

HEAVY METAL CONCENTRATION IN THE TISSUE AND CARAPACE OF TIGER PRAWN (*Penaeus monodon*) SOLD IN SELECTED SUPERMARKETS AND OPEN MARKET IN PORT HARCOURT

NWIKABARI, PHILOMENA LYNDA

DEPARTMENT OF BIOLOGY

IGNATIUS AJURU UNIVERSITY OF EDUCATION, RUMUOLUMENI

PORT HARCOURT, RIVERS STATE, NIGERIA

philomena.nwikabari@yahoo.com

AND

PROF. OKORINAMA A. F. WOKOMA

DEPARTMENT OF BIOLOGY

IGNATIUS AJURU UNIVERSITY OF EDUCATION, RUMUOLUMENI

PORT HARCOURT, RIVERS STATE, NIGERIA

Abstract

*This study was carried out to evaluate heavy metal concentration in the tissue and carapace of Tiger prawn (*Penaeus monodon*) sold in major supermarkets and market within Port-Harcourt metropolis. The prawns were purchased from Hyper city (Station 1), Next Cash and Carry (Station 2), Timeless Supermarket (Station 3) and open Market, Creek Road Market (Station 4). The tissue and carapace were tested for the presence of the selected heavy metals with their proximate composition. The concentration of heavy metals were determined by Atomic Absorption Spectrometry (AAS) method, following electro-thermal heater digestion. The Mean values recorded for the heavy metals in tissue ranged from 0.20-0.58mg/kg, 2.20-3.54mg/kg and 31.89-33.65mg/kg for Ni, Cu and Zn respectively. Concentration of Ni and Zn in tissue were higher in tiger prawn collected from open market while Cu was higher in tissues of tiger prawn collected from super market. The mean values recorded for the heavy metals in carapace ranged from 2.693-4.397 mg/kg, 3.587-7.267 mg/kg and 11.537-13.257 mg/kg for Cu, Ni and Zn respectively. The prawns collected from all stations are however, recommended for human consumption as the levels of heavy metal concentrations recorded did not exceed the limit for human consumption except for Ni. The high protein content found in the prawn should also consider it a major food for consumption.*

Keywords: Heavy Metal, Tissue, Carapace, Tiger Prawn.

Introduction

Heavy metals are natural elements characterized by their rather high atomic mass and their high density. Although typically occurring in rather low concentrations, they can be found all through the crust of our planet (Martin & Hosam, 2018). Heavy metals are seen to be very heavy and very toxic hence inter-related. Heavy metals include metalloids, such as arsenic, that are able to induce toxicity at low level of exposure (Duffus, 2002). The increase in ecological and global public health concern in recent years can be associated with environmental

contamination by these metals coupled with human exposure which has risen dramatically as a result of an exponential increase due to their involvement in several industrial, agricultural, domestic and technological applications (Bradl, 2002). Essential heavy metals like Copper, Iron, Manganese, Cobalt, Zinc, and Nickel are required by plants as they form cofactors that are structurally and functionally vital for enzymes and other proteins and often required in trace amounts in the level of 10-15 parts per million (ppm) and are known as micronutrients.

Non-essential heavy metals like

Cadmium, lead, Mercury, Chromium, and Aluminium are not required by plants, even in trace amounts, for any of the metabolic processes (Sarmistha & Apaala, 2021). Although, human activities like industrial, mining, and agricultural processes have led to a widespread distribution of heavy metals in the ecosystems posing risks to ecological and human health. Owing to their bio-accumulative potential along the food chain, high toxicity, prevalence, and persistence in the environment, heavy metals have become a major public health concern. Heavy metals can commonly be found in water and food and is known as a crucial issue for humans. The specification of heavy metal ion in drinkable water systems and foods is necessary for safety and human health. Heavy metals commonly accumulate in living organisms because of the non-biodegradability and toxic nature and non-thermo degradability.

