International Conference on Developmental Sciences and Technologies, Federal University of Agriculture, Abeokuta, Nigeria. 27 – 30 August, 2019.
https://unaab.edu.ng/2020/06/colphysproceedings/

Morphometric and Metals Relationships in African River Prawn, *Macrobranchium Vollenhovenii* (Herklot, 1852) Of Asejire Lake, Nigeria

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Abstract

Rapid urbanization and industrialization in developing countries have been associated with production and deposition of hazardous wastes in aquatic environments. Metals are major components of these wastes which have been implicated in several metal-related diseases and food poisoning in man. This study was carried out to detect concentrations of heavy metals (Fe, Cu, Zn and Pb) in relation to the morphomeristics characters of commercially vital African River Prawn (*Macrobrachium vollenhovenii*) in River Osun, Asejire Lake, Nigeria. One hundred (100) adult shrimp samples were procured and morphometric features of each prawn were measured following standard methods. Each prawn was digested and analyzed for the metals concentrations using Atomic Absorption Spectrophotometer. Data obtained were subjected to SPSS (version 20.0) for Analysis of Variance (ANOVA) and descriptive statistics to compare the metals between the male and female shrimps in relation to their body weight and sex. Pearson correlation was used to compare the relationship between the prawn morphomeristics and metals accumulation when *P* value was set at 0.05. Results revealed that *M. vollenhovenii* accumulates metals in order of Fe (105.94 ± 0.00) > Zn (104.94 ± 0.00) > Cu (114.93 ± 0.00) >Pb (1.90 ± 1.20), while lead was undetected except in the female. Generally, females (31.50 ± 2.02 and 325.24 ± 100.96) relatively possess higher weight and accumulate higher metals than males (25.00 ± 0.00 and 170.84 ± 25.93). Significant differences were found across each sex in each week for the metals determined except Pb. Also, the metals were found to be above maximum recommended admissible limits which call for close monitoring and adequate public awareness to dampen further pollution that could lead to high metal bioaccumulation and poisoning.

Keywords; Poisoning, Urbanization, Prawn, Morphometric, *Macrobrachium vollenhovenii*

1.0 Introduction

Contamination of freshwater bodies with a wide range of pollutants has become a great concern over the last few decades (Dung *et al.,* 2013; Jenyo-Oni and Oladele, 2016). Heavy metals are natural trace elements of the aquatic environment, but their levels have increased due to industrial, mining, domestic and agricultural activities (Kalay and Canli, 2000). Owing to their toxicity and cumulative effect, discharge of metals into the aquatic environments can alter the diversity of aquatic species and ecosystems (Berga, 2006). Aquatic organisms (such as fish and shell fish) accumulate metals concentrations many times higher than what is present in water or sediment (Olaifa *et al.,* 2004; George *et al*., 2013).

In Nigeria, all water bodies serve as sources of exploitation for industrial, domestic, agricultural and urban uses. This has made many water bodies to be greatly affected by these intensive anthropogenic practices. The contamination of water with a wide range of pollutants has become a matter of concern over the last few decades (Vukovic *et al.,* 2008). The natural aquatic systems may extensively be contaminated with trace metals due to the alarming situation of rapid economic growth. According to Paquin *et al.* (2003), the coastal or river waters are contaminated by the clumping of industrial wastages, domestic and other man-made activities, recent works have shown that the higher level of metal concentration will bring shattering effects to the ecological balance by altering the range of organisms in the water.

Bioaccumulation of trace metals in tissues of marine organisms has been identified as an indirect measure of the abundance and availability of metals in the marine environment (Kucuksegin *et al*., 2006). Metals could be accumulated in water, sediments and biota, but its multiple factors includes season, physical and chemical properties of the water which play a significant role (Hayat *et al.,* 2007). The accumulation of metals in an aquatic environment has direct consequences on man and the ecosystem (Fatoki *et al*., 2002).

Several researches carried out on fish have shown that metals may have toxic effects by changing their physiological activities and biochemical composition in tissue (King and Jonathan, 2003; George *et al*., 2013; Oladunjoye, 2015; Fafioye *et al.,* 2017). Fishes have been recognized as good bioaccumulators of organic and inorganic pollutant (King and Jonathan, 2003). The ingestion of food is an obvious means of exposure to metals not only because many metals are natural components but also because of environment contamination and contamination during processing (Ibeto and Okoye, 2011).

