AN ANALYSIS OF SOME HEAVY METALS PRESENT IN ORGANS OF CAT-FISH, TILAPIA-FISH AND QUAIL-FISH SPECIES FROM RIVER GALMA, ZARIA, KADUNA STATE, NIGERIA

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ABSTRACT

The accumulation of heavy metals such as cadmium (Cd), lead (Pb), Nickel (Ni), and Cobalt (Co) was determined in flesh, gills and liver of three common and eatable fish species (Cat fish, Tilapia fish and Quail fish) that are found in River Galma, Zaria using Atomic absorption spectrophotometer (AAS). Fish samples were dissected separately and digested using concentrated HNO_3 /H_2O_2 (1:1) solution. The results of the study indicates that the heavy metals concentration in the flesh, gills and liver of the fish species, were accumulated in the following trend; Cat fish; Flesh – Ni > Co > Cd > Pb: Gills – Ni > Co > Cd > Pb: Liver - Ni > Pb > Co > Cd Tilapia fish; Flesh – Ni > Cd > Co > Pb: Gills – Ni > Co > Cd > Pb: Liver – Ni > Co > Cd >Pb: Quill fish; Flesh – Ni > Co > Cd > Pb: Gills – Ni > Cd > Co > Pb: Liver – Ni > Cd > Co >Pb. The results showed limited difference between samples of fish under study as well as significant variations between the organs. Ni is the highly accumulated metal in all the samples. The highest metal concentration was mostly found in the liver followed by other organs. The concentrations of metals in the flesh were within the permissible level and safe for consumption. However, the results of the study clearly indicate the bio-magnification of metals in River Galma. Hence, the continuous monitoring and control of the presence of heavy metals in the study area is recommended.

Keywords: Heavy metals, Fish, Accumulation, Contaminants, Harmful

INTRODUCTION

Pollution of the aquatic environment by inorganic chemicals has been considered a major threat to the aquatic organisms including fishes. Fish accumulate toxic chemicals such as heavy metals directly from water and diet, and contaminant residues may ultimately reach concentrations hundreds or thousands of times above those measured in the water, sediment and food (Goodman *et al.*, 2003; Osman *et al.* 2007). Pollution by heavy metals in aquatic environment has become a global phenomenon because of their toxicity and persistence for several decades in the aquatic environment (Cheung & Wang, 2006). When pollutants like heavy metals enter rivers, they change water quality, bind to sediments and accumulate in aquatic biota causing anemia, disturbance of physiological functions and mortalities of aquatic plants and animals (Biney *et al.* 1994). According to Dougherty *et al.* (2000), aquatic animals' consumption is a major route of chemical exposure to man and heavy metal pollutants are potentially harmful to man when aquatic lives and water contaminated with heavy metals are consumed.

Bioaccumulation of heavy metals in tissues of aquatic organisms has been identified as a measure of the abundance and availability of metals in the aquatic environment (Kucuksezgin *et al.,* 2006). For this reason, monitoring fish tissue contamination serves an important function as an early warning indicator of related water quality problems (Mansour & Sidky, 2007) and enables us to take appropriate action to protect public health and the environment. Therefore, in order to maintain the quality of fish it is important to regularly monitor and evaluate the pollution levels in fish as well as in water reservoirs

The objective of this research is to determine the levels of Cd, Pb, Ni, and Co in three common and eatable fishes (Cat fish, Tilapia fish and Quail fish) that are found in River Galma so as to assess the suitability of fish from the river for human consumption.

MATERIALS AND METHODS

Description of Sampling Site

Zaria is on the north central Kaduna state of Nigeria and is located at latitude $11^0$30'N and longitude $7^0$40'E, 128 km south east of Kano city. Zaria falls into the Guinea Savanna climate which has distinct wet and dry seasons. River Galma is a tributary of River Kaduna and its source is the Jos, Plateau (The Official Website of Kaduna State, 2007). It is located in the South-Eastern part of Zaria and consists of several tributaries (Streams and Rivers). Industrial, agricultural, trade wastes, Domestic sewage and refuse are directly or indirectly discharged into the river. All these wastes point to potential pollution of the river.

Samples Collection

Fish Samples were collected during the raining season in month of May and June; 2013. Fish samples were collected using a canoe as sampling craft at 500 – 1000 meters apart. The canoe stops for fish samples to be collected using net. Fish samples were wrapped with plastic bags and all the samples were kept on ice and subsequently taken to the laboratory where they were frozen in a deep freezer (Kedebe & Wondimu, 2004).

Sample Preparation

Fish samples were dissected separately with plastic knife to remove flesh, gills and liver. The separated parts were place in Petri dishes and dried at 105°C in an oven for three (3) days until a constant weight was obtained. All dried samples were grinded and sieved using 0.5mm sieve to obtain fine powder. These were finally stored in sample bottles before digestion.

