

Heavy Metal Concentrations ~~in~~ Selected Fishes, and Water from Orogodo River, Agbor, Delta State ~~in~~ Nigeria

Abstract

This study ~~was conducted to~~ determine the heavy metal; ~~lead (Pb), cadmium (Cd), copper (Cu), zinc (Zn) and iron (Fe)~~ concentrations in ~~selected fish species including (Brycinus intermidus, Clarias gariepinus, Parachanna obscura, Ctenopoma kingsleyae, Hemichromis bimaculatus and Phractolaemus ansorgeii.)~~ and water from Orogodo River situated in Agbor, Delta State, Nigeria. Furthermore, the health risk exposures to humans who consume the fish and utilised the water in the Orogodo River was assessed ~~in order to ascertain the suitability for human consumption. Heavy metal content in the aforementioned samples was assessed using an atomic absorption spectrometric technique.~~ The ~~mean~~^[b1] concentration of the heavy metal in water ranged from 0 mg/L for Cd to 0.2mg/L for Fe. The mean concentration of metals in fish species ranged from 0.06mg/kg for Cd in *Brycinus intermidus* to 187.90mg/kg for Fe in *Parachanna obscura*. The Bioaccumulation Quotient (BQ) values ranged from 4.51mg/kg for Pb in *Hemichromis bimaculatus* to 1297.13mg/kg for Fe in *Phractolemus ansorgei*^[b2].

Keywords: Heavy metals, Fish, Water, [Bioaccumulation Quotient](#), [Health risks](#), Orogodo River, [Nigeria](#)~~Agbor~~

Introduction

~~The~~ threats from pollutants in water supplies ~~are have been~~ under ~~the spotlight~~ searchlight for some time ~~now~~ because of the ~~associated various~~ adverse effects of the pollutants ~~on hydrobionts and habitat integrity~~ (Orjiekwe *et al.*, 2013). ~~Heavy~~^[b3] metals is a general term, which applies to the group of metals and metalloids with atomic density greater than 4 g/cm³ or 5 times or more, greater than water. Heavy metal pollution is an inorganic chemical hazard, which is mainly caused by lead (Pb), chromium (Cr), arsenic (As), cadmium (Cd), mercury (Hg), zinc (Zn), copper (Cu), cobalt (Co), and nickel (Ni) (Hui *et al.*, 2014). Heavy metals are ~~toxic dangerous~~ because they ~~are persistent, non-biodegradable and readily accumulate cannot be transformed by micro organisms and therefore accumulate~~ in water, soil, bottom sediments and living organisms (Hui *et al.*, 2014). ~~Currently, there is~~ In recent years, there has been an increasing ecological and global public health concern associated with environmental contamination by heavy ~~metals~~^[b4]. Also, human exposure has risen dramatically as a result of an exponential increase of their use in several industrial, agricultural, domestic and technological applications (Paul *et al.*, 2014^[b5]).

Heavy metal pollution ~~not only~~ affects ~~aquatic ecosystem integrity~~ as metals tend to be accumulative in the trophic food webs with apex predators like crocodiles (du Preeze *et al.* 2016^[b6]) and human beings at health risk (Sparks *et al.* 2017). ~~the quality of the atmosphere and water bodies, and threatens the health and life of animals and human beings by way of the food chain. Most severe is that this kind of pollution is covert, long term and non-reversible. Severity of the exposure risks derives from the persistent and accumulative nature of the metal species in the water phase (Alloway, 1990, 2002; Utete et al., 2013). As well the contributions of the point and non-point sources of metal pollution determines their concentrations in a water body (Khair, 2009). For the Agbor State~~ major anthropogenic sources of heavy metal pollution are mining and smelting activities, atmospheric deposition, disposal of untreated/partially treated urban and industrial effluents, metal chelates from different industries, and haphazard use of heavy metal-containing fertilizers and pesticides during agricultural ~~activities~~^[b7].

~~Regardless, heavy metals~~ Heavy metals are ~~some also one~~ of the major contaminating agents in our food supply (Khair, 2009; Wepener *et al.* 2011; Sparks *et al.* 2017). Fish ~~absorb take~~ heavy metals from the surrounding water through ~~a number of pathways though for most species their~~ gills which are the primary route for the uptake of water borne pollutants ~~and contaminated them in their tissues~~ (Luoma and Rainbow, 2008; Krishna *et al.*, 2014^[b8]). The communities through which Orogodo River transverses are ~~predominantly~~ agricultural communities, thus the river is subject to dumping of agricultural wastes. The river also serves as the drainage point for all run off wastewater produced industrially or domestically

