Special Conference Edition, November, 2018

http://dx.doi.org/10.4314/bajopas.v11i1.70S

Bayero Journal of Pure and Applied Sciences, 11(1): 443 - 450
ISSN 2006 – 6996

HEAVY METALS BIOACCUMULATION IN TISSUES OF *Tilapia zilli* AS INDICATORS OF WATER POLLUTION IN KAFINCHIRI RESERVOIR, KANO – NIGERIA

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ABSTRACT

This study assessed the levels of heavy metals accumulation in water, gills and liver of Tilapia zilli fish collected from Kafinchiri water Reservoir for a period of four months with the aim of predicting health risk effect on consumers. Water and Tilapia zilli samples were collected from three different sites along the course of the dam; upstream, midstream and downstream. The concentration of copper, lead, chromium and cadmium in water and their accumulation in the liver and gills of the sampled fishes were determined using atomic absorption spectrophotometer. The results revealed that concentration of dissolved heavy metals in the water ranges from Cu (0.4mg/L- 0.6mg/L), Pb (0.9 mg/L - 1.4mg/L), Cr (undetected - 0.1mg/L) and Cd (0.01mg/L – 0.02mg/L). Accumulation in the gills of tilapia fish ranges from Cu (0.8µg/g - 0.85µg/g), Pb (0.3µg/g -0.9µg/g), Cr (≤0.1µg/g) and Cd was not detected. The accumulation of heavy metals in the liver were Cu (3.0µg/g - 5.4µg/g), Pb (2.7µg/g - 9.6µg/g) and Cr (0.1µg/g - 0.15µg/g) and Cd not detected. Water content chemical analysis indicated that; sampling point B (midstream) had the highest concentration of the heavy metals in which Pb recorded had the highest Bioaccumulation factor (BAF) of 5.76. The mean range of physicochemical parameters studied were temperature (25.90 - 27.37 °C), pH (7.60 - 8.52), DO (6.27 - 7.47mg/L), BOD (2.02 - 3.02mg/L), turbidity (28.05 - 34.00 NTU), electrical conductivity(187.60 - 361.17µS/cm), TDS (211 - 363mg/L), Total dissolved solids, electrical conductivity, turbidity and nitrate recorded significant difference between sites ($P<0.05$). It was believed that domestic activities around the reservoir is the major contributing factor to the accumulation of toxic heavy metals in fish examined. It is recommended that intervention by relevant authorities is needed curtail potential long term effect of this pollutants in the reservoir.

Key words: Heavy metals Pollution, Tilapia zilli, Bioaccumulation, Kafinchiri Reservoir

INTRODUCTION

Water is one of the natural resources and the quality of water is of vital concern for the mankind since it is directly linked with human welfare (Kumar, 2004). Water pollution is a serious environmental problem in the world; it is the degradation in quality of water that renders water unsuitable for it is intended purposes. According to Shukla *et al*. (2007) water pollutant can be broadly classified as organic, in organic, suspended solid and sediment, heavy metals, radioactive materials and heat.

Heavy metal pollution of aquatic environment has become a great concern in recent years because they are very harmful to the entire organisms due to their non-biodegradable nature, long biological half-life and their potential to accumulate in different body parts of organism. They concentrate along the food chain, producing their toxic effects on the consumer (Gupta *et al*., 2009). Compared to other types of aquatic pollution, heavy metals pollution is less visible but its effects on the ecosystem and humans is intensive (Edem *et al*., 2009). The most common potential element (PTE) listed by the FAO (1992) are mercury (Hg), arsenic (As), cadmium (Cd), chromium (Cr),copper (cu), Nickel (Ni), lead (Pb) and Zinc (Zn).

Biomarkers are measurements in body fluids, cells or tissues indicating biochemical or cellular modifications due to the presence and magnitude of toxicants (Galadima and Garba, 2012). In an environmental context, biomarkers offer promise as sensitive indicators demonstrating that toxicants have entered organisms and have being distributed between tissues and consequently eliciting a toxic effect at critical targets (Ishaq *et al*., 2011).

