



## Bioaccumulation of heavy metals in prawns and periwinkles sold in maciver market in Warri south local government area of Delta State, Nigeria

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### Abstract

Bioaccumulation of heavy metals in prawns and periwinkles sold at Maciver market in Warri South Local Government Area of Delta State, Nigeria was confirmed by this study. Heavy metals were investigated through standard methods (AOAC, 1984). Results showed that prawn contained lead ( $3.02 \pm 0.02$  mg/kg) Chromium ( $5.64 \pm 0.06$  mg/kg) and Cadmium ( $3.18 \pm 0.01$  mg/k) while periwinkle has the following values Pb ( $0.012 \pm 0.001$  mg/kg) Cr ( $0.03 \pm 0.002$  mg/kg) Cd ( $0.003 \pm 0.04$  mg/kg). Some of these values were above FAO/WHO standards. There should be regular biomonitoring of aquatic organisms (including shell fishes) and regulating edible food sources to the markets.

**Keywords:** bioaccumulation, shell fishes, heavy metals, biomagnification, *Typanostomus fucastus*, *Macrobrachium vollehovenii*

### Introduction

Heavy metals that are naturally occurring are not dangerous to the environment and they play essential roles in tissue metabolism and growth of plants and animals. However severe metal imbalances are toxic and marginal imbalances contribute to deformities and impede health <sup>[1]</sup>. Metals of major interest in bioavailability studies, as listed by the US Environmental protection Agency (EPA) are aluminum, beryllium, arsenic, cadmium, chromium, copper, mercury, nickel, lead, selenium, antimony <sup>[2]</sup>. Other metals that are presently of lesser interest to the EPA are silver, barium, cobalt, manganese, molybdenum, sodium, thallium, iron and zinc. These metals were selected because of their potential for human exposure and increased health risk.

There has been a growing interest in assessing the levels of trace heavy metals in consumed aquatic organisms like prawns and periwinkles <sup>[2]</sup>. The ingestion of food is an obvious means of exposure to metals not only because many metals are natural components of food stuffs but also because of environmental contamination during food processing/packaging. Heavy metals are considered to be the most important form of aquatic pollution because of their accumulation by aquatic organisms <sup>[3]</sup>. Metal pollution in the environment is not very visible but its impact on delicate marine ecosystems and humans are drastic. Trace metals are significant either from the viewpoint of their essentiality or their toxicity.

Metals occur in mineral deposits and can enter the environment naturally through weathering of rock and ores. Human activities such as refining of ores and many industrial processes also release metals into the environment, often at a rate far higher than natural processes. Metal contamination can be directly linked to both industrial sources and urban runoffs. The wearing of vehicle parts such as tyres, brake pads and brake lining is a major source of metal contamination. Other sources include vehicle and aircraft exhaust, leaking lubricating oil, smelters, power station, port facilities, chemical products and manufacturing plants. Other sources include aeroplanes, paved roads and motor vehicles, commercial shipping and to a lesser extent, recreational, boating, railways and fuel combustion <sup>[4]</sup>.

Some heavy metals are naturally present in some natural water sources. Some of them are essential for healthy living of organisms. However, when the concentrations of the metals are very high beyond certain tolerable limits, they become toxic <sup>[5]</sup>. Metals such as copper and zinc have biological functions and are essential elements for many organisms, although they can be toxic at higher concentrations. Some other metals, including cadmium, lead and mercury, have no known biological functions and even at low concentrations can be toxic to some form of life.

Impact of heavy metals on organisms can be in a number of ways. Their effects can be in a number of ways. These effects can be immediate or long-term. Metals can differ in their mode of action within organisms, with variations in the rate of uptake, metabolism and excretion resulting in variations of toxic effects exhibited by the metals. When a number of metals are present at one time, the total toxicity of the metals may be greater than would be expected from the sum of the individual toxicities of each metal <sup>[6]</sup>. Heavy metals can also be