Fishes are major sources of protein and could be grouped into finfish and shellfish. Finfish constitute major population of aquatic habitat and are important bio-markers of metal levels in aquatic ecosystem. Fishes are at the top of the aquatic food chain and they accumulate trace metals form the surrounding waters. Fishes could take up take up metals ions in the water and store them in their tissues. Fishes are the inhabitants that cannot escape from the detrimental effects of these pollutants (Olaifa *et al.,* 2004). Some environmental factors affect the growth and survival of fishes in their natural habitats and these factors therefore cause depletion in their population.

Shellfish including Prawns, Lobsters, Crabs, Clams, Mussels, Scallops and Oysters were sourced locally and internationally. This group of shellfish can either be caught from the wild or farmed successfully to produce a delicious menu. They are among the most common food allergens which eat a diet composed primarily of phytoplankton and zooplankton (FAO, 1990).The aim of this research was to examine metals (Fe, Cu, Zn and Pb) concentrations in a shellfish (*Macrobrachium vollenhovenii*) in relation to its morphometric characters of River Osun, Asejire Lake, Southwest, Nigeria.

2.0 Methodology

2.1 Description of the Study Area

River Osun stream is presented in figure 1. The Stream with estimated terrain of 4 metres elevation above sea level is located at the latitude and longitude coordinates of 6°33'34.96"E and 4°3'46.8"N respectively (Fig. 1). The River flows through southwestern part of Nigeria into the Lagos Lagoon and the Atlantic Gulf of Guinea. It is one of the several rivers ascribed in local mythology to have been a woman who turned into flowing waters after some traumatic event frightened or angered her (Murphy and Sanford, 2001).

2.2 Samples Collection and Determination of Morphometric Characters

One hundred (100) adult Prawns samples were procured from fishermen from the river bank between May and September, 2016. The total length (cm) and the body wet weight (g) were measured *in-situ*. The length and weight of each individual samples were measured using a standard calibrated measuring board and Metler balance respectively. They were mopped on a filter paper before being weighed to remove excess water from their body in order to ensure accuracy. They were kept in an icebox before transportation to the laboratory. At the laboratory, each Prawn was identified to species level using standard recommended methods (Tobor and Ajayi, 1979; Fischer *et al.,* 1981; Powell, 1982). Sexes of each adult shrimp were further determined using standard recommended catalogue of Fischer *et al.* (1981) by observation of wider opening at the secondary papillae in females. The samples were transferred in a tube and placed in heating blocks and digest for 15min at 150^{o}C after which the temperature is raised to 230^{o}C. Any 'cold spots' in the heating block of the rotating tubes were observed so that the nitric acid is driven off as uniformly as possible and when all tubes reached the dense white fume stage, this stage is not reached until essentially all the nitric acid have been driven off. This digestion continued for 30mins, then, the tube were removed from digesting block and allow to cool with addition of 5ml water volume while mixed thoroughly.

The digests were then allowed to cool, filtered and transferred to 25ml volumetric flasks and made up to mark with 1% nitric acid (AOAC, 2005). Metal concentrations were determined using an Atomic Absorption Spectrophotometer (VGB 210 Bulk Scientific). Working calibration standards for iron, copper, lead and zinc were prepared by serial dilutions of concentrated stock solutions in accordance to manufacturer's specification and instruction (Merck, Germany). The actual concentrations of each metal were read and calculated using the formula (Mansour and Sidky, 2002):

Actual concentration of metal in sample

= ppmR × dilution factor

Where;

ppmR - AAS Reading of digest

Dilution Factor - Volume of digest used ⁄ Weight of sample digested.

2.3 Statistical Analysis

Data obtained were subjected to statistical analysis using SPSS (version 20.0) (IBM Corp, 2011). Analysis of Variance (ANOVA) and descriptive statistics were used to compare the body weight and concentrations of metals between male and female prawns. Means were presented as Mean ±Standard error of mean.

Means were separated using the Student-Newman-Keuls (SNK). Pearson correlation was used to compare the relationship between the morphometric parameter of the Prawns and the metals accumulation. *P* value was set at 0.05.

