MPRI-JMBP | INTERNATIONAL JOURNAL OF MEDICAL, BIOLOGICAL AND PHAR. SCI. VOL. 11 NO.3 JUN-2020 ISSN: 1999-5650

ANALYSIS OF SOME SELECTED HEAVY METALS IN TWO PARTS OF *TILAPIA ZILLI* FROM RIVER BENUE AT ABINSI, GUMA L.G.A. OF BENUE STATE, NIGERIA.

DIBAL, H. I.*, DUHU B.Y. AND ABDULSALAM H.
Department of Biological Sciences, University of Maiduguri, P.M.B 1069, Maiduguri, Borno State, Nigeria

Abstract

This research work was conducted to assess the concentration of heavy metals which comprises Lead (Pb), Cadmium (Cd), Manganese (Mn), Copper (Cu) and Iron (Fe) in selected parts (liver and muscle) of Tilapia zilli purchased from River Benue at Abinsi, Guma L.G.A of Benue State. These metals were chosen because at higher concentration, they are toxic to the fish and by extension humans that consume such fish as food due to biomagnification. The samples were prepared and digested and the concentration of the metals were analysed using Flame Atomic Absorption Spectrophotometer (Bulk Scientific Model-210 VGP). Differences in heavy metals concentrations were observed between the two parts of the fish. The highest concentrations of the metals were recorded in the liver of the fish. The liver accumulated significantly higher levels of Cu, Pb, and Fe (2.034, 1.905 and 1.491). In both tissues studied, the levels of the metals were significantly low in the [redacted] *muscles (p>0.05). The concentration of Cu, Pb and Fe in the liver was higher than the permissible limit of WHO/FAO and EU while that of the muscles were below. Consumption of the muscle will not pose any health effect, but people that eat fish as whole should be mindful of the liver because constant consumption might lead to bioaccumulation in the body.*

KEYWORDS:
Heavy metals, Tilapia zilli, River Benue (Abinsi), concentration, bioaccumulation.

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INTRODUCTION

Pollution of the aquatic environment by contaminants has been considered a major threat to the aquatic organisms including fishes (Akan *et al*., 2012). These contaminants may contain heavy metals which are being taken up by fish which man consumes. Thus, heavy metals are natural component of the earth crust. They are group of metals and metalloids with atomic density greater than 4g/cm^3 or 5 times or more greater than water (Duruibe *et al*., 2007). They are also known as trace elements because they occur in minute concentrations in biological systems. These metals come from natural and anthropogenic sources. The natural sources include geological weathering, atmospheric deposition, volcanic eruption etc and the anthropogenic sources include industrial and mechanical activities, agricultural runoffs, domestic effluents, windblown, Dust from exhaust of vehicles etc. heavy metals can be incorporated into food chains and absorbed by aquatic organisms to a level that might affect their physiological state (Akan *et al*., 2012). Some of these metals are essential like Fe, Cu, Mn, Zn etc whereas others are not essential and can be very toxic even at low concentration. Examples are Pb, Cd, Cr, As, Hg etc.

Fish is considered as one of the main protein sources of food for humans (Rashed, 2001). It contributes to lower cholesterol levels in blood and provides vitamins and minerals (Al-Busaidi *et al*., 2011). These fishes are at the top of the aquatic food chain and can accumulate both essential and toxic metals which they absorb from contaminated sediments and water through their gills and skin as well as from organisms which are consumed by the fish (Saha and Zaman, 2012). Fish accumulates pollutants preferentially in their fatty tissues like liver and the effects become apparent when concentrations in tissues attain a threshold level (Authman *et al*., 2015). The response of fish to environmental change makes it suitable for use as an indicator for environmental pollution. Fish is a good bioindicator because it is easy to obtain in large quantities and has the potential to accumulate metals (Batvari *et al*., 2007).

River Benue at Abinsi receives a wide variety of waste from agricultural run-off and domestic waste being dumped at the bank of the river.