Digestion of Samples

1.00g of the pretreated fish tissue samples were weighed and placed in a clean dried beaker. Then 10cm^3 of freshly prepared concentrated HNO_3 /H_2O_2 (1:1) solution was added and the beaker covered with watch glass for initial reaction to subside. The beaker was placed on water bath and boiled at a temperature of 120°C to reduce the volume to 3cm^3. Then 20cm^{3}of distilled water was added, the solution was cooled and then filtered and transferred into a 50cm^3 volumetric flask, the solution was diluted to the mark with distilled water and transferred into a plastic bottle and labeled accordingly prior AAS analysis (Olaifa *et al.,*2004).

RESULT AND DISCUSSIONS

Table 1: Mean Metal Concentrations in each Organ of the Fish species

		Heavy metals concentrations (mg/Kg)			
Fish Species	**Organs**	**Cd**	**Pb**	**Ni**	**Co**
Cat fish	Flesh	0.225±0.01	0.008±0.01	0.323±0.03	0.242±0.14
	Gills	0.115±0.04	0.028±0.00	0.658±0.02	0.195±0.08
	Liver	0.200±0.08	0.432±0.08	0.454±0.00	0.210±0.02
Tilapia fish	Flesh	0.245±0.00	0.040±0.01	0.262±0.07	0.200±0.20
	Gills	0.160±0.16	0.041±0.01	0.716±0.05	0.204±0.00
	Liver	0.135±0.05	0.039±0.03	0.454±0.03	0.227±0.13
Quail fish	Flesh	0.125±0.15	0.052±0.00	0.281±0.12	0.175±0.11
	Gills	0.215±0.07	0.028±0.22	0.630±0.00	0.163±0.02
	Liver	0.245±0.22	0.059±0.16	0.820±0.07	0.208±0.02

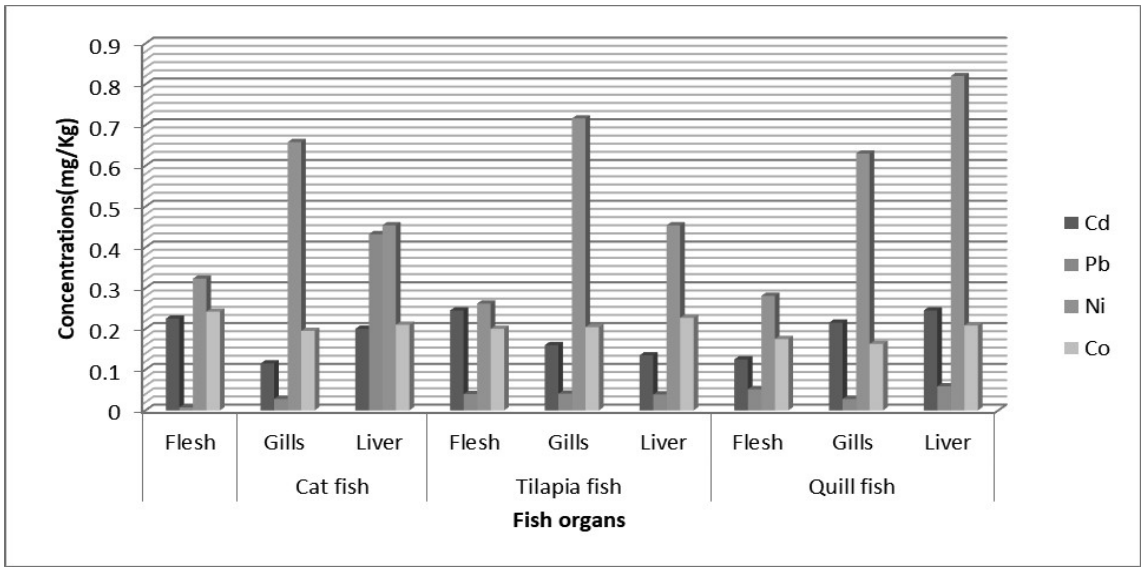

Figure 1: Distribution of Cadmium (Cd), Lead (Pb), Nickel (Ni) and Cobalt (Co) in the flesh, liver and gills of Cat, Tilapia and Quail fish species from River Galma.

