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Determination of Some Heavy Metals Contamination Status in Some Selected Fish Species Collected from River Taraba at Bali

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Abstract: **The concentrations of heavy metals (Pb, Cu, Cr, Cd and Zn) were measured in the tissues of some selected fish species (Clarias gariepinus, Oreochromis niloticus and Synodontis gambiense) from River Taraba at Bali, and also the condition factor of these fish species inhabiting the river was evaluated. The concentrations of these heavy metals in the fish sample was determine by Atomic Absorption Spectrophometry (AAS). The result show that among the five element analyzed only two were detected i.e. Cu and Zn, while Pb, Cr and Cd were below detection limit. The mean value of metal concentration of Cu and Zn in C. gariepinus, O. niloticus and S. gambiense is (0.092, 0.110 and 0.092 mgkg^{-1}) and (0.223, 0.238 and 0.172 mgkg^{-1}) respectively. The mean concentrations of heavy metals in tissues of the fish were different among species, this indicated that different species from the same area contained different levels of heavy metals in their tissues. The result also revealed that the concentration of metals among the species as compared with the international permissible limit were within the acceptable limit. The results of the ANOVA pointed that there is no significant difference in the concentration of heavy metals in fish flesh of the various fish species at (P-value < 0.05). It was also observed that the fish species recorded varying condition factors, some samples shows slight increases in K – value while others within the normal range. Most of the fish species sampled in this present study had condition factors ≥ 1, and were within the normal recommended ranges. It was also stated from previous study that condition factor greater or equal to one is good, indicating a good level of feeding, and proper environmental condition.**

Keywords: **Heavy Metals, River Taraba, Fish Species, Condition Factor.**

I. INTRODUCTION

A heavy metal is a member of a loosely defined subset of element that exhibits metallic properties. It's mainly includes the transition metals, some metalloids, lanthanide and actinides. Many different definitions have been proposed, some based on density, some based on atomic number or atomic weight and some on chemical properties or toxicity [6]. Certain heavy metals are nutritionally essential for healthy life when present in small quantities and are refer to as the trace-elements (e.g. iron, copper, manganese and zinc). While some heavy metals are toxic or poisonous to the body (e.g. lead, mercury, cadmium, Chromium and Arsenic) [3]. These elements enter into water through weathering, industrial activities and through agricultural activities. Heavy metals are also used in industrial application such as in the manufacture of pesticides, batteries, alloys, electroplated metal parts, textile dyes, steel etc. [10]. Increasing human influences through heavy metal pollution have over the years led to the depletion of our aquatic biodiversity. As a result, several important endemic fish species have become threatened. Realizing this, concern for the assessment of heavy metals in fish species

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of most water bodies have increasingly been gaining ground throughout the world [11], [15]. Fish accumulate toxic metals directly from water and diet, and contaminant residues may ultimately reach concentrations hundreds and thousands of times above those measured in the water, sediment and food. These metals are known to be environmentally stable, non-degradable and induce toxic effect. Heavy metals are normal constituents of aquatic environment that occur as a result of pollution principally due to discharge of untreated wastes and agricultural activities into the rivers [17], [10].

Bioaccumulation of heavy metals in the tissues of aquatic organisms has been identified as an indirect measure of abundance and availability of metals in the aquatic environment, and for this reason, monitoring fish tissues contamination serves an important function as an early warning for sediment contamination or related water quality problems [15]. This will enable relevant authorities to take necessary action or measures to protect the general public health and the environment [22]. Heavy metals are persistent environmental contaminants that are very harmful because of their potentials to accumulate in different body parts. Most are extremely toxic because of their solubility in water, and even at lower concentrations they may have damaging effects because of the lack of good mechanisms for eliminating them [1]. Prolonged intake of heavy metals through foodstuffs may lead to chronic accumulation in the kidney and liver of humans and animals causing disruptions of numerous biochemical processes, leading to cardiovascular, nervous, kidney and bone diseases [23], [6]. Some heavy metals such as Cu, Zn, Mn, and Co act as nutrients for the growth of animals and humans when present in small quantities, whereas others such as Cd, As, and Cr act a s carcinogens [18] and, Hg and Pb are associated with the development of abnormalities in children [14]. The aim of this research is to determine the level of heavy metals in tissues of some selected fish species from River Taraba at Bali, and to analyze the condition factor of these fish species inhabiting the river.

II. MATERIALS AND METHOD

Study Site

The study was carried out at River Taraba in Bali town, Bali Local Government Area of Taraba State, Nigeria (Fig. 1). The town lies between latitude 7°46[1] and 7°54[1] of the equator and longitude 10°30[1] E and 11°00[1] E of the prime meridian. Bali is the largest Local Government in Taraba State with an estimated land area of 11.540 km^2 and a population density of about 211,024 (NPC 2006). The town is found in dry guinea savannah, with a tropical climate marked by two seasons; dry and rainy seasons. The rainy season starts around April and ends in November occasionally, with 1350 – 1350 mm rainfall annually. The dry season is from December to March. The major occupation of the inhabitants are farming, fishing and nomadism.

