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*Full Length Research Paper*

# Determination of lead, cadmium and mercury in surrounding water and organs of some species of fish from Ikpoba river in Benin city, Nigeria

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**The mean concentration of some heavy metals (lead, cadmium and mercury) in the muscles and the organs of some common species of fish: *Metacembelus Iconnbergii, Clarias lazera, Citarinus citharus, Tilapia zilli* and *Erpetoichithy* were investigated using atomic absorption spectrophotometric method. The mean concentrations of lead in the muscle, kidney and liver were in the ranges of 0.00 – 0.004 mg/kg, 0.010 – 0.015 mg/kg, and 0.004 – 0.010 mg/kg respectively, while that of the surrounding waters were between and 0.001 – 0.005 mg/kg. Cadmium concentrations were in the range of 0.001 – 0.002 mg/kg in the muscles, 0.004 – 0.006 mg/kg in the kidney and 0.002 – 0.004 mg/kg in the liver while that of the surrounding water was 0.001 mg/kg. The levels of mercury were 0.001– 0.002 mg/kg in the muscle, 0.004 – 0.006 mg/kg in the kidney, 0.002 – 0.004 mg/kg in the liver and 0.001 – 0.002 mg/kg in the surrounding waters. From the results, it was observed that the levels of these metals in the fishes were higher than that obtained in the surrounding waters from which the fishes were obtained. The distribution of lead, cadmium and mercury in the fishes investigated showed significant variations with respect to the muscles and the organs. The kidney had higher concentration of the metals compared to the liver, which is in turn higher than that in the muscle. This indicates that the kidney of fish is a better bio-accumulator of heavy metals than the liver and the muscle. The accumulation patterns of heavy metals contaminants in fish depend on uptake and elimination rate. The implications of these contaminants beyond the World Health Organization (WHO) and Food and Agricultural organization (FAO) permissible limits were discussed.**

**Key words:** Heavy metals, fish, lead, cadmium, mercury, contaminant.

## INTRODUCTION

The body has need for approximately 70 friendly trace element heavy metals, but there are 12 poisonous heavy metals, such as lead, mercury, aluminium, arsenic, cadmium, nickel, chromium, etc., that acts as poisonous interference to the enzyme systems and metabolism of the body. No matter how many good health supplements or procedures one takes, heavy metals overload will be a detriment to the natural healing functions of the body (Kakulu et al., 1987; Elsom and Haas, 2003).

Heavy or toxic metals are trace metals that are at least five times denser than water. As such, they are stable (meaning they cannot be metabolized by the body) and bio-accumulative. They are sometimes passed up the food chain to humans (Fergosson, 1990). These metals include mercury, nickel, lead, arsenic, cadmium, aluminium, platinum and copper (metallic form and ionic form). Most heavy metals have no beneficial functions to the body and can be highly toxic (Fergosson, 1990). They are taken into the body via inhalation, ingestion and skin absorption. If they enter and accumulate in body tissue faster than the body's detoxification pathways can dispose of them, a gradual buildup of these toxins will occur. High concentration exposure is not necessary to produce a state of toxicity in the body tissue and, overtime, can reach toxic concentration levels (Khalid et al., 1978; Proti, 1989; Prusty, 1994).

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Heavy metals were present in our environment in minute concentrations until recent centuries that Industrialization brought in technological advances such as the use of metals in medicine and silver-mercury tooth amalgam. Other sources through which human beings get contaminated include: lead based paint, leaded gasoline, air, water, mining, batteries, chemical weathering of rocks and soils amongst others.

Pollution of streams and rivers flowing through agricultural areas where pesticides, fungicides, etc may have been applied, and industrial districts where there may have been metal waste deposits, all these present varied and difficult problems due to drainage into our different water bodies. Effluents discharged into rivers, which may affect aquatic animals like fish, may do so either directly or indirectly. Moriber (1974) found that drinking water contaminated by wastes from mines producing cadmium; lead and zinc resulted in ricket-like diseases. The metals ladened effluent may flow into a receiving water body.

Fish is often at the top of the aquatic food chain and may concentrate large amount of these metals from the surrounding waters.

Lead is known to cause the disease called plumbism. Lead accumulate in aquatic biomass, they are concentrated and passed up the food chain to human consumers. Lead is also known to damage the brain, the central nervous system, kidneys, liver and the reproductive system (Ademoroti, 1996a)

Cadmium is of even greater concern because of its harmful effects on plants, animal and man. Cadmium, a heavy metal is known to cause itai-itai disease; this disease is known to damage the joints, cause bones to soften and the body to shrink while the affected person dies a painful death (Ademoroti, 1996a)

Mercury gets into the body through the respiratory and gastrointestinal tract and is distributed into the liver and kidney. It is also accumulated in nervous tissue. The alkylated mercury (alkyl-Hg) accumulates in the central nervous system (CNS) tissue. It is toxic to the glial cells, mostly Schwann cell production of myelin, neuropsychotic, severe developmental CNS abnormalities in foetus and prolonged action potentials. Fish intake is the major source of exposure tp mercury, mainly in the form methyl mercury, which it accumulates from the surrounding waters (Mckinney and Rogers, 1992).

