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Heavy Metals Concentration in Fish and Water of River Osse Benin City Nigeria

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Abstract The aim of this study was to assess the heavy metals concentration on fish and potable water in River Osse (Nigeria). The need to provide good and potable water for domestic uses, protection of people and fisheries health and to ensure sustainability of the environment was a great and urgent concern in the Osse community for who the River represents their source of water supply. To this aim, fish and water samples were collected at three different points. Four metals (chromium Cr, copper Cu, nickel Ni and vanadium V) in the fish and water were analysed. The mean concentration values recorded in the fishes were in the range of 0.0667-0.2467mg/kg for Cr, 6.15-18.32mg/kg for Cu, 12.41-27.75mg/kg for Ni, and 0.2133-0.3500mg/kg for V. while the corresponding mean values recorded for water are in the range of 0-0.02mg/l for Cr, 0.17-0.19mg/l for Cu, 0.51-0.59mg/l for Ni, and 0-0.02mg/l of V. Significant differences ($P< 0.05$) were recorded between heavy metals levels in fish caught at the three points and in the water samples. The results of this research showed that the concentrations of Ni and Cr for fish exceeded the recommended limit set by FAO for fish and fishery product. The concentration of Ni exceeded the recommended limit set by WHO for potable drinking water, while the corresponding concentration of V exceeded limit reported by the Department of Petroleum Resources in freshwater environments in Nigeria.

Keywords: *heavy metal, concentration, fish, River Osse, pollution*

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1. Introduction

In recent years, in Nigeria the National Environmental Protection Laws (NEPL) is not being properly adhered. As a result, industrial, agricultural and domestic wastes are being discharged untreated into rivers and coastal waters. This has led to the deterioration of the quality of the natural environment and inevitably increased the levels of heavy metals deposition in many inland water bodies.

Duffus [12] defined heavy metals as a general collective term which applies to groups of metals and metalloids that have a selectively high density greater than $4g/cm^3$ and that are toxic or poisonous at low concentrations. Heavy metals are natural components of the earth's crust. They are stable inorganic contaminants because they cannot be destroyed or biodegradable as most organic pollutants. They tend to bio accumulate in the environment especially in bottom sediment of rivers and lakes, associated with inorganic and organic chemical combinations. They can also reach humans by consumption of contaminated fish. Some of these metals such as zinc, iron and copper are essential elements though, may play important roles in various life processes in trace amounts, become deleterious at high concentrations because they have the tendency to remain fixed in tissues and are not easily excreted [14]. The non-essential elements include mercury, lead. arsenic and cadmium and are harmful heavy metals. According to Igwe and Abia [11], Oguzie and Ogubere [9], heavy metals presence in the environment is of major concern because of their toxicity, bioaccumulation tendencies and threat to the environment and human life. Industrial, domestic and agricultural activities have led to the pollution of several inland water bodies in Nigeria and they are deposited and concentrated in sediments. Such metal pollutants can cause serious hazards as they are being incorporated into aquatic organisms including fish which serves as food for man [9]. Miroslav and Bashkin [18] reported that heavy metals are input source of pollution not just because they are toxic above a relatively low concentration but also they are persistent in the environment long after the source of pollution has been removed. Pollution of water is of grave consequence because both terrestrial and aquatic life may be poisoned. Disease may result due to the presence of hazardous substances which may distort the water quality and hinder economic activities.

In developing countries with no exception to Nigeria, the non-availability of potable water supply has led the populace to optimize river water for drinking, domestic and other activities. This is no different in River Osse in Benin-City Edo State which is a source of fish for human consumption. The sources of pollution in the River Osse include effluent from tyre production, fertilizer and pesticide from the rubber plantation. Human activities are also carried out right in the water and its surroundings. The original tropical rainforest vegetation has changed to a more open guinea savanna vegetation type. The large rubber-plantations that existed in the 1960's have been reduced to build up areas and farmlands, and thus, the use of pesticides and herbicides which serves as possible sources of heavy metals contamination or pollution. The river is a source of water for domestic and agricultural activities as well as a means of transportation. The river supplies water to the Michelin rubber plantation. Previous studies on this river had centered on the ecology and population of fishes. Heavy metal studies have not been carried out in this river. It was therefore necessary to study the metal concentrations of the river because of the increasing population of communities that depended on the river for domestic and agricultural activities.

