Research Journal of Chemical Sciences ____ ISSN 2231-606X
Vol. **3(3),** 70-75, March **(2013)** *Res. J. Chem. Sci.*

Assessment of Some Trace Metals Content of *Oreochromis niloticus* Obtained from River Okpokwu, Apa Benue State, Nigeria

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Available online at: www.isca.in
Received 5th February 2013, revised 13th February 2013, accepted 28th February 2013

Abstract

This study was conducted with the aim of determining the concentrations of As, Mn, Cu, Pb, Cd and Fe in whole Oreochromis niloticus (tilapia) and its fresh water habitat using recommended analytical procedures and compare the results with WHO's permissible limits. Samples of fresh water and the fish were collected weekly at the peak of rainy and dry seasons in the study area (October, 2010 and February, 2011) respectively at three locations; Auke, Odejo and Ochalanya along the river. Across the sampling points, the results obtained using Unicam Solar (32) Atomic Absorption Spectrophotometer showed that the trace metal contents of Oreochromis niloticus varied between 0.05±0.01µg/g As to 0.38±0.04µg/g Fe in October, 2010 and 0.09±0.03µg/g As to 0.28±0.02µg/g Fe in February, 2011. The water levels of the trace metals ranged from 0.06±0.02µg/L As to 1.24±0.05µg/L Fe in October, 2010 and 0.04±0.01µg/L As to 0.59±0.10µg/L Fe in February, 2011. There were positive correlations between the concentrations of the trace elements in the whole fish and river water. T-test analyses of the levels of the trace metals between the sampling periods were statistically significant (P < 0.05). The levels of the trace metals recorded in this study were below WHO's permissible limits. Therefore, the water and Oreochromis niloticus obtained from the study area have not become contaminated by the trace metals studied. However, periodic review should be sustained to monitor possible accumulations of the heavy metals in future due to the proliferation of anthropogenic activities around river Okpokwu.

Keywords: Agrochemicals, o*reochromis niloticus*, trace metals, river okpokwu.

Introduction

Trace metals are natural components of the environment but they have become a matter of great concern because of the continuous increase in concentration of these metals in our environment. The pollution of water bodies in the urban, industrial and agricultural areas has resulted to increased concentration of heavy metals and minerals in the internal body of fish[1]. This situation was further aggravated by the rapid growth of population, increased urbanization and expansion of industrial activities, exploration and exploitation of natural resources as well as the modern agricultural practices and lack of environmental regulations[2-4]. As heavy metals cannot be degraded, they are deposited, assimilated or incorporated in water, sediment and aquatic animals[5] and present great dangers to organisms in the food chain. Research works have shown that heavy metals can be bio-accumulated and biomagnified via the food chain and finally assimilated by human consumers with the attendant adverse health effects[6]. As a consequence, fish are often used as indicators of heavy metals contamination in the aquatic ecosystem because they occupy high trophic levels and are important food source[6,7]. Unacceptable levels of lead and mercury were reported in the study on tissues of African catfish, *Clarias gariepinus* from River Niger[8]. Similarly, the levels of lead, copper and zinc reported in the study on Nile tilapia, *Oreochromis niloticus* caught from River Delimi, Jos were too high for frequent human consumption[9].

It has been observed that the functioning of the natural ecosystems is increasingly being affected by human activities. Research work has shown that it is difficult to find a river or other water bodies whose natural regime has not been modified by man's activities[10]. The unsanitary habits of depositing industrial wastes at dumps without adequate treatment or directly into the aquatic environment is a common sight in many industrial cities in Nigeria[11]. Among the rural populace also, there has been indiscriminate usage of different agrochemicals in farm lands at the banks of rivers which provide sources of water to the host communities for domestic and agricultural purposes. The result is that toxic and hazardous materials including heavy metals are transported to several water bodies (rivers, streams, lake, and ponds) with potential effects on aquatic organisms.

Over the years there has been a remarkable degradation in the quality of River Okpokwu and its portability due to the proliferation of chemical-based agriculture, mining and block industry activities in the major settlements along the rivers. Agricultural contamination of many resources through fallout, drainage and runoff erosion is highly probable in rivers within the vicinity of intensive agricultural activities. Furthermore, there is no clear documentation of any effect of anthropogenic activities around River Okpokwu. Thus, this study provides a baseline data of the levels of some heavy metals in *Oreochromis niloticus* and water from River Okpokwu and the result formed basis for monitoring the pollution by the heavy metals in River Okpokwu.