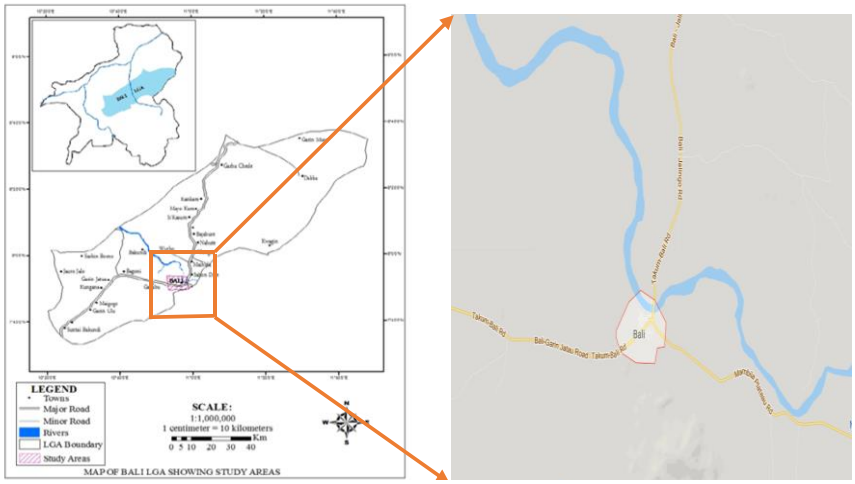

Figure 1: Map of Bali Local Government Area showing the study area

(Source: Bureau for land and survey Jalingo Taraba state)

Samples collection and analysis

The fish samples (*Clarias gariepinus*, *Oreochromis niloticus* and *Synodontis gambiense*) were collected from River Taraba, in Bali town using standard procedures as described by [21]. Samples were collected randomly from fishermen catches at the landing sites between 9:00am – 11:00am bi-monthly for six (6) months from September 2018 – February

2019. The measurements of the total length (cm) of each fish was taking from the tip of snout (mouth close) to the end of caudal fin using meter rule, body weight (g) was measured using electronic digital balance and the condition factor of individual fish sampled were recorded. The sample were then dissected and their organs (kidney, gills and muscles) was separated. The organs were oven dried and pounded into fine powder and kept in a plastic container for analysis [1]. The relationship between length and weight of the fish was examined by simple linear regression. The parameter of length-weight relationship of sampled fish species were evaluated using the equations below; [16].

$$W = aL^b \quad \text{- - - - - - - - - equation 1}$$

Where, *W* is weight of fish (g), *L* is length of fish (cm), *a*, is initial growth coefficient, and *b* is growth coefficient. The values of constant 'a' and 'b' were estimated after logarithmic transformation of eqn. 1 using the least square linear regression given:

$$\log 10W = \log 10a + b\log 10L \quad \text{- - - - - - - - - equation 2}$$

The condition factor was calculated by the formula describe by [12]:

$$\text{Condition Factor (K)} = 100W/L^3 \quad \text{- - - - - - - - - equation 3}$$

Where *W* is weight (g) and *L* is total length (cm).

Digestion of Sample and Heavy Metal Analysis

For each sample, 0.2 g was weighed into a digestion tube and 4.5 ml of the digest reagent was added. The tube was kept on a digestion block and at a temperature of 36^o C. The mixture was allowed to digest for 2 hours then cooled off. 1 ml of H_2O_2 was added to each tube and then allowed to digest completely for another hour until a clear solution is obtained. The solution was allowed to cooled, filtered through a Whitman filter paper No. 42. The filtrate was made up to the 50 ml mark by adding distilled water. The mixture was used to analyze the heavy metals contents using AAS, based on the manufacturers' instructions for each heavy metal [15], [17].

Statistical analysis

Statistical analysis was conducted to determine the differences in the heavy metal contamination of the three species of fish within the studied site. An analysis of variance (ANOVA) have been conducted to determine the statistical significant difference among the three fish species due to presence of heavy metals in the river. The statistical significance level was set at $p<0.05$. All test procedures were performed in a computer program SPSS.