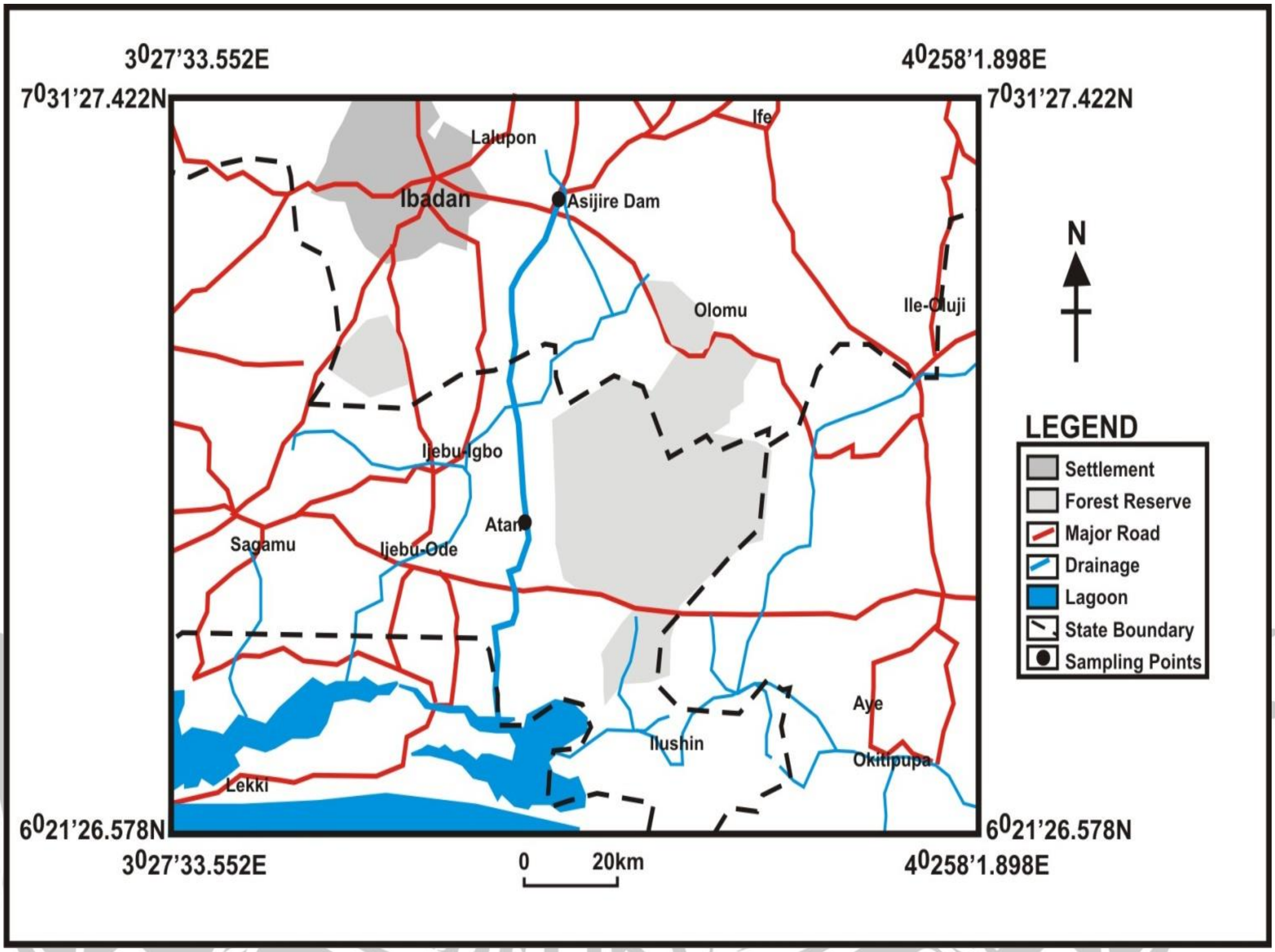

Figure 1: Map of the Study Area showing the Sampling Point (Asejire Dam)

3.0 Results and Discussions

3.1 Metals Concentration in Male and Female Prawns

Table 1 presents the results of metal concentrations in male and female prawns of Osun River during study period. Lead (Pb) was below detectable limit in the male shrimps collected over the study period. The levels of Fe were observed to reduce with increase over the months and significantly higher (P < 0.05) in May and lower in September. Also, concentration of Cu in the male shrimps was significantly higher (P < 0.05) in July and September than other months, with no significant difference recorded in the concentration of Zn of the male prawns throughout the sampling period.