within the Agbor metropolis and beyond as majority of the drainage channels constructed by the State and Local Government within the Agbor metropolis and surrounding villages, aimed at controlling flooding and checking erosion are channelled directly into the river at various points along the river length. Despite that most community members diversify into fishing as an alternative livelihood, and to sustain and supplement their nutritional requirements especially in the off agricultural season. Fish forms a part of their meal intake, however, humans may be at risk due to metal contamination in fish tissues and water derived from catchment pollution. Thus, it is imperative to assess metal pollution in the water phase, and the different fish species utilised by the communities along the Orogodo River. It is prudent as well to estimate the health risks posed by exposure to river water and consumption of fish therein. This study aimed ~~was undertaken~~ to ~~determine~~ evaluate the ~~concentrations~~ amount of heavy metals (Pb, Cd, Cu, Fe, and Zn) in water and selected fish species in the Orogodo River in Agbor located in the Delta state in Nigeria. The ~~underlying~~ objective was to estimate the health risks posed by exposure water and consumption of fish from the river. ~~lead, cadmium, copper, zinc and iron) being received in the river and its biological magnification in fish.~~

MATERIALS AND METHODS

Study area

The study was conducted ~~along~~ Orogodo River which is located within Latitude 5°43'N and 5°30'N and Longitude 6°20'E and 6°12'E (Fig 1). It ~~has~~ takes its source at Mbiri village at an elevation of 150 m above sea level. It ~~meanders~~ and flows through Agbor and Abavo communities, both in Ika South Local Government Area to Obazagbon-Nugu and Evboesi both in Orhionmwon Local Government Area, Edo State and finally empties into a swamp near Abraka in Delta state (Meye and Ikomi, 2012).

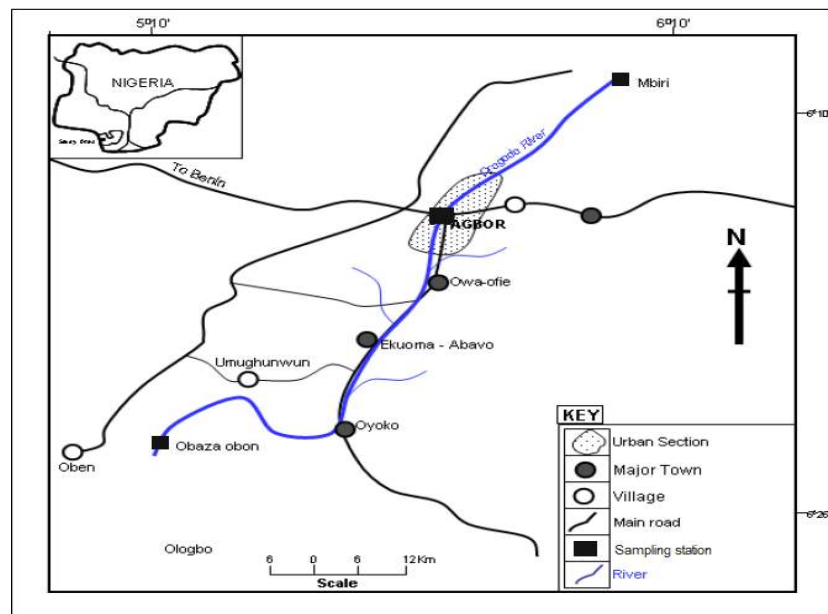


Figure 1: Map of study area showing sampling stations

Sample collection

Fish species were caught by the local fishermen using gill nets and hook and line. The fish samples were then ice-packed and transported to the laboratory, where they were identified using literature (key) as provided by Idodo Umeh (2003) and photographed using a digital camera (8.0 Megapixels). Water samples were collected using 1litre capacity plastic bottle with screw cap at a depth of 0-0.5m at each sampling station. ~~Water was collected at each sample station at approximately 30cm below the water~~

surface. The study was carried out from November 2015- April 2016, within a period of 6 months (i.e. November 2015–December 2015, January 2016–April 2016).

Digestion and Analysis

Fish samples were dried using the analytical oven (DHG-9023A) at a temperature of 75°C for 48 hours until constant weight was attained. Each sample was milled separately for homogeneity using a porcelain mortar and pestle and stored in air tight plastic vials prior to digestion and analysis. Wet digestion method was used. One gram of the ground fish samples was digested using 2.5:1 mixture of concentrated nitric acid and perchloric acid and heated until a colourless liquid was obtained. Fish digest and water samples were analyzed for Cu, Zn, Fe, Cd and Pb by means of an Atomic Absorption Spectrophotometer AAS (PG Instruments AA-500F series, Leicestershire, United Kingdom) equipped with solar software using air acetylene flame and also with lamp with Ultraviolet wavelength changed at intervals for the analysis of each metal. The concentration of heavy metals in water was expressed in mg/l, while concentration values in digested fish samples were expressed in mg/kg.

