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ORIGINAL RESEARCH

Bioaccumulation of Heavy metals in different tissues of some commercially important fish species from Warri River, Niger Delta, Nigeria

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ABSTRACT
Levels of seven heavy metals (Fe, Pb, Zn, Cu, Ni, Cr and Cd) in muscles, gill, kidney, liver and tissues of some commercial fish species caught between August 2005 – September 2007 from Warri River, Niger Delta, Nigeria were assessed. Analysis was carried out using Flame Atomic absorption spectrometry for the heavy metal analysis of the different tissues. Concentration levels of Fe and Zn in the different tissues of the fishes were higher in most cases. Apart from Cu, the level of heavy metals in the different tissues of the fish species exceeded the maximum permissible limit specified by statutory authorities such Food and Agricultural Organization/World Health Organization, Median International Standard and European Union for food fish consumed by human. The order of heavy metals are Fe>Zn>Pb>Ni>Cr>Cu>Cd in gills and Fe>Zn>Pb>Ni>Cu>Cr>Cd in kidneys, livers and muscles. The concentration of the heavy metals in the different tissues were in the order; liver> kidney>gill>muscle. The concentrations of all the heavy metals in each of the tissues were statistically different ($P<0.05$) among the different fish species. Hence consumption of fish from the Warri River poses a health risk to the consumers due to accumulation of high levels of Pb, Cd, Fe, Cr, Ni and Zn in fish through biotransfer of metals especially through water phase. Bioaccumulation of metals by humans has the potency to cause diverse ailments such as insomnia, brain damage and cancer. We, therefore, recommended that industrial and domestic effluent discharged into the Warri River be treated, controlled and monitored

KEY WORDS: *Bioaccumulation, Heavy metals, Warri River, Species Diversity.*

Introduction

The discharge of toxic substances in the form of industrial and domestic effluent into the ecosystem causes wide range of adverse effects on both biological diversities and environment itself. However, the severity of the effects depends on the type, properties, dosage and exposure duration of the substances (Omoigberale and Ikponmwosa-Eweka, 2010). The major entry points of toxic substances into aquatic ecosystem (i.e. surface water) are usually through points source industrial discharges and run offs (Aghoghovwia, 2008). In aquatic ecosystem, one of the major sources of pollution is the discharge of materials and/ or effluents containing heavy metals. Ogamba *et al*. (2015a) stated that heavy metals enter the Niger Delta environment through anthropogenic activities. Some of the anthropogenic activities include mining, chemicals use, industrial waste (Odu *et al*., 2011; Srivastav *et al.,* 2013), smelting, refining, gasoline, battery manufacturing, electrical wiring, soldering, painting, ceramic glazing, and stained glass production (Srivastav *et al.,* 2013). These substances have adverse effects on biological processes especially in productive coastal ecosystems (Odu *et al*., 2013). Fufeyin and Egborge (1998) reported that heavy metals is one of the major group of contaminants that could persist in the environment and cause toxicity in biological diversity found in aquatic ecosystem, accumulate in organisms and undergo food chain amplification.

Heavy metals are recalcitrant to degradation just like pesticides. Heavy metals have the potential to bioconcentrate and bioaccumulate in the aquatic food chain (Enuneku *et al*., 2013). Odu *et al*. (2011) reported that direct exposure of heavy metals could be toxic to man and aquatic life, while indirect toxicity through accumulations of metals in the aquatic food chain could be a focus of concern. This probably due to the fact that human consumes fish which is essential part of their diet (Elnabris *et al*., 2013). Authors have variously reported that fish represent a major source of animal protein (Ntiforo *et al*., 2012; Ineyougha *et al*., 2015; Izah and Angaye, 2015). Warri River is inland water receiving effluents and sewage from several industries, factories and markets (Aghoghovwia, 2008). The proliferation of urban, domestic and industrial establishment along the shores of Warri River, may have introduced many synthetic and organic wastes into the environment. The Warri River also serves as transport route linking water communities and main Warri town, conveying among other things, petroleum products within and outside the study area. In the Warri axis of the Niger Delta region of Nigeria studies have been carried out with regard to the fisheries composition of some rivers in the area including; Ubeji River, Warri and Delta state (Akintujoye *et al*., 2013). Several other studies have shown the level of heavy metals in the body of several freshwater fish obtain from different part of the country. Some of this studies were carried in River Nun (Ogamba *et al*., 2015a), Ikoli creek (Ogamba *et al*., 2015b), River Owan (Enuneku *et al*., 2013), River Ogbese (Olawusi-Peters *et al*., 2014), Great Kwa River (Ada *et al*., 2012), River Galma, River Kubanni and Fish Farms in Zaria (Udiba *et al*., 2014). However, information available on heavy metal levels of the food fish in Warri River, Niger Delta Nigeria is scarce in literature. Therefore, this study aimed at assessing the level of heavy metals (Iron, Copper, Lead, Chromium, Nickel, Zinc and Cadmium) in some commercially available fish species from the Warri River, Niger Delta, Nigeria.

