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HEAVY METALS LOAD IN *TILAPIA* SPECIES: A CASE STUDY OF JAKARA RIVER AND KUSALLA DAM, KANO STATE, NIGERIA

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ABSTRACT
Between August and September 2009, twenty four (24) Tilapia species, twelve (12) from each site were sampled from Jakara River and Kusalla dam in Kano, Nigeria with the view to determine the level of some heavy metals in the muscles of the fishes so as to assess their safety or otherwise for human consumption. The weight of each of the samples was determined using Gallenkamp weighing balance and recorded to the nearest grams. The fishes were dissected to separate the muscles from head, viscera and bones. Five grams of the muscle from each sample was digested using concentrated nitric acid and hydrogen peroxide solutions prepared in the ratio of 1:1. The digested samples were aspirated using 210 VGP Atomic Absorption Spectrophotometer from which copper, zinc and lead were determined. The fish samples analysed from Jakara River had the mean copper, zinc and lead concentrations of 0.46±0.14mg/kg, 15.83±5.05 mg/kg and 0.57±0.20mg/kg and those from Kusalla dam had the means of 0.38±0.31mg/kg, 12.04±2.99 mg/kg and 0.54±0.29mg/kg respectively. Comparison of the above means with FAO standards for Cu (30mg/kg), Zn (30mg/kg) and Pb (0.50mg/kg) revealed that the mean concentrations of copper and zinc are safe for human consumption. However, the mean lead concentration exceeded the limit prescribed for human consumption. This suggests the possible adverse health effect such as damage to the gastrointestinal tract and chronic damage to the Central Nervous System among others that the people consuming Tilapia species from both study sites could be exposed to. It was recommended that considerable attention be paid to the lead content in fresh water fish at both sites by appropriate authorities due to its possible health implication on the consumers. Furthermore, continuous monitoring of heavy metals load in fish will be needed in Jakara River and Kusalla dam. Similarly, measures should be put in place to control the inflow of raw effluent into the river as they are largely the possible sources of these metals.

Key words: Heavy metals, Tilapia, Dam, River, Kano

INTRODUCTION

According to Jennett *et al.* (1980) heavy metals are those elements on the periodic table with atomic numbers from 22 - 34 (Titanium - Selenium), 40 - 52 (Zirconium - Tellurium) and 72 - 83 (Hafnium - Bismuth). They occur naturally in the ecosystem with large variation in concentration. Nowadays, however, anthropogenic activities have added a lot of these metals into the environment (Duffus, 2002). Although living organisms including man require varying amount of these metals such as cobalt, iron, copper, manganese, molybdenum and zinc, excessive levels can be damaging to the organisms (Duffus, 2002). Similarly, although many heavy metals are considered as essential macro- and micro-elements especially at non-adverse effect levels, they can exert negative effect at concentrations encountered in polluted environment (Dimari *et al.,* 2008).

Heavy metals in aquatic environment are currently a major concern worldwide and ranked as major polluting chemicals in both developed and developing countries (Lloyd, 1992) due to their toxicity and threat to plant and animal life as they cause environmental contamination and some times devastating effect on the recipient environment, thus, disturbing the natural ecological balance (Farombi *et al.*, 2007; Dimari *et al.,* 2008). The specific problem associated with heavy metals in the environment is their accumulation through food chain and persistence in nature (Dimari *et al.*, 2008). Moreover, many dissolved metals that enter rivers are adsorbed onto colloid particulates and at high alkalinity and pH, the metals, particularly lead and cadmium, precipitate by forming complexes, which dramatically influence further the metal toxicity (Dimari *et al.*, 2008).

Water borne metals may alter the physiological and biochemical parameters in fish blood and tissue (Brungs *et al.*, 1977). Fish accumulate xenobiotic chemicals, especially those with poor solubility and these are chemicals carried in solution or suspension, and also the fish have to extract oxygen from the medium by passing enormous volume of water over the gills, skin, and digestive tract, which are the potential sites of absorption of water borne chemicals. The chemicals once absorbed are transported by the blood through either storage point such as bone or to the liver or they may be stored or excreted by the kidney, gills or stored in an extra hepatic tissue such as fat (Dimari *et al.*, 2008).