Therefore the goals of this study were to determine the concentration of heavy metal in water and fish of River Osse, compare the levels of heavy metals with standards set for fish and fishery products by the food and Agricultural Organization (FAO) of the United Nations and the World Health Organization (WHO) and make recommendations on the safety of heavy metals concentration in River Osse.

2. Materials and Methods

2.1. Study Area

The study area lies in the coastal region of Edo state of Nigeria. It is a stretch of River Osse, which is within latitudes 6°28' and 6°45'N of the equator and longitudes 5°21' and 5 45'E of the Greenwich meridian and flows in a Southwest direction. The climate is tropical with wet (rainy) season between the months of April and October and a dry season between November and March. Temperature ranges between 24℃ and 34℃ annually while annual relative humidity is between 69%-96%.

2.2. Sample Stations and Sample Collection

The sampling stations for the study were chosen based on effluents characteristics the river receives and the activities carried out at these stations. These included:

1. Effluents from laundry activities and bathing, which are potential sources of heavy metals contamination.
2. Domestic wastes from villages.
3. Leachates of pesticides and herbicides from their farmlands and Michelin rubber plantation during rainfall.

Duplicate water samples were collected from the three stations in acid washed polyethylene bottles. The bottles were rinsed thoroughly with concentrated nitric acid (HNO_3) and distilled water, 24 hours prior to samples collection. On sampling days, water sample (1) was collected randomly from two points at each station after the bottles were rinsed severally. The water samples were acidified prior to preservation to ensure that heavy metals did not get adsorbed to the walls of the containers during transportation and storage. The samples were stored at 40℃.

Synodontis schall and Citharinus citharus were the species used because they were dominant and readily available in the river. Fish samples were bought from fishermen who use various fishing gears (fish traps, baited hooks and long liner) to catch fishes. Fish samples were placed in a preservation pack and transported to the laboratory.

2.3. Fish and Water Analysis

The fish samples were identified using keys according to Trewevas [6] and Whitehead [13]. They were then sorted into species. Routine body measurements such as total and standard length in (cm) were determined by means of a measuring board to the nearest 0.lcm, while fish weights in (g) were determined by means of a sensitive Mettler balance (Mettler P.E. 360) and the values recorded to the nearest 0.lg. Fish samples were wrapped in foil paper, labeled and oven dried at a temperature of 105℃ for some hours. After drying, each sample was milled separately for homogeneity using a porcelain mortar and pestle. 5g of each wrapped sample was stored in polythene bags prior to digestion and analysis.

Fish samples were digested using the organic extraction technique described by Sreedevi et al. [17]. 1g of each milled sample was placed in 50ml kjeldhal flask. 10ml of nitric acid, 2ml of perchloric acid and 2ml of sulphuric acid (5:1:1 ratio) were added to the sample in the flask. Contents of the flask were treated with moderate heat under a hood. Digestion was stopped with the appearance of white fumes. An aliquot of the digest was diluted to 10ml with distilled water and further boiled for a few minutes and then allowed to cool. This was subsequently filtered into 50ml volumetric flasks. Blank samples were prepared using the same quantity of mixed acids.

Water samples were digested using the pre-concentrated nitric acid method described by Parker [3]. 50ml of a well-mixed preserved sample was transferred to a 250ml beaker. 10ml of concentrated nitric acid was added to contents of the beaker and covered with a watch glass. Content of the beaker was heated over medium flame under a hood until the volume was reduced to 10ml. The digest was transferred to a 250ml volumetric flask and made up to volume with distilled water. Each sample was stored in a sterile reagent bottle with a glass stopper prior to analysis. Blank samples were prepared using the same quantity of nitric acid (HNO_3).

2.4. Analysis of Heavy Metals

The analysis of the digests was carried out by means of an atomic absorption spectrophotometer (AAS) (Unicam 929 series) with solar software. The source of radiation was a hollow cathode lamp. The Atomic Absorption Spectrophotometer was calibrated for Cu, Ni, Cr and V. Standard solutions of each metal salt and blank sample were analyzed with each set of digests.

