

Trace Metal Concentrations in Tissues of *Tilapia zilli* Owing to Human Perturbations in Imo River

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Abstract: Studies on trace metal concentrations in *Tilapia zilli* owing to human perturbations in Imo River was conducted for 12 months (between May 2016 and April 2017). *T. zilli* samples were collected from landings of artisanal fishermen at Jaja Creek, Uta Ewa, Alscun Harbour and Eier Berge along Imo River. The intestine, liver and gills of *T. zilli* were carefully dissected for determination of trace metals. Standard analytical procedures for sample preparation in the laboratory was adhered to. Trace metals were determined using Atomic Absorption Spectrophotometer (model GBC scientific AASGF 3000). The elemental concentrations of trace metals observed in the intestine and liver of *T. zilli* during the study duration were above permissible limit for all the studied trace metal exception of Chromium which was below the threshold limit as recommended by WHO (2011). However, the concentrations of heavy metals observed in the gills were below the WHO threshold limit exception of iron which was considerably higher than the WHO recommended threshold limit for seafood consumption. From the result of findings, the water quality of Imo River is severely impacted by human activities resulting from indiscriminate discharge of domestic waste, industrial waste, agricultural run-off and sewage disposal into the river. The high concentrations of heavy metal in the study organism calls for concern as this may result in deleterious health effects to consumers of these fishes' overtime. However, this study emphasizes the need of constant monitoring of trace metal levels in tissues of edible aquatic organisms to prevent health related issues to man as the final consumer of this seafood's.

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Keywords: Trace Metal, Concentrations, *Tilapia zilli*, Human Perturbations, Imo River

1. Introduction

The increasing use of metals in industry is causing serious environmental pollution through effluent and emanations arising from indiscriminate disposal of waste generated from these industries. Among the myriad of organic and inorganic substances released into the aquatic ecosystems, heavy metals have received considerable attention due to their toxicity and potential bioaccumulation in many aquatic species (Cupta and Mathus, 1983). In general, studies in heavy metal can be very important and interesting particularly in the field of ocean sciences and other related discipline. The alarming rate of disease associated with impacts of heavy metals and the potential effects of heavy metal on the aquatic biota have made it of concern on the need to measure the accumulation of heavy metals; particularly certain metals which pose an imminent health hazard to humans and are reported from several studies (George *et al.* 2013).

Studies have shown that heavy metals have the potential to alter the physiological and biological parameters of aquatic species (Basa and Usha; 2003; Canli 1995; Tort and Torres, 1988). Generally, water along the coast (including the estuaries) contains a variety of marine resources, namely fishes, shell fish

and seaweed (Muse *et al.*, 1999) which attract fishing activities. The concern here is the contamination of water resources (fishes) by potential toxic chemical. Most of these toxic chemicals when present in a concentration above the recommended standard will result in chemical pollution. Many species of fish especially the benthos have been found to bioaccumulate most of these heavy metals in their tissue (Zn, Cu, Cd, Pb, Fe). Asuquo and Bassey, (1999) reported that the uptake of these toxins in the tissue of organism may create health hazard to human as its major predator and other fishes that prey on them.

Therefore, the aim of this research was to quantify the levels of some trace metals (Cd, Cu, Fe, Pb, Zn, Mn and Cr) in intestine, liver and gills of *Tilapia zilli* caught from Imo River, Nigeria to ascertain its safety for human consumption.

2. Material and Methods

2.1 Study Area

The study was carried out in Imo River (Fig 1) which is one of the essential rivers in Niger Delta region. It is situated on the South-East coast of Nigeria. The river originates from the Imo State (hill region) and flows through Imo, Abia and Rivers State before emptying into the Atlantic Ocean. The river is

located between Latitude 4°30'32"N and Longitude 7°32'3"E. It is a tidal River with extensive mangrove swamps, intertidal mud flats and influenced by semi-diurnal tidal regime. Industrial activities are also predominant (e.g. NNPC Power Station) add with

illegal petroleum refineries and bunkering activities. The River is a source of drinking water and livelihood of the people of the area. The major occupation of the inhabitants includes, fishing, lumbering and farming activities (Ogbuagu *et. al.*, 2011).

