 cm^3. The concentrate was transferred to a 50.0cm^3 standard flask and diluted to the mark with de-ionized water [9]. Five (5.0) g of prepared sediment sample was digested with 15.0 cm^3 nitric acid, 20.0cm^3 per hydrochloric acid and 15.0 cm^3 hydrofluoric acid and placed on a hot plate for 3 hours. On cooling, the digest was filtered into a 100 cm^3 volumetric flask and made up to the mark with distilled water [10]. Different body parts of the fish (Head, gills, bones, muscles) were dried in the oven at 105 ^{0}C until constant weight is obtained and blended. Two (2.0) g of the blended fish parts were weighed and digested using the approved method [11].

2.4 Heavy Metal Analysis

Heay metal analysis (Lead, Copper, Cadmium and Chromium) were determined in samples of body parts of *Clarias gariepinus* and *Oreochromis niloticus*, water and sediment using computer controlled Atomic Absorption Spectrophotometer (AAS VGB 210 System). The instrument setting and operational conditions were done in accordance with the manufacturers ‘specifications. All determinations were in three replicates.

2.5 Heavy Metal Concentration Factor

Heavy metal Contamination Factor (CF) was expressed using equation adopted by [12]. CF= C_m/B_m; where Cm is the mean concentration, while Bm is the background concentration of metal. CF was defined according to four categories as follows: CF< 1 = low contamination factor, 1<CF<3 = moderate contamination factor, 3 <CF<6 = considerable contamination factor and 6<CF = very high contamination factor.

2.6 Statistical Analysis

The results obtained were subjected to statistical evaluation. Parameters evaluated were grand mean, standard deviation (SD) and coefficient of variation percentage (CV %).

3. Results

The mean metal concentrations, grand mean, standard deviation and coefficient of variation percent of water and sediments were presented in Table 1. The mean concentration of metal determined in the water samples ranged from 0.02 – 0.41 mgL^{-1} and for sediments, the range was 0.09 – 0.86 mg kg^{-1}. The metals determined were Lead, Chromium, Cadmium and Copper with mean concentrations of 0.04, 0.05, 0.02 and 0.41 (mgL^{-1}) in water and 0.86, 0.61, 0.09 and 0.17 ($mgkg^{-1}$) in sediment respectively.

Table 1: Results of Heavy Metal Concentration in Water (mgL^{-1}) and Sediment ($mgkg^{-1}$) from Kpata River, Lokoja, Kogi State.

Parameters	Lead	Chromium	Cadmium	Copper
Water	0.04	0.05	0.02	0.17
Sediment	0.86	0.61	0.09	0.41
Grand mean	0.45	0.33	0.06	0.29
SD	0.58	0.40	0.05	0.17
CV %	127.8	120.0	89.81	58.51

Standard Deviation, SD; Coefficient of Variation Percent, CV%.

The mean metal concentration, grand mean, standard deviation and coefficient of variance percent in the body parts (head, gills, eyes and flesh) of African Catfish (*Clarias gariepinus*) measured in $mgkg^{-1}$ were presented in Table 2. The grand mean concentration of metals determined were Lead, Chromium, Cadmium, and Copper with grand mean concentration of 1.20, 0.21, 0.33 and 0.38 ($mgkg^{-1}$) respectively.

Table 2: Results of Heavy Metal Concentration in the Body Parts of *Clarias garipienus* ($mgkg^{-1}$) from Kpata River, Lokoja, Kogi State.

Parameters	Lead	Chromium	Cadmium	Copper
Muscle	1.23	ND	0.41	0.43
Head	1.18	0.14	0.37	0.16
Eye	1.03	0.10	0.28	0.08
Gills	2.11	0.42	0.23	0.32
Bones	1.16	0.16	0.34	0.12
Grand mean	1.34	0.21	0.33	0.22
SD	0.44	0.15	0.07	0.15
CV %	32.45	70.92	21.96	66.00

Standard Deviation, SD; Coefficient of Variation Percent, CV%; Not Detected, ND

The mean metal concentration, grand mean, standard deviation and coefficient of variance percent in the body parts (head, gills, eyes and flesh) of African Tilapia fish (*Oreochromis niloticus)* measured in $mgkg^{-1}$ were presented in Table 3. The grand mean concentration of metals determined ranged from 0.10 – 1.34 $mgkg^{-1}$. The metals determined were Lead, Chromium, Cadmium and Copper with grand mean concentration of 1.34, 0.10, and 0.22 ($mgkg^{-1}$) respectively.