Statistical Analysis

Data generated from the study were analyzed using GENSTAT computer software (Version 12.1 for Windows). One-way analysis of variance (ANOVA) was used to test for significant differences between mean values of metals at 5% level of probability. New Duncan multiple range test was used to separate significant means.

RESULTS

Table 1: Mean ($\pm$ SD) concentration of heavy metals (mg/l) in water during the study period

Months	Pb	Cd	Cu	Zn	Fe
November	0 $\pm$ ^a	0 $\pm$ ^a	0.04 $\pm$ ^{bcd}	0.08 $\pm$ ^a	0.04 $\pm$ ^a
December	0.02 $\pm$ ^a	0 $\pm$ ^a	0.03 $\pm$ ^{bc}	0.17 $\pm$ ^b	0.35 $\pm$ ^b
January	0.03 $\pm$	0.0 $\pm$ ^{7ab}	0.01 $\pm$ ^a	0.04 $\pm$ ^a	0.16 $\pm$ ^a
February	0.01 $\pm$ ^a	0 $\pm$	0.02 $\pm$ ^{ab}	0.07 $\pm$ ^a	0.10 $\pm$ ^a
March	0.01 $\pm$ ^a	0.01 $\pm$ ^b	0.04 $\pm$ ^d	0.06 $\pm$ ^a	0.11 $\pm$ ^a
April	0.01 $\pm$ ^a	0.01 $\pm$ ^b	0.04 $\pm$ ^{cd}	0.08 $\pm$ ^a	0.14 $\pm$ ^a
Standard error of mean (SEM)	0.02	0	0.01	0.03	0.05

Means in the same column with similar superscripts are not significantly different ($P>0.05$)

Table 1 shows the mean heavy metal concentration (mg/l) in the water obtained from Orogodo River. The heavy metal profile in ascending order is Pb<Cd<Cu<Zn<Fe. (Fe>Zn>Cu>Cd>Pb). There was no significant difference ($P>0.05$) in the mean concentration of Pb during the study period while significant difference was observed in the concentration of Cd, Cu, Zn and Fe observed during the study. The heavy metal profile in descending order in fish obtained from Orogodo river is Fe>Zn>Cu>Pb>Cd. There was significant difference ($P<0.05$) in the mean Fe concentration observed during the study period while Cd concentration during the study period showed no significant difference ($P>0.05$). As shown in Table 4, the BQ values ranged from 4.51 for Pb in *H. bimaculatus* to 1297.13 for Fe in *P. ansorgei*.

Table 2: Mean concentration of heavy metals (mg/kg) in fish during the study period

Months	Pb	Cd	Cu	Zn	Fe
November	0.60 ^a	0.18 ^a	1.97 ^a	48.97 ^{ab}	3.5 ^a
December	2.31 ^a	0.03 ^a	3.73 ^{ab}	70.34 ^b	286.1 ^d
January	2.40 ^{ab}	0.47 ^a	6.56 ^{abc}	82.30 ^b	100.3 ^{abc}
February	0.71 ^a	0.12 ^a	6.86 ^{bc}	22.96 ^a	22.0 ^{ab}
March	2.68 ^b	0.26 ^a	10.56 ^c	73.06 ^b	179.6 ^{bcd}
April	2.21 ^{ab}	0.25 ^a	10.57 ^c	72.06 ^b	186.8 ^{cd}
Standard error of mean (SEM)	0.74	0.27	2.04	19.35	68.2

Means in the same column with similar superscripts are not significantly different ($P > 0.05$)

Mean heavy metal concentrations in different fish species are shown in Table 3. Descending order of metal concentrations for the fish species, despite, subtle species variations, $Fe > Zn > Cu > Pb > Cd$. Relate it to the different fish ecology, physiology and dietary requirements. There are significant differences (X^2 , $p < 0.05$) in the concentrations of metals across different fish species.

Table 3: Heavy metals (Mean $\pm$ SD) in fish species obtained during the study period [b24]