Accumulation of heavy metals in fish tissue depends on factors; heavy metal bioavailability, season of sampling, physical and chemical properties of water (Weiner, 2008). Fish occupies the highest tropic level in aquatic system, with high economic value; they are suitable as water quality indicator organism, due to its potential to accumulate heavy metals and other organic pollutants (Abolude *et al.*, 2009). Heavy metals toxicity can result in damage or reduced mental and central nervous function, lower energy levels, and damage to blood composition, lungs, kidney, liver, and heart (WHO, 1999). Assessments of heavy metals in *Tilapia* sp. which is being consumed by humans will provide a base line in human health risk management and help in tracking environmental contaminants from industrial and domestic sources. In view of the foregoing this research aimed at assessing heavy metals bioaccumulation in tissues of *Tilapia zilli* as Indicators of water pollution in Kafinchiri Reservoir, Kano – Nigeria.

MATERIALS AND METHODS

Study Area

Kafin-Chiri reservoir is located in Garko local government area of Kano State. Kafin-Chiri has an elevation of 478 meters above the sea level, it's centre lies at latitude of $11^0$6 and longitude of 8^0,8'. It receives water from rivers Dudduru (Garin Ali town), Zaboro (Maimanda town) and Marmara (Daka Tsalle town) in Garko and Garin Malam Local Government area respectively. (MANR, 1982)

Fish Samples Collection

Samplings were conducted from 06:00am - 07:00am from each of the sampling stations A, B and C. Fish samples collected fortnightly (June - September, 2017) using a fishing gear such as gill nets, traps and hooks with help of fisher men as adopted by Badamasi (2014). The fishes captured were immediately identified, counted and chilled in ice blocks at the point of collection before being transported to the laboratory in the Department of Biological Sciences, Bayero University Kano, Nigeria for analysis. Identification of fish specimen was done using fish identification guide by Olaosebikan and Raji (2004).

Fish Samples Digestion and Analysis

The fish samples were dissected using the procedure adopted by Babatunde *et al.* (2012). Gills and liver were removed and oven dried at temperature of 105^o C until it reached a constant weight. Each sample was grinded into powdery form and kept in the desiccators prior to digestion. The powdered liver and gills were homogenized and subjected to digestion using concentrated nitric acid and hydrogen peroxide (1:1) v/v according to (FAO, 1992). 1g of the sample powder was weigh into a 250ml round bottom flask and 10ml each of HNO_3 (65%) and H_2O_2 (30%) was added and the content of the flask was allowed to undergo reactions. The content of the flask was heated on a heating mantle to a temperature of 130^o C till dissolution inside a fume hood to reduce the volume to 3ml - 4ml. the digested sample was allowed to cool and filtered into conical flask, the filtered sample was transferred to a 50ml volumetric flask and de-ionized water was used to further dilute the sample to 50ml in the volumetric flask. The concentration of copper, lead, chromium and cadmium (Cu, Pb, Cr and Cd) were determined using Atomic Absorption Spectrophotometer (buck scientific model) at Soil Science Department, Bayero University, Kano.

Bioaccumulation Factor for Heavy Metals in Fish Muscle (BAF)

According to USEPA (2014) guidelines, the BAF is defined as the ratio of chemical concentration in the organism to that in the surrounding water. Bioconcentration occurs through uptake and retention of a substance from water only, through gill membranes or other external body surfaces. It is the ratio of a substance's concentration in tissue of an aquatic organism to its concentration in the ambient water, in situations where both the organism and its food are exposed and the ratio does not change substantially over time. BAF was calculated as described by Malik *et al.* (2010) and adopted by Ekweozor *et al.* (2017).

BAF = M tissue/M water. Where; M tissue is the metal concentration in fish tissue mg/kg and M water, metal concentration in water mg/L.