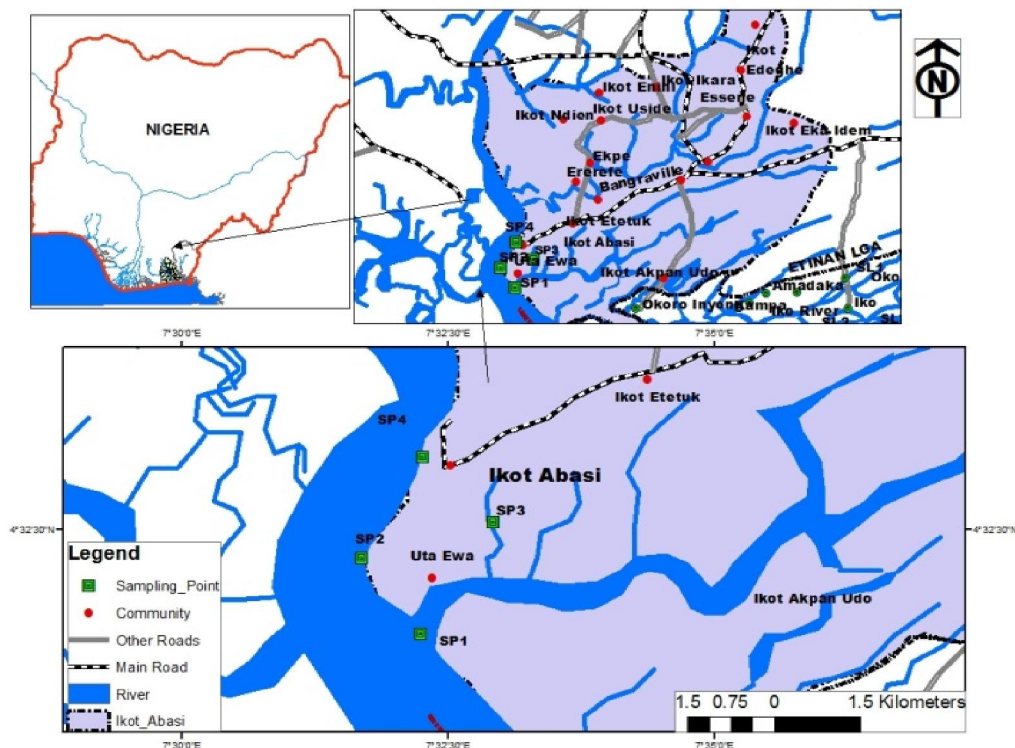


Fig 1: Map of the Study

2.2 Sampling Locations

Four sampling stations were chosen along the intertidal region of the River. The geo-location of

sample points were taken using Geographic positioning system (GPS) as shown below.

Sample Point	Sample Location	Longitude	Latitude
SP1	Jaja Creek	7°32'12.717"E	4°31'30.33"N
SP2	Uta Ewa	7°31'39.523"E	4°32'11.018"N
SP3	Alscon Harbour	7°32'52.335"E	4°32'36.717"N
SP4	Eier Berge	7°32'13.788"E	4°33'13.122"N

2.3 Collection of Samples

Ten (10) Samples of *Tilapia zilli* were collected on a monthly basis for 12 months (between May 2016 and April 2017) at jaja Creek, Uta Ewa, Alscon Harbour, Eier Berge along Imo River using the services of artisanal fishermen fishing with the aid of basket trap fishing gear.

2.4 Analysis of Samples

In the laboratory the soft tissues (intestine, liver, gills) of *T. zilli* was air - dried at room temperature for two weeks. The air-dried soft tissues were grounded to powder form, sieved, weighed and ashed at 77 °C for two hours in a furnace. Ten grams (10 g) of ashed

tissues were digested with 20 ml of concentrated HNO₃ to bring the metal into solution and then transfer to 100 ml plastic can for Atomic Absorption Spectrophotometer (AAS) analysis. Heavy metals were determined using Atomic Absorption Spectrophotometer (model GBC scientific AASGF 3000) according to APHA, (1998).

