IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)
e-ISSN: 2319-2380, p-ISSN: 2319-2372. Volume 11, Issue 6 Ver. I (June 2018), PP 32-38
www.iosrjournals.org

Bioaccumulation of Some Heavy Metals in the Cephalothorax and Abdomen of *Nematopalaemon hastatus*in the Coastal Waters of Ondo State, Nigeria

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Abstract:*The bioaccumulation level of six heavy metals in the cephalothorax and abdomen of Nematopalaemon hastatus in the coastal waters of Ondo State, Nigeria were investigated from April, 2014 to March, 2016. The species indicated allometric growth pattern with condition factor (K) ranging from 0.42 to 0.57. The metal bioaccumulation were in the decreasing order of Zn>Fe>Mn>Cu>Pb>Cd. The highest concentration of Zn (7.519mg/kg) was recorded in abdomen of N. hastatus in the wet season, while the lowest value of 5.786mg/kg was recorded in the cephalothorax in the wet season. The highest level of Fe (5.678mg/kg) observed was recorded in abdomen in wet season. Mn ranged between 3.550mg/kg(cephalothorax in the wet season) and 2.683mg/kg (abdomen in wet season). The abdomen and cephalothorax bio-accumulated the highest (2.878mg/kg) and lowest (2.250mg/kg) concentrations of Cu respectively while the highest levels of Pb (0.029mg/kg) was recorded in abdomen. Cd in both seasons ranged between 0.001mg/kg and 0.002mg/kg in the cephalothorax and abdomen. This result shows that the concentration of Fe and Mn in abdomen and cephalothorax of the examined species exceeded the 0.5mg/kg limit recommended by FEPA while Zn, Cu, Cd and Pb were lower than the FEPA limit. Thus the shrimp indicates healthy status of the studied environment.*

Keywords:*Heavy Metals, Nematopalaemon hastatus, FEPA, cephalothorax, abdomen, Ondo State.*

Date of Submission: 29-05-2018 Date of acceptance: 12-06-2018

I Introduction

N. hastatus is a translucent palaemonid shrimp that turns white after death hence its name “white shrimps”. It makes up about three-quarter of the total catch of artisanal fishermen in the coastal waters and estuaries where it is used as condiment in cooking due to the unique flavour imparted to food and the protein content of almost 70% dry matter it contains (Olawusi-Peters and Ajibare, 2014).Over the last few decades, there has been growing interest in determining heavy metal levels in the marine environment and attention was drawn to the measurement of contamination levels in public food supplied, particularly fish (Jimoh *et al*., 2011).

The knowledge about heavy metals in shrimps is important for both human consumption and especially nature management because the fates of heavy metals introduced by human activities into aquatic ecosystems have recently become the subject of widespread concern, since beyond the tolerable limits they become toxic (Adedeji and Okocha 2011). Heavy metals exhibit different accumulation pattern in organs. Jezierska and Witeska, (2006) stated that metal accumulation in fish depends on pollution, and may differ for various aquatic organisms living in the same water body. Gills, liver and kidneys accumulate heavy metals in higher concentration in comparison to muscles, which exhibit lowest levels of metals accumulation.

Chindah*et al.*, (2004) reported that shrimps have the propensity to bioaccumulate certain heavy metals in the environment than others and further suggested that they can be used as possible bio-accumulator or bio-indicator for heavy metal pollution monitoring programme. Also, Olawusi-Peters *et al.*, (2014a) obtained low condition factor for shrimps in the coastal area of Ondo State, Nigeria and attributed it to pollution status or anthropogenic activities that occur in the area and further called for pollution study to further analyze the sustainability of biodiversity. Hence, this study determined the level of Pb, Zn, Fe, Cd, Cu and Mn in the cephalothorax and abdomen of *N. hastatus* with the aim of providing some baseline information on the pollution status of the coastal waters of Ondo state and ensuring the safety of this ecosystem.