bioaccumulated in some organisms and plants. Bioaccumulation occurs when the metal is taken up at a faster rate than it is excreted. In polluted areas bioaccumulation can make some animals unsafe for consumption. Marine foods are essential delicacies and form an important staple food for daily living of every human being. The ability of heavy metal to be accumulated in marine organisms is of great interest as far as the knowledge of heavy metal is concerned [7]. Anthropogenic pollutants are sources of persistent toxic metal contaminants in the ocean [8]. Increasing industrial activities in recent decades have regularly introduced heavy and toxic metals, as well as use of fertilizers or pesticides in many ecosystems [9]. At the same time, significant amounts of municipal and agricultural wastes are discharged into the environment. These pollutants enter atmospheric and hydrological circulation and are finally deposited on river beds, swamps and in the marine environment, thus leading to a sink of which aquatic invertebrates take up and accumulate trace heavy metals which have the potential to cause toxic effects. Decapod crustaceans have the ability to metabolically regulate essential metals like zinc, copper and manganese [10] and in contrast tend to be effective as bioaccumulators of non-essential metals such as lead and cadmium, reflecting environmental levels and serve as bio-indicators of these metals [11]. Monitoring the concentration of heavy metals in water, sediment and aquatic fauna is important because the knowledge of these, especially in the sediment gives vital information regarding their sources, distribution and degree of pollution [12, 13].

Crustaceans, especially members of the order Decapoda (shrimp, crabs and lobsters) are ecologically and economically important. The fate of heavy metals introduced by human activities into aquatic ecosystems has recently become the subject of wide spread concern, since beyond the tolerable limits they become toxic [14].

Assessment of harmful and toxic substances in water sediments and biota, gives direct information on the significance of pollution in the aquatic environment [15]. The pollution of sediments, water resources and biota by heavy metals is of major concern especially in many industrialized countries because of their bio-accumulative, persistence and toxicity (PBT) [16].

Shrimps and periwinkles are organisms which are found mainly in water, in muddy and moldy terrestrial environments. Shrimps are decapod crustaceans while periwinkles are gastropod molluscs. Shrimps and periwinkles live predominantly in either marine or fresh water environments. Crustaceans and molluscs are common sources of foods. Their meats are cheap and rich in protein, omega 3 and low fat content. Furthermore, they can supply the recommended levels of essential nutrients such as Cu and Zn required for proper functioning of human body systems especially in developing countries where deficiency of these metals is common [17].

However, as nutritionally beneficial as crustaceans and molluscs are, they can be potential sources of health risks to man due to bioaccumulation of toxic heavy metals such as lead (Pb) and cadmium (Cd).

Therefore, this research seeks to provide information on the concentrations of lead (Pb), chromium (Cr) and cadmium (Cd) in the tissues of shrimps and periwinkles sold in Maciver Market in Warri-South Local Government Area of Delta State, Nigeria.

## Materials and Methods

### Description of Study Area

The study area Maciver market is in Warri South Local Government Area of Delta State. It lies between Latitude 5° 3'5. 11" N and Longitude 5°40'44. 11" E, altitude 13.5 – 17.5 m. The area is in oil rich Niger Delta-Nigeria and as such, the major activities are characterized by oil & gas exploration activities from Chevron Nigeria Limited, petrochemical refining from the Warri Refinery and Petrochemical Company, a subsidiary of Nigerian National Petroleum Corporation (NNPC) and allied companies. The economic activities of these companies has undoubtedly increased human population and thus, dumping of waste materials directly into the river, mainly from Delta Development Property Agency (DDPA). Others are aquaculture business along the river stretch, auto-mechanic workshops, wood-logging, cloth washing, bathing and swimming.



Fig 1: Map of Warri South LGA showing sampling Point

### Sample collection

Samples of fresh African river prawn (*Macrobrachium vollehovenii*) and Periwinkle (*Tympanotomus fuscatus*) were purchased from Maciver market in Warri South Local Government Area of Delta State. The samples were collected in polyethylene bags and transported to the laboratory.

### Species identification

Species of periwinkle and prawns were identified using the appropriate keys and works of Olomukoro and Azubuike<sup>[18]</sup>. The specie of periwinkle identified was *Tympanostomus fucastus* with prominent rings and that of prawn was *Macrobrachium vollehovenii* and confirmed by Mr. Jemerigbe of Department of Biology, College of Education, Warri, Delta State, Nigeria.