Materials and Methods

Study area

Warri River is one of the major Rivers in the Niger Delta region of Nigeria. Aligning Warri River is several anthropogenic activities centers including market, oil and gas facilities, municipal waste discharging center. Table 1 and Figure 1 also present the description of each collection location. The region has typical environmental and climatic condition with other Niger Delta region of Nigeria. The region has two distinct climate dry season (November- March) and raining season (April – October). The temperature and relative humidity of the study area is about 22 - 35 ºC and 50 – 95% all year round.

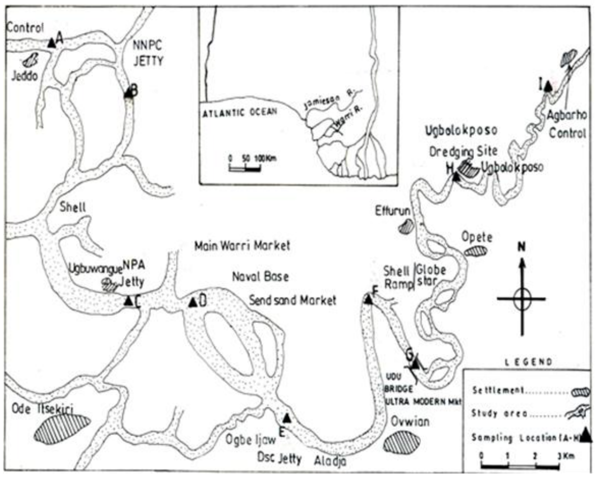

Figure 1: Map of Warri River showing the sampling locations (Source: adapted from Nigeria Ports Warri 2005

Sample collection

Samples of *Tilapia zilli, Oreochromis niloticus, Chrysicthys walkeri, Chrysicthys furcatus, Arius gigas, llisha africana, Ethmalosa fimbriata, Parachana obscura* and *Clarias Lazera,* were randomly collected from nine locations of the study location (Figure 1) between September 2005 to August 2007. The fish samples were captured using gill nets, traditional basket traps and hooks and lines. Sampling was done biannually with interval of six months. The fish species were identified to species level, using the keys and description of Holden and Reed (1972) and Egborge (2001).

Laboratory analysis

A portion of muscle, gills, kidney and liver were removed with the aid of plastic knife. About 5 -10g each of respective fish was wet digested by heating with concentrated nitric acid and sulphuric acid following Egan *et al.* (1981) method. The level of iron, copper, lead, chromium, nickel, zinc and cadmium in fish tissues (muscle, gills, liver and kidney) of appropriately digested samples were determined by Flame Atomic absorption spectrometry (Parkin Eimmer A Analyst 400 model). Standard solutions of the metals were prepared using spectrochemical grade BDH reference metal solutions.

Statistical analysis

SPSS software version 16 was used to carry out the statistical analysis. A one-way analysis of variance was carried out at α = 0.05, and Duncan Multiple Range Test was used for mean separation.

