HEAVY METALS CONCENTRATION IN TISSUES OF *Tilapia Zilli* AS BIOMARKERS OF WATER POLLUTION IN KAFINCHIRI RESERVOIR, KANO – NIGERIA

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Abstract

This study assessed the level of heavy metals accumulation in gills and liver of *Tilapia zilli* fish collected from water in Kafinchiri Reservoir for a period of four months (June – September), with the aim of predicting health risk effect on human 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 (Cu, Pb, Cr and Cd) in water and their accumulation in the liver and gills of the fishes were determined using atomic absorption spectrophotometer. The result 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 (undetected – 0.1µg/g) and Cd was beyond the detection in the gills. The accumulation of heavy metals in the liver were found to be higher with the exception of cadmium which was not detected, Cu (3.0µg/g – 5.4µg/g), Pb (2.7µg/g – 9.6µg/g) and Cr (0.1µg/g – 0.15µg/g). Water content chemical analysis had indicated that; sampling point B (midstream) had the highest concentration of accumulated heavy metals. It was believed that domestic activities around the reservoir is the major contributing factor to the accumulation of toxic heavy metals in liver, gills and water sample analyzed, it is recommended that intervention relevant authorities is needed to curtail chemical degradation of the aquatic biota over a period of time.

Keywords: Copper, Lead, Chromium, Cadmium, *Tilapia zilli*, Biomarkers

INTRODUCTION

Water is one of the natural resources and the quality of water is of vital concern for 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 its intended purposes. Water pollutant can be broadly classified as organic, inorganic, suspended solid and sediment, heavy metals, radioactive materials and heat (Botkin, and Keller, 1995).

Heavy metals contamination in water may arise in many ways. Some of them are being mobilized by man to the atmosphere and hydrosphere at rates compared to and sometimes exceeding those by weathering process. The several human activities that may result to water pollution include agriculture, irrigation, fire, urbanization, mining and industrialization (Goudie, 1990).

Pollutants are directly discharged from industrial effluents, municipal sewage, polluted runoff in urban and agricultural areas. This situation has been exaggerated as a result of the rapid growth of population, industrialization, increased urbanization and expansion of irrigation that use different fertilizers, pesticide and other modern agricultural applications as well as lack of environmental regulations (FAO, 1992).

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 become concentrated along the food chain, producing their toxic effects on the consumer. 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*, 2008). 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). Some of these PTEs are essential for the metabolic activities of living organisms, potential toxic elements such as Cr, Cu, Ni, and Zn are required by organisms at low level and become toxic at some higher levels. Increased loading of heavy metals into aquatic environment may have several ecological consequences; elevated heavy metals concentrations may lead to toxic effects or bioaccumulation in aquatic organisms (Tolulen, *et al*., 2006).

Biomarkers are measurements in body fluids, cells or tissues indicating biochemical or cellular modifications due to the presence and magnitude of toxicants, or of host response, effects at higher hierarchical levels are always preceded by earlier changes in biological processes, allowing the development of early-warning biomarker signals of effects at later response levels (Ron, 2003). 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 (Ron, 2003). Biomarkers as changes in a biological response that can be related to exposure to, or toxic effects of environmental chemicals, they are useful in predicting possible adverse

outcomes of chemicals at the population level and responses can be used to understand causative mode of action (MOA) and possible adverse outcomes after fish assay is conducted. Accumulation of heavy metals in fish tissue depends on factors; heavy metal bioavailability, season of sampling, physical and chemical properties of water (Kargin, 1996). 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 (Ahmed, 2010). 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 other vital organs (WHO, 1984). Assessments of heavy metals in *Tilapia spp* 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 concentration in tissues of *Tilapia Zilli* as biomarkers of water pollution in Kafinchiri reservoir, Kano – Nigeria.

MATERIAL 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, its 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) (Akan *et al*., 2008).