Material and Methods

The Study Area: River Okpokwu is one of the relief features in Apa LGA of Benue State, Nigeria. It is located on longitude 7.80°E and latitude 7.58°N. The River is located 4km away from Ugbokpo, Apa Local Government Headquarters. River Okpokwu meets river Ochekwu at Odejo, Agatu LGA and they flow into River Benue at Ocholonya, also in Agatu LGA. Unlike other rivers within the locality, River Okpokwu never dries up completely during dry season. The volume and size of the river increase very rapidly during rainy season. Thus, it sustains high agricultural and fishing activities. Near the source of this river, there is high gravel mining activity while along the river, there are high chemical-based farming activities and block industries. These activities constitute potential sources of surface and underground water pollution.

Samples Collections and Preservation: A total of eighteen (18) samples each of *Oreochromis niloticus* (Tilapia) and water were collected from three locations; Auke, Odejo and Ocholonya in River Okpokwu during the months of October, 2010 and February, 2011. These periods were chosen to represent the peaks of rainy and dry seasons in the study area. *Oreochromis niloticus* is a surface feeder and it feeds from its water habitat. The fish were collected and transported to the laboratory in ice boxes and rinsed with deionized water and frozen at -10°C prior to analyses[12]. The samples were preserved in a refrigerator at 5°C[1].

Water samples were collected at each extremity and median part of the river by immersion of polythene bottles to approximately 30cm below the water surface and allowed to overflow. All containers used for sampling and storage were thoroughly washed with solution of detergent and distilled water. They were then soaked in 10% “Analar” nitric acid overnight followed by rinsing with distilled water to remove trace elements contamination[13].

Samples Preparations and Analyses: Water Sample: Raw water was subjected to wet digestion. 100ml unfiltered water was measured into a 250ml beaker and 20ml “Analar” nitric acid solution plus 10ml of 50% hydrochloric acid solution were added. The acidified water was then evaporated to almost dryness on a hot plate and 5ml of 50% hydrochloric acid was again added and heated for 15 minutes. The beaker was removed and cooled to room temperature before transferring the content into a 100ml volumetric flask and made up to the mark with distilled water[13]. The digested water was filtered and analyzed for the levels of As, Mn, Cu, Pb, Cd and Fe using Unicam Solaar (32) Atomic Absorption Spectrophotometer (AAS).

***Oreochromis niloticus*:** The fishes were discaled and inviscerated and then transferred to electric oven at 40°C. They were dried in the oven at this temperature for 24hours and then pulverized in a clean dry porcelain mortar[12]. The pulverized fish samples were dried further for 1hour at reduced temperature of 20°C and put into clean dried bottles[14]. 3.00g of the dried fish samples were weighed into a silica crucible and ashed in a muffle furnace at a temperature of 600°C for 5hours[14,1]. The ashes were cooled to room temperature and filtered to remove particles and then transferred into a 250ml conical flask. Thereafter, 20ml of concentrated HNO_3 was added and then diluted to 50ml with deionised water and swirled gently. The volume was made up to 100ml marks in a volumetric flask with deionised water and analyzed for heavy metals as in the water.

Data Handling: The data generated were subjected to t-test ($p < 0.05$) to determine the significance of mean metal concentrations between the sampling periods. Correlation analysis was also carried out to assess the relationship between fish metals content and those of its water habitat.

Results and Discussion

The results in table-1 presents the concentrations (µg/g) of the trace metals in *Oreochromis niloticus* (tilapia) obtained from River Okpokwu in the months of October, 2010 and February, 2011. Across the sample locations, As and Mn concentrations in *Oreochromis niloticus* ranged from 0.05±0.02 to 0.11±0.03(µg/g) and 0.08±0.04 to 0.17±0.02(µg/g) in October, 2010 and while the concentrations in February, 2011 revealed 0.09±0.03 to 0.16±0.04(µg/g) and 0.19±0.02 to 0.22±0.03(µg/g) respectively. Copper (Cu) concentrations varied between 0.10±0.03 to 0.15±0.02(µg/g) and 0.14±0.02 to 0.23±0.03(µg/g) during the same period respectively. Cadmium (Cd) was not detected in the fish but Pb concentrations ranged from 0.03±0.01 to 0.05±0.02(µg/g) and 0.05±0.02 to 0.08±0.01(µg/g), Fe concentrations varied between 0.31±0.05 to 0.38±0.03(µg/g) and 0.21±0.08 to 0.28±0.02(µg/g) in the months of October, 2010 and February, 2011 respectively. T-test analyses of the variations of paired mean (October, 2010 and February, 2011) are statistically significant ($P < 0.05$). The overall mean concentrations of the trace metals recorded in the fish in this study (figure-1) showed very high level of iron in October. Generally, the results of the mean concentrations of the trace metals were higher in February than October. This may be due to the effect of bioaccumulation over the periods that the fish lived and fed in its water habitat. Studies have shown that direct absorption and bioaccumulation of toxic heavy metals are common in aquatic environment where organisms are exposed to the same concentrations of the substances present in the water environment[15].

