

DISTRIBUTION AND HUMAN HEALTH RISK ASSESSMENT OF HEAVY METALS IN TISSUES OF *CALLINECTES SAPIDUS* FROM IKO RIVER, AKWA IBOM STATE, NIGERIA

ABSTRACT

This study investigates the accumulation of heavy metals in the tissues of *Callinectes sapidus* (blue crab) in the study area, evaluating the human health risk of their consumption. The tissues of concern were the gills, muscles, and hepatopancreas in the male and female crab species, while the heavy metals assessed were Cd, Ni, and Pb. Heavy metals levels in the tissues of *Callinectes sapidus* ranged as follow: Ni: hepatopancreas (182.97 – 313.53 mg/kg), gills (129.93 – 192.14mg/kg), muscles (93.09 – 165.84mg/kg); Pb: hepatopancreas (22.86 – 39.65 mg/kg), gills (13.46 – 21.35 mg/kg), muscles (2.73 – 6.32 mg/kg); Cd: hepatopancreas (2.04 – 9.03 mg/kg), gills (0.12 – 4.995 mg/kg), muscles (0.105 – 2.835 mg/kg), respectively. The highest metal concentrations were observed in the hepatopancreas tissue and the female crab species. Furthermore, the metals' levels were generally higher than the permissible level by FAO/WHO in seafood. To assess the heavy metals health risk to the inhabitants of the study area, the daily intake of metal (DIM) and total hazard Quotient (THQ) were estimated and were found to exceed the recommended values. The results reflect the risk of exposure for the period of life expectancy considered and revealed that the inhabitants of the study area are highly exposed to the health risks associated with these metals.

Keywords: Heavy Metal, Callinectes sapidus, Health Risk Assessment

1. INTRODUCTION

Heavy metal pollution is a critical environmental issue of concern across the globe. As the human population increases, the intensities of the anthropogenic threats it exerts on the environment increase as a result of industrialization and aqua-cultural activities [1]. Heavy metal pollution of the aquatic environment is a cause of concern because of its toxicity; high presence, non-biodegradable, and tendency to bioaccumulate in organisms. These metals when ingested by humans, could be circulated in the bloodstream and accumulate in the target organ. Subsequently, it appears in toxic form in both aquatic organisms and humans who consume seafood [2]. The increase of these metals concentration in the environment can be transferred to organisms through the food chain with the resultant effect of damaging flora and fauna and ultimately causing death [3,4,5].

Ubong et al.[6] has stated that the increased use of metal-based fertilizer in the agricultural revolution of government could result in a continued rise in the concentration of metal pollution in the freshwater reservoir due to water run-off. As the human population increases,

the intensity of anthropogenic threats exerted on the environment increases as a result of industrialization and agricultural activities [7]. Furthermore, atmospheric inorganic contaminants of natural or anthropogenic sources with heavy metals and/or trace elements at high concentrations could lead to serious ecological consequences and pose human health risks [8]. Heavy metals are potentially hazardous to humans and various ecological receptors because of their toxicity, persistence, bioaccumulative and non-biodegradable nature. Therefore, monitoring and evaluation of heavy metal concentrations in soils, groundwater, and atmospheric environment are imperative to identify hazards to human health, prevent bioaccumulation in the food chain, and further the degradation of the ecosystem [8].

Accumulation of heavy metals in an organism depends on various bioorganic and environmental factors such as size, age, feeding habit, temperature and dissolved oxygen [9]. Feeding habit plays a significant role in the accumulation of metals in organism tissues because metals tend to be bio-magnified through the food chain. Most aquatic food chain begins from the invertebrates, which can accumulate high levels of metals, selenium, and arsenic. For this reason, it is important to determine the chemical composition of marine organisms such as crabs, particularly the heavy metal content, to evaluate the possible health risk of this aquatic product to humans.

Human health risk assessment is considered the characterization of the potential adverse health effect of humans as a result of exposure to environmental hazards [10]. This process employs statistical identification to measure the hazard and determine possible routes of exposure and finally use the information obtained to determine the potential risk [11]. This study assesses the human health risk posed by the consumption of *Callinectes sapidus* obtained from Iko River, Eastern Obolo LGA in Akwa Ibom State, Nigeria.

