



## Human Health Risk Assessment: a Case Study of Heavy Metals Accumulations in Tissues of *Callinectes latimanus* from Iko River, Eastern Obolo L.G.A., Akwa Ibom State

U. U. Ubong<sup>1</sup>, I. O. Ekwere<sup>\*1</sup> and C. O. Obadimu<sup>1,2</sup>

Received: January 18, 2023 /Accepted: March 23, 2023

© REJOST 2023

### Abstract

Heavy metals in food pose serious adverse health effects in exposed human populace. This study aims at assessing the human health risk of heavy metals in the tissues of *Callinectes latimanus* obtained from two sites (S1 and S2) in Iko River, Akwa Ibom State. The gills, muscles, and hepatopancreas of both male and female crab species were studied, and Cd, Ni, and Pb were the heavy metals of interest. The following heavy metal distribution were found in the tissues of *Callinectes latimanus*; Ni: hepatopancreas (95.7 – 111.6 mg/kg), gills (84.2 – 121.4mg/kg), muscles (91.6 – 100.2mg/kg); Pb: hepatopancreas (6.0 – 43.8 mg/kg), gills (<0.001 – 19.4 mg/kg), muscles (<0.001 – 6.7 mg/kg); Cd: hepatopancreas (0.6 – 71.3 mg/kg), gills (8.4 – 18.5 mg/kg), muscles (17.4 – 99.7 mg/kg), respectively.

✉ Ifioek Ekwere: [ifioekewere@aksu.edu.ng](mailto:ifioekewere@aksu.edu.ng)

<sup>1</sup>Department of Chemistry, Akwa Ibom State University, Nigeria

<sup>2</sup>Institute of Health Safety Security and Environment, University of Uyo, Nigeria

These results indicate a significant variation in the distribution of heavy metals in the tissues of male and female crabs under investigation. Levels of trace metals were higher in the female than those of the male, with the highest metal concentration recorded in the gills of female crab samples. The rank profile of trace metals in the crabs investigated, according to their mean values, were Ni > Cd > Pb for all study sites. The daily intake of metal (DIM) and health risk index (HRI), which were evaluated to assess the human health risk, were found to be higher than recommended levels. Target Hazard Quotient (THQ) values for all metals considered were far greater than 1 in all *Callinectes latimanus* tissues, except Cd in the hepatopancreas of the male and female crab species in S2, Pb in the gills and muscles of male and female crab species in S2. The health risk index (HRI) for all the studied tissues of *Callinectes latimanus* were generally greater than one except Pb of the gills and hepatopancreas of the male crab. Generally, THQ and HRI < 1 implies a minimal health risk

to exposed populace, while THQ and HRI > 1 indicates potential health risk.

**Keyword:** Heavy Metal; *Callinectes latimanus*; Health Risk Assessment; Target Hazard Quotient

## 1.0 Introduction

Numerous living creatures are found in the aquatic environment, which are edible to humans. Toxic metals occur naturally in aquatic environments at very low concentration. However, increased concentration levels are often recorded due to anthropogenic activities. Agriculture, mining, and industrial operations all pose a threat to the aquatic ecosystem by introducing metal contamination (Tchounwou *et al.*, 2012). Furthermore, marine pollution can be caused by sediment re-suspension, metal corrosion, heavy metals leaching, soil erosion of metal ions and their movement from water resources to soil/ground water (Tchounwou *et al.*, 2012). The incessant use of metal-based fertilizer and other allied agrochemicals could lead to the continued occurrences of heavy metal contamination of fresh water reservoir, as a result of water run-off (Ubong *et al.*, 2015). Increase in human population has resulted in an attendant anthropogenic threat on the environment, due to the discharge of pollutants from industrial and agricultural activities (Ubong *et al.*, 2020). Aside from the soil environment and aquatic ecosystem, atmospheric inorganic pollutants from natural or anthropogenic sources could have detrimental ecological effects, as well as pose health hazards to people (Ite *et al.*, 2016). The toxicity, persistence nature, bioaccumulative capacity, and lack of biodegradability of heavy metals make them hazardous and possess the potential to adversely affect humans and numerous ecological receptors. Therefore, it is imperative to monitor and assess metal profiles in environmental compartments so as to identify health risks, prevent bioaccumulation

in the food chain, and halt further ecosystem deterioration (Ite *et al.*, 2016).

Environmental pollutants have hazardous impact on aquatic organisms, and equally affect humans adversely. A variety of contaminants including toxic heavy metals are reported to be ubiquitously present in rivers, reservoirs and are harmful to aquatic organisms (Olsson *et al.*, 2002). Metals such as nickel, cadmium and lead have no function in biological system and are potentially toxic, even at trace concentration. In general, they are not biodegraded and their bioaccumulation in fish, oyster, crabs, mussels, sediments and other components of aquatic ecosystems have been reported globally. Therefore, accumulation of potentially toxic heavy metals in biota causes a potential health threat to their consumers including humans (Ikpe *et al.*, 2022; Ekwere *et al.*, 2019; Ali *et al.*, 2019).

*Callinectes latimanus*, which is the subject of this study, is an edible benthic aquatic organism and it is constantly exposed to metal pollution in the river sediments. They are used in bioaccumulation assessment because they are higher trophic level organisms and are consumed by humans (Sayyad, 2014). The tissues of *C. latimanus* include the mid gut gland, gonad, gill, muscle, limb and exoskeleton. The mid gut gland is the hepatopancreas, liver or digestive gland.

Human health risk assessment involves the description of the potential adverse human health effect due to of hazard exposure (Jan *et al.*, 2010). This process identifies hazard, assesses their exposure routes and subsequently determine the potential risk posed to the ecosystem (Storelli, 2008). Accordingly, this investigation is undertaken to compare the level of some metals (cadmium, lead and nickel) in the tissues of *C. latimanus* obtained from Iko River, Akwa Ibom State, as well as assess the attending health risk to the exposed populace.

