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Determination of the Concentration of Arsenic, Cadmium and Nickel in Tilapia Fish (Oreochromis Niloticus) in Gyawana Aquatic Ecosystem

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ABSTRACT

Study on the mean concentration of arsenic, cadmium and nickel (heavy metals) in organ and tissue of tilapia fish (Oreochromis niloticus) in Gyawana aquatic ecosystem, Lamurde Local Government Area of Adamawa State, Nigeria, was carried out. The results showed that nickel and cadmium were detected in the flesh, liver and the blood tissue of the fish, while arsenic was not detected. The mean concentration of nickel was highest in the flesh (0.025±0.002mg/g), followed by liver (0.014±0.001mg/g) and the lowest was detected in the blood (0.005±0.001 mg/g). Similarly, cadmium was higher in the flesh (0.029±0.003mg/g), followed by the liver (0.023±0.002mg/g) and the least was found in the blood (0.008±0.000mg/g). The result also reveals that male O. niloticus has higher mean concentration of these heavy metals than female O. niloticus. Nickel means concentration was slightly higher in male O. niloticus (0.016±0.009 mg/g) than in female O. niloticus (0.013±0.007mg/g). The mean concentration of cadmium was also higher in male fish with 0.021±0.010mg/g than female tilapia fish that has 0.018 ±0.008mg/g. Throughout the study period arsenic was not detected in any organ nor blood tissue of tilapia fish (Oreochromis niloticus). In conclusion, Gyawana aquatic ecosystem, cadmium and nickel were detected in both flesh and blood of O. niloticus, while arsenic was not detected at all. Male O. niloticus have higher mean concentration of cadmium and nickel than female O. niloticus. Based on the findings of this study, the researcher therefor recommends that dumping of waste and effluent in water bodies should be discourage, so that the aquatic ecosystem should be free from contaminant with heavy metals.

Keywords: Concentration, Arsenic, Cadmium, Nickel, Gyawana, Ecosystem

INTRODUCTION

Cadmium is a white shining but tarnishable metal, similar in several characteristics to zinc and tin. Cadmium is not found to a great extent in nature, its presence in the earth crust is estimated to range between 0.15 to 0.11mg/g (WHO, 2006). Cadmium can be present as a result of volcanic emission and release from vegetation, it is not essential to plant growth, but under certain conditions can accumulate in some plants to levels that are hazardous to animals and humans. Some sewage sludge contains enough cadmium to encourage air pollution and by seeping into the soil and ground water from hazardous waste dumps (Yargholi and Azimi, 2008). Cadmium accepted range in soil as stated by Ebong *et al.,* (2008) ranges between 0.01 - 300 mg/g. Cadmium was listed by EPA as one of the 129 priority pollutants and among the 25 hazardous substances. Ingestion of high level of cadmium severely irritates the stomach leading to vomiting and diarrhoea. Cadmium and its compounds are known as human carcinogens and smokers get exposed to significant amount of cadmium than non-smokers. Other effects associated with cadmium include damage of lungs, fragile bones and kidney disease (Sabine and Wendy, 2009).

Arsenic is a naturally occurring element found in soil, cereals, seafood, meat, mushrooms, baked foods, fats/oils, wine, beer, soft drinks, juices, coffee, and cocoa. Sea foods, cereals, mushroom, and poultry, usually have the highest arsenic levels (Akan *et al.* 2014). Arsenic occurs in two forms: organic and inorganic. Pesticides used on cotton plants contain organic arsenic. Pressure-treated wood contains inorganic arsenic compounds. Organic arsenic is less toxic than inorganic arsenic and organic arsenic found in fish and other foods is mostly in a non-harmful form (ATSDR, 2007). Arsenic (As) constitutes one of the most important environmental contaminants when global human health hazards are considered. Epidemiological studies reveal that chronic human exposure may be associated with peripheral artery disease, cardiovascular effects, diabetes mellitus, various cancers and adverse reproductive effects and exposure to high levels of arsenic can lead to death (Amusan *et al*. 2005; WHO, 2006).

Arsenic is a toxic compound and it is most toxic in its inorganic form. Arsenic gains access to the water environment through mining operations, the use of arsenical insecticides and from the combustion of fossil fuels. Arsenic compounds including lead and calcium arsenates and copper aceto-arsenic have been extensively used as pesticides and after many years of application may accumulate in soils to levels that become hazardous. Arsenic toxicity varies with several factors including concentration, rate of absorption and the chemical form ingested (Amusan *et al*., 2005).