III. RESULT AND DISCUSSION

This study analyze the level of heavy metals (Pb, Cu, Cr, Cd and Zn) in tissues of some selected fish species (*C. gariepinus, O. niloticus* and *S. gambiense*) from River Taraba at Bali, and also evaluate the condition factor of these fish species inhabiting the river. Table 1: Show the morphometric characteristics, average length, average weight and condition factor of the studied fish species. *O. niloticus* had the highest number of fish sampled; N = 47 with a total average length, ranging from 12.86 to 17.61 cm, and average weight ranging from 30.11 to 60.11 g. *C. gariepinus* had the medium number of fish sampled N = 42 with a total average length, ranging from 13.33 to 19.83 cm, and average weight ranging from 43.54 to 66.62 g. *S. gambiense* was the least species of fish sampled N = 40 with a range from 14.04 to 19.41 cm in total average length, and average weight ranging between 41.26 and 63.38 g. The variation in number of samples according to the fish species was largely due to their availability during collection. The highest condition factor (K – value) = 1.99 was observed in *C. gariepinus* by January, while the lowest K – value = 0.81 was recorded in *S. gambiense* by December. *O. niloticus* had a marginal K – value of 1.80 in December with the lowest K – value than with the highest K – value.

The condition factor (K) gives information on the physiological condition of fish in relation to its welfare. It is reported that fishes with a low condition index are presumably believed to have experienced adverse physical environment or insufficient nutrition [13]. According to [7], from a nutritional point of view, increase in K values indicates the accumulation of fat and sometimes gonadal development. Meanwhile from a reproductive point of view, the highest K values are reached in species if the fish is fully mature, and have higher reproductive potentiality. It was observed that the three fish species sampled in this study recorded varying condition factors, some samples shows slight increases in K – value while others within the normal range. Most of the fish species sampled in this present study had condition factors ≥

1, and were within the normal ranges as recommended by [19] who stated that condition factor greater or equal to one is good, indicating a good level of feeding, and proper environmental condition. It was recommended from previous research that K value range from 2.9 – 4.8 is suitable for matured fresh water fish [2]. The condition factors of the three fish species sampled in the present study revealed that the fish species had their K values outside and within the range recommended as suitable for matured fish in fresh water. This could be caused due to environmental factor such as damming the river [19].

Table 1: The morphometric characteristics, average length, average weight and condition factor of the studied fish species.

Collection Month	English Name of the fish	Scientific Name	Sample Size (N)	Average Weight (g)	Average Total Length (cm)	K - value
September	Cat Fish	*Clarias gariepinus*	7	61.56	17.07	1.24
October			8	60.21	15.66	1.57
November			8	43.54	13.33	1.84
December			7	47.22	17.92	0.82
January			6	55.84	14.11	1.99
February			6	66.62	19.83	0.85
September	Tilapia	*Oreochromis niloticus*	8	52.66	16.89	1.09
October			7	60.11	17.61	1.10
November			8	30.11	12.86	1.42
December			7	45.39	13.61	1.80
January			8	58.11	15.53	1.55
February			9	58.66	15.23	1.66
September	Nile Squeaker	*Synodontis gambiense*	6	63.38	19.41	0.87
October			6	41.26	14.43	1.37
November			8	52.22	14.04	1.89
December			7	61.11	19.61	0.81
January			7	60.21	15.66	1.57
February			6	53.34	16.53	1.18

The comparison among fish species in River Taraba at Bali according to their metal accumulation levels in tissues is given in Table 2 and 3. From table 2; the result show that among the five element (Pb, Cu, Cr, Cd and Zn) analyzed only two were detected i.e. Cu and Zn, while Pb, Cr and Cd were below detection limit. The mean value of metal concentration of Cu and Zn in *C. gariepinus*, *O. niloticus* and *S. gambiense* is 0.092, 0.110 and 0.092 $mgkg^{-1}$ respectively. Similarly the mean value of metal concentration of Zn in *C. gariepinus*, *O. niloticus* and *S. gambiense* is 0.223, 0.238 and 0.172 $mgkg^{-1}$ respectively**.** The mean concentrations of heavy metals in tissues of the fish were different among species, this indicated that different species from the same area contained different levels of heavy metals in their tissues. Moreover, the metal concentration of fish species in River Taraba at Bali and its comparison with International Standards (FAO, WHO, and USFDA) is given in table 3. The result revealed that the concentration of metals among the three fish species as compared with the international permissible limit were within the acceptable limit. An analysis of variance (ANOVA) have been conducted to determine whether there were significant difference in the concentration of heavy metals in fish flesh of the various fish species. The results of the ANOVA pointed that there is no significant difference in various flesh of fish species at (P-value < 0.05) due to heavy metals concentration.

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Table 2: Heavy Metal Concentration (mgkg^{-1}) of the Fish Species in River Taraba at Bali.