There are 35 metals that are of concern for us because of residential or occupational exposure, out of which 23 are heavy metals: antimony, arsenic, bismuth, cadmium, cerium, chromium, cobalt, copper, gallium, gold, iron, lead, manganese, mercury, nickel, platinum, silver, tellurium, thallium, tin, uranium, vanadium, and zinc (Mosby et al., 2012). These heavy metals are commonly found in the environment and diet. In small amounts they are required for maintaining good health but in larger amounts they can become toxic or dangerous. Heavy metal toxicity can lower energy levels and damage the functioning of the brain, lungs, kidney, liver, blood composition and other important organs. Long-term exposure can lead to gradually progressing physical, muscular, and neurological degenerative processes that imitate diseases such as multiple sclerosis, Parkinson's disease,

Alzheimer's disease and muscular dystrophy. Repeated long-term exposure of some metals and their compounds may even cause cancer (Jarup, 2013).

The toxicity level of a few heavy metals can be just above the background concentrations that are being present naturally in the environment. For instance, inorganic arsenic (arsenite/arsenate) is highly carcinogenic, linked to lung, liver, bladder, and skin cancers. Major exposure is through contaminated drinking water, a key issue in over 30 countries. Toxicity, termed arsenicosis, arises from levels 10-100 times the WHO guideline (10 µg/L). Contamination stems from industrial chemicals, pesticides, or natural deposits (Chowdhury et al., 2012; Hoque et al., 2011). Also, lead, from mining and manufacturing, contaminates air, water, and soil. Though its use has declined, exposure persists via paints, dust, and pipes. Highly toxic, it affects the nervous system and is stored in bones. It is a recognized carcinogen (Martin & Griswold, 2019; Gerhardsson et al., 2012; Papanikolaou et al., 2015; Brochin et al., 2018).

Mercury is among the most toxic metals. Industrial release leads to environmental contamination. Exposure damages the brain, kidneys, and fetus. Organic mercury, found in fatty fish, is particularly harmful. Consequently, drinking water standards are set very low (0.001-0.002 mg/L) (Alina et al., 2012; Reilly, 2016; WHO, 2004). A byproduct of zinc, cadmium is used in batteries and plastics. It is a known human carcinogen. Exposure occurs via smoking, food, and pollution. Inhalation damages lungs, while long-term exposure harms the kidneys, with smokers at higher risk (Martin & Griswold, 2019; Henson & Chedrese, 2014). Chromium persists in the

environment. While Cr(III) is essential, Cr(VI) is highly toxic and carcinogenic. Cr(VI) is absorbed more readily and can induce DNA damage, chromosomal aberrations, and other genetic alterations, posing significant health risks (Zhitkovich, 2015; Matsumoto et al., 2016). While Aluminium can adversely affect the nervous system, causing memory loss and coordination problems. It accumulates in those with kidney impairment, leading to bone and brain damage. High occupational or environmental exposure is linked to lung issues, anemia, and specific bone diseases (Krewski et al., 2017; Andia, 2016).

Prawns are crustaceans within the suborder Caridea, with about 2,500 species. Their body is segmented into a cephalothorax and pleon (abdomen). These animals, dating back 400 million years, inhabit diverse aquatic environments globally, from marine to freshwater habitats (Darry & Kathleen, 2009; Michael, 2002). Prawns are a highly nutritious food, rich in protein, vitamins (like B6), and minerals including iron, zinc, and magnesium. They are also low in fat and contain beneficial omega-3 fatty acids and antioxidants, supporting overall health and potentially aiding weight loss (Licious, 2022). Deductively, the 2,500 species of prawns that are segmented into cephalothorax and pleon inhabit diverse aquatic habitats globally. They are a nutritious, low-fat food rich in protein, vitamins, minerals, and omega-3 fatty acids, supporting overall health.