Table 1: Heavy Metal Concentrations in Male and Female Prawns from Asejire Lake

Metals	Sex	May	June	July	August	September
Fe	Male	$170.84±25.93^{a}$	$149.98±16.11^{ab}$	$112.86±7.00^{b}$	$136.57±1.80^{ab}$	$105.94±0.00^{b}$
	Female	$216.50±41.85^{a}$	$325.24±100.96^{a}$	$146.59±0.00^{a}$	$129.33±18.82^{a}$	$139.72±13.73^{a}$
	Sig.	0.44	0.06	0.05	0.64	0.27
Cu	Male	$59.02±5.37^{ab}$	$53.44±13.08^{b}$	$114.97±14.76^{a}$	$70.29±3.41^{ab}$	$114.93±0.00^{a}$
	Female	$81.50±12.69^{a}$	$76.71±12.83^{a}$	$96.73±0.00^{a}$	$77.89±8.99^{a}$	$120.75±4.86^{a}$
	Sig.	0.21	0.26	0.57	0.38	0.58
Zn	Male	$117.01±1.33^{a}$	$110.34±20.91^{a}$	$123.47±5.19^{a}$	$117.95±6.34^{a}$	$104.94±0.00^{a}$
	Female	$154.69±7.20^{a}$	$142.43±4.30^{a}$	$184.48±0.00^{a}$	$101.12±13.76^{a}$	$205.90±31.62^{a}$
	Sig.	0.01*	0.25	0.01*	0.24	0.16
Pb	Male	N.D	N.D	N.D	N.D	N.D
	Female	$1.90±1.20^{a}$	N.D	N.D	N.D	N.D
	Sig.	0.24	-	-	-	-

Note;

[abc]Mean (± Standard error) of metal concentration in the same row having similar superscript are not significantly different at $P < 0.05$.

*Mean value of heavy metal concentration significantly different between male and female prawns.

N.D = below detectable limit.

In female prawns, Pb was only detected in May samples, while the concentrations of Fe, Cu and Zn were however not significantly different ($P > 0.05$) in the female prawns collected throughout the sampling Period (Table 1). Comparing the metal concentrations between the male and the female prawns, there was no significant difference in the concentration of Fe and Cu recorded in the male and female prawns throughout the study period. On the other hand, the female prawns collected in May and July was observed to be significantly higher ($P < 0.05$) in Zn than the males.

3.2 Body Weight of the Male and Female Prawns

The weight of male and female prawns collected from Osun River during the study period is shown in Table 2. There was no significant difference ($P > 0.05$) recorded in the mean weight of the female prawns from throughout the study.

Similarly, no significant difference (P > 0.05) between the mean weights of male prawns recorded in July and August. However, significant higher (P < 0.05) difference was recorded in May and September.

3.3 Body Weights and Metals Accumulation Correlation

Results of Pearson correlation between the body weight and heavy metal accumulation in prawns collected is presented in Table 3. A negative correlation was recorded between the body weight and Fe concentration in the prawns, while the relationship between the body weight and Cu and Zn is positive on other hand (Table 3). However, the correlations were not significantly difference (P > 0.05), while a significant positive (P < 0.01) correlation was observed to exist between the concentration of Cu and Zn in the prawns.

3.4 Comparison of Weight and Metals with Sex

Figure 2 compares the weight and heavy metals by sex of prawns collected from Asejire Lake, Osun River. Both the mean weight and the mean values of heavy metals tested (Fe, Cu, Zn and Pb) were recorded higher in the female prawns than the males.

3.5 Discussion

Result obtained shows that mean weights for female shrimp (*M. vollenhovenii*) were found to be higher than mean weights for male shrimps in River Osun. Similar results were reported by Yilmaz and Yilmaz, (2007) for *Penaeus semisulcatus* collected from the Mediterranean of Turkey and also by Turkmen (2012) and Cevik *et al.* (2008) for *Penaeus kerathurus* and *Parapenaeus longirostris* respectively.

There are highly significant differences between the male and female shrimps of River Osun in the level of heavy metals accumulation (Fe, Cu, Zn and Pb) which is expected to vary in a wide range of concentrations because they reflect the exposure to environmental levels and feeding behavior (Heidary *et al.,* 2012; Guizhai *et al.,* 2015). Among the metals studied in the present study, Zn, Cu, and Fe are essential elements, while Pb is non-essential elements for most of the living organisms.