Collection of Fish Samples

Samplings were conducted from 06:00am - 07:00am. Fish samples collected were chilled in ice blocks at the point of collection before being transported to the laboratory in the Department Of Science Laboratory Technology, Kano State Polytechnic, Kano, Nigeria for analysis. Identification of fish specimen was done using fish identification guide by Olasibekan and Raji (2004). All digestion was carried out using heating.

Fish Samples Digestion and Analysis

The fish sample was dissected, gills and tissue were removed and oven dried at temperature of 105^o C until it reached a constant weight (Jackson, 1992). Each sample was grinded into powdery form and kept in the desiccators prior to digestion. The powdered tissue and gills was homogenized and subjected to digestion using concentrated nitric acid and hydrogen peroxide (1:1) v/v according to (FAO 1998). 1g of the sample powder was weighed 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^oC till dissolution inside a fume hood to reduce the volume to 3ml or 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).

Analysis of water Sample

The water samples will be collected fortnightly from four sampling points A, B and C between 6-7a.m for a period of 4 months. Sampling points were selected based on morphometric, and average values of samples were taken for each parameter studied. Three stations were selected for sampling; A, B and C; upstream, midstream and downstream respectively.

Determination of Physico-chemical parameters

Determination of Temperature (^{0}C)

Digital thermometer (Jenway 100 model) was used to measure the water temperature *in situ*, by immersing the thermometer into the water surface for about 30 seconds and allowed until stabilized readings was taken twice as described by APHA (2005).

Total Dissolved Solids (TDS)

This was measured using TDS meter (HANNA HI96301 Model) by dipping the probes into the water until the screen show a stable reading as described by the manufacturers. Readings were expressed in mg/L.

Dissolved Oxygen (DO)

It was measured *in situ* using portable DO meter (JPB-607 model) in which the probe was inserted into the water until DO reading in (mg/L) was recorded as described by the manufacturers.

5-Day Biochemical Oxygen Demand (BOD_5)

It was measured after collecting the samples at each site into a labeled 100ml dark bottle, kept in an incubator in the laboratory at 21°C for 5-days. Then DO was measured again. BOD_5 was obtained by subtracting the 5-day DO reading from the 0-day DO reading (APHA, 2005).

Turbidity

The turbidity of the water in Nephelometric Turbidity Unit (NTU) was measured using 20cm diameter Secchi disc, which was dipped into the water until the disc disappeared and the depth was recorded. It was dipped further and then withdrawn carefully and the depth at which it becomes visible was also recorded. Actual measurement was obtained by taking the average of the two readings (APHA, 2005).

Determination of Nitrate-nitrogen Concentration

It was determined in mg/L using phenol disulphuric acid method APHA (1985). The method involves nitrate determination by phenol disulphuric acid with spectrophotometer (IL251

model). Thirty (30ml) of the water sample was placed in a porcelain dish and evaporated in an oven. It was later allowed to cool. Two (2ml) of phenol disulphuric acid was added to the content of the porcelain dish. Thereafter, 20mls of distilled water and 7mls of concentrated ammonia were subsequently added and thoroughly mixed with the content of the porcelain dish. A yellow colour later developed which indicate the presence of nitrate. The intensity of the colour was measured with a spectrophotometer (IL251) set at a wavelength of 410nm in the Biochemistry Department, Bayero University, Kano. A nitrate calibration curve was later plotted from the instrument reading, using a known nitrate calibration standard to obtain nitrate concentration.

Determination of Phosphate-Phosphorus Concentration

Phosphorus was determined by the Procedure described by Boyd (1981). In this method, to every 50ml of the filtered sample, 4 ml of ammonium molybdate reagent was added and mixed. After 10 minute a yellow colour was developed. It was measured using Spectrophotometer (IL251 model) at 690nm and standard calibration curve was prepared. The value of phosphate was obtained by comparing absorbance of sample with the standard curve and expressed in mg/L.

Determination of Electrical Conductivity

This was measured using Conductivity meter (SUNTEX 9649 Model) by dipping the probes into the water until the screen show a stable reading as described by the manufacturers. Reading was expressed in µS/cm.