## 2.0 Materials and Methods

### 2.1 Sampling Site and Study Area

Figure 1 in Iko River is in Eastern Obolo L.G.A, Akwa Ibom State, Nigeria; it is bounded in the South-West by Rivers State and empties into the Atlantic Ocean in the south. The two sampling sites lie between latitude  $4^{\circ} 30''$  and  $4^{\circ} 45'$  N; longitude  $7^{\circ} 35'$  and  $7^{\circ} 40''$ E

respectively. The study area is an estuarine environment that provides a suitable habitat for several marine lives such as fish, periwinkle, shrimp and crab. Some on-going human activities in the study area that may lead to marine pollution include the use of agrochemicals, hazardous chemical spills, illegal refineries and oil bunkering activities (Ubong *et al.* 2022).

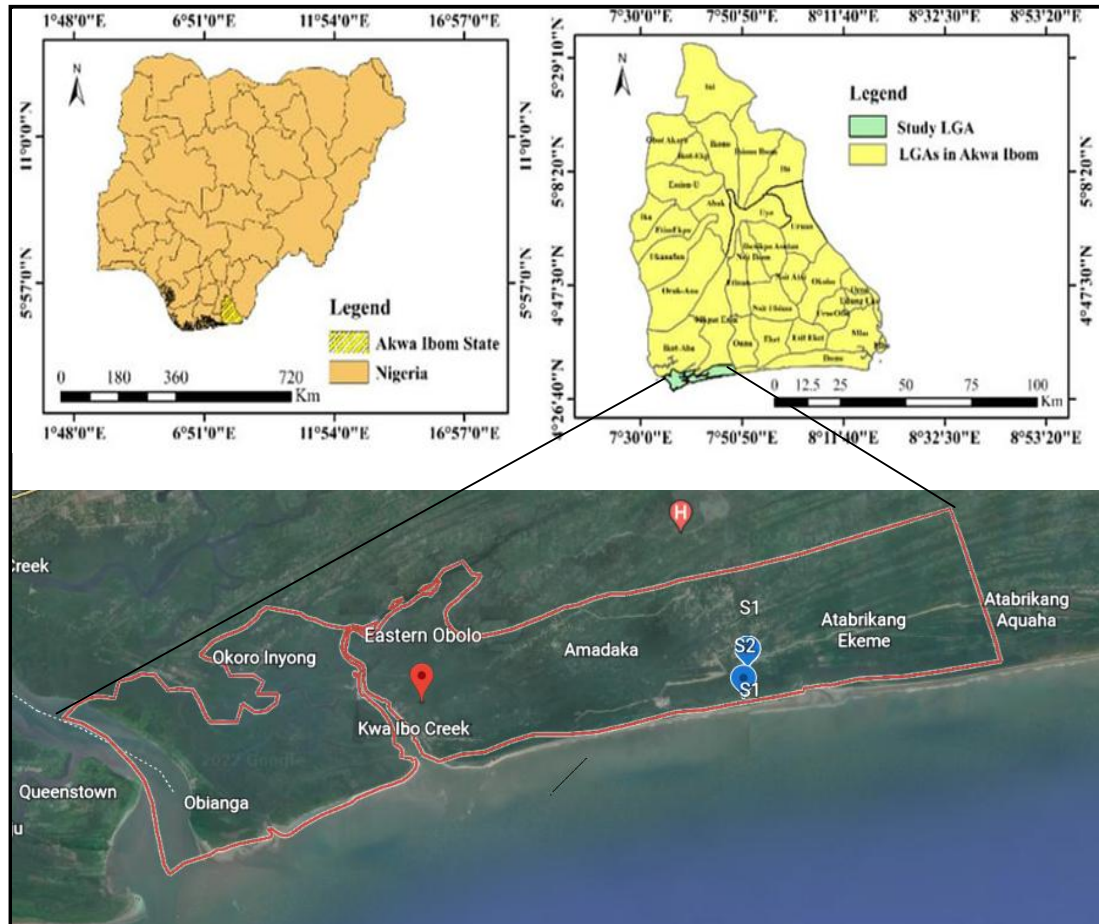


Fig. 1: Map showing Iko River and study sites

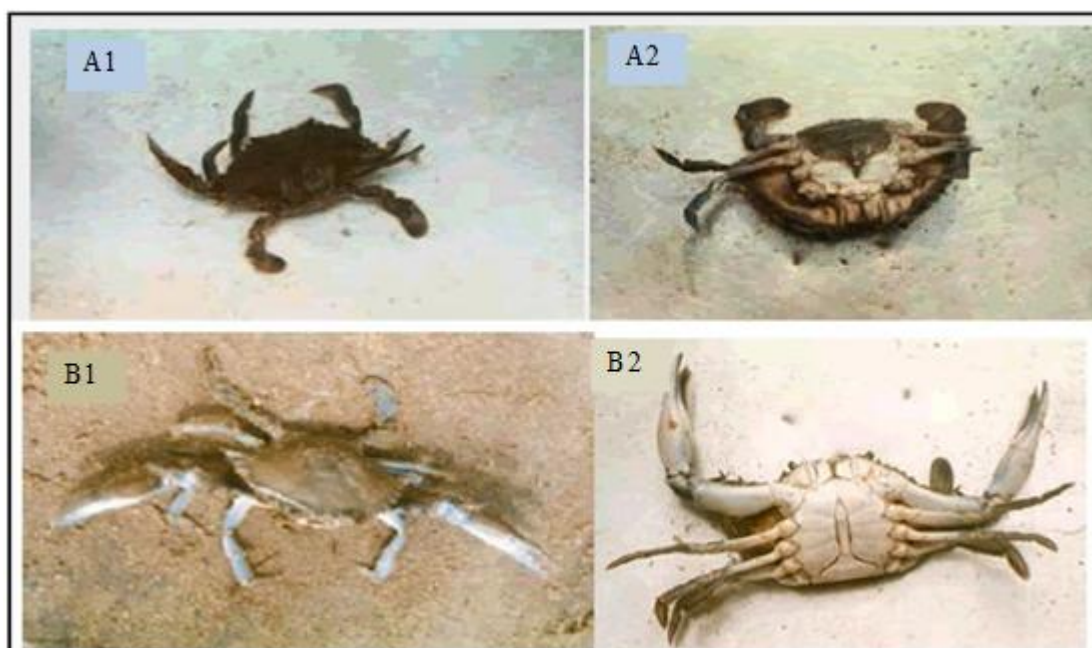
### 2.2 Sample Collection, Preparation and Instrumental Analysis