The concentrations (µg/l) of the trace metals in the river water (Table-2) showed that arsenic (As) varied between 0.06±0.02 to 0.09±0.04(µg/l) in October, 2010 and 0.02±0.01 to 0.05±0.01(µg/l) in February, 2011. The other results showed that Mn ranged from 0.26±0.05 to 0.34±0.08(µg/l), Cu varied between 0.54±0.05 to 0.74±0.02(µg/l), Pb varied between 0.06±0.01 to 0.31±0.02(µg/l) and Fe ranged from 1.03±0.02 to

1.24±0.05(µg/l) in October, 2010. Similar results in February, 2011 revealed 0.20±0.03 to 0.41±0.04(µg/l) Mn, 0.25±0.06 to 0.37±0.08(µg/l) Cu, 0.12±0.03 to 0.16±0.04(µg/l) Pb and 0.40±0.03 to 0.59±0.10(µg/l) Fe. Cadmium (Cd) was also not detected in the water.

The overall mean concentrations of the trace metals in the river water (figure-2) revealed significantly ($p < 0.05$) higher levels of iron and copper in October, 2010. This may be attributed to the input by surface run-off through quarry sites, agricultural fields and domestic wastes located along the river. Furthermore, the high iron and copper levels of the river may also depend on hydrological situation. In a study on the distribution pattern of trace metal pollutants in the sediments of an urban wetland in Southwest coast of India it was observed that trace metals are among the most common environmental pollutants and their occurrence in waters indicate the presence of natural or anthropogenic sources[16]. It has also been reported that heavy metals or their compounds may be discharged from industries, farmlands, municipal urban water runoffs, and agricultural activities into surface water and can cause pollution[17]. Most of the iron in river is particle-bound which suggests why the total iron content of the river water is influenced by the amount of suspended solids in the water and by the concentration of iron on these particles. Copper is an essential trace element used in pesticides formulations. The agricultural fields along the river received different types of pesticides during pests control of the cropping season. Thus, during the peak of raining season where the river water was very high and received maximum effluents from drainages through farms and quarry industries; the flood events mobilised varying degree of contaminants into the river so that concentration peaks may occur. Heavy metals are highly persistent and can easily enter a food chain and accumulate until they reach toxic levels. In February however, the rain fall has stopped and the volumes of effluents discharge into the river via surface run off have reduced. Consequently, substantial amount of the chemical residues initially washed into the river during rainfall settled at the bottom sediment of the river and less contents are possible in the river water. This may be responsible for the general lower levels of most of the trace metals recorded in the river water in February.

The concentrations of the trace metals in *Oreochromis niloticus* are positively correlated with the heavy metals in water (table-3). This suggests that the water metals content have significant effect on the availability of the trace metals to the fish and hence, the bioaccumulation into the tissues.

The results of the bio-accumulation factors of the trace metals (figure-3) revealed very high absorption of arsenic in both October, 2010 and February, 2011. This may present serious health challenge to the consumers of *Oreochromis niloticus* in the study area. Fish, shellfish, meat, poultry, dairy products and cereals have been reported as the main sources of dietary intake of arsenic. However, the arsenic content of fish and shellfish usually involves organic compounds (e.g. arsenobetaine) that are of low toxicity[18]. A report of the World Health Organisation indicated that the International Agency for Research on Cancer (IARC) classified arsenic and arsenic compounds as carcinogenic to humans (group 1), which means that there is sufficient evidence for their carcinogenicity in humans[19]. Generally, the levels of the trace metals recorded in this study were below the WHO's Permissible Limits of 0.05mg/L As, 1.0mg/L Cu, 0.01mg/L Pb, 0.30mg/L Fe and 0.10mg/L Mn for water and 0.03mg/g Cu , 0.10mg/g Fe, 0.02mg/g Pb and 0.01mg/g Mn for fish respectively[20].