### Digestion

In the laboratory, the specimens were properly washed with distilled water. Periwinkles tissues were removed from the shell with a clean acid washed stainless steel needle and dried to constant weight at 90°C for three days in clean acid washed glass petri dishes. After drying, the samples were kept in a desiccator and allowed to cool. The samples were then crushed into fine powders using porcelain mortar and pestle. Prawn samples were oven dried at a temperature of 80°C for 72 hours to constant weight and milled to powder using a porcelain mortar and pestle. The method used for digestion was the mixed acid procedure described by Fufeyin<sup>[19]</sup> and modified. A mass of 0.5 g each of dry pulverized samples of periwinkle and prawn contents were measured into a separate 25 ml beaker respectively. A volume of 5 ml of concentrated nitric acid was added to each and was allowed to stand for 30 minutes. Thereafter 1 ml of sulphuric acid was added to it and almost immediately 1 ml of 60% perchloric acid was added. The mixture was swirled gently and was allowed to digest slowly over a period of time at moderate to high heat under a fume hood. It was further digested for 2 – 3 hours after the appearance of white fumes, it changed into a brown colouration and later into a black colouration. The content was allowed to cool, the remaining solution was diluted to 5 ml and allowed to stand for a period of 6 hours and then diluted to 20 ml. The solution was filtered into sterile clean 25 ml beaker and later poured into 60 ml plastic containers. The final solution was directly aspirated for heavy metals analysis in the laboratory. The blank was prepared following the same procedure as it was conducted for the five sampled station, except that the blank did not have the periwinkle content.

### Determination of Metals in Periwinkle (*Tympanotomus fuscatus*) and Prawn (*Macrobrachium vollehovenii*).

After digestion of the flesh of periwinkle (*Tympanotomus fuscatus*) and the tissue of prawn, the digested samples were filtered with 20 ml of deionized water. The filtrates were collected with clean acid-washed and appropriately labeled 30 ml polyethylene containers for analysis by Atomic Absorption Spectrophotometric method (AAS-Model 210VGP BUCK Scientific, USA) using air-acetylene flame for the metal analysis against standard metal solutions. Each metal (cadmium, chromium and lead) was analyzed using the specific hollow cathode lamp at a specific wavelength according to Onyeonwu<sup>[20]</sup>.

### Statistical Analysis

The study data were subjected to mean  $\pm$  SD to show the average metal concentrations in the organisms.

## Results and Discussion

### Results

The summary result of heavy metal analysis in prawn and periwinkle is presented in Table 1.

**Table 1:** Concentration of Heavy Metals (Mean  $\pm$  S.D, mg/Kg) in Prawns and Periwinkles

Elements	<i>Macrobrachium vollehovenii</i>	<i>Tympanostonus fucastus</i>	WHO (1989) mg/kg
Pb	3.02 $\pm$ 0.02	0.012 $\pm$ 0.01	2.0
Cr	5.64 $\pm$ 0.06	0.03 $\pm$ 0.02	50
Cd	3.18 $\pm$ 0.01	0.03 $\pm$ 0.04	1.0

Source: Fieldwork, 2019

Chromium was the most bioaccumulated metals, while lead was the least in prawn. Chromium and cadmium were the most bioaccumulated in periwinkle, as observed in the studied market. Prawn highest value of 5.64  $\pm$  0.06 mg/kg was obtained for chromium, followed by cadmium (3.18  $\pm$  0.01mg/kg) and the least value of 3.02  $\pm$  0.02 mg/kg was obtained for lead. In periwinkle, chromium and cadmium have the equal concentrations of 0.03  $\pm$  0.02 mg/kg while least value of 0.012  $\pm$  0.01was obtained for lead. However, the values of lead and cadmium were higher than FAO/WHO (2011) standard of 0.3 mg/kg and 2.0 mg/kg respectively. The increasing order in metal level across all the species is Pb < Cd  $\leq$  Cr. The increasing order in metal level in prawn is Pb < Cd < Cr and that of periwinkle is Cd < Cr < Pb.