*Callinectes latimanus* in Fig. 2 were caught in the day, transported to the laboratory in an insulator box and stored at  $4^{\circ}\text{C}$ . The crabs were washed and thawed at room temperature; then the gills, hepatopancreas and the muscles were dissected using sterile blades. Samples were replicated and transferred to Petri dishes. The crab tissues were oven dried to constant weight,

crushed with mortar/ pestle and stored until analysis. 1g of the sample was weighed into a 50 ml beaker followed with the addition of 10ml of  $\text{HNO}_3$  and  $\text{HClO}_4$  (2ml). It was digested on a hot plate until complete dissolution and evaporation to near dryness. Deionized water (10 ml) was added to the digested sample and then allowed to cool to room temperature. The solution obtained was filtered through Whatman filter paper and washed with deionized water into a volumetric

flask (100 ml) and then made up to mark with deionized water. The concentration of metals in tissues of the crab was analyzed using Flame

Atomic Absorption Spectrophotometer (Buck scientific model 210 VGP-Variable Giant Pulse).



**Fig.2:** Dorsal view of male crab (A1) and female crab (B1); Ventral view of male crab (A2) and female crab (B2)

### 2.3 Health Risk Assessment

Human health risk assessment is a process that aims to estimate the risk to a given target organism, system or (sub) population, as well as the identification of consequent uncertainties, following exposure to an agent with inherent toxic characteristics (Koki *et al.*, 2015). Human health risk assessment of chemicals can be used to evaluate previous, existing and even imminent exposure to many chemicals found in air, water, soil, food, consumer product etc. They can be qualitative or quantitative in nature. Human health risk assessment is therefore the characterization of the potential adverse human health effects due to exposure to environmental hazards (Asante-Duah, 1993).

A human health risk assessment comprises four steps which include: hazard identification, dose-response assessment, exposure assessment, and risk characterization. In this study, the health risk assessment tools utilized were daily

intake of metal (DIM), health risk index (HRI), target hazard quotient (THQ)

The DIM in this study was calculated using the formula below:

$$DIM = \frac{C_{metal} \times C_{factor} \times C_{food\ intake}}{WAB} \quad (1)$$

where  $C_{metal}$  is Metal Concentration in mg/kg,  $C_{factor}$  is the Conversion factor for crab and is equal to 20.5 (Ricciardi & Bourget, 1998),  $C_{food\ intake}$  is the daily intake of crab, which was estimated to be 60 g/day, WAB is the Average body weight = 60 kg.

Health risk index (HRI) is the ratio used for the characterization of risk and also to estimate whether a particular risk has a significant impact. It is calculated using the equation (2).

$$HRI = \frac{DIM}{RFD} \quad (2)$$

RFD = Oral reference dose (Pb: 0.0035 mg/kg/day, Cd:0.001 mg/kg/day, Ni:0.020 mg/kg/day - (US-EPA & IRIS, 2006).

Total hazard quotient was estimated with the formula;

$$THQ = \frac{EF \times ED \times FIR \times CM}{RFD \times WAB \times TA} \times 10^{-3} \quad (3)$$

EF = Exposure frequency (350 days) years, ED = Exposure duration of 54 years (equivalence of the average lifetime of the Nigeria

population), FIR = Food Ingestion Rate = 60 g/person/day, CM = Concentration of the metal in mg/kg, WAB = Average body weight = 60 kg, TA = Average exposure time for non-carcinogens (ED x 365 days/year) (54 x 1 years)

### 3.0. Results

The results obtained in this study are shown in Tables 1 – 3 and Figs. 3 and 4 respectively.

**Table1:** Mean heavy metal levels in *Callinectes latimanus* in Iko River (mg/kg)

Study site	METAL	SEX	GILLS	HEPATOPANCREAS	MUSCLE
S1	Pb	Male	16.2± 0.20	23.4± 0.31	4.8 ± 0.21
		Female	19.4 ± 0.21	43.8 ± 0.20	6.7 ± 0.32
	Ni	Male	111.4 ± 0.41	102.4 ± 0.31	91.8 ± 0.40
		Female	121.4 ± 0.20	111.6 ± 0.30	96.5 ± 0.31
	Cd	Male	15.8 ± 0.20	64.2 ± 0.50	80.4 ± 0.20
		Female	18.5 ± 0.31	71.3 ± 0.31	99.7 ± 0.41
S2	Pb	Male	<0.001	6.0 ± 0.40	<0.001(ND)
		Female	2.4 ± 0.21	8.5 ± 0.20	1.4 ± 0.21
	Ni	Male	84.2± 0.31	95.7 ± 0.40	91.6 ± 0.21
		Female	98.2 ± 0.20	102.6 ± 0.50	100.2±0.20
	Cd	Male	8.4 ±0.41	0.6 ± 0.20	17.4 ± 0.30
		Female	10.2 ± 0.31	0.8 ± 0.21	17.6 ± 0.31

**Table 2:** Daily Intake of Metals (DIM), health risk index (HRI) and the Target Hazard Quotient (THQ) on human consumption

Study site	Metals	HRA	Sex	Gills	Hepatop.	Muscle
S1	Pb	DIM	Male	0.0332	0.4797	0.0984
			Female	0.3977	0.8979	0.1374
		THQ	Male	4.5652	6.5941	1.3526
			Female	5.46692	12.3429	1.8881
		HRI	Male	94.885	137.0571	28.1143
			Female	113.6286	256.5429	39.2571
	Ni	DIM	Male	2.2837	2.0992	1.8819
			Female	2.4887	2.2878	1.9783
		THQ	Male	5.4937	5.0499	4.5271
			Female	5.9868	5.5036	4.7589
		HRI	Male	114.185	104.96	94.095
			Female	124.435	114.29	98.915
Cd	DIM	Male	0.3239	1.3161	1.6482	
		Female	0.3793	1.4617	2.0439	