Table 1: Description of the sample collection point in Warri River

Location	Type of fish species captured	Description
A	*Tilapia zilli*	Jeddo (downstream) control
B	*Oreochromis niloticus*	Nigerian National Petroleum Company (NNPC) Jetty
C	*Chrysicthys walkeri*	Nigeria Ports Authority (NPA) Jetty
D	*Chrysicthys furcatus*	Main Warri Market
E	*Arius gigas*	Delta Steel Company (DSC) Jettyatr
F	*Ilisha africana*	Shell Ramp/ Globestar oil firm
G	*Ethmalosa fimbriata*	Udu Bridge/ Market
H	*Parachana obscura*	Sand Dredging site at Ugbolokposo
I	*Clarias lazera*	Agbarho – (up steam) control point

Results and Discussion

Table 2 – 5 presents the concentration of heavy metals in the tissues (gill, muscle, liver and kidney) of fish species from Warri River at different locations. For gills, the concentration of heavy metals were typically least and highest in *Clarias lazera* (25.25 µg g^{-1}) and *Chrysicthys walkeri* (129.20 µg g^{-1}) respectively, for Fe, *Clarias lazera* (1.59 µg g^{-1}) and *Ethmalosa fimbriata* (3.85 µg g^{-1}) for Cu, *Clarias lazera* (5.85 µg g^{-1}) and *Ilisha africana* (97.15 µg g^{-1}) for Pb, *Clarias lazera* (1.10 µg g^{-1}) and *Arius gigas* (7.15 µg g^{-1}) for Cr, *Tilapia zilli* (0.72 µg g^{-1}) and *Chrysicthys walkeri* (19.20 µg g^{-1}) for Ni, *Clarias lazera* (26.48 µg g^{-1}) and *Ethmalosa fimbriata* (173.02 µg g^{-1}) for Zn and *Ethmalosa fimbriata* (0.65 µg g^{-1}) and *Oreochromis niloticus* (4.39 µg g^{-1}) for Cd (Table 2). There was significant difference ($P<0.05$) among the different fish species with regard to the heavy metals. The concentration of the heavy metals apart from Ni in the gill of the different fish species from the upstream control were significantly lower than other locations. In the gills, Fe and Zn were typically higher in all the fish species. Zn were high in *Oreochromis niloticus, Chrysicthys furcatus, Ilisha Africana, Ethmalosa fimbriata* and *Clarias lazera*, while Fe was highest in the rest. This could be due to the fact that the composition of heavy metals in the water and sediment in each of the locations may be different. Aghoghovwia et al. (2015) have previously reported high concentration of heavy metals in water and sediment in the Nine location the fish samples were obtained, which was significantly different. Again, the biochemical composition of the fish may support their variation in the accumulation of heavy metals in their gills. Typically, the order of heavy metals in the gills are Fe>Zn >Pb>Ni>Cr>Cu>Cd.

In the muscles of the different fish species, the level of heavy metals ranged from 8.13 - 61.25 µg g^{-1} (Fe), 0.90 - 5.10 µg g^{-1} (Cu), 0.91 - 39.83 µg g^{-1} (Pb), 0.91 - 4.10 µg g^{-1} (Cr), 2.90 - 11.75 µg g^{-1} (Ni), 13.28 - 60.13 µg g^{-1} (Zn) and 0.43 - 3.73 µg g^{-1} (Cd) (Table 3). Basically, there was significant variation ($P<0.05$) among the different fish species with regard to the heavy metals concentration. Apart from few instances, the concentration of the heavy metals in the muscles of the various fish species from the upstream control were significantly lower that other locations. Like gills, the concentration Fe and Zn were highest in all the different fish species apart from Pb which was second highest in *Arius gigas*. The order of the heavy metals in the muscle include Fe>Zn>Pb>Ni>Cu>Cr>Cd.