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Anthropogenic activities coupled with expanding human population, intensive agricultural practices and discharge of massive amount of waste water into the river may result into deterioration of fish water quality. The river at this location is one of the main fish supply sources for this area and beyond because major fishing communities in Benue state are resident at Abinsi with a daily market. This study investigates the levels of these metals (Pb, Cd, Mn, Cu and Fe) in some parts (Liver and Muscle) of *Tilapia zilli* so as to determine their suitability as aqua-drive food to the inhabitants of the immediate environment and beyond.

MATERIALS AND METHODS

Study area

Guma is a Local Government Area in Benue State, Nigeria. The headquarter is at Gbajimba. The Local Government has a total land mass of 2882km and a population of 191599 at the 2006 census. It has nine council wards of Nyiev, Mbayer-Yandev, Mbawa, Mbabai, Uvir, Abinsi, Kaambe, Saghev, Nzorov and Mbadwem.

The area of interest is Abinsi, a one-time headquarters of the then Benue Province. It is a few kilometers away from the city of Makurdi, Benue's state capital. It is located about 24Km along the Makurdi-Gboko highway. It is a town lying on the eastern bank of River Benue largely inhabited by the Jukun fisher-men. The water from the river is used by the inhabitants of this area for domestic purposes like washing of plates and pots, washing of clothes and washing of motorcycles and cars among others. There are a lot of dumpsites by the river bank which serves as point source for leachate that runs down the river. Other runoffs are from farmlands in the area and from catchments area of the river.

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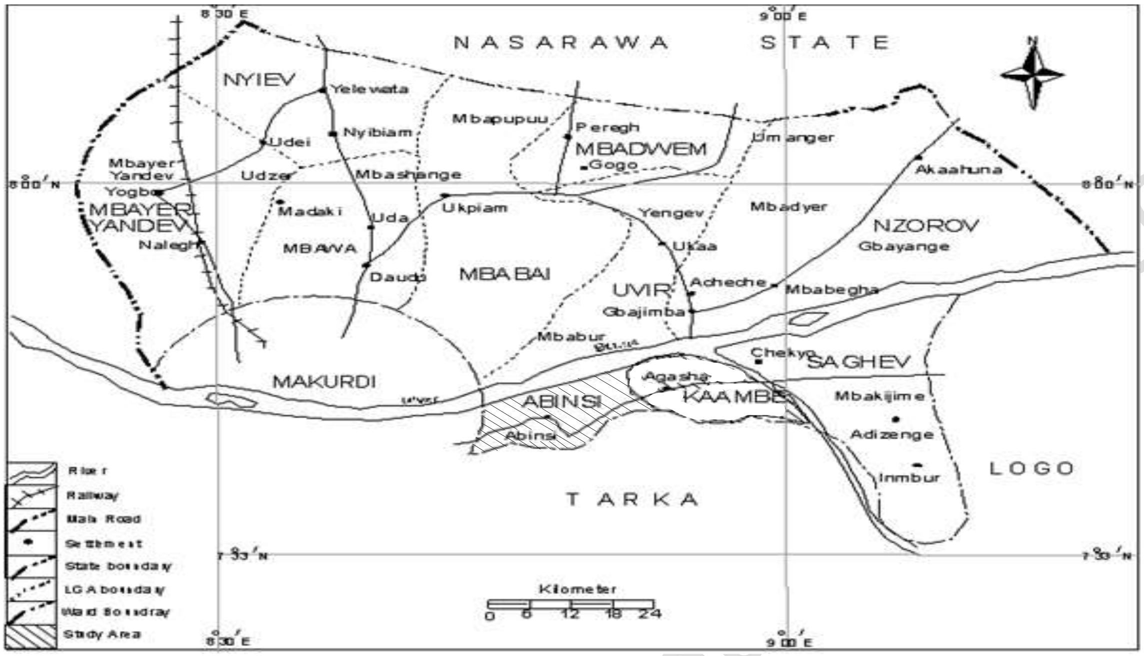

Figure 1: Map of Guma LGA showing Abinsi
(Source: Ministry of Land and Survey, Makurdi, Benue State.)