Nickel is the fifth most abundant element on Earth; however, it is one hundred times more concentrated below the earth's crust and it is believed to be the second most abundant element in the earth's inner core, with iron being the first by a large margin. Nickel is typically found in two types of deposits that is laterite deposits which are the result of intensive weathering of surface nickel- rich rocks and magmatic sulfide deposits. Nickel can also be found in manganese nodules and crusts on the deep sea floor, fuel production, electroplating, pigments, ceramics, batteries, food production, but currently these are not being mined (Pedersen, 2016). The main mineral sources of nickel are limonite, garnierite and pentlandite. Nickel allergy is one of the most common causes of allergic contact dermatitis, a common irritant in jewelry that contain nickel such as white gold (Saglam *et al.* 2004; Pedersen, 2016).

Heavy metals are members of loosely defined subset of elements that exhibit metallic properties. It mainly includes the transition metals, some metalloid lanthanides, and actinide. Heavy metals occur naturally in the ecosystem with large variations in their concentration (McDowell *et al.* 2006; Mohsen and Salisu, 2008; Salwa *et al.* 2013). They are metallic elements that are toxic and have high density, specific gravity or atomic weight and rarely toxic (Kabata-Pendias and Pendias, 2001; Pierzynski *et al*. 2000). Anthropogenic activities and acceleration of nature's slowly occurring geochemical cycling of metals by man have caused most soils and environments to accumulate one or more of the heavy metals above defined background values, high enough to cause risks to human health, plants, animals, ecosystems, or other media (D' Amore *et al*. 2005, Buba *et al.,* 2018).

Tilapia fish *(Oreochromis niloticus)* are freshwater fishes belonging to Family Cichlidae, with 1699 species, widely distributed in Africa, Southeast Asia, the Middle East and South and Central America (Froese and Paul, 2014a). Tilapia often referred to as 'aquatic chicken', thrives in ponds, cages, tanks and rice paddle fields, exhibiting accelerated growth and enhanced national value when provided with the right feed (Perschbacher, (2014).

Fish are excellent biological indicators reflecting the relative health of aquatic ecosystems. Tissues concentrations of chemicals are a function of uptake, storage and excretion and therefore are excellent indicators of environmental load of a specific toxicant but usually do not directly reflect the physiological and ecological consequences (NIST, 2004; Gintare and Gintaras, 2017). Meanwhile, heavy metals can affect fish at all levels of biological organization; biochemical, physiological, cellular behavioral, increase mortality and reduce reproduction, individual growth and susceptibility to multiple types of disease (Froese and Pauly, 2014b; Fabio *et al.* 2016).

Gyawana ecosystem in Lamurde Local Government Area of Adamawa State, Nigeria, receives a wide variety of waste from almost every significant human activity. These include mostly the dumping of domestic wastes, sewage, agricultural wastes and industrial smokes and effluent. Such contaminations might accumulate in various organs of organisms and may affect humans and other species that prey on such organisms as food (Buba *et al.,* 2018), hence the need of this study, in Gyawana aquatic ecosystem. This research work aimed at determining the mean concentration of arsenic, cadmium and nickel in the blood, liver and flesh of tilapia fish *(Oreochromis niloticus)* in Gyawana Ecosystem, Lamurde Local Government Area of Adamawa State.

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The presence of heavy metals in aquatic animals like fish is becoming a threat, thereby making them unfit for human consumption. For this reason, the investigation of arsenic, cadmium and nickel in fish is essential since even slight changes in their concentration above the acceptable levels, whether due to natural or anthropogenic factors, can result in serious environmental and subsequent health problems. The determination of heavy metals in Gyawana aquatic organisms is relatively less studied; therefore, this study is a step in that direction. This will create awareness to the people of Gyawana about the levels of these heavy metals in their aquatic ecosystem.

MATERIALS AND METHOD

The study was carried out in Gyawana Canal River, Lamurde Local Government Area, Adamawa State of Nigeria. Gyawana is located at latitude 9˚.35' N and longitude 11˚.55' E and is 135 meters above Sea level. Lamurde Local Government Area lies between longitude 9˚.36' 03.92"N and latitude 11˚.47' 36.25"E at an elevation of 137 meters above sea level and has a population of 77,522 people (Adebayo and Tukur, 2004). Adamawa State is located in the North Eastern part of Nigeria, and lies between latitudes 7˚ and 11˚ N and between longitudes 11˚ and 14˚ E. It is on an altitude of 185 meters above Sea level and covers a land area of about 39,741km2 (Adebayo and Tukur, 2004).

Sampling and preparation

A total of twelve (12) freshly caught six (6) of each sex (male and female) *Oreochromis niloticus* were randomly selected and bought from fish-mongers, at Canal rivers. Random composite sampling technique was used for both sexes and the samples were identified taxonomically. The fish was transported to the Department of Fisheries and Aquaculture Laboratory, Adamawa State University, Mubi, Adamawa State, Nigeria, for identification and biometric measurement.