Table 3: Results of Heavy Metal Concentrations ($mgkg^{-1}$) in the Body Parts of *Oreochromis niloticus* from Kpata River, Lokoja, Kogi State.

Parameters	Lead	Chromium	Cadmium	Copper
Muscles	1.21	ND	0.22	0.14
Head	1.15	ND	0.18	0.17
Eye	1.13	ND	0.14	0.11
Gill	1.35	0.11	0.37	0.31
Bones	1.17	0.08	0.19	0.16
Grand mean	1.00	0.10	0.22	0.19
SD	0.45	0.02	0.09	0.08
CV %	45.03	22.31	40.27	43.34

SD, Standard Deviation; CV%, Coefficient of variation Percent; ND, Not Detected

The mean bioconcentration factor, grand mean, standard deviation and coefficient of variance percent in the body parts (head, gills, eyes and muscle) of African Catfish (*Clarias garipienus*) were presented in Table 4. The grand mean bioconcentration of metals determined ranged from 0.92 – 30.05. The metals determined were Lead, Chromium, Cadmium and Copper with grand mean of 30.05, 4.03, 16.30 and 0.92 respectively.

Table 4: Results of Bioconcentration Factors of the Various Metals in the Body Parts of *Clarias garipienus* from Kpata River, Lokoja, Kogi State.

Parameters	Lead	Chromium	Cadmium	Copper
Muscles	30.75	ND	20.50	2.52
Head	29.50	2.80	18.50	0.94
Eye	25.75	2.00	14.00	0.47
Gills	52.75	8.40	11.50	1.88
Bones	29.00	3.20	17.00	0.71
Grand mean	33.55	4.03	16.30	1.30
SD	10.89	2.96	3.58	0.86
CV %	32.46	73.48	21.97	66.00

SD, Standard Deviation; CV %, Coefficient of Variation Percent; ND, Not Detected

The mean bioconcentration factor, grand mean, standard deviation and coefficient of variance percent in the body parts (head, gills, eyes and muscles) of African Tilapia fish (*Oreochromis niloticus*) were presented in Table 5. The grand mean bioconcentration of metals determined ranged from 0.54 – 33.55 $mgkg^{-1}$. The metals determined were Lead, Chromium, Cadmium and Copper with grand mean of 33.55, 1.90, 11.00 and 0.54 ($mgkg^{-1}$) respectively.

Table 5: Results of Bioconcetration Factors of the Various Metals in the Body Parts of *Oreochromis niloticus* from Kpata River, Lokoja, Kogi State.

Parameters	Lead	Chromium	Cadmium	Copper
Muscles	30.25	ND	11.00	0.82
Head	28.75	ND	9.00	2.29
Eye	28.25	ND	7.00	1.00
Gills	33.75	2.20	18.50	1.82
Bones	29.25	1.60	9.50	0.94
Grand mean	30.05	1.90	11.00	1.37
SD	2.20	0.42	4.43	0.65
CV %	7.30	22.32	40.27	47.00

SD, Standard Deviation; CV %, Coefficient of Variation Percent; ND, Not Detected

The regulatory standard for World Health Organization (WHO) recommended allowable limits of heavy metals in food were presented in Table 6.

Table 6: The regulatory standard for World Health Organization (WHO) for Heavy Metals

Metal	Water (mgl^{-1})	Fish ($mgkg^{-1}$)
	WHO	WHO
Lead	0.01	2.0
Copper	1.2	0.6
Cadmium	0.003	0.5
Chromium	-	3.0

(**Source:** WHO, 2003)

4. Discussion

In this study, the levels of Lead, Chromium, Cadmium and Copper were determined in various body parts of two species of fish; *Clarias garipienus* and *Oreochromis niloticus*, water and sediment samples from Kpata River using Atomis Absorption Spectrophotometer.