S2	Pb	THQ	Male	15.5836	63.3205	79.2986
			Female	18.2466	70.32	98.3342
		HRI	Male	323.9	1316.1	1648.2
			Female	379.3	1461.7	2043.9
		DIM	Male	$2.05 \times 10^{-5}$	0.123	$2.05 \times 10^{-5}$
			Female	0.0492	0.1743	0.0287
	Ni	THQ	Male	$2.818 \times 10^{-4}$	1.6908	$2.818 \times 10^{-4}$
			Female	0.6763	2.3953	0.3945
		HRI	Male	0.0059	35.1429	0.0059
			Female	14.0571	49.8000	8.2000
		DIM	Male	1.7261	1.9619	1.8778
			Female	2.0131	2.1033	2.0541
	Cd	THQ	Male	4.1523	4.7195	4.5173
			Female	4.8427	5.0597	4.9414
		HRI	Male	86.305	98.095	93.89
			Female	100.655	105.165	102.705
		DIM	Male	0.1722	0.0123	0.3567
			Female	0.2091	0.0164	0.3608
		THQ	Male	8.2849	0.5918	17.1616
			Female	10.0603	0.7890	17.3589
		HRI	Male	172.2	12.3	356.7
			Female	209.1	16.4	360.8

Table 3: The Daily Intake Rate ( $\text{mg person}^{-1} \text{ day}^{-1}$ )

SITE/SEX		Pb (mg/kg)			Ni (mg/kg)			Cd(mg/kg)		
		Gills	Hep.	Musc.	Gills	Hep.	Musc.	Gills	Hep.	Musc.
S1	M	0.0332	0.4797	0.0984	2.2837	2.0992	1.8819	0.3239	1.3161	1.6482
	F	0.3977	0.8979	0.1374	2.4887	2.2878	1.9783	0.3793	1.4617	2.0439
S2	M	$2.05 \times 10^{-5}$	0.123	$2.05 \times 10^{-5}$	2.2837	2.0992	1.8819	0.1722	0.0123	0.3567
	F	0.0492	0.1743	0.0287	2.4887	2.2878	1.9783	0.2091	0.0164	0.3608
*DI ( $\text{mg day}^{-1} \text{ person}^{-1}$ )		0.00	0.00	0.00	0.50	0.50	0.50	0.0000	0.0000	0.0000
*UL ( $\text{mg day}^{-1} \text{ person}^{-1}$ )		0.240	0.240	0.240	1.00	1.00	1.00	0.064	0.064	0.064

\*Recommended Daily Intake (DI) and Upper Tolerable Daily Intake (UL) levels of heavy metals in foodstuffs (Trumbo *et al.*, 2001; Garcia Rico 2007)

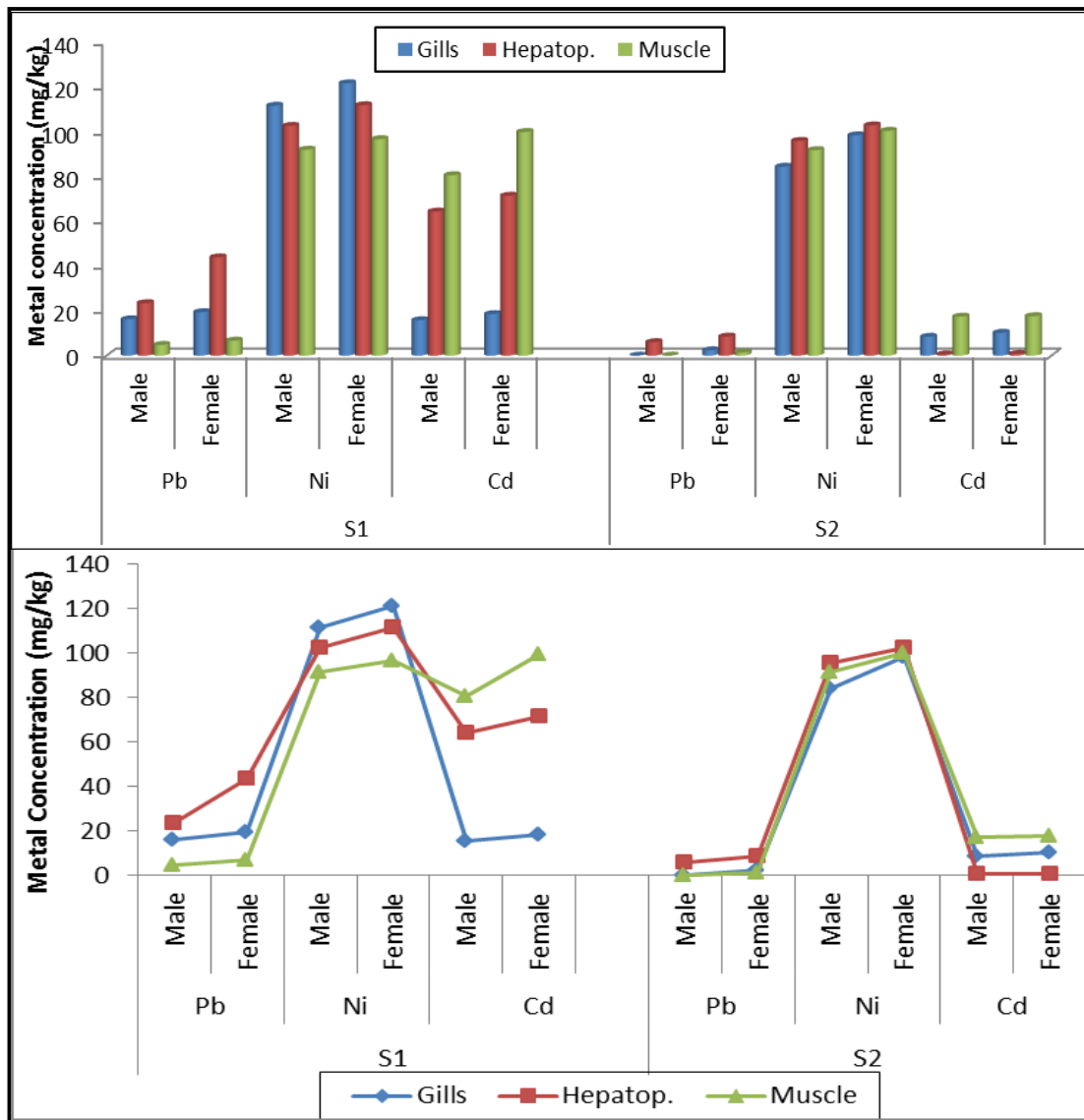


Fig. 3: Metal concentration in the tissues of male and female *Callinectes latimanus*