II Materials And Methods

Study area:

The study was carried out in the coastal area (Ilaje Local Government Area) of Ondo State, Nigeria. The study area is at the extreme southern part of Ondo State. The coastal towns of Ayetoro (06°06'N 04°46'E), Idiogba (06°05'N 04°47'E), Bijimi (06°04'N 04°49'E), and Asumogha (06°03'N 04°39'E) were purposely selected for this study based on earlier information for extensive shrimp fishing activities in the towns, accessibility and possible anthropogenic inputs from activities of oil exploration, transportation, farming practice, domestic and cottage industrial discharges into rivers and streams which finally emptied into Atlantic Ocean in the southern part. This area is noted for sea foods which are consumed within and outside the state. The area is positioned within the equatorial evergreen swamp forest with two major seasons; the dry season and the wet season (Bayode *et al.*, 2011).

Collection and Identification of Shrimps: Specimens were collected monthly from April, 2014 to March, 2016 with the assistance of artisanal fishermen after which the specimens were preserved (immediately) in ice and transferred to the laboratory where they were frozen at -4^oC before being used for the research. The shrimps were then sorted and identified to species level using the FAO Species Identification Sheets, (Volume VI) (FAO, 1981), Powell (1980, 1982).

Determination of Length and Weight: After thawing the shrimps, the weight of each shrimp sample was measured with top loading sensitive weighing balance (Model BL100001) to the nearest 0.01g while the total length (from the tip of the rostrum to the extremity of the telson) was measured using graduated measuring board to the nearest 0.01 cm.

Determination of Heavy Metals: In the laboratory of the department of Land and Water resources, Institute of Agricultural Research and Training, Ibadan, Nigeria; the shrimp samples were dissected with clean stainless steel instruments, separating the cephalothorax from the abdomen. The tissues (cephalothorax and abdomen) were oven dried at 60^oC for 48hours. Individual whole specimens were pulverized to a uniform particle size and 0.2g of pulverized weight was put in a 50ml digestion tube. 2.5ml of H_2SO_4/selenium mixture was added and placed in an aluminum block on a hot plate. This was heated at approximately 200^0C until solution fumed. Each tube was removed from the hot plate and allowed to cool for 10 minutes. 1ml of 30% H_2O_2 was added to each tube. After reaction subsided, each tube was followed with an additional 2ml H_2O_2. Each tube was replaced on hot plate, heated to 330^0C until clear (usually for 2hrs). The yellow tint of the solution disappeared as the digest was completed. The solution was poured into a centrifuge tube and made up to 30ml mark with distilled water. This was centrifuged at 3000 r.p.m. for 10mins. The supernatant was decanted into sample vials for analysis. The concentration of heavy metal was determined using ACCUSYS 211 Atomic Absorption Spectrophotometer.

Statistical analysis: Multi-VariateAnalysis of Variance (MANOVA) and Duncan multiple range test was used to evaluate the significant difference in the concentration of different parameters with respect to different sites. A probability level of less than 0.05 was considered significant. Standard deviations were also estimated. Descriptive analysis was also used to present tables and figures

Determination of Length-Weight Relationship (b) and Condition Factor (K)
Length-Weight Relationship (b):
The relationship between the length (L) and weight (W) of shrimps was expressed by the equation:

$W = aL^b$ (Pauly, 1983) ……………eq 1

Where

W=Weight of shrimps in (g), L=Total Length (TL) of shrimps in (cm)
a=Constant (intercept), b=The Length exponent (slope)

The "a" and "b" values were obtained from a linear regression of the length and weight of shrimps.
Condition Factor: The condition factor (k) of the shrimps was estimated from the relationship:

$K = \frac{100W}{L^3}$ ……………….eq 2

Where K = Condition factor, W = Weight of shrimps (g),L = Length of shrimps (cm)
The mean lengths and weights of each species were used for data analysis, the format accepted by FISAT (Gayanilo and Pauly, 1997).