Analysis of Variance (ANOVA) was used to analysed the metals in the fish species while Duncan multiple test was used to compare the means.

3. Results and Discussion

3.1. Heavy Metals Concentration in Osse River Water

The mean concentrations of heavy metals in Osse River water at three sampled stations showed that chromium had equal value 0.02mg/l at the three stations.

Copper concentration had equal values at stations 2 and 3 compared to the lowest value at station 1 (Table 1). The mean concentration of nickel was highest at station 2 (0.57mg/l) and lowest at station 3 (Table 1). At the three stations, vanadium had equal metal values (Table 1).

Nickel had the highest total mean value when compared to the values of other metals while both vanadium and chromium had the lowest total mean values (Table 1). There were significant differences (P< 0.05) between the metals in the water sampled at the three stations (Table 1).

The profile of ranking of the heavy metals in descending order in the water was as follows: Ni> Cu> Cr> V.

3.2. Heavy Metals Concentration in Fishes of Osse River

The two species of fish sampled for at the three sampling stations had levels of 'concentrations of heavy metals that varied (Table 2).

The higher value of Cr was recorded in *Synodontis schall* (Table 2). Cr concentration was higher in *S. schall* caught at station 2 compared to the lower values recorded in *C. citharus* caught at stations 1 and 2.

The higher concentration of Cu was recorded in *S. schall* lowest (Table 2). Cu concentration was highest in *S. schall* caught at station I compared to the lowest values recorded in *C. citharus* caught at station 2 and 3. There were significant differences (P<0.05) in the concentration of Cu in the fish sampled at the three stations.

For Ni the highest value was recorded in *S. schall*. Ni concentration for *S. schall* was highest in station 2.

The mean concentration level of V in the fish species was highest in *S. schall* (Table 2). The highest value of V was determined in *S. schall* caught at station 2. There were significant differences (P<0.05) in V concentration in the fishes sampled at the three stations. (Grand Mean = 0.203).

There were significant differences (P<0.05) in the concentration of Cr in the fishes sampled at the three stations (Table 5). Grand Mean = 0.1033mg/kg.

There were significant differences (P<0.05) in the concentration of Ni in the fishes sampled at the three stations (Table 6). Grand Mean = 13.16.

Findings from this study indicated the occurrence of Cu, Ni, Cr and V in water and in dominant fish species of Osse River. The mean concentrations of these heavy metals in water of Osse river were lower than the recommended limit for heavy metals concentration in fresh water environments in Nigeria set by the Department of Petroleum Resources [4]; Enujuigha and Nwanna, [21] except for Ni concentration that exceeded the limit. Thus Osse river water is unpolluted to an extent and could be considered safe for drinking and other domestic activities.

3.3. Heavy Metals in Water

The concentrations of heavy metals in water were generally low. The low metals levels in water are similar with reports by Egborge [1] on Warri river and Obasohan et al. [5] on Ogba river.

The concentration of Cr was lower compared to the value reported for Ovia River (0.09mg/l) by Abolagba et al. [15]. This low value may be due to low availability of chromium and chromium compounds [2]. The mean concentration value (0.02mg/l) of Cr was lower than the value (0.05mg/l) recommended for portable drinking water by WHO [22].

The mean concentration of copper at station 2 and station 3 were higher than the concentration of Cu at station 1. The total mean concentration recorded for Cu corresponded to the value reported for Warn River by Egborge [1]. This relatively high copper may be attributable to wastes in flood water run- off, leachates from garbage dumps and other forms of domestic wastes washed into the river by the inhabitant. However, the mean concentration value was lower than the WHO recommended standard (1 .0mg/l) for portable drinking water.

Table 1. Mean Concentrations (Mg/L) of Heavy Metals in Osse River Water and Mean Comparison of Heavy Metals Using Duncan's Multiple Range Test

Heavy Metal	Station 1	Station 2	Station 3	Mean
Cr	0.02	0.02	0.02	0.02[a]
Cu	0.17	0.19	0.19	0.18[c]
Ni	0.55	0.59	0.51	0.55[b]
V	0.02	0.02	0.02	0.02[a]

Means in the same vertical row with different letters are significantly different at 5% probability level.