Analysis of water Sample

The water sample was collected between 7:00am-8:00am for determination of physicochemical parameters from the three for sampling sites A, B and C categorized as upstream, midstream and downstream respectively. Sample was collected at the surface level by dipping 1 litre plastic sampling bottle sliding over the surface of the water with their mouth against the water current to permit undisturbed passage of the water into the bottle. The physico-chemical parameters such as water temperature, turbidity, total dissolved solids, pH, electrical conductivity, dissolved oxygen, B.O.D, nitrate-nitrogen (NO3-N) and phosphate –phosphorus (PO4-P) were analyzed according to APHA (1999).

Statistical Analysis
Data was analyzed using descriptive statistics to determine (means and standard deviations). The data was also subjected to one way analysis of variance (ANOVA) to determine differences between sites, and where differences existed they were separated with Duncan multiple range test (DMRT) at 0.05%.

RESULTS
Physicochemical Parameters
Mean physicochemical values obtained from Kafinchiri Reservoir is illustrated in table 1. The mean range of the water temperature recorded was between 25.90^oC and 27.37^oC with the lowest value recorded in June and the highest in August. Temperature variations between months and sites indicated no significant difference (P<0.05). The range of pH values was pH 7.65-8.50 with the lowest value recorded in June and the highest in September. There was no significant difference recorded between the months (P< 0.05). The monthly difference for TDS indicates mean monthly values of 211mg/L and 363mg/L. It revealed significant differences between the months at P> 0.05.
The DO ranged between 6.27 mg/L in July and to 7.47mg/L in August. The monthly variations in the mean BOD values indicated that site A had the highest value with 3.02mg/L while the least was recorded at site C with 2.02mg/L. Statistically, there was no significant difference in DO and BOD between the months and sites (P<0.05). Mean monthly values of turbidity ranged between 34.0NTU and 28.05NTU at site B and A respectively. Mean turbidity values revealed significant difference between the months (P< 0.05).

Table 1. Mean physicochemical values obtained from Kafinchiri Reservoir, Kano State

Sampling Sites	A	B	C	Standard limits
Water temperature (°C)	25.90±2.43a	27.37±2.13a	26.50±2.55a	<40°Cmg/L*
DO (mg/L)	7.47±0.22a	6.27±0.26a	7.37±30a	5.0-9.0mg/L**
TDS (mg/L)	363±5.90a	240±3.85a	211±0.55a	3.0-6.0mg/L**
BOD (mg/L)	3.02±0.55a	2.05±0.13a	2.02±0.55a	<500mg/L***
Electrical Conductivity (µS/cm)	231.72±0.28	187.60±0.49	361.17±0.45	<1000µS/cm**
Turbidity (NTU)	28.05±3.10	34.00±1.15	31.75±1.50	<25 NTU***
pH	7.60±0.64	8.52±1.05	7.65±0.98	6.0-9.0*

*FEPA (1991), **FME (2001), ***WHO (1999)
Values are mean ±S.D, values with the same letters within the same season were considered not significantly different (P<0.05)

Heavy Metal Analysis
Table 2 illustrate heavy metals concentration in water, gills and liver of *Tilapia zilli* from the reservoir. It revealed that there was no bioaccumulation of Cr at the sampling sites as shown by the BAF of < 1. Cu, Cd and Pb however showed bioaccumulation with BAF of 1.03, 1.00 and 5.76 respectively.
Heavy metal analysis showed that Chromium was below detection level at site B and C water samples, while Lead had the highest concentration in site B (1.42mg/l) followed by site C with 1.02mg/l and the least was recorded at site A (0.8 mg/l) (Fig. 1). However sites variation revealed no significant difference between the metals analyzed (P<0.05). Comparison of heavy metal accumulation in gills and liver tissues revealed that Cd was not detected in gills samples while 0.01 µg/g was recorded in liver tissues (Table 2).
The mean values of heavy metals concentration in the gills follows the order; Cr >Pb > Cu>Cd each with 0.70 µg/g, 0.10 µg/g, 0.04 µg/g and 0.0 µg/g respectively. They differ significantly in all the sampling sites (p<0.05). The liver tissues metals concentration follows the order: Pb>Cu>Cr>Cd each with 9.60µg/g, 1.12 µg/g, 0.37 µg/g and 0.01 µg/g respectively. They differ statistically (p<0.05) (Fig. 2). This was statistically significant in all sites (p<0.05) (Fig. 2). Sampling sites variation revealed that liver had the highest metal concentrations of Pb with 9.60 µg/g, at site B while the lowest was recorded at site A with 2.2 µg/g (Fig.3). Higher Pb concentrations in liver among other metals statistically revealed significant difference (P<0.05).