III Results

LENGTH, WEIGHT,LENGTH-WEIGHT RELATIONSHIP AND CONDITION FACTOR OF *N. hastatus*

In the wet season the mean total length ranged from 4.90±0.99cm at Idiogba to 5.31±0.76cm at Bijimi while it ranged from 4.87±1.03cm (Idiogba) to 5.29±0.50cm (Bijimi) in the dry season. The Table shows that the mean total weight of *N. hastatus* in the wet season ranged from 0.58±0.21g at Ayetoro to 0.65±0.18g at Bijimi while the mean total weight ranged from 0.56±0.20g (Ayetoro) to 0.64±0.18g (Bijimi) in the dry season (Table 1). Table 1 also shows that there was no significant difference between the means obtained for total length in wet and dry seasons and weight in wet and dry seasons in the four stations at P=0.05.The exponential (b) values obtained for *N. hastatus* in the wet season ranged between 1.43 (a= -2.78) and 1.77 (a= -3.49) in Idiogba and Ayetoro respectively while the corresponding 'b' obtained in the dry season ranged from 1.33 (a= -2.62) at Idiogba and 1.66 (a= -3.23) at Bijimi. Furthermore, the minimum 'K' value (0.42) recorded for *N. hastatus* in the wet season was for the 608 individuals caught at Ayetoro and the maximum was 0.52 for 584 individuals captured at Idiogba while the 'K' value in the dry season ranged from 0.43 (n= 604 at Ayetoro; n= 551 at Bijimi) and 0.53 (n= 662 at Idiogba).

Table 1: LENGTH, WEIGHT, LENGTH-WEIGHT RELATIONSHIP AND CONDITION FACTOR OF *N. hastatus*

Station	Season	Length	Weight	a	b	n	R^2	K
Ayetoro	Dry	5.08±1.13	0.56±0.20	-2.94	1.43	604	0.81	0.43
	Wet	5.17±1.01	0.58±0.21	-3.49	1.77	608	0.87	0.42
Asumogha	Dry	5.18±1.00	0.62±0.20	-3.00	1.51	623	0.73	0.44
	Wet	5.18±0.91	0.63±0.19	-3.04	1.55	611	0.80	0.45
Bijimi	Dry	5.29±0.80	0.64±0.18	-3.23	1.66	551	0.80	0.43
	Wet	5.31±0.76	0.65±0.17	-3.05	1.56	595	0.72	0.44
Idiogba	Dry	4.87±1.03	0.62±0.20	-2.62	1.33	662	0.80	0.53
	Wet	4.90±0.99	0.61±0.19	-2.78	1.43	584	0.89	0.52

a=Constant (intercept); b=The Length exponent (slope); n= number of individuals; R^2 = Regression Coefficient; K= Condition Factor.

Heavy metal concentration in Abdomen and Cephalothorax of *N. hastatus*

The result of the heavy metal analysis as presented in Figure 1 shows that in the wet season, the mean concentration of Cd in the abdomen and cephalothorax was 0.001±0.00mg/kg and 0.002±0.00mg/kg in the sampling stations respectively while in the dry season, the mean concentration of Cd in the abdomen and cephalothorax was 0.001mg. This shows that in the wet season, the concentration of Cd in the abdomen was significantly lower ($p<0.05$) than the concentrations recorded in the cephalothorax in the four sampling stations but was not significantly different ($p>0.05$) in the dry season. Also, there was no seasonal variation in the concentration of Cd in both the abdomen and the cephalothorax.

Moreover, Figure 1 shows that the mean concentration of Pb in the abdomen and cephalothorax in the wet season ranged from 0.021±0.002mg/kg (Bijimi) and 0.015±0.003mg/kg (Asumogha, Ayetoro, Idiogba) to 0.029±0.002mg/kg (Idiogba) and 0.017±0.003mg/kg in (Bijimi) respectively while in the dry season, it ranged from 0.020± 0.003mg/kg (Asumogha) and 0.015±0.002mg/kg (Ayetoro) to 0.029±0.003mg/kg (Idiogba) and0.016±0.003mg/kg (Asumogha, Bijimi and Idiogba) respectively. This shows that the concentration of Pb in the abdomen was significantly higher ($p<0.05$) than the concentrations recorded in the cephalothorax in the four sampling stations in both seasons. The Figure further reveals that there was no seasonal difference ($P\geq0.05$) between the Pb recorded in the abdomen across the four sampling stations so also in the cephalothorax across the four sampling stations.