2.5 Statistical analysis

Mean values (\pm SE) of triplicate experiment were taken for each analysis. One-way analysis of variance (ANOVA) and Least Significant Difference (LSD) test were employed to separate significant differences

in mean values. The probability level was set at $p = 0.05$.

3. Results

Table 1 to Table 3 shows the wet and dry season range and mean values of parameters observed in the tissues of *T. zilli* during the study duration. Significant seasonal variations were observed in the studied parameters. However, it was observed that the studied parameters were above the WHO (2011) permissible limit for seafood in the intestine and liver, exception of chromium that was within the tolerable range. The

elemental concentrations of trace metals in the gills was however low when compared to the values obtained in the intestine and liver of the same species. The values obtained were below the WHO permissible limit exception of iron which was above the WHO acceptable limit for human consumption. Significant seasonal variations were observed for Cd, Cr, Cu, Pb, Co and Zn ($p < 0.05$) exception for Iron ($p > 0.05$). The mean variation of trace metals for wet and dry season in the tissues of *T. zilli* during the study duration is presented in Fig 2 and Fig 3.

Table 1: Seasonal Range, Mean Variation, Standard Error of Trace Metal Concentration (mg/kg) in the intestine of *Tilapia zilli* obtained from Imo River for wet and dry Season (May, 2016 – April, 2017)

Parameter	Units	Range (Wet Season)	Range (Dry Season)	Mean \pm S.E (Wet Season)	Mean \pm S.E (Dry Season)	WHO Permissible Limit
Cadmium	mg/kg	0.00 – 0.93	0.48 – 1.02	0.55 \pm 0.16	0.86 \pm 0.08	0.01
Copper	mg/kg	1.20 – 3.80	3.30 – 3.70	2.57 \pm 0.38	3.53 \pm 0.80	1.0
Iron	mg/kg	6.50 – 20.80	21.50 – 29.50	15.19 \pm 2.50	23.62 \pm 1.23	0.3
Lead	mg/kg	0.02 – 0.61	0.46 – 0.98	0.33 \pm 0.09	0.80 \pm 0.08	0.05
Zinc	mg/kg	8.60 – 37.60	30.40 – 38.70	28.82 \pm 4.20	34.17 \pm 1.52	3.0
Manganese	mg/kg	0.00 – 4.91	3.90 – 4.15	1.28 \pm 0.74	3.98 \pm 0.04	-
Chromium	mg/kg	0.00 – 0.01	0.00 – 0.01	0.00 \pm 0.00	0.01 \pm 0.00	0.05

Where: S.E = Standard Error, WHO = World Health Organisation, BDL = Below Detectable Limit

Table 2: Seasonal Range, Mean Variation, Standard Error of Trace Metal Concentration (mg/kg) in the liver of *Tilapia zilli* obtained from Imo River for wet and dry Season (May, 2016 – April, 2017)

Parameter	Units	Range (Wet Season)	Range (Dry Season)	Mean \pm S.E (Wet Season)	Mean \pm S.E (Dry Season)	WHO Permissible Limit
Cadmium	mg/kg	0.48 – 1.02	0.10 – 0.23	0.86 \pm 0.08	0.17 \pm 0.02	0.01
Copper	mg/kg	3.30 – 3.70	0.02 – 0.20	3.53 \pm 0.08	0.08 \pm 0.04	1.0
Iron	mg/kg	21.50 – 29.50	3.40 – 3.80	23.62 \pm 1.23	3.70 \pm 0.06	0.3
Lead	mg/kg	0.46 – 0.98	0.01 – 0.04	0.80 \pm 0.08	0.02 \pm 0.01	0.05
Zinc	mg/kg	30.40 – 38.70	2.40 – 3.80	34.17 \pm 1.52	2.88 \pm 0.20	3.0
Manganese	mg/kg	3.90 – 4.15	0.50 – 0.75	3.98 \pm 0.04	0.61 \pm 0.04	-
Chromium	mg/kg	0.00 – 0.01	0.20 – 0.30	0.01 \pm 0.00	0.22 \pm 0.02	0.05