**3.1 Discussion**

The data (Tables 1 – 3 and Figs. 3 & 4) on heavy metal concentration in *C. latimanus* at the sampling stations (S1 and S2) from the Iko River indicates that the level of heavy metal contamination was higher in S1 than S2. S1 is close to an industrial sewage discharge area of the Utapete operational zone, which may explain the higher heavy metal levels observed. This area had witnessed oil exploration activities for decades and is currently hosting a major indigenous oil company. Generally, the observed levels of trace metals were higher in the female than the male *C. latimanus*, with the highest value recorded for Ni in the female as

follows (Table 1): Gills (121.4 mg/kg) > Hepatopancreas (111.6 mg/kg) > Muscle (96.5 mg/kg). This trend was also observed for Ni in male samples in S1 as indicated on Fig 3. However, at S2, the observed trend of increase of Ni in the female crab was Hepatopancreas (102.6 mg/kg) > Muscle (100.2 mg/kg) > Gills (98.2 mg/kg) (Fig. 3). Lower levels of Ni were found in the male crab, even though it also followed the same pattern as females in S2: Hepatopancreas (95.7 mg/kg) > Muscle (91.6 mg/kg) > Gills (84.2 mg/kg). The distribution of metals in the *Callinectes latimanus* in both sample sites gave the trend; Ni > Cd > Pb and a breakdown of the distribution of these metals in

the sample tissue reveals that at S1; Ni > Pb > Cd (Muscle) while at S2; Ni > Cd > Pb (Gills), Cd (Gills), Ni > Cd > Pb (Hepatopancreas), Ni > Cd > Pb (Muscle).

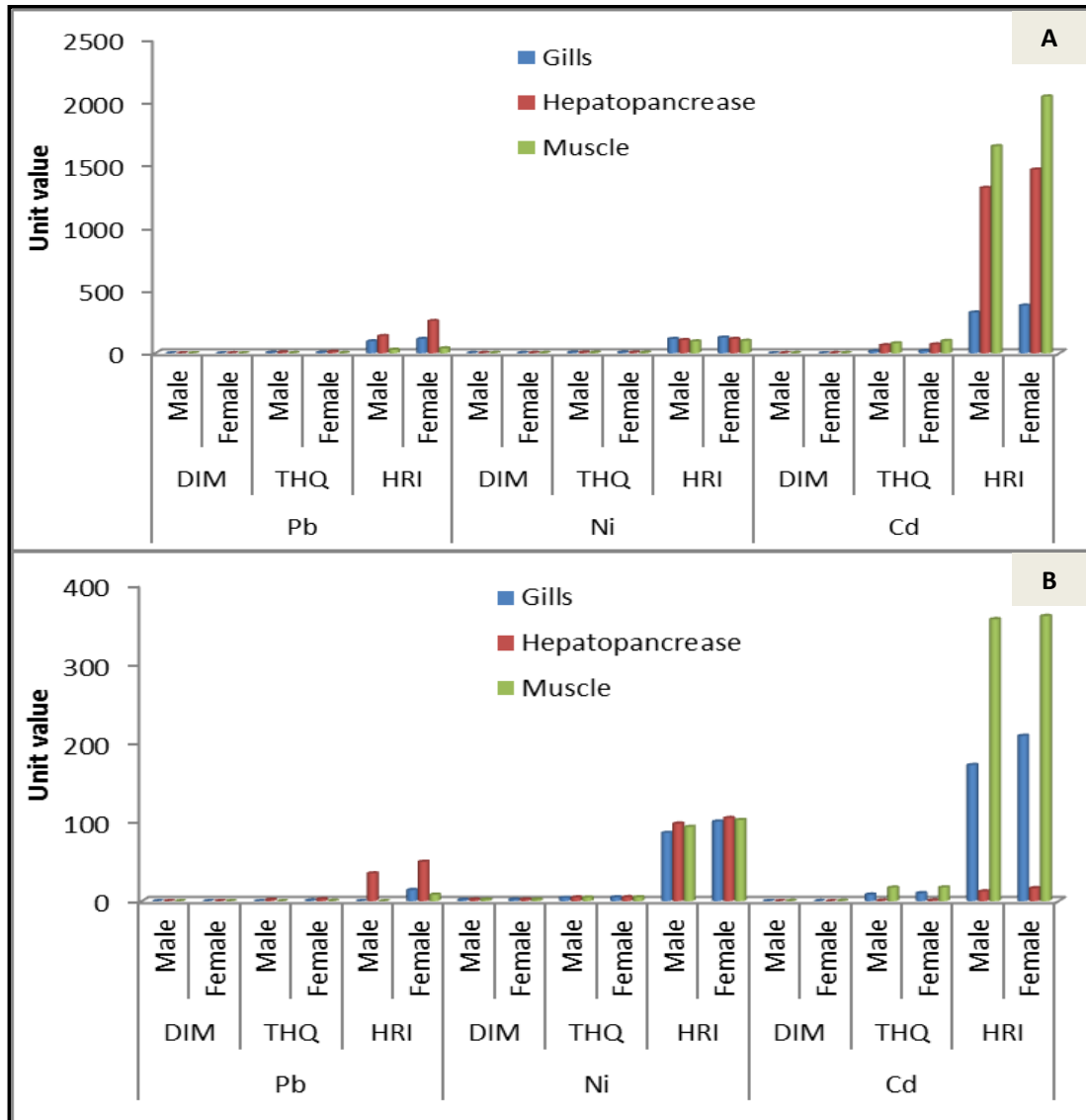


Fig. 4: Human Health Risk Assessment indicators of metals in S1 (A) and S2 (B)

This observation differs with the findings of Kumar *et al.* (2012), who investigated the distribution of metals in a crab species, *Portunus pelagicus* with the following results; Cd > Ni > Pb (Gills), Cd > Ni > Pb (Hepatopancreas), Ni > Cd > Pb (Muscle). This disagreement may be attributed to environmental factors or even physiological differences of the crab species. De Boeck *et al.* (2003) have stated that the predominant adsorption site of water pollutants and metal accumulation in aquatic organisms are species specific,

highlighting the role of species variation in pollutants bioaccumulation.