Sample collection

20 Fresh fish samples of uniform size of *Tilapia zilli* were collected twice directly from different fisher-men at different points at the bank of River Benue at Abinsi. The fish samples were identified using keys from Idodo-Umeh (2003). The fish samples were put in a plastic container with ice block and transported to the Advanced Research laboratory of the Department of Biological Sciences, University of Agriculture Makurdi for preparation on the same day.

Sample preparation

The fish samples were allowed to thaw at room temperature, after then they were rinsed with tap water then rinsed twice with distilled water to remove dirty and impurities. The scales of the fish were removed before the fish samples were dissected with clean stainless-steel knife to remove the liver. Other unwanted parts like the head, fins and offal were removed and the rest of the fish bodies were cut into smaller pieces to aid oven drying. The liver and the muscles of the fish were placed differently on a foil paper and put in an oven at a temperature of 105°C for 24 hours to obtain a constant weight (AOAC, 1990). After oven drying, the bones were removed from the muscles and the samples were then homogenized using porcelain mortar and pestle. The powdered samples were then sieved using sethi standard test sieve BSS 40. The samples were then put in a sterile sample bottles and labelled.

Sample digestion

Powdered samples (0.5g of each fish sample) were weighed accurately with a weighing balance (Ohaus Model- AR 2130) and put into a flat bottom flask. 5ml of Nitric/per chloric acid (HNO_3/$HCLO_4$) in the ratio 2:1 was measured using a measuring cylinder and added to each sample and shaken. It was then placed on a hot plate (ES-3615) in a fume hood (Bio base model- FH 1800) to digest until a transparent or clear solution is attained. The solution was allowed to cool then filtered with whatman No.1 filter paper. The filtrate was then filled up to a mark of 25ml using deionized water. The solution was then transferred into a labelled sample bottle for analysis.
Sample blank was also prepared using the same digestion procedure but without the fish samples in it and transferred into sample bottles for analysis.

Sample analysis

An atomic absorption spectrophotometer (Buck scientific Model- 210 VGP) using element specific hollow cathode lamp by flame absorption mode was used for the analysis. Calibration of the instrument was performed by first analysing three standard solutions for each metal, followed by the blank analysis before the sample analysis. Before analysing each metal, its standard solutions and blank have to be analysed first. For quality assurance, all samples were analyzed in triplicate. The metals analyzed for were Cadmium, Copper, Iron, Lead and Manganese.

RESULTS

The concentration of the heavy metals in the fish is shown in figure 2.