2. MATERIAL AND METHODS

2.1 Sampling Site and Study Area

Iko River is in Eastern Obolo L.G.A, Akwa Ibom State bounded South-West by Andoni, Rivers State, and empties into the Atlantic Ocean in the south. Iko River has many adjoining tributaries, part of it drains into the Andoni River estuary, which opens to the Bright of Bonny. The study station sites 1 and 2 lies along latitudes $4^{\circ} 30''$ N and $4^{\circ} 45''$ N; longitude $7^{\circ} 35''$ E and $7^{\circ} 40''$ E respectively.

2.2 Sample Collection, Preparation, and Instrumental Analysis

Blue crab (*Callinectes Sapidus*) were caught during the day, stored in an insulated box, transported to the laboratory, and stored at 4°C . Before the analysis, the crabs were cleaned with running tap water and thawed at room temperature. The gills, hepatopancreas, and muscles of the crab were dissected using a pair of sterile stainless steel scissors. All the parts were replicated and transferred to Petri dishes. The tissues were dried in an oven with a foil plate for three days. The dryweight of the crab tissues crushed inside mortar with a pestle 1g of the sample was weighed and 10ml of HNO_3 and 2ml of HClO_4 were added. It was digested on a hot plate until it dissolved and evaporated to near dryness. 10 ml of deionized water was added to the completely digested sample and allowed to cool to room temperature. The resulting solution was filtered through Whatman filter paper and washed with deionized water into a 100ml volumetric flask, which was then made up to the mark by adding deionized water. The metal concentration in the crab tissues was analyzed using Atomic Absorption Spectrophotometer.

2.3 Human Health Risk Assessment

The potential health risk of heavy metal consumption through *Callinectes sapidus* were assessed based on the daily intake of metal (DIM) [10], health risk Index (HRI), and the target hazard quotient (H/Q) [2,11].

These parameters were estimated thus;

$$\text{DIM} = \frac{(\text{Metal} \times \text{C factor} \times \text{C food intake})}{\text{WAB}} \quad 2.1$$

- DIM (Daily Intake of Metal)
- Metal Concentration in mg/kg
- C Factor: The conversion factor for *C. sapidus* is 20.5 [12]
- C food intake: The daily intake of crab was estimated as 60g/day
- WAB (Average body weight): 60kg

$$\text{HRI} = \frac{\text{DIM}}{\text{RfD}} \quad 2.2$$

- RfD=Oral reference dose (Pb:0.0035mg/kg/day, Cd:0.001mg/kg/day, Ni:0.020mg/kg/day)[13]

$$\text{THQ} = \frac{\text{EF} \times \text{ED} \times \text{FIR} \times \text{C}}{\text{RfD} \times \text{WAB} \times \text{TA}} \times 10^{-3} \quad 2.3$$

- EF = Exposure frequency (350 days) years
- ED = Exposure duration 54 years, equivalent to the average lifetime of the Nigerian population.
- FIR = Food Ingestion Rate = 60g/person/day
- C = Concentration of the metal
- WAB = Average body weight = 60kg
- TA = Average exposure time for non-(carcinogens ED x 365 days/year) (54 x 1 years)

If THQ is greater than 1, the exposure is likely to cause adverse health effects.

3. RESULTS AND DISCUSSION

The present study indicated that there were differences in heavy metal concentration in the two sample areas. This difference in heavy metal concentration depends on the availability of metal and the source of pollution in the different habitats.