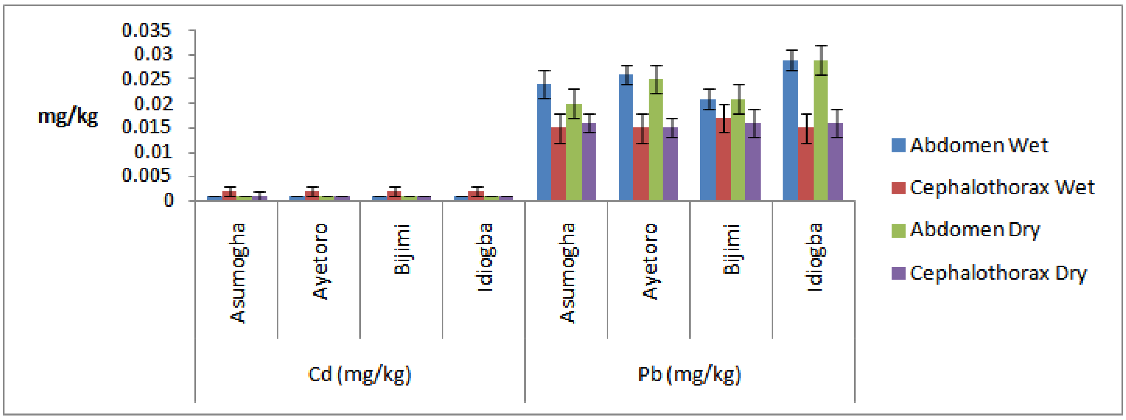

Figure 1: Concentration of Cd and Pb in the Study Area

The result of Mn and Cu is presented in Figure 2.The Figure shows that in the wet season, the mean concentration of Mn in the abdomen and cephalothorax was 2.683±0.391mg/kg and 3.258±0.528mg/kg in Asumogha, 3.311±0.398mg/kg and 3.212±0.580mg/kg in Ayetoro, 3.055±0.405mg/kg and 3.500±0.542mg/kg in Bijimi, 3.312±0.303mg/kg and 3.229±0.663mg/kg in Idiogba respectively while in the dry season, the mean concentration of Mn in the abdomen and cephalothorax was 2.783±0.322mg/kg and 2.919±0.457mg/kg in Asumogha, 3.139±0.348mg/kg and 2.803±0.640mg/kg in Ayetoro, 3.197±0.478mg/kg and 3.292±0.510mg/kg in Bijimi, 3.136±0.389mg/kg and 3.006±0.654mg/kg in Idiogba respectively. The Figure also reveals that in the wet season, the concentration of Mn in the abdomen was significantly lower than the concentration recorded in the cephalothorax of *N. hastatus* in Asumogha and Bijimi while in the dry season, concentration of Mn in the abdomen was not significantly different ($p>0.05$) from the concentration recorded in the cephalothorax in the four stations. The mean concentration of Mn observed in the abdomen showed seasonal variation in both Ayetoro and Idiogba while cephalothorax exhibited seasonal variation at Asumogha, Ayetoro and Bijimi.

Also, the Figure shows that the mean concentration of Cu recorded in the abdomen and cephalothorax in the wet season, was 2.378±0.326mg/kg and 2.351±0.175mg/kg in Asumogha, 2.292±0.397mg/kg and 2.432±0.157mg/kg in Ayetoro, 2.786±0.391 and 2.409±0.195mg/kg in Bijimi, 2.356±0.394mg/kg and 2.400±0.186mg/kg in Idiogba respectively. Also, in the dry season, the mean concentration of Cu in the abdomen and cephalothorax was 2.536±0.364mg/kg and 2.389±0.204mg/kg in Asumogha, 2.453±0.442mg/kg and 2.442±0.223mg/kg in Ayetoro, 2.878±0.358mg/kg and 2.250±0.249mg/kg in Bijimi, 2.539±0.513mg/kg and 2.472±0.247mg/kg in Idiogba respectively. There was significant difference ($P<0.05$) between the concentration of Cu in the abdomen and Cephalothorax of *N. hastatus* recorded at Ayetoro and Bijimi in the wet season, while there was no significant difference ($p>0.05$) between the concentration of Cu in the abdomen and Cephalothorax recorded at Ayetoro and Idiogba in the dry season. The Figure also shows that there was no seasonal variation in the means recorded in the abdomen and cephalothorax, except in the cephalothorax collected from Bijimi.