Where: S.E = Standard Error, WHO = World Health Organisation, BDL = Below Detectable Limit

Table 3: Seasonal Range, Mean Variation, Standard Error of Trace Metal Concentration (mg/kg) in the gills of *Tilapia zilli* obtained from Imo River for wet and dry Season (May, 2016 – April, 2017)

Parameter	Units	Range (Wet Season)	Range (Dry Season)	Mean \pm S.E (Wet Season)	Mean \pm S.E (Dry Season)	WHO Permissible Limit
Cadmium	mg/kg	0.00 – 0.35	0.00 – 0.00	0.11 \pm 0.07	0.00 \pm 0.00	0.01
Copper	mg/kg	0.00 – 3.70	0.02 – 0.76	0.23 \pm 0.12	0.16 \pm 0.12	1.0
Iron	mg/kg	2.60 – 7.80	1.80 – 11.80	4.17 \pm 0.95	4.70 \pm 1.47	0.3
Lead	mg/kg	0.00 – 1.00	0.00 – 0.00	0.17 \pm 0.17	0.00 \pm 0.00	0.05
Zinc	mg/kg	1.30 – 2.20	0.40 – 3.80	1.76 \pm 0.15	1.63 \pm 0.49	3.0
Manganese	mg/kg	0.00 – 0.43	0.00 – 0.66	0.14 \pm 0.09	0.19 \pm 0.12	-
Chromium	mg/kg	0.00 – 0.17	0.00 – 0.00	0.03 \pm 0.03	0.00 \pm 0.00	0.05

Where: S.E = Standard Error, WHO = World Health Organisation, BDL = Below Detectable Limit

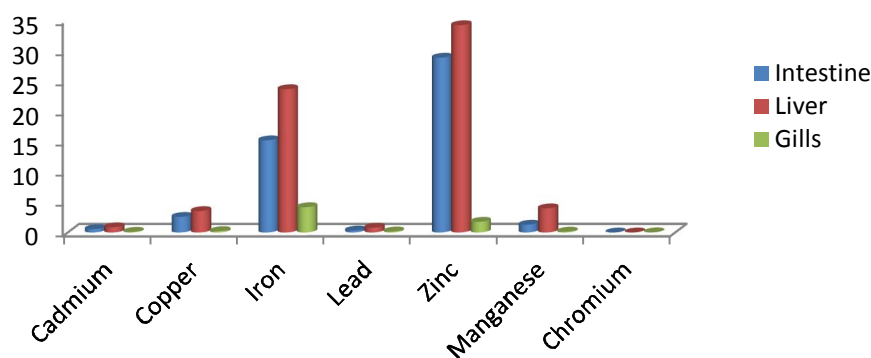


Fig 2: Mean Wet Season Variation of Heavy Metals in different Tissues of *Tilapia zilli* Caught from Imo River System (May, 2016 - April 2017)

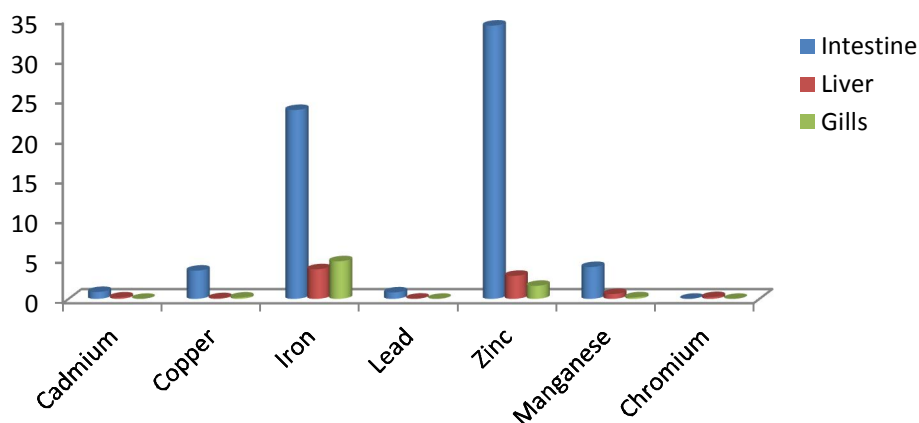


Fig 3: Mean Dry Season Variation of Heavy Metals in different Tissues of *Tilapia zilli* Caught from Imo River System (May, 2016 - April 2017).