3.1 Physico-chemical parameters

The physicochemical analyses of water obtained from the study site reveal a high salt concentration; especially in S2 (table 1). This can be attributed to the closeness of the river to the Atlantic Ocean, whereby S2 has the closest proximity to the ocean. For S2, salinity was 0.08%, TDS (762 mg/l), Conductivity (1529 $\mu\text{S}/\text{cm}$) while S1: salinity (0.03%), TDS (324 mg/l), Conductivity (649 $\mu\text{S}/\text{cm}$) as shown on Table 1. The mean metal concentration in water obtained from site 1 were Pb (15.413 mg/l), Cd (11.927 mg/l), Ni (1.642 mg/l) while for S2: Pb (12.107 mg/l), Cd (8.649 mg/l), Ni (1.126 mg/l). Generally, S1 and lead gave the highest metal concentration, followed by cadmium while the least metal concentration was nickel. Lead is transportation-related arising from fuel combustion and rainfall washes particles out of the air and stops re-entrainment of particles. The origin of the high lead and cadmium levels in the sample area can be linked to the numerous oil spillages and

bunkering activities in the region; this should be a major cause for concern since these metals are very harmful to exposed humans.

Table 1. Physico-chemical parameters of Water obtained from the Ikelko River

PARAMETERS	S1	S2
Salinity	0.03%	0.08%
TDS (mg/l)	324	762
Temperature (°C)	27.1	27.1
Conductivity (us/cm)	645	1529
Current I (nA)	1295	1343
pH	6.9	6.5
DO (Dissolved oxygen)	46.7	52.1

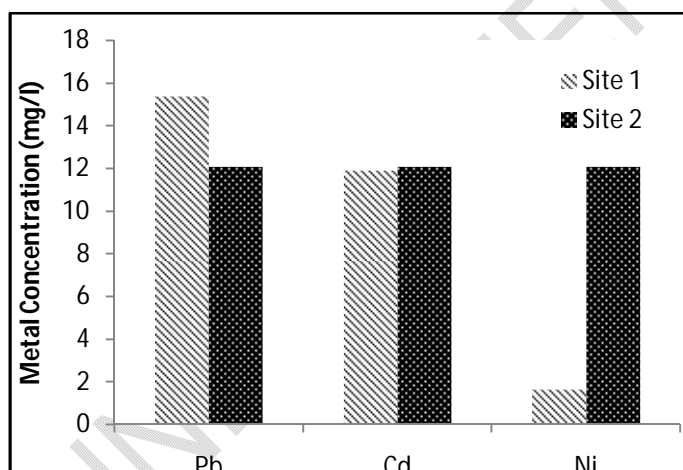


Fig. 1 Mean levels of trace metals in water

3.2 Heavy metals in tissues of *Callinectessapidus*

Heavy metals levels in the tissues of *Callinectessapidus* ranged as follow: Ni: hepatopancreas (182.97 – 313.53 mg/kg), gills (129.93 – 192.14mg/kg), muscles (93.09 – 165.84mg/kg); Pb: hepatopancreas (22.86 – 39.65 mg/kg), gills (13.46 – 21.35 mg/kg), muscles (2.73 – 6.32 mg/kg); Cd: hepatopancreas (2.04 – 9.03 mg/kg), gills (0.12 – 4.995 mg/kg), muscles (0.105 – 2.835 mg/kg) respectively, with site 1 showing higher values than site 2. These results show that metal concentration in the different organs followed the hierarchical pattern Hepatopancrease> Gills > Muscle. Nickel gave the highest concentration while cadmium was the least in concentration. Several studies [14,15,16] have indicated that the high levels of metals in the hepatopancreas in comparison to other tissues may be

attributed to the synthesis of low-molecular-weight metal-binding metallothionein-like protein, which has been widely recorded in different crustacean species. The metallothionein protein contains a high percentage of amino groups, nitrogen, and sulfur that sequester metal in stable complexes. It has been reported [17] that the accumulation of metals in the tissues of crab species depends on the abundance of metallothionein protein in the tissue. Accordingly, this study has demonstrated that the hepatopancreas is the main site of storage and detoxification of metals, as indicated in the highest metal concentration recorded in this tissue. Gills usually reflect the concentration of metals in the surrounding water, since they are directly in contact with water and can absorb suspended materials from the aquatic environment. They also serve a variety of physiological functions such as osmoregulation and gas exchange. Due to these functions, gills have a remarkable influence on the exchange of toxic metals between a crab and its environment. Furthermore, the result of this study has shown that the crab muscles tend to accumulate less metal in comparison to other tissue, suggesting a relatively low concentration of metallothionein in the muscles.