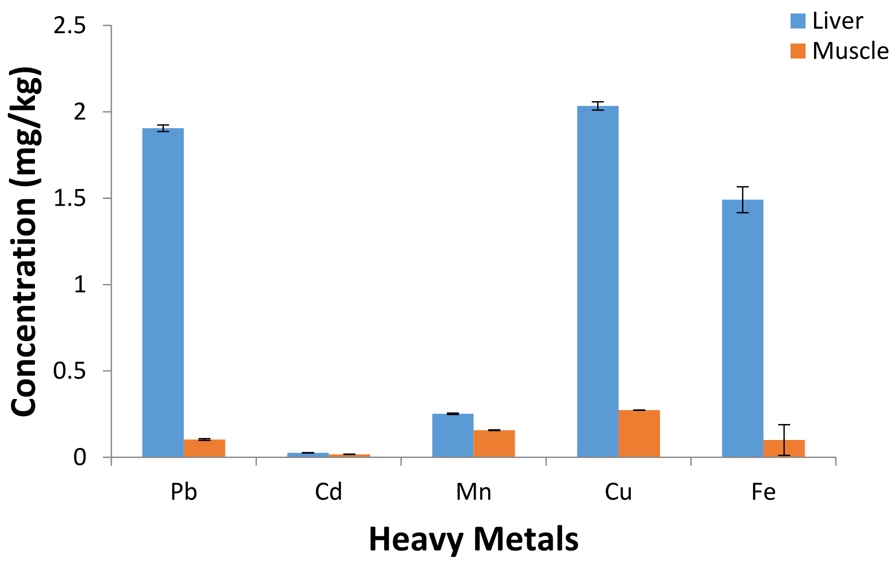

Figure 2: Comparison of heavy metals between tissues of *Tilapia zilli.*

For the liver, the concentrations (mean±S.D) of the metals Pb, Cd, Mn, Cu and Fe were found to be 1.905±0.019, 0.026±0.001,0.252±0.004, 2.034±0.024 and 1.491±0.075mg/kg dry weight respectively. For the muscles, concentration of the metals was found to be 0.103±0.005, 0.017±0.000,0.157±0.002, 0.237±0.001 and 0.1±0.03mg/kg. The metal concentration pattern in the tissues of the fish differs. The highest concentrations were mostly found in the liver with Cu having the highest value of 2.034mg/kg followed by Pb with 1.905mg/kg and Fe with 1.491mg/kg. Analysis of variance conducted on the data showed that there is a significant difference in metals concentration between the muscles and the liver ($p<0.05$). The pattern of metal concentration in the liver of the fish was in the order Cu>Pb>Fe>Mn>Cd while that of the muscle is in the order Cu>Mn>Pb>Fe>Cd

Table 1: Heavy Metals concentration (Mg/Kg) in fish species

Fish	Tissue	Heavy metals				
Tilapia zilli		Pb	Cd	Mn	Cu	Fe
	Liver	1.905±0.019[b]	0.026±0.001[a]	0.252±0.004[a]	2.034±0.024[b]	1.491±0.075[b]

	Muscle	0.103±0.005[a]	0.017±0.000[a]	0.157±0.002[a]	0.273±0.001[a]	0.100±0.030[a]

Mean with the same letter within a column are not significantly different at $p>0.05$

Table 2: Comparison of Heavy Metals concentration (Mg/Kg) in fish species with WHO/FAO and EU standards.

Heavy metals	Fish part		WHO/FAO	EU
	Liver	Muscle		
Pb	1.905	0.103	0.3	0.3
Cd	0.026	0.017	0.5	0.05
Mn	0.252	0.157	0.5	
Cu	2.034	0.273	0.5	
Fe	1.491	0.100	0.8	

All values are means of triplicate determinations

DISCUSSION

Heavy metals pick their target body part based on the amount of the metabolic activity (Toochaeia *et al.*, 2013). There have been many studies on concentration of heavy metals in fish tissues which shows that metals may concentrate at different levels in different fish body parts.

The result of this study indicates that Pb, Cu and Fe concentrate more in the liver of the fish than the muscles. This result is in consistent with the findings of Erhabor and Obasohan (2011) who observed higher values of Cu, Fe and Mn in *Chrysichthys nigrodigitatus* and *Parachanna obscura* from Ibiekuma stream, Ekpoma, Edo state.

Pb concentration in the fish was significantly higher ($P<0.05$) in the liver with the value 1.905mg/kg. This value is higher than the WHO/FAO and EU permissible limits of 0.3mg/kg in fish. The concentration of Pb in the muscle of the fish was lower than the permissible limits. This result is in agreement with the findings of Eletta *et al.* (2003) who found out higher concentration of Pb in *Tilapia zilli* and *Synodontis membrane* from Asa River in Ilorin. Bolowa and Gbenle, (2010) also found higher concentrations of Pb in *Tilapia oreochromis* from Makoko and Carter Bridge in Lagos. Lead is a toxic metal which have no significant biological function. It can induce carcinogenic effects on living organisms and humans even at low concentrations. Other toxicological effects of lead include: rise in blood pressure, kidney damage, brain damage, disruption of nervous system, miscarriages and subtle abortions etc. When lead accumulates in the human body, it replaces calcium in bones (DHSS, 1980). Waste runoff from the use of chemicals on farmlands from catchment areas of the river, lubricants like engine oil which may run down into the river from mechanic workshop around and as inhabitants of the area wash their motorcycles and cars at the bank of the river may be responsible for the presence of lead in the water which the fish are found. Other sources could be from the exhaust of vehicles run with leaded fuels that reaches the river by a way of wind-blown dust and other anthropogenic activities upstream.