Table 2: Level of heavy metals in the gill of different fish species from Warri River at different location

Location	Fish species	Fe, $\mu g\ g^{-1}$	Cu, $\mu g\ g^{-1}$	Pb, $\mu g\ g^{-1}$	Cr, $\mu g\ g^{-1}$	Ni, $\mu g\ g^{-1}$	Zn, $\mu g\ g^{-1}$	Cd, $\mu g\ g^{-1}$
A	*Tilapia zilli*	87.90^{d}	3.76^{c}	11.56^{ab}	1.60^{ab}	0.72^{a}	69.28^{b}	0.81^{ab}
B	*Oreochromis niloticus*	104.02^{e}	2.63^{ab}	15.10^{b}	2.38^{bc}	16.50^{f}	106.02^{c}	4.39^{f}
C	*Chrysicthys walkeri*	129.20^{f}	6.50^{d}	12.60^{b}	2.15^{bc}	19.20^{g}	66.13^{b}	0.99^{abc}
D	*Chrysicthys furcatus*	67.25^{bc}	3.10^{bc}	15.28^{b}	1.90^{ab}	6.30^{bcd}	117.02^{c}	1.24^{cde}
E	*Arius gigas*	121.02^{f}	2.19^{ab}	85.85^{d}	7.15^{d}	4.03^{b}	67.85^{b}	1.44^{de}
F	*Ilisha africana*	64.25^{b}	3.68^{c}	97.15^{e}	6.90^{d}	4.78^{bc}	75.63^{b}	1.64^{e}
G	*Ethmalosa fimbriata*	78.75^{cd}	3.85^{c}	42.08^{c}	2.88^{c}	7.61^{d}	173.02^{d}	0.65^{a}
H	*Parachana obscura*	75.75^{bcd}	1.80^{a}	16.83^{b}	2.06^{bc}	12.50^{e}	66.75^{b}	1.20^{bcd}
I	*Clarias lazera*	25.25^{a}	1.59^{a}	5.85^{a}	1.10^{a}	6.70^{cd}	26.48^{a}	0.73^{a}

Data is expressed as mean (n=4); Different letter along the column indicate significant different (P<0.05) based on Duncan Multiple Range Test

Table 3: Level of heavy metals in the muscle of different fish species from Warri River at different location

Location	Fish species	Fe, $\mu g\ g^{-1}$	Cu, $\mu g\ g^{-1}$	Pb, $\mu g\ g^{-1}$	Cr, $\mu g\ g^{-1}$	Ni, $\mu g\ g^{-1}$	Zn, $\mu g\ g^{-1}$	Cd, $\mu g\ g^{-1}$
A	*Tilapia zilli*	53.50^{c}	2.19^{bc}	13.28^{b}	1.61^{b}	11.75^{e}	43.15^{bc}	2.44^{c}
B	*Oreochromis niloticus*	34.50^{b}	1.53^{ab}	7.14^{ab}	2.35^{c}	5.84^{c}	60.13^{d}	3.73^{d}
C	*Chrysicthys walkeri*	61.25^{c}	5.10^{e}	7.48^{ab}	2.68^{c}	7.91^{d}	38.93^{b}	0.84^{ab}
D	*Chrysicthys furcatus*	37.95^{b}	3.57^{d}	38.75^{c}	2.10^{bc}	5.20^{bc}	50.50^{cd}	1.10^{ab}
E	*Arius gigas*	55.00^{c}	2.14^{bc}	39.83^{c}	3.80^{d}	3.58^{ab}	37.10^{b}	1.25^{b}
F	*Ilisha africana*	29.73^{ab}	2.70^{cd}	4.10^{ab}	4.10^{d}	3.30^{a}	42.15^{bc}	1.18^{ab}
G	*Ethmalosa fimbriata*	28.00^{ab}	2.68^{cd}	3.40^{ab}	2.27^{c}	2.90^{a}	58.25^{d}	0.43^{a}
H	*Parachana obscura*	39.00^{b}	1.94^{bc}	11.52^{ab}	0.91^{a}	4.68^{abc}	13.28^{a}	0.43^{a}
I	*Clarias lazera*	18.13^{a}	0.90^{a}	0.91^{a}	0.91^{a}	3.65^{ab}	15.18^{a}	0.58^{ab}

Data is expressed as mean (n=4); Different letter along the column indicate significant different (P<0.05) based on Duncan Multiple Range Test