This study has shown a preferential accumulation of metals in the hepatopancreas, followed by the gills (Fig. 3). However, an exception was observed for Cd which recorded their highest concentration in the muscle for both study sites. Yilmaz *et al.* (2007) proposed that the hepatopancreas is a significant target tissue for metals accumulation. The high concentration of metals in the hepatopancreas,



when compared with other tissues, may be attributed to the metallothionein (MT) protein content in hepatopancreas. According to Hosseini *et al.* (2014), metallothionein protein is high in the hepatopancreas plays a vital role in the detoxification and regulation of metals. Metallothioneins (MT) are low molecular weight peptides, rich in the amino acid cysteine, contains a thiol group (-SH) and has a high affinity for divalent heavy metals (Wang & Shi, 2001; Thirumoorthy *et al.*, 2007). Therefore, the high bioaccumulation of metals in the hepatopancreas of the sample could be due to the relative large quantity of metallothioneins proteins, when compare to the muscle and gills. Gills usually reflect the concentrations of metals in surrounding water. They are in direct contact with water and suspended materials and could therefore allow for the absorption of various compounds from the marine environment. Gills perform several physiological functions, like gas exchange and osmoregulation. These roles imply that gills have a significant impact on how harmful metals are exchanged between an organism and its environment. In this study, the muscle tends to accumulate more cadmium, than lead and nickel. It could therefore be suggested that the metallothioneins and other components of the muscle of *C. latimanus* has a higher affinity for cadmium than the other metals investigated.

This study examines the influence of sex orientation of *C. latimanus* on metal accumulation and distribution within its organs; revealing that bioaccumulation in female species were higher than in male tissues (Fig. 3), and agrees with an investigation by Ubong and Ekwere (2022) on another crab species, *Callinectes sapidus* in the same study area. This study results show that metal concentrations in male *C. latimanus* were as follows: Ni (93.09 – 231.17 mg/kg), Pb (2.73 – 29.76 mg/kg), Cd (0.05 – 4.10 mg/kg); female crab species: Ni (165.63 – 313.53 mg/kg), Pb

(4.77 – 37.08 mg/kg), Cd (0.26 – 4.10 mg/kg). Despite the prevalent studies on metals accumulation in crustaceans, few researches have considered the influence of sexuality on the metal bioaccumulation and distribution among tissues. Hossein *et al.* (2014) has opined that heavy metal accumulation in marine organisms correlates with some environmental and biological factors, which include age, feeding habit, size, dissolved oxygen and temperature. Variation in bioaccumulation between the organism sexes has been largely attributed to differences in habitat or diet (Hossein *et al.* 2014). According to Williams (1981), male crabs feed more on bivalvia and fish while female species of crab consume mostly plant, detritus and shrimp (Williams, 1981). Plants have a close proximity to the sediment and obtain more metals associated with sediment. Plants roots have an important cleansing role in water and sediment, retaining large quantities of inorganic and organic compounds brought by the tides (Hossein *et al.* 2014). The translocation of metals from roots to buds is hindered due to the attachment to the plant cell wall. However, entry of metals through the root system is sometimes hindered because plants are salt-excluders (Hosseini *et al.*, 2014). Some metal species are easily accumulated within crustacean tissues at higher levels. Shrimps, for instance, are a significant vector for the transfer of mercury to upper aquatic predators of the food chain. Thus, female crabs which feed more on shrimp and plants can be assumed to receive higher levels of mercury than the male crabs.

Feeding habit plays a significant role in the bioaccumulation of metals in tissues of marine organisms (Karadede *et al.*, 2004), due the tendency for biomagnification through the food chains (Dalman *et al.*, 2006). According to Karami *et al.* (2012), large organisms exhibit a higher level of bioaccumulation and large crabs, which occupy the upper end of the food chain

accumulate more metals since they consume a variety of foods and smaller organisms. This study has revealed a higher metals concentration in female crab tissues because they are larger and consume more food. Generally, heavy metal levels increase with age and size of crab, especially in species that occupy higher trophic levels (Gregory *et al.*, 1980). Based on this reason, there would be higher metal concentration in larger predators.

The rank profile of trace metals in the crabs investigated according to their concentration mean values were; Ni > Cd > Pb for both study sites. However, the result indicates differences in metal concentration in crabs from study sites. The indicated variances of metal content in the same crab species depend on their habitats (Yilmaz *et al.*, 2007), since metal speciation, chemical reactions, metal bioavailability and pollution sources that could potentially affect the bioaccumulation of metals, vary between sampling stations.

According to Ubong *et al.* (2020), Ni in *Tympanotonus fuscatus* and sediments of Iko River ranged from  $0.77 \pm 0.3$  -  $83.6 \pm 0.2$  mg/kg and  $2.42 \pm 0.3$  -  $91.6 \pm 0.2$  mg/kg, respectively, which is largely lower than the amounts recorded in this study. It has been stated that some metal species can accumulate easily within crustacean tissues at higher concentration than the amount in the sediment and water column (Hosseini *et al.* 2014). In another study by Ubong *et al.* (2011) on heavy metal distribution in tissues of *C. latimanus* from the New Calabar River, it was observed that the levels of lead in the sediments from the study sites were in consonance with the amounts found in all the tissues of the crab, highlighting a possible link between sediment load and that of the crab.