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

The mean range of the water temperature recorded was between 22.0^{o}C and 27.8^{o}C with the lowest value recorded in June and the highest in August. Temperature variations between months indicated no significant difference ($p<0.05$). The range of pH values was pH 5.9 – 9.3 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 416.3mg/L and 763mg/L. It revealed significant differences between the months at $P< 0.05$.

The DO ranged between 4.6 mg/L in July and to 6.9mg/L in August. Monthly, the highest mean DO value during June was 5.0±1.25mg/L while August season had the least value of 6.9±1.00mg/L. The monthly variations in the mean BOD values indicated that June had

2.7±0.20mg/L while September recorded 3.9±0.81mg/L. Statistically, there was no significant difference in DO and BOD between the months ($p<0.05$). Mean monthly values of turbidity ranged between 28NTU and 42NTU. The mean value recorded during the month of July was 27.5±1.00NTU while 38.0±1.80NTU was recorded during the month of August (Table 2). Mean turbidity values revealed significant difference between the months ($p< 0.05$).

Table1. Mean physicochemical values obtained from Kafinchiri Reservoir, Kano State

Parameters	A	B	C
Temp. (°C)	22.90±2.43a	23.37±2.13a	23.50±2.55a
pH	7.47±0.22a	7.27±0.26a	7.37±30a
TDS (mg/L)	38.25±5.90a	40.77±3.85a	38.87±0.55a
DO (mg/L)	4.02±0.55a	5.05±0.13a	4.02±0.55a
BOD (mg/L)	2.72±0.28	2.60±0.49	2.17±0.45
Tranparency(cm)	28.05±3.10	34.00±1.15	31.75±1.50
NO3- (mg/L)	11.60±0.64	12.52±1.05	16.65±0.98
PO4-3(mg/L)	0.96±0.47	0.72±0.27	5.35±0.26

Values are mean ±S.D, values with the same letters within the same season were considered not significantly different ($P<0.05$)

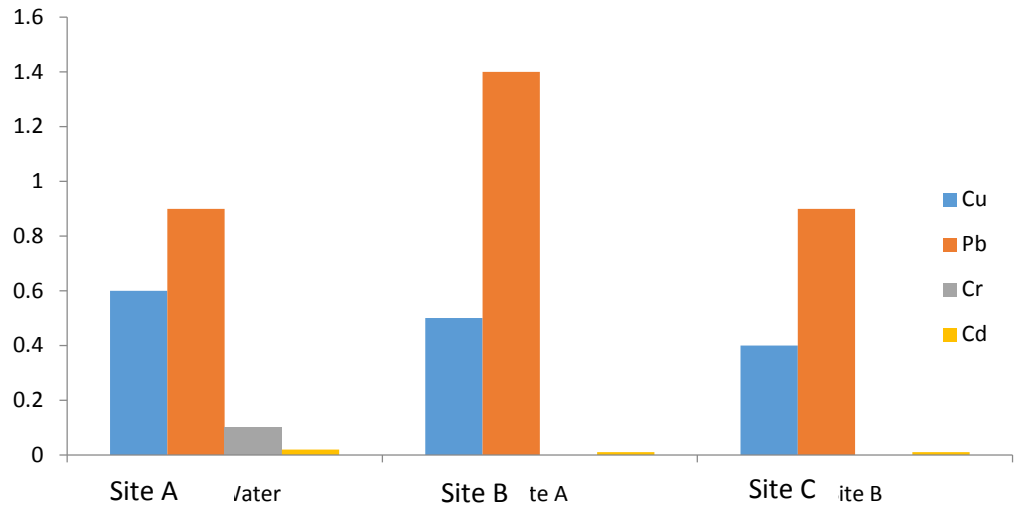

Fig.1 shows mean concentration of heavy metals in Kafinchiri Reservoir water samples