Table 2: Heavy metals Concentration in Water, Gills and Liver of *Tilapia zilli* from Kafinchiri Reservoir, Kano State

metal concentration (μg/g)	Water	Gills	Liver	BAF	FAO (1992, 2004)
Cu	1.12 ± 0.01	0.04±0.01	1.12±0.18	1.03	NA
Pb	1.48 ± 0.02	0.10±0.01	9.60±1.21	5.76	0.5
Cr	1.53 ± 0.14	0.70±0.01	0.37±0.01	0.69	0.5
Cd	0.01 ± 0.01	0.0±0.0	0.01±0.01	1.00	0.01

BAF = Bioaccumulation Factor, NA= Not available

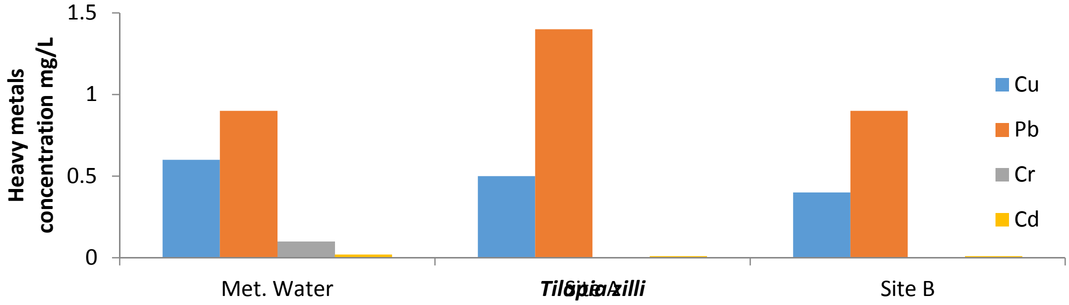

Fig.1: Mean Concentration of Heavy Metals in Kafinchiri Reservoir water samples

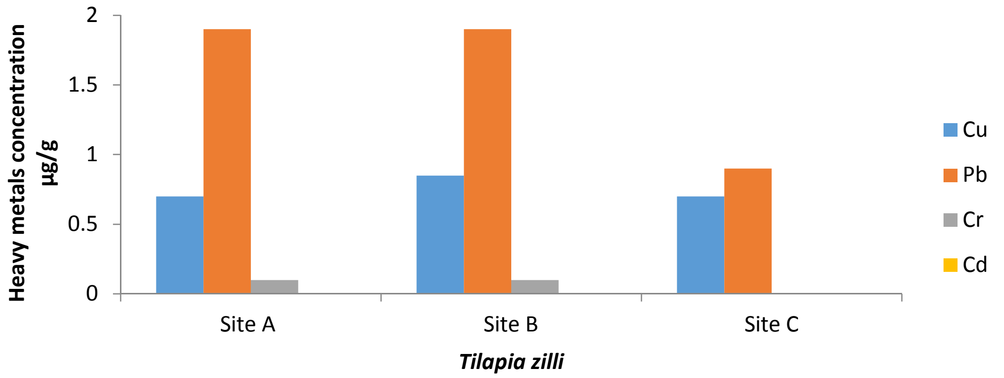

Fig.2 Variation of heavy metals accumulation in gills of *Tilapia zilli* among the sampling sites