Tiger Prawn (*Penaeus monodon*), the giant tiger prawn, is a widely farmed marine species. Juveniles live in estuaries, moving to deeper waters as adults. This nutrient-rich crustacean is a valuable food source but is vulnerable to aquatic pollutants like heavy metals, which pose

significant health and ecosystem risks (Motoh, 2010; Dayal et al., 2013; Ezemonye et al., 2019). Given this, prawns are said to hold substantial economic value globally. For example, Nigeria exported billions of Naira worth of shrimp and prawns in 2016. Many species are cultivated for food due to their high-quality protein and nutritional benefits, making them a key product in the fishing and aquaculture industries (Holthius, 1980; Josephine & Caleb, 2017).

Statement of the Problem

Heavy metal pollutants are particularly hazardous contaminants in food and the environment. In general, they are not biodegradable and have long biological half-lives. Heavy metals must be controlled in food sources in order to assure public safety. Excessive concentration of food heavy metals is associated with the etiology of a number of diseases, especially cardiovascular, renal, neurological, and bone diseases. Metal accumulation in freshwater decapods has been acclaimed and perceived to cause serious health concerns when transferred to humans along the food chain. Health risks associated with heavy metals such as renal failure, skeletal deformation, and hepatic failure have been linked to their non-decomposable and persistence nature in the visceral organ-parts of humans. This can lead to severe maladies like dysentery, stomach aches, head-tremor, anemia, paralysis, nausea, paroxysm, melancholy and even respiratory disorders, which can be either acute or chronic forms; neuron toxicity, oncogenic, genetic alteration or teratogenicity and so a major reason to monitor levels of toxic metals in foods follows from the fact that contamination of the general environment has increased.

Aim and Objectives of the Study

The study was aimed at evaluating heavy metals concentration of frozen tiger

prawn (*Panemusmonodon*) sold in major markets within Port-Harcourt metropolis. To achieve this, the study seeks to:

1. Determine the concentration of heavy metals in the tissue of frozen prawn sold in market in Port-Harcourt.
2. Determine the concentration of heavy metals in the carapace of the prawn.

Significance of the Study

The demand for more food will continually be on the rise likewise the level of industrialization and globalization. Humans with the urge to satisfy hunger and enrich their bodily mineral nutrients can't be insatiable and as a matter of fact, industrialization has led to rapid effluent discharge which has affected aquatic lives in different ways. This research work will be relevant to health agencies, and individuals by providing them with information on the consumability of prawns and also the comparison between frozen prawn and prawns purchased from open market will provide the consumers with a preferred choice of prawns to be consumed.

Scope of the Study

This study was limited to bioaccumulation of selected heavy metals (Lead, Cadmium, Nickel, Copper, and Zinc) of tiger prawns sold in three supermarkets and open markets within Port Harcourt metropolis which took place within March - June 2023.

Materials and Methods

Study Area

Port Harcourt popularly called Garden City is the capital and largest city in Rivers State, Nigeria. It is the fourth most populous city in Nigeria after Lagos, Kano, and Ibadan. It lies along the Bonny River and is located in the Niger Delta. As of 2016, the Port Harcourt urban area had an estimated population of 1,865,000

inhabitants, as against 1,382,592 recorded in 2006. The population of the metropolitan area of Port Harcourt is almost twice its urban area population with a 2021 United Nations estimate of 3,171,076. Port-Harcourt lies within latitude 4°49'27"N 7°2'1"E with an estimated area of 360 km² (140 sq mi). A notable example is the oil mill market which attracts visitors and businesses from neighbouring cities and states is located off Aba Road at Rumuokwurusi community and is a house to so many shopping malls such as; Everyday supermarket, Market square, Port-Harcourt mall (Spar), Hyper City, Wide choice making it possible for the inhabitants to obtain foods at ease. Port Harcourt which was originally a small settlement, expanded rapidly after the discovery of hydrocarbon. This rapid expansion has continued till today, hence communities such as Rumuokurushi, Oroworoko, Rumuola, Rumuokuta, Rumueme, Rumuobekwe, Woji, Mile 3, Elekahia and many more are now considered part of the greater Port Harcourt metropolis.