From this study, it is advisable that people that eat fish whole should be mindful of some of the parts they eat especially the liver because of its tendency to bio accumulate metals. It is advisable that the liver of *Tilapia zilli* caught from river Benue at Abinsi should be removed before fish consumption to avoid contamination from lead.

Cadmium like Pb is also a toxic metal with no known biological function. Effects of Cd on human health include: bone fracture, damage to central nervous system, psychological disorder, acute and renal failure in humans etc.

The concentrations of Cd in the tissues of the fish were significantly low (P>0.05). This means that there is no significant difference between metal concentrations in the tissues of the fish species. Cd concentration was found to be 0.026 and 0.017mg/kg in the liver and muscle of the fish respectively. These values are below the 0.05mg/kg permissible limit of WHO/FAO and EU. Akan *et al*. (2012) also found similar results when they studied *Tilapia zilli, Clarias anguillaris, Synodontis budgetti* and *Oreochromi sniloticus* from river Benue at Vinikilang, Adamawa state. Ekpo *et al*. (2008) findings from Ikpoba River in Benin City were also consistent with the result of this study.

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From this result, it can be said that the water from river Benue at Abinsi is not contaminated with Cd, therefore consumption of fish from this study location could not pose any cd-induced health hazard to humans.
Mn is an essential micronutrient needed in the body. It is found mostly in bones, liver, kidneys and pancreas. Mn helps the body form connective tissues, bones, blood clotting factors and sex hormones. It also plays a role in fat and carbohydrate metabolism, calcium absorption and blood sugar regulation. Toxic effects of Mn include: hallucinations, forgetfulness and nerve damage. It can also cause lung embolism and bronchitis. When men are exposed to Mn for a longer period of time, they may become impotent. The concentration of Mn in the tissues of the fish is significantly low ($P>0.05$) when compared with the maximum permissible limit by WHO/FAO for presence of Mn in food. The concentrations are 0.252 and 0.157mg/kg for the liver and muscle respectively. Mn concentration in the fish is lower than that reported by Edward *et al*. (2013) in *Clarias gariepinus* in Ado Ekiti and Yaduma and Humprey (2009) in *Clarias anguillaris* and *Heterotis niloticus* from Lake Geriyo in Yola. This result corresponds with the report of Rashed (2001) who found out lower levels of Mn in the muscle of *Tilapia nilotica* from Nasser Lake in Egypt. Eneji *et al*. (2011) also found lower concentrations of Mn in the organs of *Clarias gariepinus* and *Tilapia zilli* from river Benue in Makurdi. This result indicates that fish from river Benue at Abinsi is not contaminated with Mn and consuming it will not cause any Mn toxicity. Mn is not found as a free element in nature, it does not occur naturally as a metal in aquatic ecosystems (Edward *et al*., 2013). It is often found in combination with Fe and in many minerals.
Copper is essential to all living organisms as a trace dietary mineral because it is a key constituent of the respiratory enzyme complex cytochrome c oxidase. The main areas where copper is found in humans are liver, muscle and bone (Johnson and Larry, 2008). Copper concentration in the fish tissues was significantly higher ($P<0.05$) in the liver with the value 2.034mg/kg. The concentration in the muscle was significantly low ($P>0.05$). One of the diets of *Tilapia zilli* is detritus and one of the natural sources of copper is decaying vegetation. Therefore, the fish might have accumulated

this level of Cu from feeding on detritus at the bottom of the river. Other sources of Cu may be from wind-blown dust and accumulation of domestic and agricultural wastes. Cu is an essential part of several enzymes and it is necessary for the synthesis of haemoglobin but can do harm at high concentrations (McCluggage, 1991). The effects of copper toxicity in human body include: vomiting, diarrhea, liver and kidney damage, brain damage and renal disease. The result of the study is consistent with the report of Rashed (2001) who found higher levels of Cu in the liver of *Tilapia niloticus* but lower in the muscle. Ezekiel *et al*. (2012) also found higher concentration of Cu in the liver of *Chrysichthys nigrodigitatus* from Cross River State. Akan *et al*. (2009) recorded high level of Cu from Lake Chad in the liver tissues studied. They conducted that it was due to the fact that the liver is a target organ for the accumulation of this element. Canpolat (2013) found similar values in the tissues and organs of *Capoeta umbla* from lake Hazar, Turkey. He reported that the liver contains the higher concentration of the metal (Cu).