Table 2: Mean concentration of metals in each fish species

	Total Concentration of heavy metals(mg/Kg)			
Fish species	**Cd**	**Pb**	**Ni**	**Co**
Cat fish	0.180	0.156	0.478	0.216
Tilapia fish	0.180	0.040	0.477	0.210
Quill fish	0.195	0.046	0.577	0.256

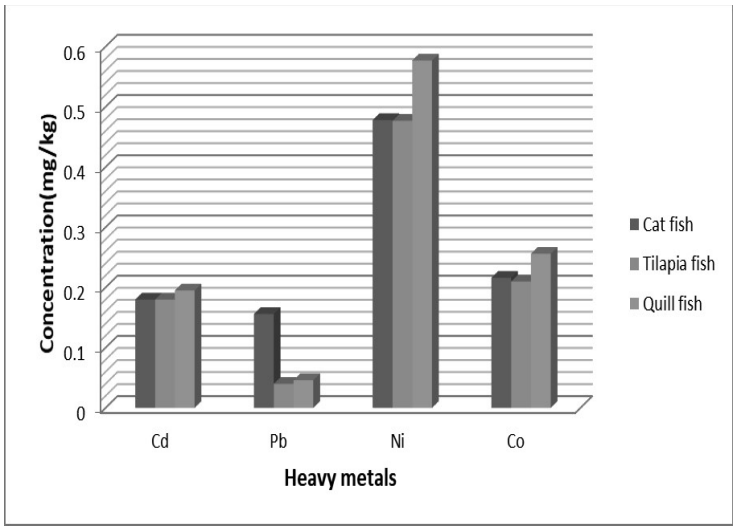

Figure 2: Total concentrations of Cadmium (Cd), Lead (Pb) Nickel (Ni) and Cobalt (Co) in organs of Cat, Tilapia and Quail fish species from River Galma.

Table 3: Total mean concentration of each metal in different organs of the fish species

Metal	Metal concentration (mg/Kg)			(FEPA (2003) Limit of fish food
	Flesh	Gills	liver	
Cd	0.198	0.163	0.193	2.00
Pb	0.033	0.032	0.174	2.00
Ni	0.289	0.675	0.576	0.5 – 0.6
Co	0.206	0.187	0.215	-

The metals cadmium (Cd), cobalt (Co), Nickel (Ni) and lead (Pb) were determined and the levels of the heavy metals concentration in each organ of the organs, flesh, gills and liver of each of the fish samples were measured using Atomic Absorption Spectrophotometer (AAS). The results of the analysis were summarized in table 1.

The results of the study indicates that the heavy metal concentrations in the organs flesh, gills and liver of the fish species Cat fish, Tilapia fish, Quill fish were accumulated in the trend; Cat fish; Flesh – Ni > Co > Cd > Pb: Gills – Ni > Co > Cd > Pb: Liver - Ni > Pb > Co > Cd Tilapia fish; Flesh – Ni > Cd > Co > Pb: Gills – Ni > Co > Cd > Pb: Liver – Ni > Co > Cd >Pb: Quill fish; Flesh – Ni > Co > Cd > Pb: Gills – Ni > Cd > Co > Pb: Liver – Ni > Cd > Co >Pb

Concentration of Cd ranges from 0.115 mg/Kg in gills to 0.225 mg/Kg in flesh of Cat fish species, from 0.135 mg/Kg in liver to 0.245 mg/Kg in flesh of the Tilapia species and 0.125 mg/Kg in the flesh to 0.245 mg/Kg in the liver of the Quail fish species. The mean concentration of Cd in the organs flesh, gills and liver were 0.198 mg/Kg, 0.163 mg/Kg and 0.193 mg/Kg respectively. The levels of Cd recorded (0.115 – 0.245 mg/Kg) in the fish samples were lower than the maximum recommended limits of 2.0 mg/Kg (Federal Environmental Protection Agency [FEPA], 2003) in fish food except for the flesh of Cat fish 0.245 mg/Kg and the liver of quail fish 0.245 mg/Kg. Cd like any other metal could be absorbed via gills and has been known to cause damage to fish gills. In man, cadmium poisoning could lead to anemia, renal

damage, bone disorder and cancer of the lungs (Ademoroti, 1996).

The concentration of Pb varied from 0.0075 mg/Kg to 0.423 mg/Kg in Cat fish, from 0.039 mg/Kg to 0.041 mg/Kg in Tilapia fish and in Quail fish from 0.028 mg/Kg in gills to 0.059 mg/kg in quail fish liver. The mean concentration of Pb in flesh, gills and liver were 0.033, 0.032 and 0.174 mg/Kg respectively. The concentrations of Pb in all the organs of the fish samples were relatively low except in the liver of the Cat fish species with a concentration of 0.423 mg/Kg which appears to be the highest concentration and far well above others. The levels of Pb (0.0075 – 0.423 mg/Kg) recorded in fish samples under study were lower than the maximum limit of 2.00 mg/Kg (FEPA, 2003) in fish food. Low level of Pb recorded in this study could be attributed to low possibility of contamination of the river by the activities of car wash operators and automobile repair workshops located around the area. Lead is a toxic element which has no significant biological function and show carcinogenic effects on aquatic biota and human even at low exposures. Lead exposure is known to cause muscular, skeletal, renal, neurological, immunological, reproductive and developmental effects (Agency for Toxicology Substances and Disease Registry [ATSDR], 2006).