Sample Collection

Samples of frozen prawn notably *Penaeus monodon* was purchased from four different major markets namely Next Cash and Carry Supermarket latitude N 4°49'33.828" E 7°2'9.786", Hyper City Supermarket Latitude N 4°48'16.968" E 7°0'34.938" Timeless Supermarket latitude N 4°52'6.192" E 6°57'34.524" and Creek Road market latitude N 4°45'31.722" E 7°1'37.092".

Determination of Heavy Metal Concentration in Prawns

Prawn was rinsed with ultrapure water before dissection. They were dissected by using stainless steel scalpels and Teflon forceps. Carapace and tissue

were removed and dried in an oven at 70 OC until a constant weight was obtained. The dried samples were then grounded into powdery form using a blender.

Digestion of Prawn Samples

1 gram of dried prawn carapace or tissue sample was placed into conical flask. Then, 6 ml of 65 % nitric acid (HNO₃), and 2 ml of 35 % hydrogen peroxide (H₂O₂) were added for acid digestion. The sample was heated on hot plate until the sample solution became clear. Then, the sample solution was allowed to cool at room temperature and was filtered by using filter paper. The filtrate was then transferred into a 25 ml volumetric flask and diluted to the mark with ultrapure water. Each sample was prepared for three replicates. Blank samples were also processed in the same way to avoid possible contamination during analysis. Samples were subjected to flame atomic absorption spectrometer (AA-320) to analyze for Pb, Cd, Ni, Cu, Zn Stock standard solutions (1000 mg/L) of each element were used to prepare calibration solutions to obtain calibration curves.

To avoid any possible contamination, all the glasswares were kept in 10 % nitric acid (HNO₃) solution for overnight, rinsed with ultrapure water and air dried before use. The accuracy of the analysis was checked with blanks and quality control samples made up

of standard solutions. Recovery studies of metal determination were conducted to demonstrate the efficiency of the method and to determine the accuracy of applied analytical procedures.

Statistical Analyses

The data obtained were subjected to SPSS data analysis to determine the standard error, mean number, standard deviation and enable us to know the significance of occurrence of heavy metals between the different super markets.

Results

Concentration of Heavy Metals in Frozen Prawns Sold in Markets in Port-Harcourt Heavy Metal Concentrations in Tissue of Prawns

Results showing the mean concentrations of heavy metals in tissues are as presented in Table 1. Mean values recorded for the heavy metals ranged from 0.20-0.58mg/kg, 2.20-3.54mg/kg and 31.89-33.65mg/kg for Ni, Cu and Zn respectively. The analysis of variance (ANOVA) on means heavy metal concentrations in tissue showed significant difference between metals ($F_{2,24}=167132.151, P<0.05$) and sampling stations ($F_{3,24}=9.645, P<0.05$) as well as a significant interaction ($F_{6,24}=58.401, P<0.05$) (Table 1).

Table 1: Mean Concentrations of Heavy Metals in Tissue

Metal	Concentration (mg/kg) ($\bar{x}\pm SD$)			
	Station 1	Station 2	Station 3	Station 4
Ni	0.307±0.012	0.2±0.01	0.3±0.01	0.583±0.038
Cu	3.537±0.032	2.937±0.031	3.1±0.01	2.2±0.095
Zn	32.11±0.12	32.86±0.14	31.89±0.032	33.65±0.48

Source: Researchers Computation, 2024.

Heavy Metal Concentrations in Carapace of Prawns

Results showing the mean concentrations of heavy metals in carapace are presented

in Table 2. Mean values recorded for the heavy metals ranged from 3.587-7.267 mg/kg, 2.693-4.397 mg/kg and 11.537-13.257 mg/kg for Ni, Cu and Zn respectively.

The analysis of variance (ANOVA) on mean heavy metal concentrations in tissue showed significant difference between metals ($F_{2,24}=10150.651, P<0.05$) and

sampling stations ($F_{3,24}=161.518, P<0.05$) as well as a significant interaction ($F_{6,24}=119.858, P<0.05$) (Table 2).