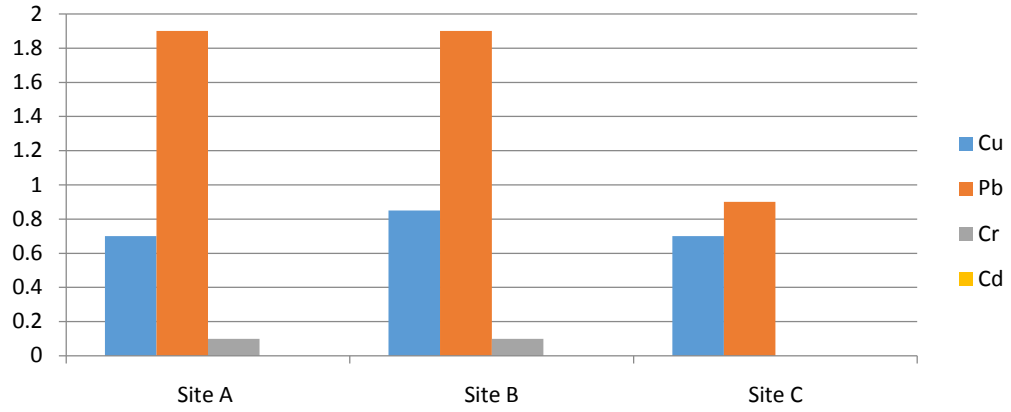

Fig.2 Variation of heavy metals accumulation in gills of *Tilapia zilli* among the sampling sites

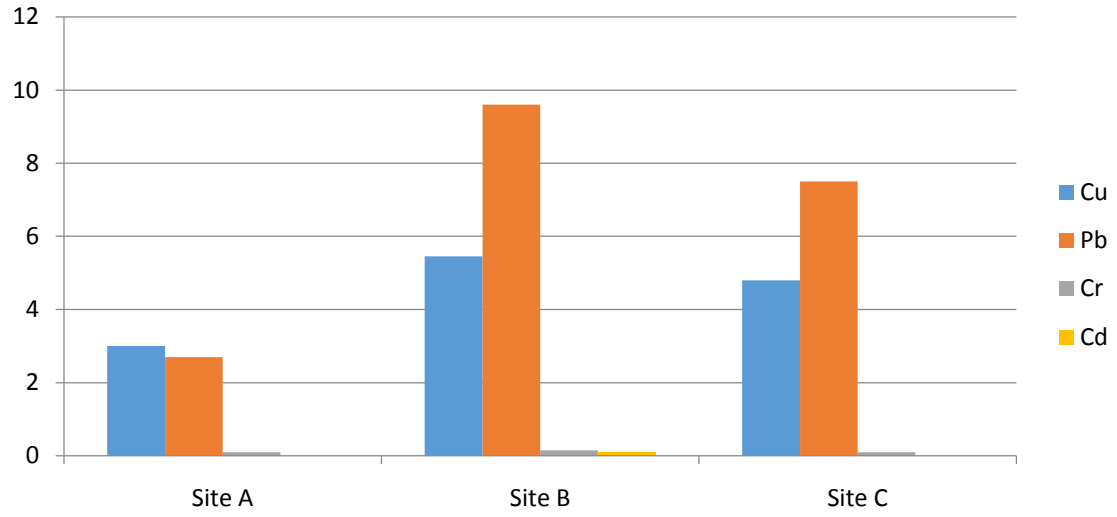

Fig.3 Variation of heavy metals accumulation in liver of *Tilapia zilli* among the sampling site