Study revealed that nickel has the highest mean concentration in each organ, 0.289 mg/Kg, 0.675 mg/Kg, and 0.576 mg/Kg in flesh, gills and liver respectively of the metals analyzed. The concentration of nickel varied in Cat fish from 0.323 mg/Kg in flesh to 0.658 mg/Kg in gills, in Tilapia fish from 0.262 mg/Kg in flesh to 0.716 mg/Kg in gills and from 0.281 mg/Kg in flesh to 0.820 mg/Kg in liver of the Quail fish. The result from the present study shows that the level of Ni in the gills of all the fish species were higher than the maximum recommended limit 0.5-0.6 mg/Kg (FEPA, 2003) in fish foods. The high concentration of the metal (Ni) in gills could be attributed to the element complexion with the mucus covering in the gills which cannot be completely recovered from the gill's lamellae before analysis (Olaifa, *et al.,* 2004).

The concentration of cobalt varied in cat fish from 0.195 mg/Kg in gills to 0.242 mg/Kg in flesh, in Tilapia fish from 0.200 mg/Kg in flesh to 0.227 mg/Kg in liver and 0.163 mg/Kg in gills to 0.208 mg/Kg in liver of Quail fish. However, the level reported in this study was in agreement with the findings in *Oreochronuis mossambicus* from Jannapuk Lake of India. The distributions of cobalt in the various organs shows that the liver has the highest mean concentration of 0.215 mg/Kg while the flesh has concentration 0.206 mg/Kg and gills with 0.187 mg/Kg.

The accumulation of the heavy metals (Cd, Pb, Ni and Co) is higher in liver than in gills and flesh. The gills and guts are the main sites of heavy metal uptake by fish while the liver and kidneys are known to accumulate high amount of metals (Gbem *et al.,* 2001). However, there is no significant difference in the accumulation of these metals in any of the species ($P < 0.05$). Gills tissues play important role in interface with the environment in performing its function in gas exchange, ion regulation, acid balance and waste excretion while muscle on the other hand is not an active tissue on bioaccumulation (Baje *et al.*, 2005). The total metal concentration in the gills surface and liver is high due to the fact that metals get absorbed onto the gills surface as the first target or point of contact for pollution in water.

It was observed from the study that the total mean concentration of Cd in all the organs studied was significantly higher than that of Pb ($P < 0.05$) but not significantly higher than that of Co. Nickel was significantly higher than Co in all the species investigated. The difference noticed in the levels of accumulation in different organs of a fish can be attributed to the difference in their physiological roles towards maintaining homeostasis, feeding habits, regulatory ability and behavior of each fish. This is in accordance with the findings of Cross *et al.*, 1973). The trend of heavy metals accumulation in the organs Liver > Gills > Flesh showed that the flesh has the least concentration of heavy metal compared to the gills and liver in the fish species sampled. This is in agreement with previous study by (Ishaq *et al.*, 2011) which revealed that the muscle is not an active organ in the accumulation of heavy metals. Gills on the other hand have been reported as metabolically active site and can accumulate heavy metals in higher level.

In summary, the concentrations of the various heavy metals analyzed in the fish species depict the pattern: Quail fish > Cat fish > Tilapia fish and as such Quail fish can serve as better bio indicator species for monitoring heavy metal concentration in aquatic ecosystem. Also, the pattern of concentrations of the metals in all the fish species depicts Ni > Co > Cd > Pb. This may be attributed to the abundance of these metals in water body. Aquatic organisms including fish are reported to accumulate metals from the surrounding medium or food by ingestion or absorption (Ademoroti, 1996), hence the possible source of the metals recorded in this study. Several fish species have become threatened leading to the depletion of our fish resources and substantial reduction in their nutritive values (Srivastava & Srivastava, 2008). Chemical analysis of fish therefore ensures dietary safety of the fish from a particular body of water.

CONCLUSION AND RECOMMENDATIONS

In view of the importance of rivers and fish to the diet of man, it is necessary that biological and chemical monitoring of the water, fish and aquatic plants and animals meant for consumption be monitored regularly to ensure continuous safety of the water and animals in the water body. Safe disposal of domestic sewage and industrial effluents should be encouraged and where possible, recycled to avoid these metals and other contaminants from going into water body. Laws enacted to protect our environment should be enforced. The activities at the bank of River Galma should be kept under strict surveillance as they are capable of increasing the heavy metals discharge into the river, especially as population is bound to increase. The values reported in this study can serve as baseline data to monitor future anthropogenic activities along the river bank. The study showed a need for continuous pollution assessment study of aquatic organisms in Nigeria.

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