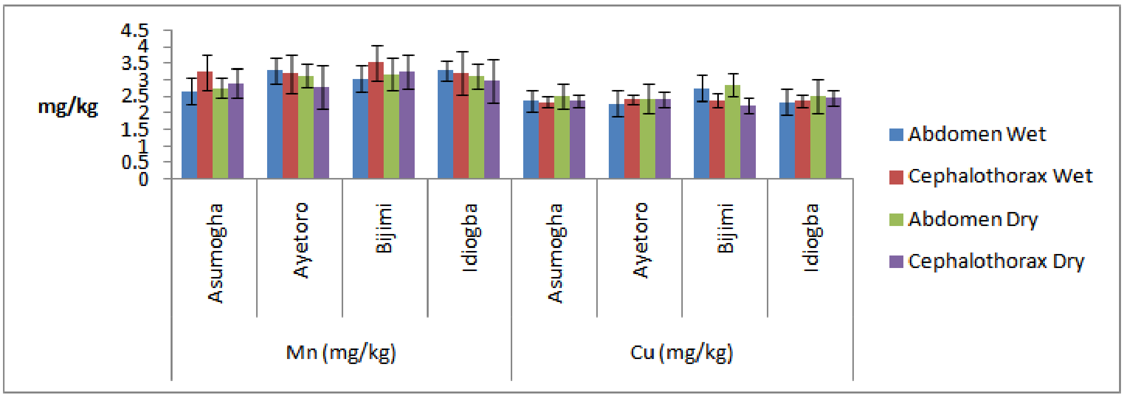

Figure 2: Concentration of Mn and Cu in the Study Area

The result of the heavy metal analysis as presented in Figure 3 shows that in the wet season, the mean concentration of Zn in the abdomen and cephalothorax was 7.040±0.383mg/kg and 5.929±0.732mg/kg in Asumogha, 7.519±0.259mg/kg and 6.106±0.700mg/kg in Ayetoro, 7.038±0.376mg/kg and 5.786±0.639mg/kg in Bijimi, 7.002±0.555mg/kg and 6.009±0.0.796mg/kg in Idiogba respectively while the mean concentration of Zn in the abdomen and cephalothorax examined in the dry season was 6.794±0.485mg/kg and 6.447±0.570mg/kg in Asumogha, 7.258±0.338mg/kg and 6.739±0.475mg/kg in Ayetoro, 6.706±0.418mg/kg and 6.381±0.546in Bijimi, 6.944±0.418mg/kg and 6.636±0.56mg/kg in Idiogba respectively. Furthermore, the Figure shows that the concentration of Zn in the abdomen was significantly higher ($p<0.05$) than the concentrations in the cephalothorax in the four sampling stations in both seasons. The Figure also reveals that the mean concentration of Zn in the abdomen and cephalothorax of *N. hastatus* exhibited seasonal difference in all sampling stations except in Idiogba.

Furthermore, the Figure shows that in the wet season, the mean concentration of Fe in the abdomen and cephalothorax was 5.460±0.486mg/kg and 5.506±0.329mg/kg (Asumogha), 5.000±0.594mg/kg and 5.552±0.274mg/kg (Ayetoro), 5.678±0.488mg/kg and 5.596±0.272mg/kg (Bijimi), 4.828±0.771mg/kg and 5.433±0.315mg/kg (Idiogba) respectively while the mean concentration of Fe in the abdomen and cephalothorax in the dry season was 5.233±0.664mg/kg and 5.578±0.326mg/kg in Asumogha, 5.108±0.588mg/kg and 5.600±0.235mg/kg in Ayetoro, 5.597±0.699mg/kg and 5.658±0.399mg/kg in Bijimi, 5.011±0.821mg/kg and 5.519±0.312mg/kg in Idiogba respectively. The Figure further shows that in the wet season, the concentration of

Fe in the abdomen was significantly different from the concentrations observed in the cephalothorax of *N. hastatus* recorded in Ayetoro and Idiogba while there was no significant difference (p>0.05) between the concentration of Fe in the abdomen and cephalothorax of *N. hastatus* recorded in Bijimi in the dry season. The Figure also shows that there was no seasonal variation between the means of Fe recorded in the abdomen and cephalothorax across the four stations.