The concentration of heavy metals in the liver among the various fish species obtained in different location ranged from; it ranged from 43.43 - 187.02 $\mu g\ g^{-1}$ (Fe), 2.54 - 26.50 $\mu g\ g^{-1}$ (Cu), 11.68 - 111.02 $\mu g\ g^{-1}$ (Pb), 2.85 - 11.30 $\mu g\ g^{-1}$ (Cr), 9.18 – 37.25 $\mu g\ g^{-1}$ (Ni), 33.50 - 163.02 $\mu g\ g^{-1}$ (Zn) and 1.23 - 12.08 µg g-1 (Cd) (Table 4). Apart from Cu concentrations, there was significant variation (P<0.05) among the different fish species with regard to the heavy metals concentration. Again, Fe was highest in the liver of all the fish species apart from *Oreochromis niloticus, Chrysicthys furcatus, Ethmalosa fimbriata* and *Ilisha africana*. Also, the concentrations of the heavy metals in the muscles of the various fish species from the upstream control were significantly lower. Pb was second to Zn in the liver of *Ilisha africana* and *Ethmalosa fimbriata.* But generally, the heavy metals in the liver were in the order species obtained in different locations in Warri river ranged from 50.61 - 168.19 µg g^{-1} (Fe), 2.45 - 9.42 µg g^{-1} (Cu), 9.64 -110.65 µg g^{-1} (Pb), 1.14 - 11.34 µg g^{-1} (Cr), 1.18 - 26.60 µg

Fe>Zn>Pb>Ni>Cu>Cr>Cd just as in the muscles.

The concentration of heavy metals in the kidney of the fish g^{-1} (Ni), 35.99 - 210.20 µg g^{-1} (Zn) and 1.100 - 6.57 µg g^{-1} (Cd) (Table 5).

Table 4: Level of heavy metals in the Liver of different fish species from Warri River at different location

Location	Fish species	Fe, µg g^{-1}	Cu, µg g^{-1}	Pb, µg g^{-1}	Cr, µg g^{-1}	Ni, µg g^{-1}	Zn, µg g^{-1}	Cd, µg g^{-1}
A	*Tilapia zilli*	187.02^{d}	6.23^{a}	39.50^{b}	4.23^{ab}	37.25^{e}	130.02^{bc}	7.40^{c}
B	*Oreochromis niloticus*	122.02^{bc}	3.23^{a}	17.50^{a}	6.78^{b}	16.00^{cd}	163.02^{d}	12.08^{d}
C	*Chrysicthys walkeri*	176.20^{d}	14.04^{a}	16.50^{a}	7.23^{b}	18.25^{d}	110.02^{b}	2.58^{ab}
D	*Chrysicthys furcatus*	116.20^{bc}	10.00^{a}	20.25^{a}	5.93^{b}	14.45^{bcd}	152.20^{cd}	3.35^{ab}
E	*Arius gigas*	146.02^{cd}	26.50^{a}	94.00^{c}	11.18^{c}	12.05^{abc}	112.20^{b}	3.80^{b}
F	*Ilisha Africana*	90.25^{ab}	8.53^{a}	108.2^{d}	11.30^{c}	9.18^{a}	121.20^{b}	2.90^{ab}
G	*Ethmalosa fimbriata*	88.53^{ab}	10.03^{a}	111.02^{d}	6.93^{b}	9.25^{a}	160.02^{d}	3.00^{ab}
H	*Parachana obscura*	108.02^{bc}	3.80^{a}	11.68^{a}	2.85^{ab}	11.18^{ab}	43.80^{a}	1.23^{a}
I	*Clarias lazera*	43.43^{a}	2.54^{a}	11.85^{a}	4.63^{ab}	10.63^{ab}	33.50^{a}	1.63^{ab}

Data is expressed as mean (n=4); Different letter along the column indicate significant different (P<0.05) based on Duncan Multiple Range Test

Table 5: Level of heavy metals in the kidney of different fish species from Warri River at different location