To assess the health risk associated with heavy metal intake from crab consumption, the daily intake of metal (DIM), health risk index (HRI)

and target hazard quotient (THQ) were calculated and presented in Table 2. The DIM was compared with the recommended daily intake of metals and the upper tolerable daily intake level (UL) (Trumbo *et al.*, 2001; García-Rico *et al.*, 2007) as indicated on Table 3. The daily intake of Pb in the gills of *C. latimanus* was observed to be within the DI and UL limits for S1 (male) and S2 (male and female) while S1 (female) was above the limit. At the hepatopancreas, the Pb content is above the limit in S1 and within the limit in S2 while the muscle values were within limit for S1 and S2. The daily intake of Ni for S1 and S2 were above the DI and UL limit of  $0.5 - 1.0 \text{ mg day}^{-1} \text{ person}^{-1}$ . The observed values of Cd for the gills, hepatopancreas and muscles for male and female at both sites were higher than the DI and UL limit of  $0.0 - 0.064 \text{ mg day}^{-1} \text{ person}^{-1}$  (Table 4). The daily intake of metals (DIM) was calculated to estimate the average daily metal loading into the biological system of a particular consumer, considering the body weight. This information will help assess the relative bioavailability of metal, but fails to consider the possible metabolic ejection of the metals; however, the probable ingestion rate of a particular metal can be estimated.

The THQ is a ratio of the measured metal concentrations and the oral reference dose, based on the duration and frequency of exposure, average body weight and ingested quantity (Tsafe *et al.*, 2012). When THQ value is greater than 1, there is heightened health risk to the exposed population for the period of life expectancy considered and exposure duration. Generally, Cd and Pb are not essential nutrients in biological system and are considered to be of much higher risk to human (Alexander *et al.*, 2006), compared to nickel. Table 2 shows that THQ values for all metals analyzed were far greater than 1 in the tissues, except Cd in the hepatopancreas of the S1 (male and female) and Pb in the gills and muscles of S2 (male and female). This indicates potential health risk to

the exposed populace, which will likely to be higher for special populations with vulnerabilities (eg. pregnant women and children), than for the normal population.

The HRI for all the studied tissues of *C. latimanus* were generally greater than one except Pb of the gills and hepatopancreas of the male crab, which were less than 1. Generally,  $HRI < 1$  implies that the exposed population is under minimal health risk from the assessed metals, while  $HRI > 1$  indicates a heightened adverse health risk (Khan *et al.*, 2008). The HRI were highest for Cd in both sample sites (Fig. 4), with the tissue rank profile for S1: Muscle > Hepatopancreas > Gills and S2: Muscle > Gills > Hepatopancreas

#### 4.0 Conclusion

This study gives an overview on the pollution levels and assessment of the potential health risk posed by heavy metals in *Callinectes latimanus* in Iko River. The study indicates a significant variation of heavy metal amount in all the studied tissues of the male and female crab. Levels of heavy metals were generally higher in the female than male species, with Ni recording the highest concentration in all sites while Pb was the least. The rank profile of trace metals distribution in the tissues, according to their concentration mean values were; Hepatopancreas > Gills > Muscle except for Cd, which followed the trend; Muscle > Hepatopancreas > Gills. The metals' concentrations in studied samples were mostly higher than the permissible level by WHO/FAO in seafood. DIM and HRI were estimated to assess the human health risk to exposed individuals, revealing values above the recommended limits. DIM of Ni for all sites were above the DI and UL limit of 0.5 – 1.0mg day<sup>-1</sup> person<sup>-1</sup>. THQ values for all examined metals were far greater than 1 in the tissues, except Cd in the hepatopancreas of the male and female crab species in S2, as well as Pb in the muscles and gills of S2 (male and

female). The HRI for all the studied tissues of the crab and the metals were generally greater than one except Pb in the hepatopancreas and gills of the male. Consequently, the male and female *Callinectes latimanus* obtained from the study sites along Iko River is unfit for human consumption. The exposed populace should be discouraged from consuming the crab due to a high accumulation of Pb, Ni and Cd in their tissues.

#### References

- Alexander, P., Alloway, B., & Dourado, A. (2006). Genotypic variations in the accumulation of Cd, Cu, Pb and Zn exhibited by six commonly grown vegetables. *Environmental Pollution*, 144(3), 736-745.
- Ali, H., Khan, E., & Ilahi, I. (2019). Environmental Chemistry and Ecotoxicology of Hazardous Heavy Metals: Environmental Persistence, Toxicity, and Bioaccumulation. *Journal of Chemistry*, 2019, 6730305. doi:10.1155/2019/6730305
- Asante-Duah, K. (1993). *Hazardous waste risk assessment*: CRC Press.
- Dalman, Ö., Demirak, A., & Balcı, A. (2006). Determination of heavy metals (Cd, Pb) and trace elements (Cu, Zn) in sediments and fish of the Southeastern Aegean Sea (Turkey) by atomic absorption spectrometry. *Food Chemistry*, 95(1), 157-162.
- De Boeck, G., Ngo, T. T. H., Van Campenhout, K., & Blust, R. (2003). Differential metallothionein induction patterns in three freshwater fish during sublethal copper exposure. *Aquatic Toxicology*, 65(4), 413-424.