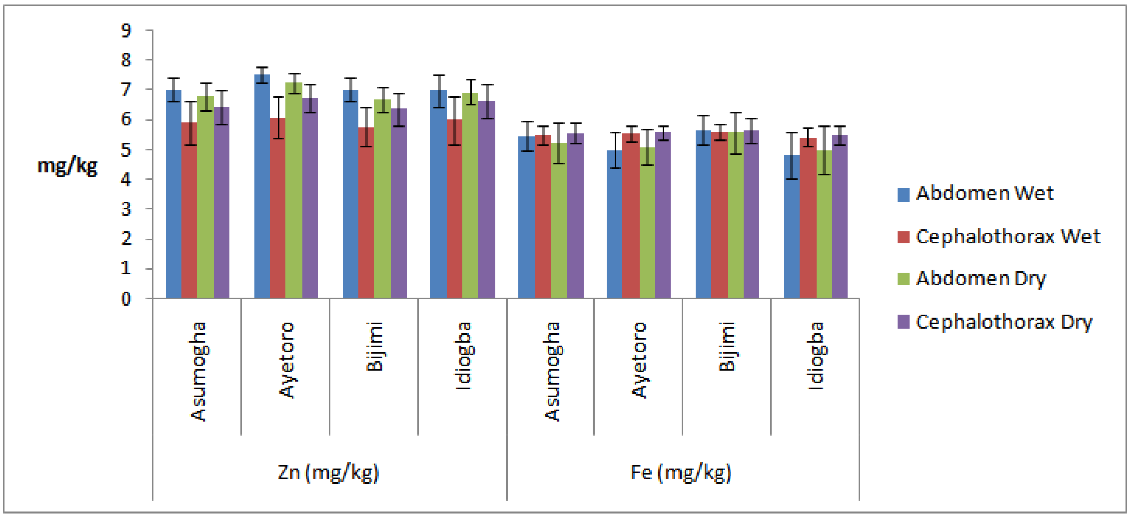

Figure 3: Concentration of Zn and Fe in the Study Area

IV Discussion

The consistency recorded throughout the study reflects a steady environment which in turn gives the shrimps steady condition in terms of length and weight even in both seasons. However, the sizes and weight of shrimps encountered throughout the study were much smaller than those reported for the Lagos lagoon by Adetayo and Kusemiju (1994) and Lawal-Are and Owolabi (2012); it can therefore be suggested that the study area may be acting as a nursery ground for fish assemblages as a similar situation was recorded for fish biota by Emmanuel and Kusemiju (2005) in Agboyi creek. The 'b' values obtained for individual species in this study was allometric as b values were less than 3 and are within the range obtained by Enin*et al.*, (1991) for Cross River estuary. Waribugo (2005) reported that the growth pattern of *N. hastatus* and *Palaemon maculates* were allometric while *M. macrobrachion* was reported by Deekae and Abowei (2010)inLuubara creek (Nigeria) to have allometric growth pattern.

The values of 'b' obtained were also similar to the results obtained by Olawusi-Peters *et al.*, (2014a) on the same species in the Ondo state coastal waters while the condition factor corroborates the view of Ekelemu and Zelibe (2006) that fishes with allometric growth patterns often have K factor values of less than 1.The low mean condition factor may indicate the state of growth and food availability (Enin and Enidiok, 2002).Moreover, Olawusi-Peters *et al.*, (2014a) opined that reduced or low condition factor indicates either a period of unfavourable ecological conditions or a period which the species might have undergone stress from low food availability and/or reproductive processes.