Because heavy metal pollution and its management has been a major global concern for environmentalists due to their non-biodegradable and hazardous nature, this study was conducted with the view to determine the level of some heavy metals (zinc, lead and copper) in *Tilapia* species sampled from Jakara River and Kusalla dam so as to evaluate their safety for human consumption.

MATERIALS AND METHODS

Study Area

The areas studied were Jakara River and Kusalla dam located in Kano State, Nigeria. Kusalla dam is located in Karaye Local Government Area about 40km away from Kano city. The main source of water for this dam is rain water that it receives from Mukugara River. The dam receives agricultural wastes and runoff from nearby farm lands. The dam is used for commercial fishing. Jakara River (a perennial stream) on the other hand, originated from the North Western part of Kano metropolis. The river is characterized by a gentle flow and flows several kilometres passing through Kurmi market and Fagge quarters from where it meanders its way to the outskirts of the city before finally streaming out into North Easterly direction (Adamu, 2008). Waste water from domestic sources, drainages and raw sewage from the city are discharged into the river. Also, blood and animal excreta from the Kano Abattoir are discharged into the river, thus, making it highly contaminated.

As the river streams out of metropolis, it is joined by Getsi River, which drains from Nassarawa quarters of the metropolis. Domestic and industrial effluents from Bompai, Gama, Tudun Murtala and Dakata areas are discharged freely into Getsi River. The two rivers serve as tributaries to Wasai reservoir, which is located within Gezawa and Minjibir local governments. The reservour is located on latitude 12^o 53^{1}N and longitude 8^o 32^{1}E (Adamu, 2008). The reservoir, which is an earth-filled dam was primarily built to provide water for irrigation purposes and to provide fish to supplement the diet of the populace.

Sample Collection and Identification

The *Tilapia* species used for this study were purchased from local fishermen in the areas. The samples were transported to the laboratory in a cold box where they were identified according to Reed (1967). Twelve (12) fish samples each were analyzed from both sites.

Weighing and Dissection of Fish Samples

Fish samples were weighed using Gallenkamp weighing balance, and values were recorded to the nearest grams. The weighed samples were dissected with plastic knife to separate the muscles from head/viscera and bones as described by Nnaji *et al.*(2007).

Digestion of Samples

The fish samples were digested as described by Olaifa *et al.* (2004). The procedure involved weighing 5g of the samples and placing each in a separate beaker. 10ml of freshly prepared concentrated HNO_3/H_2O_2 (1:1) solution was added to each beaker and covered with watch glass for initial reaction to subside. The beaker was placed on water bath and boiled at a temperature not exceeding 160^{o}C for 2 hours to reduce the sample volume to 3 - 4ml. It was cooled and transferred to a 50ml volumetric flask, made up to volume with distilled deionised water and used for metal analysis using 210 VGP Atomic Absorption Spectrophotometer as described by the manufacturers.

Preparation of Standard Metal Concentrations and Atomic Absorption Spectrophotometric Determination of the Metals

Aqueous stock solutions were prepared for copper, lead and zinc using appropriate salts. Four working standards were prepared in triplicate for each metal by serial dilution of the stock solution. These and blank solution were aspirated into the Buck Scientific model 210 VGP Atomic Absorption Spectrophotometer as described by the manufacturers to obtain the absorbance of each of the samples and standard solutions for each of the metals. A calibration curve for absorbance versus concentration of the standard metal concentrations was prepared for each metal from which calibration graph for each of the metals in the sample was determined as described by Nnaji *et al.* (2007). The metal concentrations of the samples from the sites were determined from the above graphs.

Statistical Analysis

The results were analyzed using Pearson Moment Correlation Analysis, mean and Standard Deviation (Mukhtar, 2003).