## Discussion

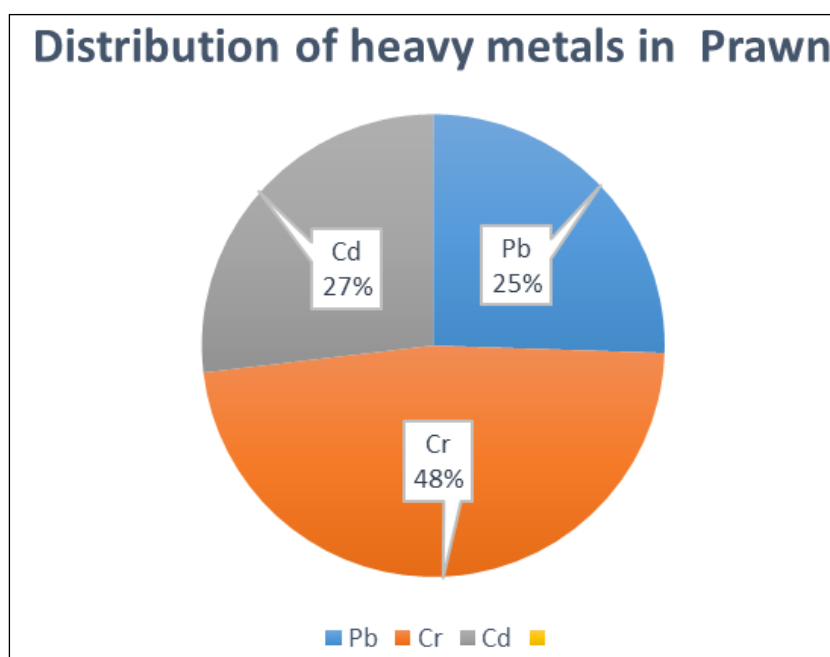
The concentration of lead and cadmium metals found in the gastropod tissue and crustacean at the study area were higher than the WHO standards. However the values of chromium was less than WHO value. Similarly the level of Cr in tissue showed significant difference ( $p < 0.001$ ) likewise, Cd ( $p < 0.05$ ) between the stations examined. The result of this study compared favourably with the concentration sequence of metal ( $Fe > Zn > Cr > Pb$ ) obtained by Ikejimba and Sakpa<sup>[21]</sup> in *T. fuscatus* but actual metal concentration differed considerably. According to Daka *et al.*<sup>[22]</sup> *T. fuscatus* is a good organism for the biomonitoring of Cd but not for Zn and Cu stating that the ambient concentration of Cu and Zn may affect the accumulation of Cd and need to be considered in the interpretation of Cd data in *T. fuscatus*. Daka *et al.*<sup>[22]</sup> also reported that size of *T. fuscatus* and salinity of the water affect bioaccumulation of heavy metals in *T. fuscatus*. The concentration of Cd in *T. fuscatus* observed in this study however, is in contrast with the report of Emmanuel<sup>[23]</sup> in a study of heavy metals in sea food crab (*Callinectes amnicola*) and Periwinkle (*Tympanotonus fuscatus*) collected from Uta Ewa Creek.

The highest concentration of Lead (Pb) in *Tympanotonus fuscatus* ( $0.012 \pm 0.01$  mg/kg) was observed at study area. This agreed with the works of Davies *et al.*<sup>[24]</sup>, which showed the bioaccumulation of three metals; Chromium, Cadmium and Lead in *T. fuscatus* (shell and soft tissue) collected from four stations along Elechi Creek, Niger Delta. Contamination of Pb in sediment have detrimental effect on benthic organism<sup>[25]</sup>.

The values of Pb ( $3.02 \pm 0.02$  mg/kg) recorded in *M. macrobrachion* is more than the value of Pb in *T. fuscatus* ( $0.012 \pm 0.01$  mg/kg). This could be as a result of the level of metals in the sediment that was taken up and concentrated by *M. macrobrachion*. However, the mean values of Cr, Pb and Cd found in the tissue of *Tympanotonus fuscatus* in the current study were below the recommended limits in seafood (FAO/WHO 1989)<sup>[26]</sup>.

The mean Pb concentration (mg/kg) in *M. macrobrachion* is higher than the specified Maximum acceptable concentration of 2 mg/kg as prescribed by WHO<sup>[26]</sup>. Pb is known as deadly and accumulative poison even when consumed in small quantities and is capable of death of nerve receptors in man<sup>[27]</sup>. From the public health point of view, lead toxicity reportedly causes renal tubular dysfunction indicated by proteinuria, aminoaciduria, glucosuria, hyperphosphaturia and impairment of sodium transport<sup>[27]</sup>.

The mean Cd concentration of  $3.18 \pm 0.01$  mg/kg in prawn was above the prescribed value of 1 mg/kg<sup>[26]</sup>. Cadmium a highly toxic metal, is present throughout the environment and accumulates in liver and kidney of mammals through the food chain<sup>[28]</sup>.