Table 2: Weight of Male and Female Prawns FromAsejire Lake during the Study Period

Weight	Male	Female	Sig.
Week 1	25.00 ± 1.73^{a}	22.33 ± 4.02^{a}	0.62
Week 2	16.33 ± 1.17^{b}	20.50 ± 0.87^{a}	0.03*
Week 3	22.75 ± 1.59^{ab}	22.00 ± 0.00^{a}	0.83
Week 4	20.33 ± 1.48^{ab}	31.50 ± 2.02^{a}	0.01*
Week 5	25.00 ± 0.00^{a}	26.25 ± 1.35^{a}	0.66

Note;

^{abc}Mean (± Standard error) of body weight in the same column having similar superscript are not significantly different at P < 0.05.

*Mean value of body weight significantly different between male and female prawns.

It was reported that the relationship between metal accumulation and sex may be due to the difference in metabolic activities between the males and the females, and the faster-growing sex (usually the female) can be expected to contain lower concentrations of metals (Yılmaz and Yılmaz, 2007; Baboli and Velayatzadeh, 2013;

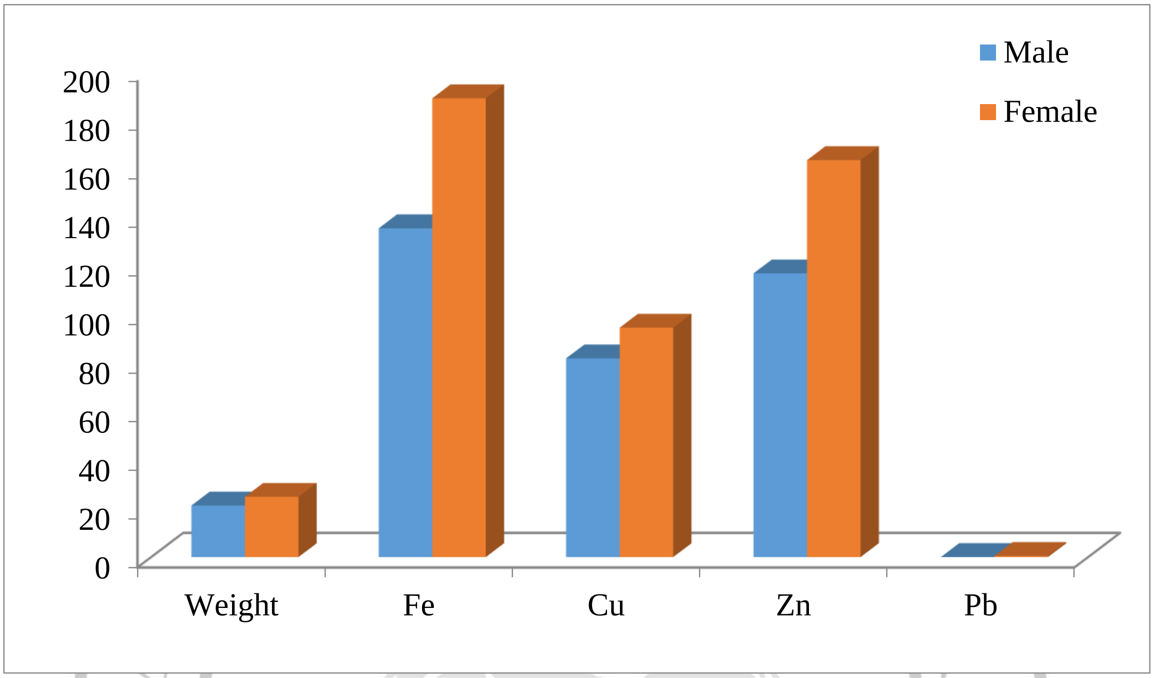

Figure 2: Comparison of Weight and Metals in Relation with Sex of Prawns Obtained From Asejire Lake

Ghorade *et al.,* 2015). Fe, Cu and Zn were detected regularly in all the samples and the Zn concentrations in both males and females were found to be relatively higher when compared to other metals concentrations except Fe. *M. vollenhovenii* in River Osun accumulated metal in the ascending other of Fe > Zn > Cu >Pb which was in agreement with the finding of Oladunjoye and Fafioye (2015) of heavy metals in fishes of Majidun River, Lagos.