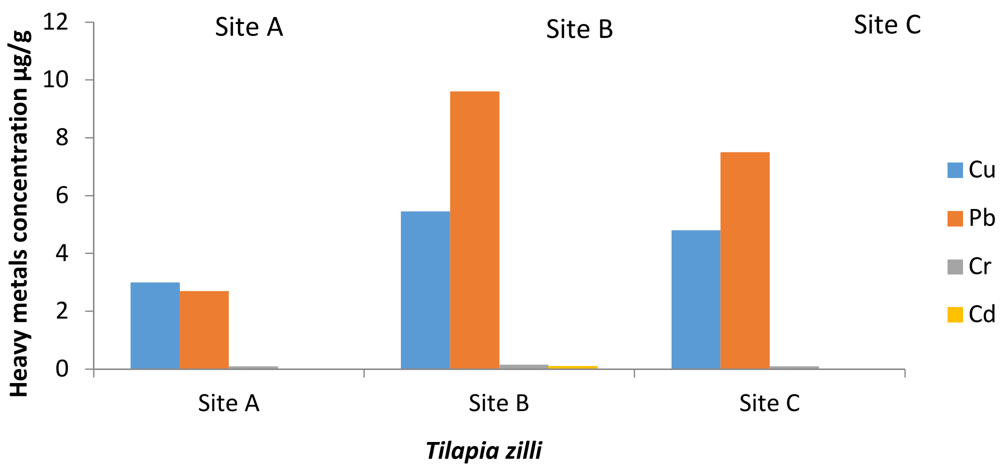

Fig. 3 Variation of Heavy Metals Accumulation in Liver of *Tilapia zilli* among the Sampling Sites

DISCUSSION

Physicochemical parameters

Physicochemical parameters of Kafinchiri reservoir were observed to fluctuate slightly during the study period. The mean water temperature of the dam fluctuates between 25.90°C and 27.37°C. This trend of temperature variation is in tandem with the findings of Nafiu and Ibrahim (2017) in Thomas Dam, Kano State and Kefas *et al.* (2015) in Lake Geriyo, Adamawa State.

The pH value recorded in this study 7.65-8.50 was observed to increase slightly from June to September, but there is no variation in pH between the sampling sites. The pH recorded fall within the acceptable limits of 5.9 - 9.3 for fresh water bodies set FAO (2004). TDS in water consist of inorganic salts and dissolved materials and high values of TDS may lead to change in water taste (Usman *et al.*, 2017). The TDS values recorded in the reservoir varied from 211mg/L to 363mg/L, which is within the limit of 600mg/L set by FEPA (1991). In the present investigation, dissolved oxygen ranged between 6.27 - 7.47mg/L, which is quite satisfactory to support aquatic life perhaps due to good aeration rate and photosynthetic activity as reported by Ibrahim and Nafiu (2017) and Jaji *et al.* (2007). The distribution of dissolved oxygen in water body has been reported to be governed by a balance between input from the atmosphere, rainfall, photosynthesis and losses by the chemical and biotic oxidations (Arimoro *et al.*, 2000). Turbidity of the water body also varied significantly between months it ranged from 28.05NTU – 34NTU during the study period. The water turbidity during the study period might be related to cloudiness of water body as a result of particulate matter being suspended within it. Similar observation was made by Rabiu *et al.* (2017) in Watari Reservoir, Kano State.

Heavy Metals Concentrations in Fish

Heavy metals are believed to be potent toxic substances due to their slow degradation rate and long half-life period (Prajapati *et al.*, 2012). Table 2 illustrate heavy metals Concentration in water, gills and liver of *Tilapia zilli* from the Kafinchiri reservoir. It revealed that there was no bioaccumulation of Cr at the sampling sites as shown by the BAF of < 1. Cu, Cd and Pb however showed bioaccumulation with BAF of 1.03, 1.00 and 5.76. These are variations found within same species that depends on many factors, like the age of the fish migratory ability of fish, differential exposure and health conditions (El-Moselhy *et al.*, 2014; Ekweozor *et al.*, 2017).

Copper is an essential element and is regulated by physiological mechanisms in most organisms. However, it shows toxic effect when organisms are exposed to levels higher than standard permissible limit (Biney *et al.*, 1994). In the present study the mean values of copper concentration in gills tissues and in liver were 0.04 µg/g and 1.12 µg/g respectively. Low levels of Cu concentration recorded in the gills may be attributed to the very low water contamination and lack of wide spread industries within the vicinity of the reservoir that involve in production of perfumes, oils and fats, cement-making, quarrying and brick-making which release Cu as their byproduct as reported by Agarwal *et al.* (2007) and Dimari *et al.* (2008). But presence of agricultural activities, sewage effluents and vehicles smoke among others contribute to the Cu concentration recorded.