RESULTS

The results of weight of *Tilapia* species from both study sites were presented in Table 1. The mean weight of *Tilapia* species from Jakara River and Kusalla dam were 190$\pm$36.52g and 66.50$\pm$20.88g respectively. Table 2 shows the values for metal concentration in *Tilapia* muscles from both study sites. The mean values for copper, zinc and lead from Jakara River were 0.46$\pm$0.14mg/kg, 15.83$\pm$5.05mg/kg and 0.57$\pm$0.20mg/kg while those from Kusalla dam were 0.38$\pm$0.31mg/kg, 12.04$\pm$2.99mg/kg and 0.54$\pm$0.29mg/kg respectively. The lowest concentrations of copper, zinc and lead determined in fish muscles from Jakara River were 0.13mg/kg, 9.50mg/kg and 0.17mg/kg respectively. Similarly, the lowest concentration of copper, zinc and lead from Kusalla dam were 0.13mg/kg, 7.00mg/kg and 0.27mg/kg respectively (Table 2). The results (Table 2) also revealed that the highest concentrations of all the metals studied were found in *Tilapia* species sampled from Jakara River (Cu, 0.81mg/kg; Zn, 25.50mg/kg; Pb, 0.87mg/kg). The profile of metals content in *Tilapia* muscles from both sites were Zn > Pb > Cu.

Statistical analysis showed that although there was a positive correlation between weight of the fish and load of copper and lead in the samples from Jakara River and also between the load of copper and zinc in the samples from Kusalla dam as shown in Table 3, the load of zinc and lead in the samples from Jakara River and Kusalla dam respectively were negatively correlated with the weight of the sampled fishes from the two sites. In both cases, however, the relationship was not significant at P = 0-05 (Table 3).

Table 1: Weight of *Tilapia* Species Sampled from Jakara River and Kusalla Dam in Kano, Nigeria.

Jakara River		Kusalla Dam	
Code	**Weight (g)**	**Code**	**Weight (g)**
A_1	195	B_1	47
A_2	190	B_2	44
A_3	262	B_3	45
A_4	200	B_4	53
A_5	230	B_5	58
A_6	150	B_6	72
A_7	158	B_7	67
A_8	140	B_8	84
A_9	146	B_9	78
A_{10}	214	B_{10}	89
A_{11}	200	B_{11}	97
A_{12}	195	B_{12}	64
Mean±SD (g)	**190±36.52**		**66.50±20.88**

Table 2: Heavy Metals (mg/Kg) in *Tilapia* Species sampled from Jakara River and Kusalla dam in Kano, Nigeria.

	Jakara River				Kusalla dam		
Code	**Cu**	**Zn**	**Pb**	**Code**	**Cu**	**Zn**	**Pb**
A_1	0.58	15.50	0.40	B_1	0.13	8.50	0.47
A_2	0.49	13.00	0.81	B_2	0.18	12.50	0.81
A_3	0.81	14.00	0.70	B_3	0.22	10.50	0.34
A_4	0.63	24.00	0.87	B_4	0.36	7.00	0.67
A_5	0.40	13.00	0.20	B_5	0.18	12.00	0.27
A_6	0.27	11.50	0.47	B_6	1.00	9.50	0.81
A_7	0.49	21.50	0.77	B_7	0.45	13.00	0.54
A_8	0.49	15.00	0.30	B_8	0.13	12.50	0.30
A_9	0.63	25.50	0.17	B_9	1.00	15.00	0.47
A_{10}	0.36	14.50	0.67	B_{10}	0.18	11.00	0.64
A_{11}	0.13	9.50	0.64	B_{11}	0.49	16.00	0.30
A_{12}	0.18	13.00	0.81	B_{12}	0.27	17.00	0.81
Mean±SD (mg/kg)	**0.46±0.14**	**15.83±5.050**	**0.57±0.20**		**0.38±0.31**	**12.04±2.99**	**0.54±0.29**
FAO,1983 (mg/kg)	**30.00**	**30.00**	**0.50**		**30.00**	**30.00**	**0.50**