This investigation has considered the influence of sexuality of the organism on metal accumulation and distribution among its tissues; revealing that metal accumulation was higher in tissues of female species than the male, which disagrees with a previous study [17] on the new Calabar river in the same region as the present study. Metal concentration in male *C. saipidus* ranged as follows: Ni (93.09 – 231.17 mg/kg), Pb (2.73 – 29.76 mg/kg), Cd (0.05 – 4.10 mg/kg) while the range for female crab species were: Ni (165.63 – 313.53 mg/kg), Pb (4.77 – 37.08 mg/kg), Cd (0.26 – 4.10 mg/kg). According to a study [18], male crabs feed more on fish and *Bivalvia* while females consume mostly shrimp plants and detritus. Since plants are rooted in the sediment, they receive more sediment-associated metals. These metals are subsequently accumulated in the female crabs, which feed mainly on the plants. Furthermore, the elevated levels of metals in female crabs may be attributed to their relatively larger sizes, higher metabolic activities, and better feeding habit.

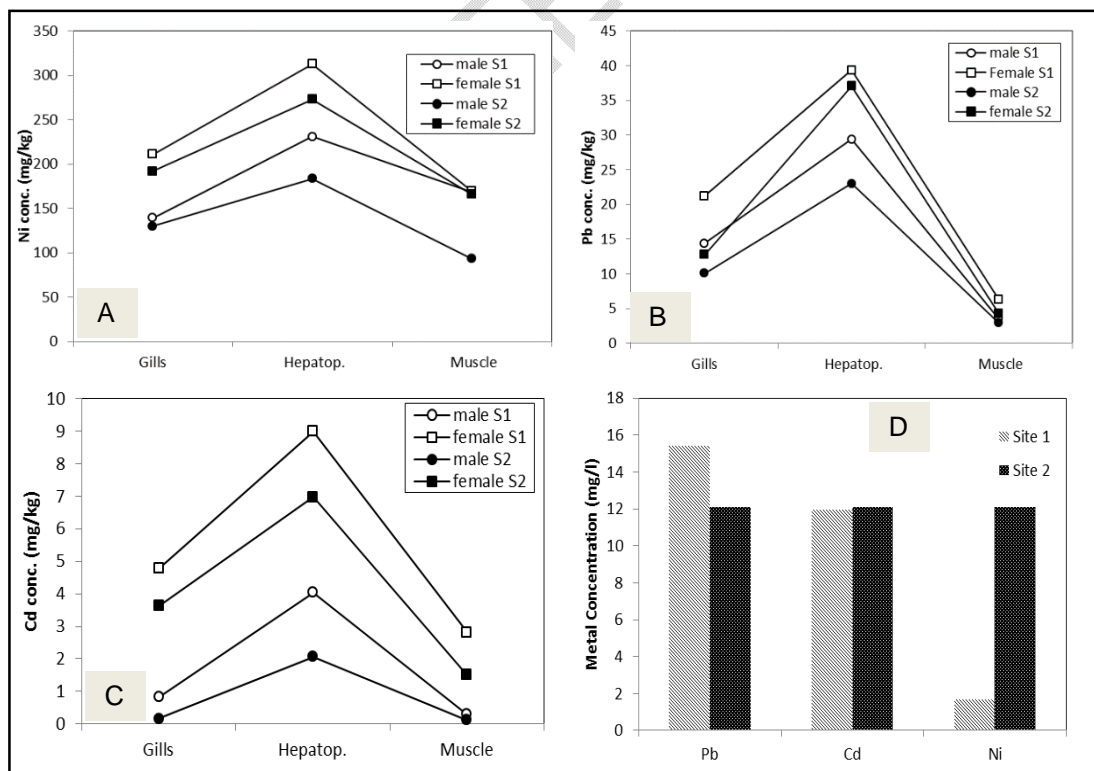


Fig 2 Metals in the tissue of *Callinectes sapidus* and water obtained from Iko River (A) Ni in *C. sapidus* (B) Pb in *C. sapidus* (C) Cd in *C. sapidus* (D) Metals in the water of Ikoriver