- Ikpe, E., Ubong, U. and Archibong, U. (2022). Proximate Analysis, heavy metals and total hydrocarbon content of *Callinectes sapidus* obtained from Ibaka River, Akwa Ibom State, Nigeria. *Reserachers Journal of Science & Technology*, 2(2): 32 - 43
- Ekwere, I. O., Horsfall, M. and Otaigbe, J. O. E. (2019). A study on the Photocatalytic Reduction of Some Metals ions in Aqueous Solution using UV – Titanium dioxide System, *International Research Journal of Pure & Appl. Chemistry*, 18(2): 1 – 7
- García-Rico, L., Leyva-Perez, J., & Jara-Marini, M. E. (2007). Content and daily intake of copper, zinc, lead, cadmium, and mercury from dietary supplements in Mexico. *Food and Chemical Toxicology*, 45(9), 1599-1605.
- Gregory, W., Krapovickas, A., & Gregory, M. P. (1980). Structure, variation, evolution, and classification in *Arachis*. *Structure, variation, evolution, and classification in Arachis.*, 469-481.
- Hosseini, M., Nabavi, S. M. B., Pazooki, J., & Parsa, Y. (2014). The levels of toxic metals in Blue Crab *Portunus segnis* from Persian Gulf. *Journal of Marine Science. Research & Development*, 4(1), 1.
- Ite, A. E., Ubong, U. U., Etesin, U. M., Nsi, E. W., Ukpong, E. J., Ekanem, A. N., . . . Udo, A. I. (2016). Heavy metals in epiphytic lichens and Mosses of Oil-Producing Commities of Eket and Ibeno, Akwa Ibom State-Nigeria. *American Journal of Environmental Protection*, 4(2), 38-47.
- Jan, F. A., Ishaq, M., Khan, S., Ihsanullah, I., Ahmad, I., & Shakirullah, M. (2010). A comparative study of human health risks via consumption of food crops grown on wastewater irrigated soil (Peshawar) and relatively clean water irrigated soil (lower Dir). *Journal of Hazardous Materials*, 179(1-3), 612-621.
- Karadede, H., Oymak, S. A., & Ünlü, E. (2004). Heavy metals in mullet, *Liza abu*, and catfish, *Silurus triostegus*, from the Atatürk Dam Lake (Euphrates), Turkey. *Environment International*, 30(2), 183-188.
- Karami, A., Homae, M., Afzalnia, S., Ruhipour, H., & Basirat, S. (2012). Organic resource management: impacts on soil aggregate stability and other soil physico-chemical properties. *Agriculture, Ecosystems & Environment*, 148, 22-28.
- Koki, I. B., Bayero, A. S., Umar, A., & Yusuf, S. (2015). Health risk assessment of heavy metals in water, air, soil and fish. *African journal of pure and applied chemistry*, 9(11), 204-210.
- Olsson, G. E., White, N., Ahlm, C., Elgh, F., Verlemyr, A.-C., Juto, P., & Palo, R. T. (2002). Demographic factors associated with hantavirus infection in bank voles (*Clethrionomys glareolus*). *Emerging Infectious Diseases*, 8(9), 924-929. doi:10.3201/eid0809.020037
- Ricciardi, A., & Bourget, E. (1998). Weight-to-weight conversion factors for marine benthic macroinvertebrates. *Marine Ecology Progress Series*, 163, 245-251.
- Sayyad, N. (2014). Heavy metal concentrations in different body part of crab, *Barytelphusa cunicularis* from Godavari river. *Int J Advan Agri Environ Eng*, 1(1), 51-53.
- Storelli, M. (2008). Potential human health risks from metals (Hg, Cd, and Pb) and

- polychlorinated biphenyls (PCBs) via seafood consumption: estimation of target hazard quotients (THQs) and toxic equivalents (TEQs). *Food and Chemical Toxicology*, 46(8), 2782-2788.
- Tchounwou, P. B., Yedjou, C. G., Patlolla, A. K., & Sutton, D. J. (2012). Heavy metal toxicity and the environment. *Exp Suppl*, 101, 133-164. doi:10.1007/978-3-7643-8340-4\_6
- Thirumoorthy, N., Kumar, K. M., Sundar, A. S., Panayappan, L., & Chatterjee, M. (2007). Metallothionein: an overview. *World journal of gastroenterology: WJG*, 13(7), 993.
- Trumbo, P., Yates, A. A., Schlicker, S., & Poos, M. (2001). Dietary reference intakes: vitamin A, vitamin K, arsenic, boron, chromium, copper, iodine, iron, manganese, molybdenum, nickel, silicon, vanadium, and zinc. *Journal of the Academy of Nutrition and Dietetics*, 101(3), 294.
- Tsafe, A., Hassan, L., Sahabi, D., Alhassan, Y., & Bala, B. (2012). Evaluation of heavy metals uptake and risk assessment of vegetables grown in Yargalma of Northern Nigeria. *Journal of Basic and Applied Scientific Research*, 2(7), 6708-6714.
- Ubong, U. U., & Ekwere, I. O. (2022). Distribution and Human Health Risk Assessment of Heavy Metals in Tissues of *Callinectes sapidus* from Iko River, Akwa Ibom State, Nigeria. *Asian Journal of Environment & Ecology*, 19(3): 1-8. <https://doi.org/10.9734/ajee/2022/v19i3408>
- Ubong, U., Ubong, I., Ubong, E., & Etukudoh, O. (2015). Assessment of Quality of Potable Water Sources in Eket Local Government Area of Akwa Ibom State, Nigeria. *International Journal of Advanced and Innovative Research*, 4(8), 2278-7844.
- Ubong, U. U., Ekwere, I. O., & Ikpe, E. E. (2020). Risk and Toxicity Assessments of Heavy Metals in *Tympanotonus fuscatus* and Sediments from Iko River, Akwa Ibom State, Nigeria. *International Journal of Environment and Climate Change*, 10(3), 38-47.
- Ubong, U. U., Horsfall, M., & Ubong, I. U. (2011). Distribution of heavy metals in tissues of *Callinectes latimanus* from the New Calabar River Nigeria. *Afr. J. Environ. Pollut. Health* 9 (1): 7-13.
- US-EPA, & IRIS. (2006). United States, Environmental Protection Agency, Integrated Risk Information System. In.
- Wang, S., & Shi, X. (2001). Molecular mechanisms of metal toxicity and carcinogenesis. *Molecular and Cellular Biochemistry*, 222(1-2), 3-9.
- Williams, M. J. (1981). Methods for analysis of natural diet in portunid crabs (Crustacea: Decapoda: Portunidae). *Journal of Experimental Marine Biology and Ecology*, 52(1), 103-113.
- Yılmaz, F., Özdemir, N., Demirak, A., & Tuna, A. L. (2007). Heavy metal levels in two fish species *Leuciscus cephalus* and *Lepomis gibbosus*. *Food Chemistry*, 100(2), 830-835.