Table 2: Mean Concentrations of Heavy Metals in Carapace of Prawns

Metal	Concentration (mg/kg) ($\bar{x}\pm SD$)			
	Station 1	Station 2	Station 3	Station 4
Ni	7.267±0.14	4.383±0.15	5.173±0.06	3.587±0.040
Cu	4.397±0.23	2.693±0.33	3.773±0.21	3.443±0.14
Zn	12.397±0.11	12.327±0.09	11.537±0.08	13.257±0.14

Source: Researchers Computation, 2024

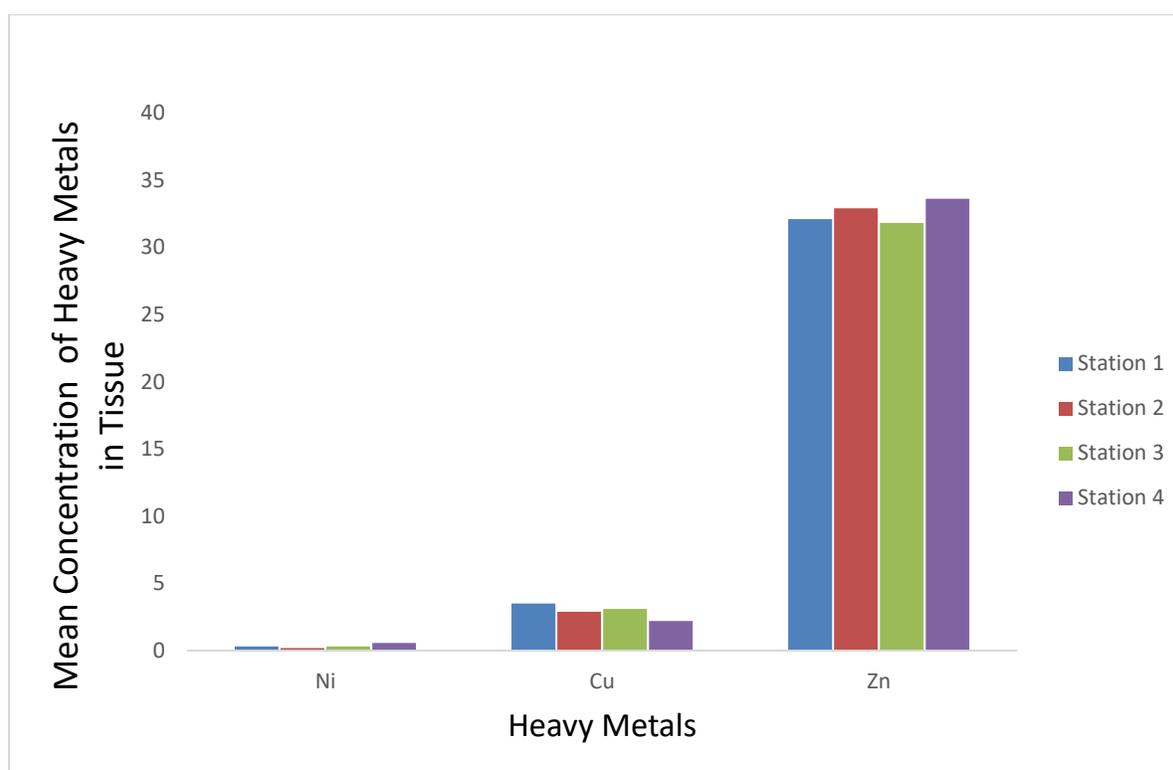


Fig. 1: Heavy metal concentration in tissue of frozen prawns purchase from supermarket to that of open market

Figure 1 illustrates the mean concentrations of three heavy metals—nickel (Ni), copper (Cu), and zinc (Zn), detected in tissue samples collected from four distinct sampling stations. A clear trend is observed across all locations: zinc consistently exhibits the highest concentration, followed by copper, while nickel consistently registers the lowest levels. Notably, the data reveal spatial

variability in contamination. Station 4 recorded the highest overall concentrations for all three metals, indicating the most significant level of pollution among the sites. Conversely, the lowest concentrations were generally measured at Station 1. In summary, zinc is the most prevalent metal in the sampled tissues, and Station 4 represents the area of greatest heavy metal accumulation.