From this study, it is advisable that people that eat fish whole especially *Tilapia zilli* should be mindful of the liver because of its tendency to bio-accumulate metals. It is advisable that the liver of *Tilapia zilli* caught from River Benue at Abinsi should be removed before fish consumption to avoid contamination from Cu. There is no health hazard associated with the consumption of *Tilapia zilli* muscle.

Fe is a metal essential for life. It is present in every living cell and is necessary for the production of haemoglobin, myoglobin and certain enzymes (Akoto *et al*., 2014). Fe is also necessary for growth, development, normal cellular functioning and synthesis of some hormones and connective tissue. Fe concentration was found to be significantly higher ($P<0.05$) in the liver of the fish species. Therefore, there is a significant difference in Fe concentration between the tissues. Lower concentration was found in the muscles. The concentration was 1.491mg/kg in the liver of the fish. This high concentration recorded was above the WHO/FAO permissible limits for Fe in food. Asaolu and Olaofe (2004) reported that Fe occurs at high

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concentration in Nigerian soils; therefore, the fish might have gotten this Fe from the sediments in the river.

Fe toxicity can result in DNA damage, damaging of cells in the heart, liver and elsewhere which can cause significant adverse effects including coma, shock, liver failure, adult respiratory distress syndrome, long term organ damage and even death. Makimilua and Afua, (2013) found similar results in both catfish and tilapia from Densu river in greater Accra of Ghana. Edward *et al*. (2013) also found similar result. Toochaei *et al*. (2013) reported that Fe has the highest concentration in the liver of loach fish (*Paracobitis rhadinaea*) in sistan'schahnimeh reservoirs, Iran. Erhabor and Obasohan (2011) found similar result as well from the fishes they studied from Ibiekuma stream in Edo state. They stated that higher level of the metal in the fishes is expected because the metal is an essential element required in an organism's blood haemoglobin for oxygen transportation. Eneji *et al.* (2011) reported higher concentration of Fe in both the organs of *Tilapia zilli* and *Clarias gariepinus* from River Benue.

It can be observed based on the result of this study that the liver accumulated most of these metals than the muscle. The reason that explains why metals accumulate higher in the liver than muscles may be due to the following: the liver is the tissue in charge of metal compounds. It is the centre of metabolic activities; it plays an important role in the storage and detoxification of heavy metals (Erhabor and Obasohan 2011). Liver is considered to be a suitable indicator for studying long term exposure to heavy metals because it is the metabolism place of metals (Filazi *et al*., 2003). Ekpo *et al.* (2013) reported similar result that metals accumulate more in the liver than any other tissue. Muscles accumulate lower levels of metal in both species. This is of great importance because muscles contribute the greatest mass of the flesh being consumed as food for man and other animals. The reason for low metal concentration in the muscles may be because it is not an active organ in metabolic activities. This agrees with what Eneji *et al.* (2011), Al-weher (2008) and Babatunde *et al*. (2012) reported.

CONCLUSION

Based on the findings of this study, the muscle of *Tilapia zilli* is not contaminated with the metals investigated. Metals like Pb, Cu and Fe were found to be at higher concentration in the liver. Thus, consuming the muscles will not cause any problem to humans but people that consume fish as whole should be mindful of the liver because of its tendency to bioaccumulate metals. Tilapia zilli can be used as a good bioindicator for heavy metal monitoring in water.

RECOMMENDATIONS

1. Periodical monitoring of heavy metals level in the fishes is needful, especially for *T. zilli* liver because of its tendency to accumulate metals at high concentrations.
2. Dumping of waste and washing of automobiles at the river bank should be prohibited because these are sources of metal contaminants in the water.
3. The use of compost manures should be encouraged in order to reduce the use of chemical fertilizers in agriculture to reduce runoffs of chemicals into the water body.

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