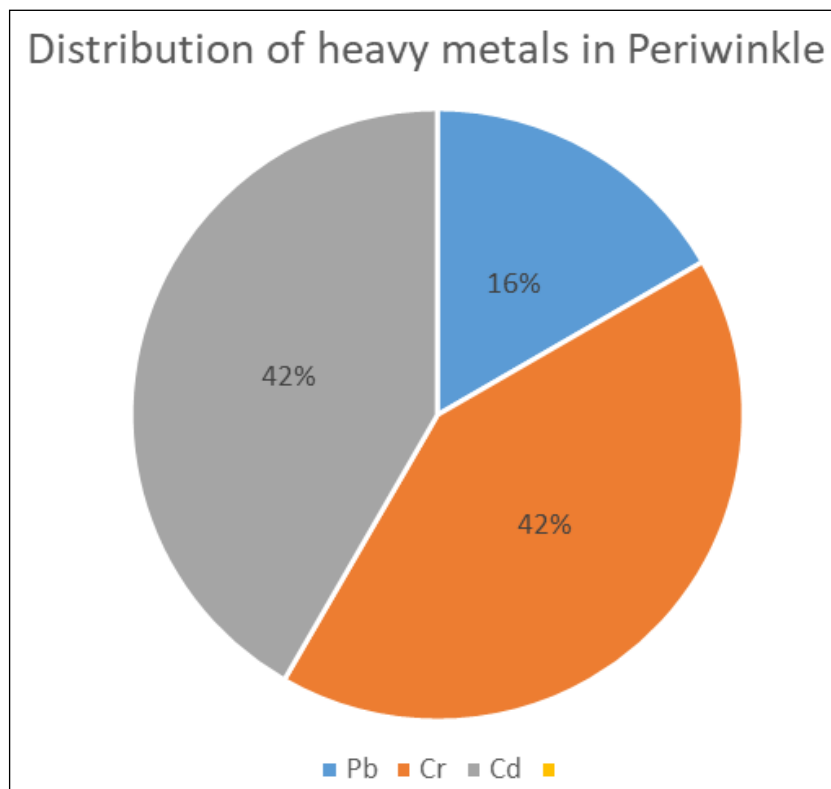


**Fig 2:** Summary of % contribution of heavy metals bioaccumulation in prawn

Figure 2 and 3 further affirm the study result of heavy metal distribution in prawn and periwinkle. The high bio-accumulation and bio-concentration of metals in prawn may be due to feeding habit, body mass, sizes to their body cavity.

However, chromium has the highest concentration (48%) in prawn. Chromium is a compound of biological interest in view of its role in glucose and lipid metabolism as an essential nutrient<sup>[29]</sup>. However, the compounds of chromium have been found to be mutagenic and carcinogenic in a variety of test systems. Death in acute chromium poisoning is usually due to uraemia. Chronic intoxication by inhalation or skin contact leads to incapacitating eczematous dermatitis, with oedema and ulceration<sup>[29]</sup>. It is interesting to know that the values of

Cr in prawn and periwinkle samples are far lesser than the prescribed value of 50 mg/kg as prescribed by WHO [26].



**Fig 3:** Summary of % contribution of heavy metals bioaccumulation in periwinkle

The present study did not only affirm the reports of Isibor and Oluowo [30], of significant increases in heavy metals concentrations of shell fishes. This study also agreed with the works of Ayenimo *et al.* [31] of heavy metals contamination of periwinkle sold in public markets including that of the study area, but went further to alarm the potential health risk from consumption.

### Conclusion

This study has confirmed the increasing bioaccumulation of heavy metals (lead, chromium and cadmium) in shell fishes (prawn and periwinkle) and has placed the abundance and consumption of shell fishes (prawn and periwinkle) as food in the region at high risk, coupled with previous report of contamination of investigated periwinkle sold in market places.

### Recommendations

1. The present study recommend regular biomonitoring of the river to check source of pollution and encourage government/institutional funding for in-depth research.
2. There should be regular biomonitoring of aquatic organisms (including shell fishes) and regulating edible food sources to the markets.
3. Regular environmental awareness on the toxic effects of heavy metal contaminations of shell fishes should be carried out by relevant agencies such as NESREA.

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