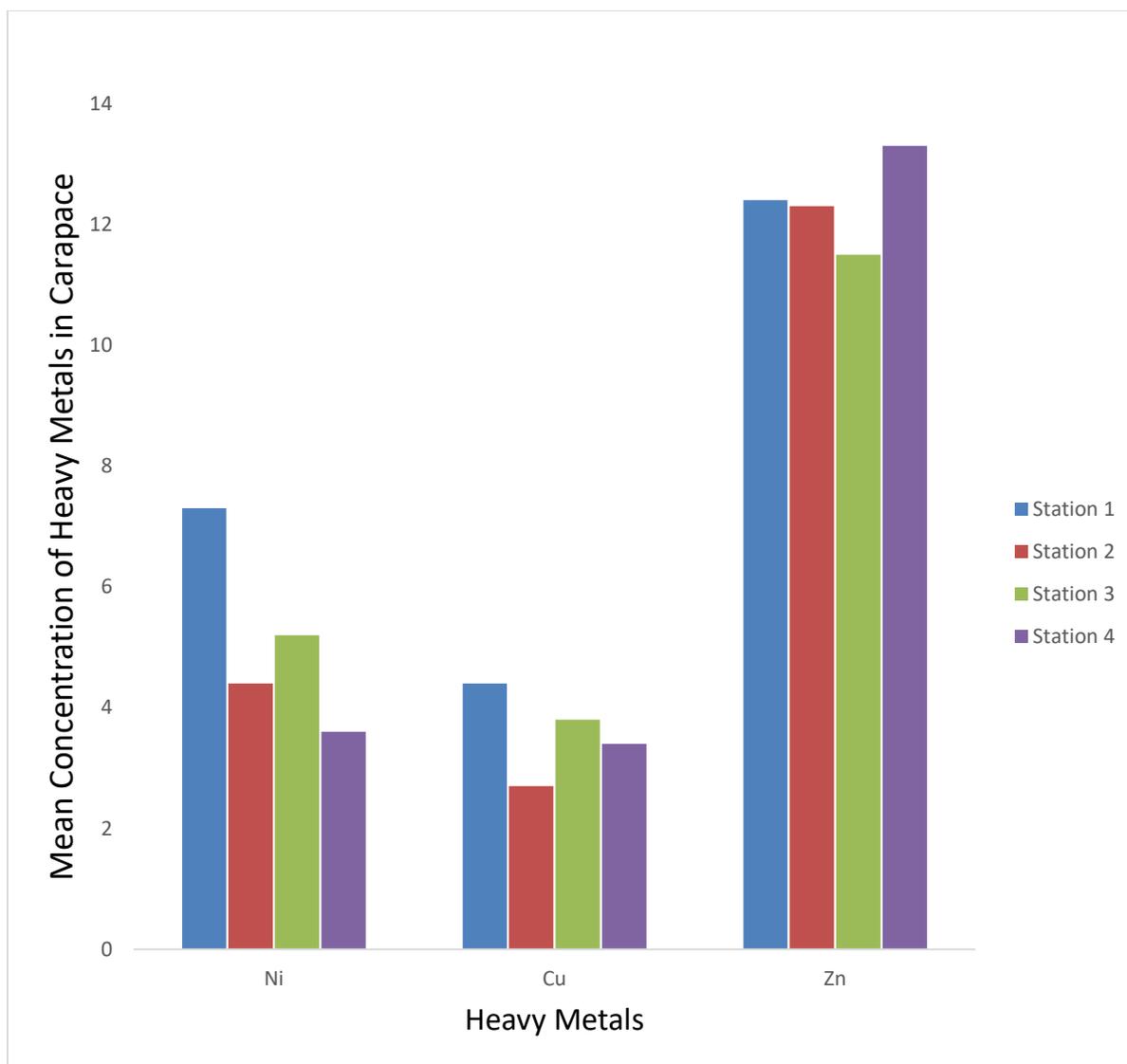


Fig. 2: Heavy metal concentration in carapace of frozen prawns purchase from supermarket to that of open market