Total length was measured from the top most part of the mouth to the tip of the caudal fine and standard length was measured from the top most part of the mouth to the tip of hypural bone, using a meter rule. Fresh weights were measured using an electronic weighing balance after removing water and other substances (Froese and Pauly, 2014). The male tilapia genital papilla is tapered or cone-shape, while female genital papilla is more rounded and has a small triangular- shape indentation in the center. The male tilapia fish are more aggressive than the female tilapia fish, in term of size; the male tend to be smaller in size. (Anoop *et al.* 2009; Buba *et al.,* 2018) Dissection and digestion were done in the Department of Animal Production Laboratory, Adamawa State University, Mubi, Adamawa State, Nigeria as in Olatunde (1983); Buba *et al.,* 2022).

Determination of heavy metals

The fish samples (*Oreochromis niloticus*) were washed with tap water before dissecting with dissecting instruments to remove the liver and flesh. Blood was collected on Whatman No.1filter paper immediately after dissection and adequately labelled in the laboratory. The liver and flesh of each fish sample were transferred into individual sterile sample bottles, labeled and kept for digestion and analysis to determine the heavy metals. Each fish organ was dried at 105 ºC until a constant weight was obtained and ground separately by sex, using porcelain mortar and pestle. The ground fish samples were transferred to a porcelain basin and put into a muffle furnace and the temperature was increased gradually until 550ºC was reached. Samples where digested with tri-acid mixture (H_2SO_4) HNO_3:HCO_4:H_2SO_4) in the ratio of 10:4:1 respectively at a rate of 5mls per 0.5g of sample and placed on a hot plate of 100ºC temperature. Determination of heavy metals was done directly on each final solution using a Buck scientific 200A model, Atomic Absorption Spectrophotometer (AAS). Value obtained were expressed in milligram per gram (mg/g) as in (APHA, 2005, AOAC, 2000; Buba *et al*., 2018; Buba *et al*., 2022)

Data analysis

Data obtained was analyzed by one-way analysis of variance (ANOVA), followed by Duncan's Multiple Range Test (DMRT) for means separation. Student T-test was used for difference of heavy metals level between male and female *O. niloticus*. The results were presented as mean ± standard error and P>0.05 was regarded as not statistically different

RESULTS

Mean concentration of As, Cd and Ni in organs of *O. niloticus* in Gyawana ecosystem

The result of this study reveals that the mean concentration of nickel (Ni) and cadmium (Cd) is high in the flesh of *O. niloticus* with 0.0025±0.002mg/g and 0.0029 ± 0.0003 mg/g, respectively differ significantly, followed by the value recorded in the liver, with a mean value of 0.0025 ± 0.002mg/g and 0.0029 ± 0.0003mg/g nickle and cadmium respectively. The least mean value was detected in the blood of *O. niloticus* with the value of 0.0005±0.002mg/g of Ni and 0.0008±0.0000mg/g of Cd. Statistically there is significant differences at P>0.05. In all the organs and tissue of *O. niloticus,* sampled, arsenic was not detected as shown in table1.

Mean Concentration of As, Cd and Ni by Sex of *O. niloticus* in Gyawana ecosystem

The result of the male and female tilapia fish (*O. niloticus)* shows that the male has higher concentration of heavy metals than the female. The mean concentration of nickel in male *O. niloticus* is 0.0016±0.0009mg/g, while female mean concentration of nickel is 0.0013±0.0009mg/g. Cadmium mean concentration is 0.0021±0.0010mg/g and 0.0018±0.0008mg/g in male and female respectively. Statistically, there is no significant different at P>0.05.

Table 1: Concentration of As, Ni and Cd in organs of *O. niloticus* in Gyawana Ecosystem

Organ	Arsenic (As)	Nickle (Ni)	Cadmiun (Cd)
Flesh	$0.000{\pm}0.000^{a}$	$0.025{\pm}0.002^{c}$	$0.029{\pm}0.003^{b}$
Liver	$0.000{\pm}0.000^{a}$	$0.014{\pm}0.001^{b}$	$0.023{\pm}0.002^{b}$
Blood	$0.000{\pm}0.000^{a}$	$0.005{\pm}0.002^{a}$	$0.008{\pm}0.000^{a}$

Means carrying the same superscripts along the column are not significantly different at P>0.05

Table 2: Mean Concentration of As, Ni and Cd by Sex of Tilapia fish in Gyawana Ecosytem