4. Discussion

The present study demonstrates evidence of trace metal (Cd, Cu, Fe, Pb, Zn, Mn and Cr) accumulation in tissues (intestine, liver and gills) of *Tilapia zilli* obtained from Imo River during the duration of study. Heavy metals are endocrine disruptors with the ability to cause hormonal imbalances affecting various physiological processes such as reproduction.

Interesting pattern was observed for trace metal accumulation in the tissue of the studied organism. The pattern followed the trend Zn>Fe>Cu>Mn>Cd>Pb>Cr for intestine, Zn>Fe>Mn>Cu>Cd>Pb>Cr for liver and Fe>Zn>Cu>Mn>Pb>Cd>Cr for the gills. Differential uptake of trace metals was observed in the tissues with preference to season. The studied tissues were in the order of liver> intestine> gills for wet season while intestine> liver> gills for dry season.

The highest concentration of Cadmium was observed in the intestine and liver tissue of *T. zilli*, during dry and wet season respectively. while the

lowest concentrations were detected in the gill's tissues of the studied species. Cadmium is a non-essential trace metal that is potentially toxic to most fish and wildlife particularly freshwater organism (Robertson *et al.*, 1991). Cadmium production, consumption and emissions to the environment have increased dramatically during the 20th century, due to its industrial use (batteries, electroplating, plastic stabilizers, pigment), and consequently lead to contamination of aquatic habitats (Jarup, 2003). The use of cadmium containing fertilizer, agricultural chemicals, pesticides and sewage sludge in farm land, might also contribute to the contamination of water (ATSDR, 2003). As a non-degradable cumulative pollutant, Cd is considered capable of altering aquatic trophic levels for centuries (Sorensen, 1991). This heavy metal has been shown to accumulate mainly (about 75 %) in kidney, liver and gills of freshwater fishes (Chowdhury *et al.*, 2004). However, the concentration of cadmium recorded in the tissue of the studied species exceeded the 0.05 mg/kg (EU

standard) and 0.01 mg/kg (WHO standard) threshold considered harmful to fish and predators.

Copper (Cu) is an essential trace metal and micronutrient for cellular metabolism in living organisms on account of being a key constituent of metabolic enzymes (Monteiro *et al.*, 2011). However, it can be extremely toxic to intracellular mechanisms in aquatic animals at high concentrations which exceed normal levels (Hernandez *et al.*, 2006; Abdei-Tawwab *et al.*, 2007). It is an abundant element which occurs as a natural mineral with a wide spread use (Sfakianakis *et al.*, 2015). Copper pollution is through extensive use of fungicides, algacides, molluscicides, insecticides and discharge of wastes (Michael, 1986). WHO (1989) reported that Copper toxicity in fish is taken up directly from the water via gills and stored in the liver, the present study showed similar accumulation of Copper in the tissues of the *T. zilli*. Effects of high concentration of Copper in fish are not well established; however, there is evidence that high concentrations in fish can lead to toxicity (Woodward *et al.*, 1994). However, the concentration of Copper levels in the intestine and liver of *T. zilli*, from Imo River system were above the maximum level of 1.0 mg/kg reported by (WHO, 2011) exception of the gills which had low values and were below the threshold limit.

Evidence of iron accumulation was observed in all the studied tissues. However, the highest concentration of iron was recorded in the liver during the wet season. This assertion agrees with the findings of Van Rensburg (1989) and Grobler *et al.*, (1991) who reported high bio-concentration of iron in the liver and gonads of *Tilapia sparrmanii*. Recently, Omar, *et al.*, (2014), proved that the fish liver is the target organ for iron accumulation. Iron is prevalent component of industrial and mining effluents that are often discharged into aquatic environments via run-off.