The accumulation of lead (Pb) in the gills and liver of Tilapia fish collected from Kafinchiri reservoir were 0.10µg/g and 9.60µg/g. Their presence might be through the use of fertilizer that contains lead, the use of gasoline, paints and cosmetics within the vicinity of the reservoir. The value of lead recorded is of public health concern above the recommended allowable concentration of 0.3 µg/g and 0.01 mg/kg (WHO, 1999; FAO, 2004 and Nigerian Industrial Standard, 2007) in fish food. Exposure to lead at high concentration has been attributed to lead poisoning which include hypertension, renal dysfunction, fatigue, sleeplessness, convulsions, abdominal pain and loss of appetite, headache, numbness, arthritis, and hallucination. In chronic situations, birth defect, autism, allergies, muscular weakness, paralysis (beginning in the forearms), mental retardation, psychosis, hyperactivity, lack of concentration, weight loss, mood swings, nausea and seizures (Justina and Udotong, 2015). The values obtained for lead in this study is in line with that of Daka *et al.* (2008) who obtained 0.01-0.06ppm in fish species from Azuabie Creek in the Bonny Estuary, Nigeria.

Chromium act as regulator of metabolisms of glucose and cholesterol but in higher concentration chromium is proof to be toxic. The present study reveals the range of chromium between undetected at site C; 0.1 µg/g at site A and B, the concentration in the gills and liver ranged between 0.1µg/g at site A and C to 0.15 µg/g at site B. The Chromium level recorded in this study is lower than 29.8 – 31.6ppm in *T. zilli* and 28.1 – 32.2ppm in *C. gariepinus* recorded from River Benue by Ishaq *et al.* (2011). Cr might have come from dying and tanning activities by the locals along the reservoir tributaries as reported by Yilmaz (2009).

Cadmium exposure even at low level can cause DNA damage and stress, it is toxic and carcinogenic, and it usually accumulates profoundly in kidney and liver (Obasohan *et al.*, 2006; Justina and Udotong, 2015). Cadmium in gills of *Tilapia* sp. was not detected in the entire sampling sites with the exception of site B which was found in the liver with the value 0.01 µg/g and this concentration is in line with the permissible value of 0.01 µg/g approved by W H O (1999).

The cadmium concentration reported from this study in *T. zilli* is lower than the concentrations obtained by Farombi *et al. (*2007) who reported a concentration of 0.69ppm in the kidney and 0.25ppm in the heart of *C. gariepinus* from Ogun River. Ishaq *et al.* (2011) also reported 0.927ppm and 0.994ppm in *C. gariepinus* and *T. zillii* respectively from River Benue. High incidence of Cd from site B may be due to contamination of fish from super phosphate and pesticides from agricultural activities, electrical appliances and ceramics which could be considered as important sources of Cd pollution in the water. In fish, it can cause anemia and vertebral fractures, osmoregulatory problems, decreased digestive efficiency, hematological and biochemical effects, growth deficits (Hosnia *et al.*, 2015). However, adverse effects from cadmium can occur with dietary levels of 0.1 µg/g. Cadmium could have find their way into the reservoir from naturals sources or as run off from agricultural activities around the reservoir where phosphate fertilizer have been used (Dimari *et al.,* 2008).

CONCLUSION AND RECOMMENDATION

From the present findings it revealed that *Tilapia zilli* used as bio-indicator contains variable levels of heavy metals analyzed with of Cu, Pb, Cr and Cd observed. Consumption of this aquatic biota by humans may pose risk from ingestion of toxic heavy metals at unacceptable concentration through bioaccumulation. Continuous monitoring of heavy metals concentration in Kafinchiri reservoir by the relevant authority to ascertain the extent the level of metal pollutant is recommended. Effective methods of waste disposal should be adopted to prevent agricultural runoff into these water bodies.

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