Table-1
Concentrations (µg/g) of the trace metals in *Oreochromis niloticus* obtained from river Okpokwu in October, 2010 and February, 2011

Heavy Metals	Auke		Odejo		Ocholonya	
	Oct. 2010	Feb. 2011	Oct. 2010	Feb. 2011	Oct. 2010	Feb. 2011
As	0.11^{a}±0.03	0.16^{b}±0.04	0.05^{a} ±0.02	0.09^{a} ±0.03	0.07^{a}±0.03	0.11^{b}±0.02
Mn	0.17^{a} ±0.02	0.21^{b}±0.06	0.13^{a}±0.01	0.22^{b}±0.03	0.08^{a}±0.04	0.19^{b}±0.02
Cu	0.13^{a} ±0.05	0.17^{b}±0.04	0.10^{a}±0.03	0.14^{b}±0.02	0.15^{a}±0.02	0.23^{b}±0.03
Cd	-	-	-	-	-	-
Pb	0.05^{a}±0.02	0.07^{b}±0.03	0.04^{a}±0.02	0.08^{b}±0.01	0.03^{a}±0.01	0.05^{b}±0.02
Fe	0.31^{a}±0.05	0.21^{b}±0.08	0.38^{a}±0.03	0.28^{b}±0.02	0.37^{a}±0.06	0.27^{b}±0.04

''-'' = Not detected. T-test of paired mean (October, 2010 and February, 2011) with different alphabets are statistically significant ($P < 0.05$). Data presented are mean ± SD of replicate analyses (n=4). SD = standard deviation

Table-2
Concentrations (µg/L) of the trace metals in water obtained from river Okpokwu in October, 2010 and February, 2011

Heavy Metals	Auke		Odejo		Ocholonya	
	Oct. 2010	Feb. 2011	Oct. 2010	Feb. 2011	Oct. 2010	Feb. 2011
As	$0.06^a±0.02$	$0.02^b±0.01$	$0.07^a ±0.03$	$0.05^a ±0.01$	$0.09^a±0.04$	$0.04^b±0.01$
Mn	$0.34^a ±0.08$	$0.20^b±0.03$	$0.31^a±0.02$	$0.41^b±0.04$	$0.26^a±0.05$	$0.36^b±0.03$
Cu	$0.54^a ±0.05$	$0.35^b±0.02$	$0.59^a±0.04$	$0.37^b±0.08$	$0.74^a±0.02$	$0.25^b±0.06$
Cd	-	-	-	-	-	-
Pb	$0.31^a±0.02$	$0.16^b±0.04$	$0.08^a±0.01$	$0.13^b±0.02$	$0.06^a±0.01$	$0.12^b±0.03$
Fe	$1.06^a±0.05$	$0.40^b±0.03$	$1.03^a±0.02$	$0.58^b±0.03$	$1.24^a±0.05$	$0.59^b±0.10$

''-'' = Not detected. T-test of paired mean (October, 2010 and February, 2011) with different alphabets are statistically significant ($P < 0.05$). Data presented are mean ± SD of replicate analyses (n=4). SD = standard deviation

Table-3
Correlation Coefficient of the Concentrations of the Trace Metals in the River Water and *Oreochromis niloticus*

	As	*Mn*	*Cu*	*Pb*	*Fe*
As	1.0000				
Mn	0.7327	1.0000			
Cu	0.4989	0.9554	1.0000		
Pb	0.8788	0.9687	0.8520	1.0000	
Fe	0.3931	0.9138	0.9930	0.7843	1.0000

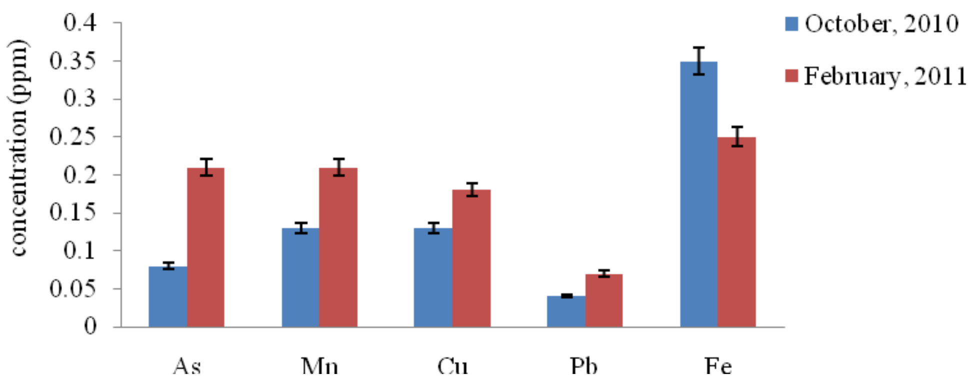

Figure-1
Overall mean concentrations (ppm) of the trace matals in *Oreochromis niloticus*