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 22 – 23.5°C. This trend of temperature variation is in tandem with the findings of Ibrahim (2009) in Challawa River, Kano State and Kefas *et al*. (2015) in Lake Geriyo, Adamawa State. The pH value recorded in this study (7.5 -8.9) was observed to increase slightly from June to September. 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 (Pandey, 1997). The TDS values recorded in the reservoir varied from 38mg/L to 40mg/L, which is within the limit of 600mg/L set by FEPA (1991). In the present investigation, Dissolved Oxygen ranged between 4.6 - 6.9mg/L, which is quite satisfactory to support aquatic life perhaps due to good aeration rate and photosynthetic activity as reported by 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 (Adesalu and Nwankwo, 2010). Transparency of the water body also varied significantly between months ranged from 28cm – 34cm during the study period. The water transparency during the study period might be related to cloudiness of water body as a result of particulate matter being suspended within it (Nafiu*et al.*, 2017). Phosphates- phosphorus ranges between 0.72-5.2mg/L and Nitrate- nitrogen with 11. – 16mg/L. The values recorded were higher than the standard limit for fresh water set by FEPA (1991). This corroborates with the findings of Ibrahim and Nafiu (2017) who recorded higher values of both nitrate and phosphate in their work in Thomas Dam, Kano State. The higher values of phosphate and nitrate concentrations could be attributed to the inputs from agricultural activities around the study area. The values recorded were higher than what was reported by Kefas *et al*. (2015) in Lake Geriyo, Adamawa state, Nigeria.

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). Through various paths, heavy metals enter the food chain/web and ultimately cause adverse physical and physiological effects on biotic elements of earth and get accumulated in flora and fauna, which is called bioaccumulation. Fishes are used as bioindicators of aquatic ecosystems for estimation of heavy metals pollution and possible risk potential for human consumption (Agarwal, *et al*, 2007). Bioaccumulation of metals in fishes takes directly, from the water by gills and indirectly from food (Barron, 1990).

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 copper concentration ranged from 0.8ug/g - 0.85ug/g in gills and from 3.0ug/g - 5.45ug/l in liver. Therefore, Cu concentration in the fish tissue varied significantly among the three sampling sites.

The accumulation of lead (Pb) in edible muscle of tilapia fish collected from Kafinchiri Reservoir ranged between 0.3µg/g - 0.4µg/g. the value of lead toxicity recorded is of public health concern and is above the recommended allowable concentration of 0.3 µg/g (WHO, 1985 and FAO, 2004) in fish food. This result was lower compared to the findings of Doherty *et al.* (2010) who recorded lead concentration in fish tissue of 0.395 – 0.62ppm from Lagos lagoon. 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. However, the accumulation of this metal was slightly higher than permissible limit of WHO, 1999. The Chromium level recorded in this study is in tandem with of Obasohan (2007) from Ogba River in Benin City. The results in this investigation were lower than 29.8 – 31.6ppm in *T. zillii* and 28.1 – 32.2ppm in *C. gariepinus* from River Benue (Ishaq *et al.*, 2011).

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. The accumulation of cadmium in gills of *Tilapia spp* of the study area was found not detected in the entire sampling sites with the exception of site B which was found in the liver with the value 0.1 µg/g and this concentration is much higher than the permissible value of W H O (1984). The cadmium concentration reported in the tissue of *T. zilli* is in agreement with the studies 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. Several studies have reported higher levels of Cd in different fish samples from some Nigerian water bodies. These include Odoemelan (2005) who reported 1.50 ppm and 1.23ppm in *Alestes nurse* and *Synodontis nigritis* respectively from Oguta Lake and Ishaq *et al.* (2011) who reported 0.927ppm and 0.994ppm in *C. gariepinus* and *T. zillii* respectively from River Benue.

Conclusion and Recommendation

From the present findings, it revealed that *Tilapia zilli* used as bio-indicator as it contains variable levels of heavy metals analyzed with of Cu, Pb, Cr and Cd observed. In order to reduce excessive discharge of metals into the reservoir there should be reduction of farming activities around the Reservoir. Besides, the consumption of this aquatic biota obtained from the water body by humans may pose risk from ingestion of toxic heavy metals at unacceptable concentration. Continuous monitoring of heavy metals concentration in Kafinchiri Reservoir by the relevant authority to ascertain the extent the level of pollutant is recommended. Effective methods of waste disposal should be adopted to prevent agricultural runoff into these water bodies.

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