Zinc being an essential element for normal growth and metabolism of organisms, exhibited highest accumulation in the shrimp samples when compared with the other metals (Akan *et al.,* 2012; Meshram *et al.,* 2014; Girum *et al.,* 2015). According to Pourang *et al.* (2014) findings, Zn is the most abundant element detected followed by Cu and Pb which the results

Table 3: Correlation between Body Weight and Metal Accumulation in the Prawns

	Weight	**Fe**	**Cu**	**Zn**
Weight	1			
Fe	-0.201	1		
Cu	0.069	-0.106	1	
Zn	0.232	0.090	0.382**	1

Note; ** Correlation is significant at the 0.01 level (2-tailed).

of this finding were in is in agreement with. The observed variability in the concentration of metals in the Prawns samples of River Osun is a reflection of varying degrees of metal thresholds in the animals. This can be described as a function of homeostatic control mechanism as well as rate of bioaccumulation of metals, which is species-dependent (Bhattacharyya *et al.,* 2013; Hall, 2014; James*et al.,* 2015; Jenyo-Oni and Oladele, 2016).

The absorptive differences that occurred between species in this investigation may be attributed to the differences in the absorptive capabilities among animals and the animals' anatomic considerations (Batvari *et al.,* 2013; Khan *et al.,* 2013; Oladele and Jenyo-Oni, 2015). In contrast to other metals, the relatively high concentration of Fe may be attributed to being essential micronutrient associated with many proteins and enzymes (Kwok *et al.,* 2014; Guizhai *et al.,* 2015) in these aquatic animals. The relatively high concentration of Fe in *M. vollenhovenii* may also be ascribed to the abundance of the metal in inland waters where these animals live (Kuklina *et al.,* 2013; Meshram *et al.,* 2014; Mine-Perçin *et al.,* 2015).

The observed low concentrations of lead may be attributed to their non-dietary nature or due to efficient mechanism of elimination by these animals (Maryam *et al.,* 2014; Amoozadeh *et al.,* 2014; Sarkar e*t al.,* 2014). The presence of Fe and Pb can be traced to the agrochemicals used by farmers in crop farms around the lake. The mechanism of Pb accumulation in water is likely to be through adsorption and complexing of free Pb ions (Heidarieh *et al.,* 2013; Squadrone *et al.,* 2013; Giri and Singh, 2014).

Fe and Pb compounds transported during rainfall and erosion especially from household sources, where domestic wastes are deposited along the courses of the water body, may have also contributed to the presence of these metals in the water column. Reports obtained from the fishermen and the members of staff of Asejire Water Processing Unit corroborated disposal of household wastes along the courses of the water body. The contribution of metallic rusts and chemical degradation of abandoned machine parts, metallic pipes and equipment cannot be overlooked, as various damaged machines and equipment were found littering the lake vicinity.

The dissimilarity in Fe concentrations showed the differences in the accumulative capacities of the shrimps by sex. Relatively high concentration of Fe in *M. vollenhovenii* as against the minute quantities of other metals (Cu and Pb) may be attributed to the fact that it is an essential micronutrient associated with many proteins and enzymes (Dung *et al.,* 2013; Thuong *et al.,* 2013; Yao-Wen, 2015).

In addition to being a nutrient element, the high concentration of Fe is not unexpected. This is due to the abundance of Fe in most soils in Nigeria on which the inland waters flow which is also in line with the submissions of Olowu *et al.* (2010), which opined that Nigerian soils belong to the group, known as 'ferruginous' tropical soils, formed from basement rock minerals which are rich in iron oxides (Perugini *et al.,* 2014; Salahshur *et al.,* 2014; Ghorade *et al.,* 2015). Pb sources could be traced to wastes which emanated from domestic wastes as well as ores of zinc, copper and lead, which may be present in the minerals of surrounding rocks.

The comparison between metal concentration in *M. vollenhovenii* with National and International standards (Federal Environmental Protection Agency, 2001 and World Health Organization, 2014 respectively) revealed that all the metals except Fe were within the standard allowable limits.

4.0 Conclusion

The study indicated that *M. vollenhovenii* from Asejire Lake were safe to consume since the metal (Fe, Cu, Zn and Pb) concentrations were below international admissible limits for human consumption. But it may be suggested that continuous care must be taken, especially for a long period and according to the season to monitor the metal levels not to exceed the maximum permitted concentrations for human consumption. It is apparent from this study that Asejire Lake contains varying levels of Fe, Cu, Zn and Pb as detected in the prawns samples.

Non-detection of Pb in the metals in the prawns is a trend of relatively low metal concentration in the prawns as found to be within the limits of National and International standards. Also, the pollution level of the lake can be considered as relatively low. However, presence of these metals call for close environmental monitoring.

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