Table 3: Values of Pearson Correlation Analysis (r) for Fish Weights and Metal Loads in Fish Samples Collected From Jakara River and Kusalla Dam (August – September 2009)

Metal	**Jakara River**	**Kusalla dam**
Copper	+0.196	+0.329
Zinc	-0.328	+0.466
Lead	+0.294	-0.210

N.B.: n = 12, df = n-2 = 12-2 = 10. Tabulated value of r at df = 10 and P = 5% = 0.576

DISCUSSION

The results of this study indicated that fish samples from Jakara River were bigger than those from Kusalla dam (Table 1) as they have diverse sources of food supply than those from Kusalla dam, hence accumulated higher concentration of heavy metals which contradicts the results of the study reported by Rahmawati *et al.*(2008) that the concentration of heavy metals in smaller fish is always higher than in bigger fish. However, the results of this study agreed with that of Fostner and Wittman (1981) who reported that aquatic microflora and fauna which constituted fish food are capable of incorporating and accumulating heavy metals into their living cells from their environment thus, implying that bigger fish will need more food and therefore accumulate more heavy metals. Similarity, the results of this study corroborate with the report of Ademoroti (1996) that size of organism is one of the major factors influencing bioaccumulation although Silene and Sandra (2004) reported that bioaccumulation of metals like chromium, cadmium, copper and zinc is independent of body size.

In the muscles of *Tilapia* species studied, the metals were bioaccumulated to varying levels. The fishes of Jakara River had higher mean metal loads (Table 2). The general pattern of accumulations in both sites was similar with zinc being the most bioaccumulated. This observation agrees with the results obtained by Monday and Nsikak (2007) and Nnaji *et al.* (2007) where they recorded higher concentration of zinc in the muscles of *Tilapia* species they studied. However, in the muscle tissue of *Tilapia* species sampled from both sites, copper was the least bioaccumulated probably because it was the least available metal in the water.

The above observation could be due to the fact that accumulation of metal toxicants from the aqueous environment by fish depend upon the availability and persistence of the contaminant in water and food (Larsson *et al.,* 1985) thus, the less available it is the less it will be accumulated. In addition, aquatic organisms including fish are reported to accumulate metals from their surrounding medium or food by ingestion or absorption (Fostner and Wittman, 1981; Ademoroti, 1996), hence, the possible sources of the metals recorded in this study.

Since many environmental factors have been identified to influence the bioaccumulation of heavy metals to toxic levels in organisms (Monday and Nsikak, 2007), it may be considered that the variations in the metals load in the two study sites might have been largely influenced by the contamination level of the areas, implying that Jakara River is more contaminated than Kusalla dam, that receives large influx of metals-rich runoff, which contains domestic, drainage and agricultural waste, industrial effluent, and domestic sewage in addition to the extensive agricultural operations around the area (Shanthi *et al.,* 2000; Nnaji *et al.,* 2007).

Comparing the mean metal concentrations obtained in this study with FAO (1983) standard for fish muscles indicated that the mean copper and zinc loads of 0.46 ± 0.14mg/kg and 15.83 ± 5.05mg/kg respectively are safe for human consumption from both study sites. However, the mean lead concentrations of 0.57 ± 0.20mg/kg and 0.54 ± 0.29mg/kg from Jakara River and Kusalla dam respectively, indicated that they are slightly above the level for this metal of 0.50mg/kg set by the FAO (1983) for human consumption, thus a fear can be expressed over the consumption of *Tilapia* species from both sites. This suggests the possible adverse health effect that the people consuming *Tilapia* species from both study sites could be exposed to as a result of consumption of these fishes, which include chronic damage to the Central Nervous System and gastrointestinal tract as reported by Duriebe *et al.* (2007). Based on the findings of this study it was recommended that:

a) Considerable attention should be paid to the lead level in fresh water fish from both study sites by continuous monitoring of heavy metals concentration in edible fresh water fish from the sites.
b) Measures should be put in place to regulate the indiscriminate discharge raw effluent into the river.
c) Regular public health checks on the level of heavy metals among the communities that border the area can be employed in order to safeguard public health.

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