Studies shows that fish accumulate these heavy metals from the surrounding water bodies thereby leaving a health risk if taken as food (Proti, 1989; Prusty, 1994; US.DPHHS, 2005).

Ikpoba River is a major source of water supply for the inhabitants of the area and there are lots of business activities going on along the river course. Mechanic workshops, car wash, battery charging, dyeing of fabric, etc. are common in this area. Also, people dump their waste indiscriminately in the river. These activities may have impact on the water body, thereby introducing some of these heavy metals into the waters, which is subsequently ingested and absorbed by the fishes. The present study investigates the levels of these metals (Pb, Cd and Hg) in some common species of fish so as to determine their suitability as seafood to the inhabitants of the immediate environment and beyond.

## MATERIALS AND METHODS

Fish samples were collected at different points along the river course in the period of August to November 2006. The fish species selected were based on abundance along the course of the river and widely eaten by the inhabitants of these areas.

### Sample preparation

The samples were carefully cut opened using a plastic knife in order to remove the organs (kidney and liver), they were freeze dried and pulverized into a uniform particle size prior to analysis. The small sized particles were subjected to acid digestion using nitric acid.

### Sample analysis

After digestion, all samples were analyzed for Cd and Pb using air-acetylene flame atomic absorption spectrophotometer (Perkin Elmer A.A. 3100) with D2 background correction device. Cold vapour technique was used for the analysis of Hg. (Kingston and Jessie, 1988; APHA, 1995; Ademoroti, 1996b; Medham, 2000)

## RESULTS AND DISCUSSION

### Results

The results of this analysis are shown in Tables 1 - 3

## DISCUSSION

From the results in Tables 1 – 3, the mean concentrations of lead, cadmium and mercury ranges from 0.001 mg/l, 0.001 – 0.002 mg/l and 0.001 – 0.002 mg/l respecttively in the surrounding waters from which the fish samples were collected. These values are within World Health Organization (WHO) permissible limits for portable and drinking water. The results in table 1 shows that the amount of lead in the muscle, kidney and liver of the various fish ranges from 0.002 – 0.008 mg/kg, 0.012 – 0.015 mg/kg and 0.004 – 0.010 mg/kg respectively. These values are higher than that of the surrounding waters, this is due to the fact that these fishes bio-accumulate these metals over time. These values may reach dangerous trend if the sources of these metals are not checked. As it is known Lead is toxic and may damage the brain, the central nervous system, kidney, liver and the reproductive system when it exceed the tolerable limit in humans (Ademoroti, 1996a). Waste products from the use of chemicals like lube 106 and other lubricants like diesel oil which are spilled here and there especially as car wash is located along the river course may be responsible for the presence of lead in the waters Table 2 shows the result.

**Table 1.** Concentrations of lead in some selected species of fish.

| Fish species | Mean Concentration of lead (mg/kg) | | | |
|---|---|---|---|---|
| | Surrounding water | In muscles | In kidney | In liver |
| *Metacembelus Iconnbergii* | 0.001 ±0.00 | 0.002 ±0.001 | 0.012±0.002 | 0.007 ±0.001 |
| *Clarias lazera* | 0.002 ±0.001 | 0.003 ±0.001 | 0.013±0.002 | 0.006 ±0.001 |
| *Citarinus citharus* | 0.003 ±0.001 | 0.004 ±0.001 | 0.010±0.002 | 0.007 ±0.001 |
| *Tilapia zilli* | 0.002 ±0.001 | 0.002 ±0.001 | 0.015±0.003 | 0.004 ±0.001 |
| *Erpetoichithys* | 0.005 ±0.001 | ND | 0.014±0.001 | 0.010 ±0.001 |
| WHO limit for heavy metals in food | 0.05 | 0.05 | 0.05 | 0.05 |
| FAO limit for Heavy metals in fish | 0.05 | 0.05 | 0.05 | 0.05 |

All values are mean values of triplicate determinations ±SD.

**Table 2.** Concentrations of cadmium in some selected species of fish.

| Fish Species | Mean Concentration of Cadmium (mg/kg) | | | |
|---|---|---|---|---|
| | Surrounding water | In muscles | In kidney | In liver |
| *Metacembelus Iconnbergii* | 0.001±0.00 | 0.001±0.00 | 0.005 ±0.001 | 0.003 ±0.001 |
| *Clarias lazera* | 0.001 ±0.00 | 0.001 ±0.00 | 0.004 ±0.001 | 0.003 ±0.001 |
| *Citarinus citharus* | 0.001 ±0.00 | 0.002 ±0.00 | 0.005 ±0.001 | 0.003 ±0.001 |
| *Tilapia zilli* | 0.001 ±0.00 | 0.001 ±0.00 | 0.004 ±0.001 | 0.002 ±0.001 |
| *Erpetoichithys* | 0.001 ±0.00 | 0.002 ±0.00 | 0.006 ±0.001 | 0.004 ±0.001 |
| WHO limit for heavy metals in food | 0.01 | 0.01 | 0.01 | 0.01 |
| FAO limit for Heavy metals in fish | 0.5 | 0.5 | 0.5 | 0.5 |