Location	Fish species	Fe, µg g^{-1}	Cu, µg g^{-1}	Pb, µg g^{-1}	Cr, µg g^{-1}	Ni, µg g^{-1}	Zn, µg g^{-1}	Cd, µg g^{-1}
A	*Tilapia zilli*	121.85^{abc}	7.02^{bc}	14.93^{a}	2.37^{a}	1.18^{a}	88.58^{ab}	1.98^{a}
B	*Oreochromis niloticus*	149.86^{bc}	4.03^{a}	20.27^{a}	3.76^{a}	26.60^{d}	136.22^{bc}	6.57^{b}
C	*Chrysicthys walkeri*	168.19^{c}	9.42^{c}	17.72^{a}	3.74^{a}	25.65^{d}	93.34^{ab}	1.73^{a}
D	*Chrysicthys furcatus*	80.12^{ab}	6.33^{bc}	19.08^{a}	2.81^{a}	9.43^{abc}	153.38^{bc}	1.53^{a}
E	*Arius gigas*	157.59^{bc}	3.96^{a}	110.95^{c}	11.34^{b}	6.56^{ab}	97.29^{ab}	1.87^{a}
F	*Ilisha africana*	88.01^{abc}	5.36^{bc}	130.22^{c}	9.07^{b}	8.07^{abc}	89.51^{ab}	2.29^{a}
G	*Ethmalosa fimbriata*	102.20^{abc}	6.36^{bc}	65.10^{b}	4.11^{a}	10.72^{abc}	210.20^{c}	1.00^{a}
H	*Parachana obscura*	115.89^{abc}	3.29^{a}	25.91^{a}	3.34^{a}	17.52^{cd}	82.88^{ab}	2.10^{a}
I	*Clarias lazera*	50.61^{a}	2.45^{a}	9.64^{a}	1.14^{a}	12.50^{bc}	35.99^{a}	1.05^{a}

Data is expressed as mean (n=4); Different letter along the column indicate significant different (P<0.05) based on Duncan Multiple Range Test

Typically, there was significant variation (P<0.05) among the different fish species with regard to the heavy metals concentration. Beside Ni, the concentration of the heavy metals in the muscles of the various fish species from the upstream control were significantly lower. The concentration of Fe and Zn were highest in the kidney of the fish species apart from Pb concentration in *Ilisha africana* which was has the highest concentration and *Arius gigas* which is also second to Fe. The order of the heavy metals in the kidney was the same in the liver and muscles.

The heavy metal concentrations from this study exceeded the permissible limit for fish food apart from copper. For instance, European Union (2002) cited in Senarathne and Pathiratne (2007), Senarathne *et al*. (2006) specified maximum allowable levels of Pb and Cd in fisheries consumed by humans on wet weight basis as 0.2 and 0.05 $\mu g\ g^{-1}$ respectively. Philips (1993) cited in Senarathne and Pathiratne (2007), Senarathne *et al*. (2006) also reported the Median International Standard for tolerable levels of Pb,Cd, Cr, Cu and Zn as 2, 0.3, 1, 20 and 45 $\mu g\ g^{-1}$ on wet weight basis respectively. FAO/WHO (1989) cited in Elnabris *et al*. (2013) also presented maximum allowable limit for Cd, Pb, Zn and Cu as 0.5, 0.5, 40 and 30 $\mu g\ g^{-1}$ respectively, on wet weight basis.

The trend of heavy metals in this study fluctuates between location and fish species. This fluctuation trend is in agreement with the study of Akan *et al*. (2012), Wokoma (2014), Ekeanyanwu *et al.* (2011). The concentration levels of Fe in organs was in order of liver> Kidney>gill>muscle tissues and Zn is ranked next to Fe. This trend is in accordance with the trend of heavy metal in liver>gill>muscle in *Mystus gulio* inhabiting Bologoda Lake, Sri Lanka as reported by Senarathne and Pathiratne (2007). The highest accumulation in the liver could be to the fact that it's the center of metabolism and detoxification.