Table 2. Mean Concentrations of Heavy Metals (Mg/Kg) in Fishes Caught at the Three Stations

Fish	***Synodontis schall***				***Citharinus citharus***			
	Station				**Station**			
Metal	1	2	3	Mean	1	2	3	Mean
Cr	0.15	0.25	0.23	0.21	0.067	0.07	0.10	0.08
Cu	18.32	18.2	17.57	18.02	8.77	6.15	7.94	7.62
Ni	25.54	27.7	25.55	26.28	12.41	12.97	12.56	12.6
V	0.31	0.35	0.29	0.32	0.21	0.27	0.32	0.28

Table 3. Mean Comparison of Heavy Metals Using Duncan's Multiple Range Test

Metals	Mean	Remarks
Cr	0.145	A
Cu	12.91	B
Ni	19.42	B
V	0.295	A

Means in the same vertical row with different letters are significantly different at 5% probability level

Table 4. Analysis of Variance for Chromium in Fish Species

Source of variation	D.F	S.S	M.S	V.R	F.P
Total	26	0.23			
Batch	2	0.09	0.00	1.89	0.18
Sample	2	0.17	0.08	35.27	<001
Batch * Sample	4	0.01	0.00	1.16	0.36
Error	16	0.04	0.00		

Table 5. Analysis of Variance for Nickel in Fish Species

Source of variation	D.F	S.S	M.S	V.R	F.P
Total	26	3069.50			
Batch	2	5.05	2.52	0.72	0.50
Sample	2	2982.18	1491.09	429.32	<001
Batch * Sample	4	5.20	1.30	0.37	0.82
Error	16	55.57	3.47		

Table 6. Acceptable And Allowable Limits of Selected Heavy Metals in Drinking Water (Mg/L) and Fish (Mg/Kg)

Heavy metals	Limits in fish/foods (mg/kg)	Limits in drinking maximum acceptable	Maximum Allowable
Cr	0.15	0.05	0.05
Cu	30.0	1.0	1.5
Ni	-	0.1	-
V	-	-	-

Source: [20].

Table 7. Limits for Heavy Metals Concentration in Fresh Water Environments in Nigeria

Heavy Metals	Concentrations(mg/l)
Lead	0.05
Vanadium	0.01
Copper	1.00
Zinc	1.00
Chromium	0.03

Source: [4,21].

The mean concentration of Ni was higher than the values recorded for other metals. This relatively high mean Ni value (0.55mg/l) may be attributed to leachates from fertilizers applied on the rubber plantation and other domestic activities that are carried out in the river by the inhabitants. The mean concentration value of Ni was higher than the value (0.1mg/l) recommended for drinking water by WHO (Table 7).

The mean concentration of vanadium was low maybe due to low availability of vanadium [2]. The level of V in water was higher than the level (0.01mg/l) reported by DPR [4]; Enujuigha and Nwanna [21], (Table 6) which is the limit for V in fresh water environments in Nigeria.

3.4. Heavy Metals in Fish

Heavy metal concentration was higher in fish than in water of Osse River. This may be due to the ability of fish to bioaccumulate much of these metals into their body tissues from the aquatic environment. The bioaccumulation of metals by fish has been reported by many researchers including Oguzie and Izevbigie [10], Wangboje and Oronsaye [16] and Murugan et al., [19]. Metals including Cr, Cu, Ni, and V were bioaccumulated to varying levels. This is because fish like other aquatic organisms, have the ability to concentrate heavy metals in their tissues to concentration levels which comprised of several orders of magnitude higher than those in water [8].

The highest mean value of chromium was recorded in *S. schall*. Sample of *S. schall* with concentration value of 0.2467mg/kg caught at station 2 had a higher mean Cr value than the Cr values reported by Abolagba et al. [15]. The mean concentrations of Cr in the *S. schall* from stations 2 and 3 were higher than the FAO recommended limit (0.015mg/kg) for Cr in fish. However the mean concentration of Cr in *S schall* caught at station 1 and the values of Cr in *C. citharus* caught at the three stations were lower than FAO allowable limit. As a non-essential metal, high levels of Cr are undesirable to humans and fish since it is toxic even at low concentrations [20].