Lead (Pb) is a persistent heavy metal which has been categorized as a priority hazardous substance (Sfakianakis *et al.*, 2015). Although Pb is a naturally occurring substance, its environmental concentrations are significantly increased by human mediated sources which include base metal mining, battery manufacturing, Pb-based paints and leaded gasoline (Mager, 2011; Monteiro *et al.*, 2011). Lead in water may come from industrial and smelter discharges; from the dissolution of old lead plumbing, lead containing pesticides, through precipitation, fallout of lead dust, street run-off, and municipal wastewater (Sepe *et al.*, 2003). The concentration and bioavailability of Pb is mainly dependent on the absorption into the sediments and the natural organic matter content of the water as well as the pH, alkalinity and hardness (Mager, 2011; Sepe *et al.*,

2003). Aquatic organisms bio-accumulates Pb from water and diet, although there is evidence that Pb accumulation in fish, is most probably originated from contaminated water rather than diet (Creti *et al.*, 2010) which may account for the low concentration of lead recorded in all the tissues during the study duration. Accumulation of lead in different fish species has been determined in several works (Castro-Gonzalez and Mendez-Armenta, 2008), leading to disorders in fish body.

Zinc (Zn) is the second most abundant trace element after Fe and is an essential trace element and micronutrient in living organisms, found almost in every cell and being involved in nucleic acid synthesis and occurs in many enzymes (Sfakianakis *et al.*, 2015). This assertion supports the present findings in which zinc and iron had the highest concentration in all the studied tissues. It may occur in water as a free cation as soluble zinc complexes, or can be adsorbed on suspended matter. Zinc and its compounds are extensively used in commerce and in medicine. The common sources of it are galvanized ironwork, zinc chloride used in plumbing and paints containing zinc (Clarke, *et al.*, 1981). However, the concentrations were above WHO, 2011 threshold limit for intestine and liver exception of the gills which recorded low values below the recommended limit.

Chromium is an essential nutrient metal, necessary for metabolism of carbohydrates (Frag *et al.*, 2006). Chromium enter the aquatic ecosystem through effluents discharged from leather tanneries, textiles, electroplating, metal finishing, mining, dyeing, printing industries, ceramic, photographic and pharmaceutical industries etc. (Abbas and Ali, 2007). Poor treatment of these effluents can lead to the presence of Cr (VI) in the surrounding water bodies, where it is commonly found at potentially harmful levels to fish (Li *et al.*, 2011; Pacheco *et al.*, 2013). Generally, the concentration of chromium was low in all the studied tissues throughout the duration of study. The low concentration observed during the study could be attributed to the absence of the above mention human activities within the study area.

Manganese tends to reside in the tissues of the studied species, although in minute concentration. However, the concentration of Mn in the intestine and liver exceeded the guideline limit of 0.7 mg/kg set by (Charbonneau & Nash, 1993) exception of the gills where lower concentrations were recorded.

5. Conclusion

The elemental concentrations of trace metals observed in the intestine and liver of *T. zilli* during the study duration were above permissible limit for all the studied trace metal exception of Chromium which was below the threshold limit as recommended by WHO

(2011). However, the concentrations of heavy metals observed in the gills were below the WHO threshold limit exception of iron which was considerably higher than the WHO recommended threshold limit for seafood consumption. From the result of findings, the water quality of Imo River is severely impacted by human activities resulting from indiscriminate discharge of domestic waste, industrial waste, agricultural run-off and sewage disposal into the river. The high concentrations of heavy metal in the study organism calls for concern as this may result in deleterious health effects to consumers of these fishes' overtime. *T. Zilli* is a common commercial finfish consumed in Nigeria, notably the Niger Delta Region by most rural dwellers and riverine communities owing to their cheap source. However, this study emphasizes the need of constant monitoring of trace metal levels in tissues of edible aquatic organisms to prevent health related issues to man as the final consumer of this seafood's.

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