Mean heavy metal levels for the water and sediment was shown in table 1. The levels of all the heavy metals in the sediment were found to be higher than the values in water. This corresponds with most of the research findings of other works that sediments usually serve as sink for heavy metals [19, 20]. Thus, the heavy metal content of the water follow the trend Cu >Cr >Pb > Cd, whereas the heavy metal contents of the sediment follow the trend Pb > Cr > Cu > Cd.

The trend in the accumulation of Lead (Pb) in the tissues of the studied fishes varied (Table 2 and Table 3). The two studied species displayed a relative high concentration of Lead in their gills. This is not surprising because the gills perform the function of respiration and are directly in contact with water and pollutants that may be present in water. Thus, the concentrations of heavy metal in gills reflect the concentration of trace metals in the waters where the fish lives [13].

The average concentrations of Lead in the different tissues of the Catfish (Table 1) were higher than Tilapia fish. This may be due to difference of feeding habits of the two species. Catfish occur in shallow water with muddy bottom. They are mainly omnivorous, feeding on insect larvae, fish, molluscs, plankton organisms, seeds, worms and detritus which accumulate large amount of heavy metals [14]. Tilapia fish on the other hand feeds mainly on phytoplankton. Moreover, the concentrations of Lead in the tissues of the fishes were below the permissible limit of 2.0 $mgkg^{-1}$ set by regulatory bodies [15]. This result is in agreement with earlier studies by [16] from the same water body.

Likewise, the trend in the accumulation of Copper in the different tissues of the studied fishes varied (Table 2 and Table 3). The concentration of Copper (Cu) in the tissues of the two fishes were below the permissible limit of 2.0 $mgkg^{-1}$ set by regulatory bodies [15]. The concentrations of Copper in the different tissues of the Tilapia fish were higher than Catfish. The higher level of Copper in the fish tissues relative to the other metals (Cadmium and Chromium) could be due to the fact that the metal is naturally abundant in Nigeria soil which is the main source of metals in the surrounding water of the fish sample [17, 16] in a related experiment observed similar trend of heavy metal accumulation in the tissues of three studied fish species.

The trend in the accumulation of Cadmium and Chromium in the tissues of the two studied fishes also varied, with relatively higher values in Catfish compared to the Tilapia fish. Cadmium and Chromium are toxic at very low concentration and have no known functions in biochemical processes [16, 18]. The levels of Cadmium and Lead were however, below the concentrations recommended by regulatory bodies.

The presence of the metals analyzed in the body parts of fish serves as an indicator for the extent of heavy metals pollution of the water body from where the two fish species were obtained [16, 20]. Also, the presence of most of the metals determined in the fish parts agreed with the results of the report of heavy metals in aquatic organisms from different water bodies [19, 20]. They all reported that aquatic animals, fish, inclusive, bio-accumulate heavy metals in considerably amount, and because these metals are mostly non-biodegradable, the metal tend to stay in the fish tissues for a very long time which upon consumption of these fish, the heavy metals get transferred to man, leading to heavy metal poisoning in man especially if present in higher concentrations.

Table 4 and Table 5 show the bioconcentration factors for *Clarias garipienus* and *Oreochromis niloticus* respectively. Most of the values obtained for the various fish parts were relatively high (>1) which showed there was biological magnification of metal concentration in fish samples except for Copper in head, eye and bones for *Clarias garipienus* and Copper in muscles for *Oreochromis niloticus*. Grand mean bioconcentration factor in the various parts of *Clarias garipienus* was moderate contamination for Lead and Cadmium. Whereas, the grand mean bioconcentration factor in the various parts of *Oreochromis niloticus* was moderate for Copper and Chromium and very high contamination for Lead and Cadmium. This result is in conflict with earlier studies by [16] from the same water body.

5. Conclusion

This study examined the concentrations of Lead (Pb), Cadmium (Cd), Chromium (Cr) and Copper in the muscle, head, eye, gills and bones of fish samples from Kpata River and compared the results with the World Health Organization (WHO) allowable limits.

The observed differences in metal concentrations in the two species of fish examined indicated difference in metal uptake. Although, the results obtained does not show any form of danger posed to consumers of sea foods and water from this river but the possibility of deleterious effect after long period cannot be ruled out due to their bioaccumulative nature in human and aquatic environment.

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