Figure 2 presents the mean concentrations of the heavy metals nickel (Ni), copper (Cu), and zinc (Zn) measured in the carapace at four sampling stations. The analysis reveals two primary patterns. First, zinc is present in dramatically higher concentrations than either copper or nickel across all locations. Second, a distinct spatial gradient is evident, with the concentrations of all three metals increasing progressively from Station 1, which recorded the lowest levels, to Station 4, which exhibited the highest

contamination. These results indicate that zinc bioaccumulates most significantly in the carapace and that Station 4 represents the area of greatest heavy metal exposure.

Discussion of Findings

Heavy metals are readily absorbed by aquatic life forms and can accumulate at larger concentrations (El Sherif, 2012). The concentration of heavy metals in tiger prawns (*Panesus monodon*) acquired from three super markets and one open market were investigated for accumulation of Lead

(Pb), Cadmium (Cd), Nickel (Ni), Copper (Cu) and Zinc (Zn). Lead and cadmium were not detected in any of the station throughout the investigation. This result however differs from results reported by Biswas et al. (2021), who detected Pb and Cd in Bangladesh, though within WHO recommended standard. The differences could be attributed to the type of anthropogenic activities carried out in the study areas by geographical locations. Prawn obtained from the location accumulated varying concentrations of heavy metals which were low. The concentration of Ni, Cu and Zn in this study from all sampled location did not exceed the WHO recommended limit for human consumption even though concentration varied according to location. This result also differs from those reported by Heidarieh et al. (2013) who evaluated heavy metal concentration in shrimp and crabs in higher concentrations.

The accumulation of heavy metals in the tissue and carapace of the Tiger prawn from supermarkets and open market was also analyzed. Pb was not detected in both tissues and carapaces of tiger prawn from all the locations. There was more accumulation of Cu and Ni in the tissues of prawn than carapace. The result from this study shows that the carapace accumulated more Ni and Cu than tissue from all the stations sampled. This trend however changed in the concentration of Zn in tissues and carapaces of Tiger prawn. There was higher accumulation of Zn in the tissues than carapaces. This shows that tissues of prawn accumulate more of Zn than the carapace. This shows that the level of accumulation of different heavy metals is dependent on parts of prawn making it seem like absorption is achieved selectively. While carapace would easily and readily

accumulate Ni and Cu, Zn might take a different pace to bioaccumulate. The bioaccumulation of heavy metals in this study also appeared to be lower in concentration and may not pose any threat to humans when consumed. The concentration of these heavy metals however, whether in tissue or carapace, did not exceed their respective WHO permissible limit for human consumption. This conforms with results reported by Zodape (2014) and Mansur et al. (2018). However, it is different from those reported Adedeji and Okocha (2011) whose reports were where higher than WHO recommended limit. The concentration of the heavy metals in tissue and carapace was statistically significant.

Conclusion

The results of this study demonstrated that the tiger prawn accumulated varying concentrations of heavy metals though in levels are within the WHO permissible limit for human consumption. The concentrations of the selected heavy metals were dependent on the body part of the prawn; there was however no correlation between concentration in frozen prawn and those purchased from open market.

Recommendations

Based on the findings of the study, the following recommendations were proffered:

1. The prawns acquired from all station are recommended for human consumption as the levels of heavy metal concentrations recorded are safe for human consumption.
2. The tissue of prawn is recommended as a better source of protein compared to the carapace.

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