All values are mean values of triplicate determinations ±SD.

of Cadmium content of fish and the surrounding waters. From the results, it can be observed that the amount of cadmium in the muscle, kidney and the liver of the fish are in the range of 0.001 - 0.002 mg/kg, 0.004 – 006 mg/kg and 0.002-0.004 mg/kg respectively. These values are also higher than the cadmium contents in the surrounding waters but are within WHO permissible limits for potable water. Cadmium is bio-accumulative, that means it is persistent and increase with time since it is non-biodegradable. Cadmium wastes washed into aquatic bodies accumulate in aquatic biomass, they are concentrated and pass up to the food chain, cadmium is toxic even if absorption by ingestion is low, chronic exposure to high levels of cadmium in food has caused bone disorders, including osteoporosis and osteomalacia. Long-term ingestion, by a Japanese population, of water and food contaminated with cadmium was associated with a crippling condition, (itai-itai) (ouch-ouch) disease. The affliction is characterized by pain in the back and joints, osteomalacia (adult rickets), bone fractures and occasional renal failure, and most often affects women with multiple risk factors such as multiparity and poor nutrition. Other consequences of cadmium exposure are: anemia, yellow discoloration of the teeth, rhinitis, occasional ulceration of the nasal septum, damage to the olfactory nerve, and anosmia (Gustav, 1974; Mckinney et al., Nweodozie, 1989; 1992; Ademoroti, 1996a; Elson and Haas, 2003).

Table 3 depicts the results of mercury concentration in the muscle, kidney and the liver of the common fish used in this study. From the result, the amount of mercury in the muscle is in the range of 0.001 - 0.002 mg/kg and that of the kidney and the liver are in the ranges of 0.004 - 0.006 mg/kg and 0.002 - 0.00 4mg/kg respectively. These values are also higher than the amount of this metal in the surrounding waters but within the World Health Organization (WHO) and Food and Agricultural Organization (FAO) limits for potable drinking water and food respectively. The levels of these metals in the fishes were higher than that obtained in the water samples from the same river. This could be attributed to the metals being lipophilic; they reside and accumulate in fatty tissues. Heavy metals enter fishes not only by ingestion but also through dermal absorption and respiration. When these chemicals are taken in by the fish, they bio-accumulate, bio-magnify, and remain in the fish till they are caught and use as food by humans or eaten by bigger fishes which are eventually eaten by humans. It was observed from the results that the concentration in milligram's per litre of these metals in the fishes analyzed and in their surrounding waters were within the WHO and FAO permissible limit for these heavy metals (Pb, Cd and

**Table 3.** Concentrations of mercury in some selected species of fish.

| Fish Species | Mean Concentration of Mercury (mg/kg) | | | |
|---|---|---|---|---|
| | Surrounding water | In muscles | In kidney | In liver |
| *Metacembelus Iconnbergii* | 0.002 ±0.001 | 0.002 ±0.001 | 0.006 ±0.001 | 0.004 ±0.001 |
| *Clarias lazera* | 0.001 ±0.00 | 0.001 ±0.00 | 0.005 ±0.001 | 0.003 ±0.001 |
| *Citarinus citharus* | 0.001 ±0.00 | 0.001 ±0.00 | 0.005 ±0.001 | 0.004 ±0.001 |
| *Tilapia zilli* | 0.001 ±0.00 | 0.002 ±0.001 | 0.005 ±0.001 | 0.003 ±0.001 |
| *Erpetoichithys* | 0.001 ±0.00 | 0.001 ±0.00 | 0.004 ±0.001 | 0.002 ±0.001 |
| WHO limit for heavy metals in food | 0.01 | 0.01 | 0.01 | 0.01 |
| FAO limit for Heavy metals in fish | 0.5 | 0.5 | 0.5 | 0.5 |

All values are mean values of triplicate determinations ±SD.
ND = Not Detected.

Hg) (FAO, 1983; WHO, 1971). On this ground, one would suggest that the use of these fishes for the preparation of seafood for consumption and also suggest the possibility of using the fish species for heavy metals pollution monitoring. However, the metals will not pose health hazard to the communities around the river since they depend solely on the river as a source of drinking water and the fish as a source of seafood. More so, the distribution of lead, cadmium and mercury in the fish showed significant variations with respect to the muscle and the organs. The kidney had higher concentration of the metals as compared to the liver, which is in turn higher than that in the muscle. This indicates that the kidney of fish is a better bio-accumulate of heavy metals than the liver and the muscle.

## Conclusion

There is significant variability in the concentration of these metals in the muscle and organs of the fish. The accumulation patterns of heavy metals contaminants in fish depend on uptake and elimination rate. Studies have shown that fish accumulate these metals (Pb, Cd and Hg) from surrounding waters.

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