The mean concentration of Cu in fish caught in Osse River was high. The mean value of Cu (18.32mg/kg) in *S schall* caught at station 1 was higher than values recorded at station 2 and 3. Similar fish samples caught at stations 2 and 3 recorded mean values lower than the standard limit of 30mg/kg recommended by WHO [22] and FAO [7] for fish and fishery products. The mean concentration of Cu in *C citharus* caught at station 1 was relatively high compared to that reported by Abolagba et al. [15]. The mean concentrations of Cu in *C. citharus* caught at the three stations were generally low compared to the recommended value set by WHO (Table 6) and FAO. This implies that fishes from Osse River could be considered safe for consumption.

The mean concentration of Ni in fish caught in Osse River was also higher. Ni had the highest mean concentration in fish caught at all stations (Table 2). The mean value of Ni in *S. schall* caught at station 2 was the highest. The mean concentrations of Ni in *C. citharus* caught at the three stations were generally low compared to that of *S. schall* (Table 2). The concentrations of Ni in *S. schall* and *C. citharus* were higher than the FAO recommended limit (0.06mg/kg) for Ni in the fish. This implies that fish from River Osse shows possible contamination and could be considered unsafe for human consumption. Nickel is a source of fertilizer and the high level of Ni from this study may be as a result of the use of fertilizer in the rubber plantation located near the river and this could provide possible explanation for this finding.

S. schall had a higher mean value of vanadium compared to *C citharus*. The mean value of V in *S. schall* caught at station 2 was the highest. The mean value of V in *C.citharus* of station 3 was higher than in *S. schall* at stations 1 and 3. This trend was not recorded for the other metals with *S. schall* having higher values than *C. citharus* in all the fish sampled at the three stations (Table 2).

4. Conclusion

Heavy metals pollution occurs where there is high population density, industrial concerns, agro allied enterprises and where the water bodies are too small or flow rate is too slow to provide adequate dilution of effluents produced.

Findings from this study confirm the occurrence of heavy metals (Cr, Cu, Ni and V) in water and fish of Osse River. The level of chromium and nickel in fish exceeded the WHO and FAO recommended standards for chromium and nickel in fish and fishery products. These two metals were the major contaminants that were detected during this study. This implies that the consumption of contaminated fish species from this river might be harmful to consumers. The level of nickel in water also exceeded the WHO and FAO standard limits for nickel in portable drinking water, while the level of Cu, Cr and V fell below the standard limits set by WHO and FAO. This implies that the water might not be safe for drinking due to the high nickel content but can be used for other domestic functions.

According with the results of this study, the following recommendations are suggested.

1. More studies on the concentrations of heavy metals in fish and water and the fish community in River

Osse should be carried out since previous studies on this river were centered on the ecology and population of fishes.

2. With regards to the present level of contamination of fish in Osse River, effective management and monitoring assessment should be carried out on a regular basis in order to control pollution level in Osse River.
3. The inhabitants of the fishing communities along the course of Osse River should be alerted on the present condition of the river. Practices capable of increasing the heavy metals level should be prohibited.
4. Emphasis should be placed on the need to minimize waste generation and industries close to the river should be encouraged to adopt low and non-wastes technology (LNWT) at all stages of a product's life and also waste generated by industries should be treated properly before discharging.
5. Proper wastes and sewage disposal should be provided and projects on building of public toilets and wastes recycling should be introduced and financed by the government, non-governmental organisations as well as private bodies.

References

[1] Egborge A.B.M, Industrialization and heavy metal pollution in Warri river. 32nd Inaugural lecture series, University of Benin, Benin City, Nigeria. 31pp. 1991.

[2] Uzu A.P, Heavy metals of surface waters in Ovia River, Nigeria B.Sc. Project, Unviersity of Benin, Benin City. 46pp. Oct.2007.

[3] Parker C.R, Water Analysis by Atomic Absorption Spectroscopv variari Techton Paty Ltd., Australia 1972.

[4] Department of Petroleum Resources (DPR). Guidelines and standards for Petroleum Industry in Nigeria. The department of petroleum Resources, Ministry of petroleum and Mineral resources, 1991.