Apart from the concentration of Ni, the level of heavy metals was typically least in *Clarias lazera* in the gills and kidney of the fish species. This trend was also similar to the observation in the muscle and liver of the fishes under study. This could be linked to passage or influx of relatively fresher water from river source, which gets to Agbarho first (Location 1) (Figure 1). The heavy metals concentrations obtained in the fisheries from Warri River are higher than the findings of other authors in Nigeria. Some of these studies include heavy metal in the flesh of *Oreochromics niloticus* from Ibrahim Adamu Lake, Jigawa state (Sambo *et al*., 2014), gills, intestines, head, flesh of *Synodontis schall* and *Clarias garepinus* from UKE Stream, Nasarawa State (Opaluwa *et al*., 2012) tissue of tissues of tilapia fish from Okumeshi river, Delta state (Ekeanyanwu *et al.,* 2011), gills, liver, stomach, kidney, bones of *Tilapia zilli*, *Clarias anguillaris*, *Synodontis budgetti and Oreochronmis niloticus* from River Benue in Vinikilang, Adamawa State, Nigeria (Akan *et al*., 2012), bones, gills, livers and muscles of *Oreochromis niloticus* from Henshaw town beach market in Calabar Nigeria (Edem *et al*., 2009), tissues of *Clarias gariepinus* from River Galma, River Kubanni and Fish farms in Zaria, Nigeria (Udiba *et al*., 2014), bones and tissues of *Oreochromis niloticus* and *Clarias camerunensis* from Ikoli creek, Bayelsa state (Ogamba *et al.,* 2015b) and muscles of *Citharinus citharus* and *Synodontis clarias* from the Amassoma Axis of River Nun, Bayelsa state (Ogamba *et al*., 2015a). Also, the findings of this study have some similarity with the report of Titilayo and Olufemi (2014) on the distribution of heavy metals in the muscles, gills and liver of *Clarias gariepinus* from Selected Streams in South Western Nigeria;

Wokoma (2014) on the level of heavy metals in the tissue of *Pseudotolithus elongates, Mugil cephalus* and *Chrisichthyes nigrodigitatus* from Lower Sombreiro River, Niger Delta, Nigeria; Ada *et al*. (2012) on the heavy metal level in the gills, kidney, liver, stomach and muscles from *Chrysichthys nigrodigitatus, Clarias gariepinus and Oreochromis niloticus*) in the Great Kwa River, Cross River State, Nigeria. The possible cause of the variation could be attributed to differences in the heavy metal concentration in the water and sediment in the various locations the fish species were caught from and to a lesser extent due to biochemical composition and habits of the fish species.

Aghoghovwia et al. (2015) have reported that Warri river contain high concentration of heavy metals (Fe, Zn, Cu, Ni, Cr, Cd, Pb) in water and sediment in the Nine location the fish samples were obtained from. The authors attributed the influx of heavy metal in Warri River to anthropogenic activities and post industrialization era aligning the environment of Warri River. Some of these activities that causes contamination in the Warri River include activities of the Jetty, market, steel plant, oil industry facility, Udu bridge/market and Ugbolokposo dredging site (Aghoghovwia et al., 2015).

The age of fish, lipid content in the tissue and feeding habits could also affect the accumulation of heavy metals in fisheries (Enerji *et al.,* 2011). Other possible determinant of accumulation potentials in fisheries include tissue/organ, age, size of the fish, exposure period, mechanisms of uptake, intrinsic factors environmental conditions of the habitant of fisheries (Perera *et al.,* 2015).

Only copper out of all the heavy metals investigated in this study had values considered to be acceptable from the point of view of their suitability for human consumption. However the consumption of commercial fish species from the Warri river pose a health risk to the consumers due to high levels of Pb, Cd, Fe, Cr, Ni and even Zn in the edible portions of their bodies.

Conclusion

This study investigated the concentration of seven heavy metals in body tissues of nine freshwater fish from Warri, Niger Delta, Nigeria. The findings showed that the river water is contaminated with heavy metal, which probably became bio-accumulated in the fish tissues/organs. As such the level of the heavy metals exceeded the limit specified by Food and Agricultural Organization/Word Health Organization, Median International Standard and European Union. Industrial activities may have been largely responsible for the increased heavy metal concentration in the fishes. Industrial activities discharging effluents or operating within the Warri River include oil servicing companies, oil and gas exploration firms, petrochemicals, as well as steel manufacturing, ports authority activity and dredging. These activities may threaten the health status of individuals who consumes these fishes contaminated by heavy metals. To avoid further deterioration of aquatic resources of the Warri River, it is expedient to continuously monitor the quality of the river and its reforms, since many people depend on its resources.

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