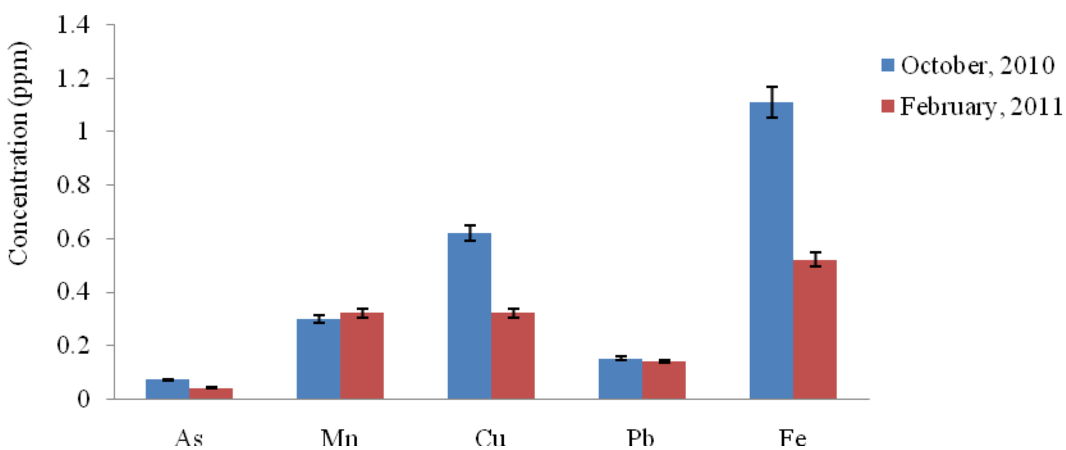

Figure-2
Overall mean concentrations (ppm) of the trace matals in the river water

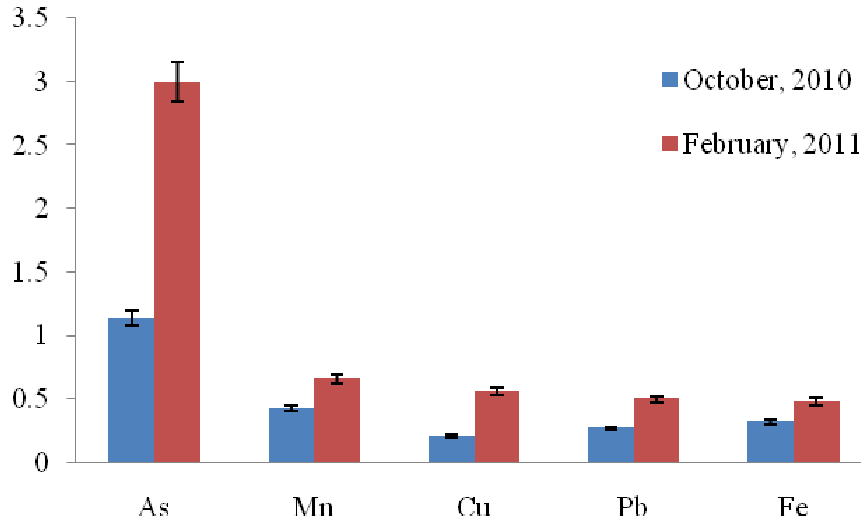

Figure-3

Bio-accumulation factors of the trace metals in *Oreochromis niloticus*, Bio-accumulation factor = Metal concentration in fish/Metal concentration in river water

Conclusion

The results of this study revealed variable concentrations of As, Mn, Pb, Cu and Fe in *Oreochromis niloticus* (Tilapia) and water obtained from river Okpokwu in October, 2010 and February, 2011. The water recorded elevated levels of the trace metals in October which may due to the high surface runoff of effluents from agricultural lands, quarry industries and domestic waste into the river. The fish contents of the trace metals were higher in February, probably due to the effect of bioaccumulation over the periods of its habitation and feeding in the water environment. However, the levels of the trace metals recorded in this study were below the WHO's Permissible Limits. Accordingly, the water and *Oreochromis niloticus* from the study area have not become contaminated by the trace metals studied. Therefore, periodic review should be sustained to monitor possible accumulations of the trace metals in future due to the proliferation of anthropogenic activities around river Okpokwu.

Acknowledgement

The authors are thankful to the management of Sheda Science and Technology Complex (SHESTCO), Abuja for providing the required laboratory facilities and skills for the analyses.

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