3.3 Human Health Risk Assessment

To assess the health risk associated with the consumption of the study crab, the daily intake of metal (DIM) and target hazard quotient (THQ) is presented in Table 2. The DIM was compared with the recommended daily intake of metals and the upper tolerable daily intake level (UL) [19,20]. The THQ is a ratio between the measured concentrations and the oral reference dose, weighted by the length and frequency of exposure, the amount ingested and body weight [21]. THQ value greater than 1 denotes health risk to the exposed population for the period of life expectancy considered and exposure duration. Generally, Pb and Cd are not important nutrients for humans and are considered to be of much higher risk to humans [22], compared to nickel. Table 2 indicates that THQ values for all metals considered were far greater than 1 in *C. sapidus* tissues, except Cd in the muscle of the male crab species. Thus, *C. sapidus* consumption in the study area poses serious health risk concerns and the inhabitants are highly exposed to health risks associated with these metals in the order of Ni > Pb > Cd. For special populations like those with a weak constitution (eg. pregnant women and children), the potential health risk of heavy metal consumption through consumption will likely be higher than for the normal population.

Table 2 Daily intake of metal (DIM) and total Hazard Quotient (THQ) of sample

Heavy Metal	<i>C. Sapidus</i> tissue	DIM (mg/kg)	THQ
Ni (S1)	Male Gills	2.85	6.67
	Male Hepatopancreas	4.73	11.11
	Male Muscles	2.14	5.00
	Female gills	4.33	10.19
	Female Hepatopancreas	6.41	15.0
	Female muscles	3.47	8.15
Pb (S1)	Male gills	0.29	3.89
	Male Hepatopancreas	0.61	8.15
	Male Muscles	0.07	0.98
	Female gills	0.44	5.83
	Female Hepatopancreas	0.81	10.74
	Female muscles	0.13	1.67
Cd (S1)	Male gills	0.02	0.74
	Male Hepatopancreas	0.083	3.89
	Male Muscles	0.01	0.37
	Female gills	0.12	4.26
	Female Hepatopancreas	0.184	8.70
	Female muscles	0.15	3.70
Ni (S2)	Male gills	2.67	6.30
	Male Hepatopancreas	3.76	8.89
	Male Muscles	1.91	4.44
	Female gills	3.94	9.26
	Female Hepatopancreas	5.59	14.44
	Female muscles	3.40	8.33
Pb (S2)	Male gills	0.21	2.78
	Male Hepatopancreas	0.47	6.30
	Male Muscles	0.06	0.56
	Female gills	0.26	3.50
	Female Hepatopancreas	0.76	10.15
	Female muscles	0.1	1.34

Cd (S2)	Male gills	0.0034	0.16
	Male Hepatopancreas	0.04	1.99
	Male Muscles	0.0025	0.12
	Female gills	0.007	3.48
	Female Hepatopancreas	0.18	6.69
	Female muscles	0.031	1.44

4.0 Conclusion

This research has presented data on the concentration of heavy metals in water and *C. sapidus* at the two sites (S1 and S2) from the Iko River, indicating that S1 was more polluted. This site is close to the Utapete operational zone, an oil exploration facility, which received sewage discharge. Thus, the high bioaccumulation of metals in the crab tissues is believed to be due to the rigorous anthropogenic input of bio-accumulative contaminants into the aquatic environment. It was evident from the study that heavy metal accumulations in *C. sapidus* were higher than almost all the international standard levels. Research findings showed that the water body is contaminated with heavy metals such as Pb, Cd, and Ni and hence can contaminate seafood and humans as a whole. The heavy metals in water were above the permissible limits of national and international standards and pose a serious environmental and human health risk. Most of the physicochemical parameters were slightly above the permissible limits of regulatory agencies, implying that the Iko River is heavily contaminated and potentially hazardous to the exposed populace.

Results indicate high metal bioaccumulation in the crab species studied, with higher accumulation in female species than the male species. Human health risk assessment showed that THQ in all tissues of *Callinectes Sapidus* (except Cd in some male gills and muscle) is far greater than 1. Therefore, benthic crab obtained from the study sites in the Iko River is considered unsafe for consumption.

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