Month	Fish Species	Pb	Cu	Cr	Cd	Zn
September	*CG*	BDL	0.132	BDL	BDL	0.352
	ON	BDL	0.044	BDL	BDL	0.232
	SG	BDL	0.022	BDL	BDL	0.186
October	*CG*	BDL	0.173	BDL	BDL	0.165
	ON	BDL	0.044	BDL	BDL	0.283
	SG	BDL	0.044	BDL	BDL	0.313
November	*CG*	BDL	0.044	BDL	BDL	0.386
	ON	BDL	0.088	BDL	BDL	0.516
	SG	BDL	0.044	BDL	BDL	0.359
December	*CG*	BDL	0.088	BDL	BDL	0.275
	ON	BDL	0.176	BDL	BDL	0.190
	SG	BDL	0.132	BDL	BDL	0.068
January	*CG*	BDL	0.066	BDL	BDL	0.108
	ON	BDL	0.086	BDL	BDL	0.049
	SG	BDL	0.154	BDL	BDL	0.068
February	*CG*	BDL	0.044	BDL	BDL	0.049
	ON	BDL	0.042	BDL	BDL	0.197
	SG	BDL	0.132	BDL	BDL	0.038
	CG	BDL	0.092	BDL	BDL	0.223
Mean	*ON*	BDL	0.110	BDL	BDL	0.238
	SG	BDL	0.092	BDL	BDL	0.172

NB: BDL = Below Detection Limit, *CG = C. gariepinus*, *ON = O. niloticus*, *SG = S. gambiense*

Table 3: Permissible limits of heavy metal concentration (mgkg^{-1}) in fish

Heavy metal	FAO 1983	FAO 2003	WHO 2006	USFDA 1993	HM concentration in fish for current study		
					C. gariepinus	*O. niloticus*	*S. gambiense*
Pb	0.5	0.5	2.0	0.5	BDL	BDL	BDL
Cu	30	30	3.0	-	0.092	0.11	0.092
Cr	1.0	-	0.15	-	BDL	BDL	BDL
Cd	0.5	0.5	-	0.01-0.21	BDL	BDL	BDL
Zn	30	40	20	-	0.223	0.238	0.172

NB: BDL = Below Detection Limit

Essential element

Excessive Zn intake is detriment to human health and can cause poisoning, diarrhea and fever [10]. In this study the highest concentration of Zn was detected in *O. niloticus* (0.516 mg/kg) followed by *C. gariepinus* (0.386 mg/kg) and *S. gambiense* (0.359 mg/kg) with a marginal difference between them. The lowest value of Zn was observed in *S. gambiense* (0.038 mg/kg) while *C. gariepinus* and *O. niloticus* has same value of (0.049 mg/kg). The mean value of Zn accumulation level in the tissue of *C. gariepinus*, *O. niloticus* and *S. gambiense* is 0.223 mg/kg, 0.238 mg/kg and 0.172 mg/kg

respectively. Hence the high Zn concentration detected in Tilapia could be due to their feeding on benthic worms and crustaceans [3]. The Zn concentration from fish in this study was lower when compared with other studies like [3] with (0.434 mg/kg) and [9] with (28 to 49.5 mg/kg) mean concentration. Cu plays a vital role in enzymatic process and are essential for the synthesis of hemoglobin. Although, very high intake will cause health problems [5]. The highest concentration of Cu was detected in *O. niloticus* (0.176 mg/kg) and the lowest value was detected in *S. gambiense* (0.022 mg/kg). Cr was below detection limit in this study. Therefore, it is generally observed that the concentration of Zn, Cu and Cr in all the fish species sampled in the study area were below the WHO, FAO and USFDA limit as presented in table 3.

Non-essential element

Report from previous study show that long term intake of Cd causes renal, prostate and ovarian cancers [3]. The minimum mean concentration limit of Cd detected from various fish species in previous research was (0.5 mg/kg) [4], [5] while [20] detected (0.01 to 0.21 mg/kg). However, the maximum Cd concentration limit was set at (1 mg/kg) Malaysian Food Act [8]. Meanwhile, the acceptable mean concentration limit of Pb as suggested by [5], [22], [8] and [20] were (0.5 mg/kg), (2.0 mg/kg), (2.0 mg/kg) and (0.5 mg/kg) respectively. However, the concentration of Cd and Pb from the three fish species in study were below detection limit (Table 2). Therefore it can be concluded that there is less adverse toxic effect of Cd and Pb in the study area.

IV. CONCLUSION

The mean concentrations of heavy metals in the fish tissues were different among species, this shows that different fish species from the same area contained different levels of heavy metals in their tissues. The result revealed that the concentration of metals among the species as compared with the international permissible limit (FAO, WHO, and USFDA) were within the acceptable limit. The result shows no significant difference in the concentration of heavy metals in fish flesh of the various fish species at (P-value < 0.05). It was also observed that the fish species recorded varying condition factors, some samples shows slight increases in K – value while others within the normal range. Most of the fish species sampled in this present study had condition factors ≥ 1, and were within the normal ranges as recommended by [19] who stated that condition factor greater or equal to one is good, indicating a good level of feeding, and proper environmental condition. Therefore, the results of the present study can serve as baseline data for these species and for comparisons with future studies.

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