Fish species	Pb	Cd	Cu	Zn	Fe
<i>Clarias gariepinus</i>	1.87 $\pm$ 0.1 ^{ab}	0.195 $\pm$ 0.01 ^a	7.97 $\pm$ 0.2 ^{de}	52.61 $\pm$ 1.5 ^b	125.03 $\pm$ 5.1 ^{ab}
<i>Brycinus intermidus</i>	0.57 $\pm$ 0.05 ^a	0.060 $\pm$ 0.005 ^a	4.00 $\pm$ 0.1 ^b	77.08 $\pm$ 2.5 ^c	60.20 $\pm$ 1.2 ^a
<i>Parachanna obscura</i>	2.60 $\pm$ 0.1 ^b	0.615 $\pm$ 0.02 ^b	6.97 $\pm$ 0.3 ^{cd}	91.62 $\pm$ 3.5 ^c	187.90 $\pm$ 8.5 ^{bc}
<i>Phractolemus ansorgei</i>	2.76 $\pm$ 0.1 ^b	0.100 $\pm$ 0.01 ^a	10.07 $\pm$ 0.4 ^e	71.09 $\pm$ 2.8 ^{bc}	274.15 $\pm$ 10.5 ^c
<i>Ctenopoma kingsleyea</i>	0.29 $\pm$ 0.02 ^a	0.230 $\pm$ 0.01 ^a	1.34 $\pm$ 0.05 ^a	28.30 $\pm$ 1.2 ^a	5.70 $\pm$ 0.3 ^a
<i>Hemichromis bimaculatus</i>	0.06 $\pm$ 0.01 ^a	0.150 $\pm$ 0.01 ^a	5.11 $\pm$ 0.2 ^{bc}	14.08 $\pm$ 0.8 ^a	11.0 $\pm$ 0.5 ^a

Table 4: Bioaccumulation quotient (BQ) in fish species obtained from Orogodo River [b25]

Fish species	<i>C. gariepinus</i>	<i>B. intermidu</i>	<i>P. obscura</i>	<i>P. ansorgei</i>	<i>C. kingsleyea</i>	<i>H. bimaculatus</i>
Pb	140.60	42.57	195.49	207.52	21.80	4.51
Cd	34.82	10.71	109.82	17.86	47.06	26.79
Cu	265.67	133.33	232.33	334.67	44.67	170.33
Zn	630.82	924.22	1098.56	852.40	339.33	168.82
Fe	833.33	401.33	1252.67	1297.13	38.00	73.33

Interpretative table must be included for easy clarity

DISCUSSION

The mean Pb concentration (0.01mg/l) recorded in the water was higher than values reported by Arise *et al.* (2013) in creeks around the Kokori-Erhoike Petroleum Flow Station in Delta State (0.002mg/L). The mean value for Cd (0.015mg/l) was higher than the WHO recommended limit (0.01mg/l). However, the mean concentration of Cu (0.03mg/L) was lower than the Cu value (0.34mg/L) reported by Wangboje and Oronsaye (2001) for Ogba River in Edo state and higher than the concentration (0.216mg/L) reported by Issa *et al.*, (2011) for Orogodo River. The value of Zn observed in this study (0.08mg/l) was higher than the concentration reported by Orjiekwe *et al.*, (2013) for Ogbese River in Edo state (0.0315mg/L) and lower than the value reported by Enuneku *et al.*, (2013) for River Owan in Edo State (0.11mg/L). The mean concentration of Fe 0.15mg/L was lower than the recommended value 0.3mg/L by SON (2007).

The mean concentration of Pb observed in fish obtained was 1.82mg/kg which exceeded the recommended range (0.5mg/kg) by FAO (2008). The mean Cd concentration observed (0.22mg/kg) was lower than the value reported by Ogunfowokan *et al.*, in Asunle River in Ile-Ife, Osun state (57.28mg/kg) and higher than the value 0.00mg/kg reported by Wokoma (2014) in Sombreiro River in Niger Delta. The mean concentration of Cu observed in this study was 6.71mg/kg which was lower than the recommended value (30mg/kg) set by FAO (2008) for fish and fishery products. The mean concentration of Zn (61.62g/kg) recorded was higher than the recommended value (30mg/kg) by FAO (2008) but lower than the value (67.51mg/kg) reported by Adekola and Eletta (2007) in Asa River in Illorin, Kwara state. The mean Fe concentration (129.73mg/kg) was higher than the maximum recommended value (100mg/kg) as reported by WHO (2006) and the value (0.0578mg/kg) observed by Uwem and Bassey (2014) in Itu River in Cross-River State.

CONCLUSION

The study show that the concentration of Zn, Cu and Fe in water were lower than the maximum recommended limit while the concentration of Pb and Cd was higher than the values recommended by Standard Organization of Nigeria, (SON, 2007) and World Health Organization, (WHO, 2006). Also, the concentration of Pb, Cd, Zn and Fe were higher than the values recommended by Food and Agricultural Organization, (FAO, 2006) and WHO (2006) while the concentration of Cu was lower than the recommended values by the aforementioned bodies. The concentration of these heavy metals in the fish and water thus indicate that it was have cumulative deleterious effect on any aquatic organism and man who feeds on the fish and drinks the water. There is the need for waste water to be treated and channeled from drainages into farmlands for irrigation purposes.

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