All the heavy metals analyzed were found in the examined shrimps. The metal bioaccumulation in the shrimps were in the decreasing order of Zn > Fe > Mn > Cu > Pb > Cd which was similar to the trend observed by Adedeji and Okocha (2011) in *M. macrobrachion* and *M. vollenhovenii* from Asejire River. Furthermore, in comparison to the 30mg/kg recommended as maximum limit for Zn in fish (WHO, 2003) the levels recorded in shrimps' samples in this study were low, consequently, there cannot be Zn-induced health hazards on the environment. The range of Zn level in shrimps' parts in this study is also low when compared to the zinc level reported by Adedeji and Okocha (2011), Jimoh *et al.*, (2011) and Edward *et al.*, (2013) in Epe Lagoon and Odo Ayo river respectively.

Mn levels in the abdomen and cephalothorax of the shrimps did not show a definite pattern in both seasons and exceeded the 0.5mg/kg limit recommended by FEPA (2003) but was lower than the concentration observed by Adedeji and Okocha (2011) and Zodape (2014) in prawns and shrimps species collected from both Epe lagoon, Lagos and Asejire River, Nigeria and Kolaba market of Mumbai (west coast) India respectively. This may be due to the different ways by which Mn is being bio-accumulated by aquatic organisms. Many authors indicate that metals show different affinity to various organs which may differ particularly in accumulation of essential metals such as iron, zinc, copper, manganese or cobalt which is organ-specific (Giguere*et al.*, 2004). Olawusi-Peters *et al.* (2014b) stated that Mn does not accumulate with age, thus increase in population, urbanization, industrialization and agriculture practices may be said to be responsible.

The observed mean value of Fe in the shrimps far exceeded the WHO (2003)/FEPA (2003) recommended limits of 0.5mg/kg in fish foods. Though Fe is an essential heavy metal, it has the tendency to become toxic to living organisms, even when exposure is low. Even though Fe becomes poisonous when it exceeds 0.5mg/kg, it is an essential micronutrient which comprises nearly 300 enzymes in marine organisms and is responsible for certain biological functions that require relatively higher Fe (Asaolu and Olaofe, 2004) and it is also critical for aquatic organisms, including fishes (FAO, 1983). Moreover, the concentration of Fe in the cephalothorax at individual station was numerically higher than the concentration in the corresponding abdomen and this is similar to the reports of Khalil and Faragallah, (2008) who observed higher concentration in the gill and argued that metals get adsorbed onto the gills surface as the first target or point of contact for pollutants in water.

The high concentration of Mn and Fe may be due to anthropogenic activities such as washing, swimming, bathing, transportation, agriculture and waste disposal which continuously increases the amount of heavy metals in the water body as supported by Giguere*et al.*, (2004) and Olawusi-Peters *et al.*, (2014b) who reported that relatively high concentrations of Mn and Fe are found in agricultural products such as fertilizers which may eventually accumulate in agricultural soils and become exposed to the aquatic environment through run-offs especially during the rainy season.

The concentration of Cu in the sampled shrimp species (irrespective of the part) was slightly below the FAO (1983) guideline of 3mg/kg, it can be said that shrimps captured from the study area will bioaccumulate Cu with time. The mean concentrations of Lead (Pb) in the studied species exhibited no statistical difference between the abdomen and cephalothorax across the four sampling locations although the concentration of Pb in the abdomen was higher than the concentration in the cephalothorax in all the four stations even though it was below the permissible limit of 2mg/kg of FAO (1983). Cd levels recorded in this study were low when compared to WHO (2003) and FEPA (2003) maximum permissible limit of 0.5mg/kg in fish food and with the report of Okoronkwo, (1992) and Idodo-Umeh (2002) in fishes of Olomoro water body and the River Niger.

V Conclusion

The concentrations of heavy metals in the examined shrimp did not show a definite pattern of bio-accumulation in the abdomen and cephalothorax in both seasons. Also, the level of heavy metals recorded in this study was generally low when compared to the WHO (2003) and FEPA (2003) recommendations which is an indication of the healthy status of the studied environment. However, the fact that some levels of bioaccumulations were found in the examined shrimp species is a cause for constant monitoring of the water because the surrounding villagers depend on the water downstream for domestic, navigation and agricultural purposes.

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