[5] Obasohan, E.E., Oronsaye, J.A.O. & Obano, E.E, Heavy metal concentrations in Malapterirus electricus and chrysichthys nigrodigitatus from Ogba river Benin City, Nigeria. *Afr. J. Bio Technol*. 5(10), 914-982. Sept.2006.

[6] Trewevas E, Tilapias: Taxonomy and speciation, P.3-13 In: *the Biology and culture of tilapias*(R.S.V Pullin and R.H Lowe-McConnell, eds.). International center for Living Aquatic Resources Management, Manila Philipines. Conference Proceedings 1982 7: 432pp.

[7] Food and Agricultural Organization (FAO). Committee for Inland Fisheries for Africa: Working party on Pollution and Fisheries FAO fish, 2: 105-119. 1999.

[8] Oguzie, F.A, Relationships between heavy metals content and body weight of selected freshwater fish species of the lower Ikpoba River in Benin City, Nigeria. *Pak. J. Sci. Ind. Res*. 46(4), 246-250. Feb.2003.

[9] Oguzie, F.A. and Ogubere, C.A, Bioaccumulation of Heavy metals in the African Catfish, (Clarias gariepinus from Aze River and Idonior Fish in Isoko, Delta State, Nigeria *Nig. J. Appl. Sci*. 25: 185-196. Nov.2007.

[10] Oguzie, F.A. and Izevbigie, E.E, Heavy metals concentration in the organs of the Silver Catfish, chrysichthy negrodigitatits (Lacepede) caught upstream of the Ikpoba River and the Reservoir in Benin city *Bioscience Research communications* 21(4), 189-197. Sept.2009.

[11] Igwe, J.C. and Abia, A.A, Maize Cob and Husk as Adsorbents or removal of Cd, Pb, and Zn ions from waste water. *The physical Sci*., 2: 83-94. Aug.2003.

[12] Duffus, J.H, "Heavy Metals" A meaningless term *Pure and App, Chem* 74, 793-807. Jun.2002.

[13] Whitehead, P.J.P, Family Clupeidae Daget, J. Gosse, J.P Thys. Van den audenneered, D.F.S (Eds.). *Checklist of Freshwater Fisheries of Africa*. 1 11-20. Apr.1984.

[14] Lenntech. Heavy metals 2010 [E-book] Available: www.lenntech.com/heavy_meials.him.

[15] Abolagba, O.J., Igene, J.O. and Oronsaye, J.A.O, Investigations on the fishing practices in Ekenwan area of Ovia NorthEast Local Government Area of Edo State, Nigeria. *J. Agr. For. Fis*. 6(1), 35-40. Nov.2005.

[16] Wangboje, O.M. and Oronsaye J.A.O, Bioaccumulation of iron, lead, mercury, copper, zinc and chromium by fish species from Ogba River, Benin City, Nigeria. *Afr. J. AppLZool. Envrion. Biol* 3 45-49. Apr.2001.

[17] Sreedevi, P.A., Suresh, A.,Siraramakrishna, B., Prebhavathi, B. and Radhadrishanaiab, K, Bio accumulation of nickel in the organs of the freshwater fish, Cyprinus carpio and the water mussel Lamethodens marginals under lethal and sublethl nickel stress. *Chemosphere*. 24(l), 29-36. May.1992.

[18] Miroslav, R. and Bashkin, V.N, Practical Environmental analysis. Royal Society of Chemistry, Madison. 1999, 466pp.

[19] Murugan, S.S., Karuppasamy, R., Podngodi, K. and Rivaneswari, S, Bioaccumulation pattern of Zinc in freshwater fish Channa Punctatus (Bioch.) after chronic exposure *Turk. J. Fish. Aquat Sci*. 8: 55-59. Sept.2008.

[20] Albergoni, V. and Paccini, E, Biological response to trace metal and their effects In: Trace element speciation in surface water, (ed) G.G Lepard, Plennum Press, New York Biochem. 1983, 159-175.

[21] Enujuigha, V.N. and Nwanna, L.C, Aquatic Oil Pollution Impact indicators. *J. App. Sci. Envron. Mgt.*, 8(2), 71-75. Jul.2004

[22] World health Organization (WHO). Guidelines for drinking water quality Vol. 1, Recommendations. WHO, Geneva 1984, 130Pp.