Sex	Arsenic (As)	Nickle (Ni)	Cadmiun (Cd)
Male	$0.000{\pm}0.000^{a}$	$0.016{\pm}0.009^{a}$	$0.021{\pm}0.010^{a}$
Female	$0.000{\pm}0.000^{a}$	$0.013{\pm}0.009^{a}$	$0.018{\pm}0.008^{a}$
Total	0.000±0.000	0.015±0.009	0.020±0.009

NB. Means carrying the same superscripts along the column are not significantly different at P>0.05

DISCUSSION

The study on the determination of mean concentration of arsenic, cadmium and nickel in organs and tissue of tilapia (*Oreochromis niloticus*) in Gyawana aquatic ecosystem, Lamude Local Government Area, Adamawa State, shows that arsenic was not detected in all the organs and tissue of (*Oreochromis niloticus*) of the study area. Nickel was observed high in the flesh with mean concentration of 0.025±0.002mg/g, followed by liver with value of 0.014±0.001mg/g, and the least was found in the blood (0.05± 0.002mg/g). This concurs with the findings of Orosaye *et al.,* (2010), who reported low mean concentration (0.025±0.30mg/g) of nickel in the body of fish in ikpoda river, Benin city Nigeria. However a higher level has been reported by Idodo Umeh (2002), Mohammed *et*

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al, (2012), Ayeloja *et al.,* (2014) and Lalel *et al*., (2016), who reported higher mean concentration, which was above the permissible limits. This may be due to high level of biochemical substances in that ecosystem and may also be due to the species of fish used. The major source of nickel by humans is in their food and uptake from natural sources as well as food processing (Nas-NRC 1975; Akan *et al.,* 2012). Increased incidence of cancer of the lungs and nasal cavity in animals is caused by high intake of nickel (Anonymous, 2013).

The cadmium mean concentration in organ and tissue of *O. niloticus* shows that, flesh has the highest concentration of 0.029±0.003mg/g, followed by liver with the mean value of 0.023±0.002mg/g, while the least was detected in the tissue (blood) with mean concentration of 0.008±0.000mg/g. However, cadmium levels in this study are below permissible level for fish which is 0.07mg/g of body weight of fish reported by (FAO/WHO 2005; Stanchella *et al.*, 2014). The findings of cadmium mean concentration in this study is not in line with the result of Stancheva *et al*., (2014) who reported a value below 0.01mg/g for the muscle of *Clarias gariepinus,* this may be due to differences in the species of fish used in this study. It may also be due to differences in the geographical location of the study area. Gyawana is full of human activities and the industrial waste from Sugar Company and fertilizers used by farmers in both dry and wet season farming, Cadmium at high concentration above 10mg/g may pose a risk in pregnancy by damaging the placenta and reduce the weight of the new born baby as reported in both humans and rats (Diaz *et al,* 2014).

Arsenic (As) mean concentration was not detected (0.000±0.000mg/g) throughout the study period in both male and female tilapia fish (*O. niloticus*) sampled. The result of this study is line with the result of Buba *et al.,* (2022) who reported low levels of arsenic in cat fish (C*larias gariepinus*) in Gyawana aquatic ecosystem, Lamude Local Government Area, Adamawa State.

In comparison of mean concentration of As, Cd and Ni in this study by sex of tilapia fish (*O. niloticus*) the result shows that nickel (Ni) concentration was slightly higher in male fish (0.016±0.009mg/g) than in female fish (0.013±0.009mg/g), but the difference was not statistically significant at P>0.05. The result of this study is Similar to the findings of (Akan *et al.,* 2012) who reported no significant difference in nickel concentrations between male and female fish. Cadmium (Cd) concentration was also higher in male fish (0.021±0.010mg/g) when compared to female fish (0.018±0.008mg/g), but the difference was not significantly different at P>0.05. The findings of this study is in line with the results of Buba *et al.,* (2018) who reported that there was no significant difference in cadmium concentrations between male and female fish.

CONCLUSION

The study indicates that the mean concentration of As, Cd and Ni in tilapia fish (*O. niloticus*) in Gyawana aquatic ecosystem, Lamurde Local Government Area of Adamawa State, Nigeria are within permissible limit. Males' tilapia fish (*O. niloticus*) has higher concentrations of nickel and cadmium than females. Arsenic was not detected in the organs and blood of all the fish sampled during this study.

RECOMMENDATION

Based on the findings of this study, the researcher therefore proffers these recommendations;

1. Monitoring and regulation of heavy metal levels in aquatic ecosystem and fish populations should be implemented to ensure safety of the ecosystem.
2. Public health awareness campaigns should be conducted to inform consumers about the potential risks associated with consuming fish contaminated with heavy metals.
3. Consideration should be given to implementing measures to reduce heavy metal accumulation in fish and other aquatic organisms, such as improving water quality or using phytoremediation techniques and provide good dumping site

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