



Proximate Analysis, heavy metals and total hydrocarbon content of *Callinectes sapidus* obtained from Ibaka River, Akwa Ibom State, Nigeria

Edidiong Ikpe^{1*}, Uwem Ubong¹ and Ukeme Archibong²

Received: September 7, 2022 /Accepted: November 29, 2022

© REJOST 2022

ABSTRACT

The utilization of faunas as bio indicators for environmental monitoring has been very useful especially in the evaluation of heavy metal contamination and hydrocarbons. This study aims at assessing the Total Hydrocarbon Content (THC), concentration of Heavy Metals (lead, cadmium, copper, zinc and chromium) and proximate determination in *Callinectes sapidus* (blue crab) collected from five stations along Ibaka River, Mbo Local Government Area of Akwa Ibom State. However, the metals analysis was determined using Atomic Absorption Spectrophotometer (Buck Scientific 210VGP model). The mean results were obtained in mg/kg as follows Pb (1.0912 ± 0.4000), Cd (0.0644 ± 0.1000), Cu (4.0176 ± 0.0800), Zn (0.2464 ± 0.1000), and Cr (0.8202 ± 0.0600).

✉ **Edidiong Ikpe**¹: ikpeemmanueledidiong@yahoo.com

¹ Department of Chemistry, Faculty of Physical Sciences, Akwa Ibom State University, Ikot Akpaden, Nigeria

² Department of Science Laboratory Technology, Faculty of Life Sciences, University of Benin, Benin City, Edo State, Nigeria.

The results obtained from proximate analysis showed that the *Callinectes sapidus* has moisture content of (59.99 %), Ash (15.03%), Fat (21.00%), Crude Fibre (0.43 %), Protein (3.88%), and Carbohydrate (15.03 %). The THC was analyzed using gas chromatography with flame ionization detector (GC-FID) and the results were above the department of petroleum resources (DPR) regulatory limits (0.6 mg/kg). The value obtained during the heavy metal analysis exceeded the World Health Organization (WHO) and National Environmental Standard and Regulations Enforce Agency (NESREA) and also above the Permissible limits for aquatic food. These revealed that the area is under a serious pollution threat. To ensure healthier and cleaner environment, there is need for early remediation to avoid potential health risk.

Keywords: Heavy metals; Total Hydrocarbon content; *Callinectes sapidus*; proximate analysis

1.0 Introduction

The accumulation of heavy metals and total hydrocarbon content in marine ecosystem has

become an issue of universal ecological concern. In the natural world, aquatic organisms are continuously exposed to pollutants, such as heavy metals and hydrocarbons, as a result of natural geochemical processes and anthropogenic activities (William *et al.*, 2014). According to Ezekonkwo *et al.* (2014), the factors, which contribute principally to the damaging environmental effect of metals, are their inadequate biological degradation and the trend of metals to accumulate, largely remaining in the aquatic environment. Metal pollution has been a major international issue since the 1960s, when thousands of people were poisoned in Minamata, Japan after consuming mercury-polluted sea foods (Nazanin *et al.*, 2013). Jibri *et al.* (2018) stated that the key sources of metal pollution are domestic/industrial sewages; industrial effluents; oil and chemical spills; combustion emission, mining operations, metallurgical activities and non-hazardous landfill sites. Often times, these anthropogenic actions usually lead to accelerated release of other chemical pollutants into the aquatic environment, which poses serious and harsh threats to aquatic life and man, due to their proven toxicity, persistence, bioaccumulation and biomagnifications in the food chain (Ikpe, 2019). Benthic aquatic organisms are particularly vulnerable to aquatic pollution due to their sedimental habitation, which serves as the ultimate sink of aquatic pollutants. Crabs dwell and feed from sediments and mud, with the attendant heightened exposure to pollutants in the aquatic system. They have immense nutritional and economic importance, serving as a source of food and income to the populace. They are effective as pollution bio-indicators and their sensitivity to pollutant contamination/accumulation, and it is the basis of selection for this study. Therefore, this study aims at determining the levels of heavy metals

and hydrocarbon content in *Callinectes sapidus* obtained from Ibaka River, with the goal of assessing the ecological risk posed by these pollutants to the studied river. Furthermore, the study area is a proposed site for the establishment of a deep seaport in Nigeria. The results obtained can serve as an important baseline data for the assessment of the environmental impact of the proposed project on the ecosystem.

2.0 Materials and Methods

2.1 Study Area

Ibaka River in Mbo Local Government area of Akwa State, Nigeria is a major hydrographic feature of the Niger Delta; it lies between latitude 4° 38' 0'' to 4° 42' 0'' N and longitude 8° 18' 0'' to 8° 19' 0'' E coordinates. Ibaka has a long stretch that opens into Gulf of Guinea and the water is brackish and highly saline. It is a good nursery ground for cultivation of blue crabs and breeding of different fish and sea food species for fishermen.

2.2 Sample Collection and Treatment (Sampling) Fauna

One hundred (100) mature fresh samples of *Callinectes sapidus* (blue crabs) were collected in triplicate using Quadrant sampling method, according to Besage *et al.* (2013), where a series of square (Quadrant) were placed in the habitat of interest and the species identified and collected. The samples were collected from five different sites along the river body namely; Utang Udombo (Point A), Esouk speed boat (Point B), Atak Esouk (Point C), Esouk Nka – Itiata (Point D) and Ineah – wakah (Point E), during the dry (December, 2020 and January, 2021) and wet (July, August, September, 2021) seasons. They were identified by a zoologist in the Department of Animal and Environmental Biology, Faculty of Biological Sciences, Akwa Ibom State University, Ikot Akpaden, Nigeria.

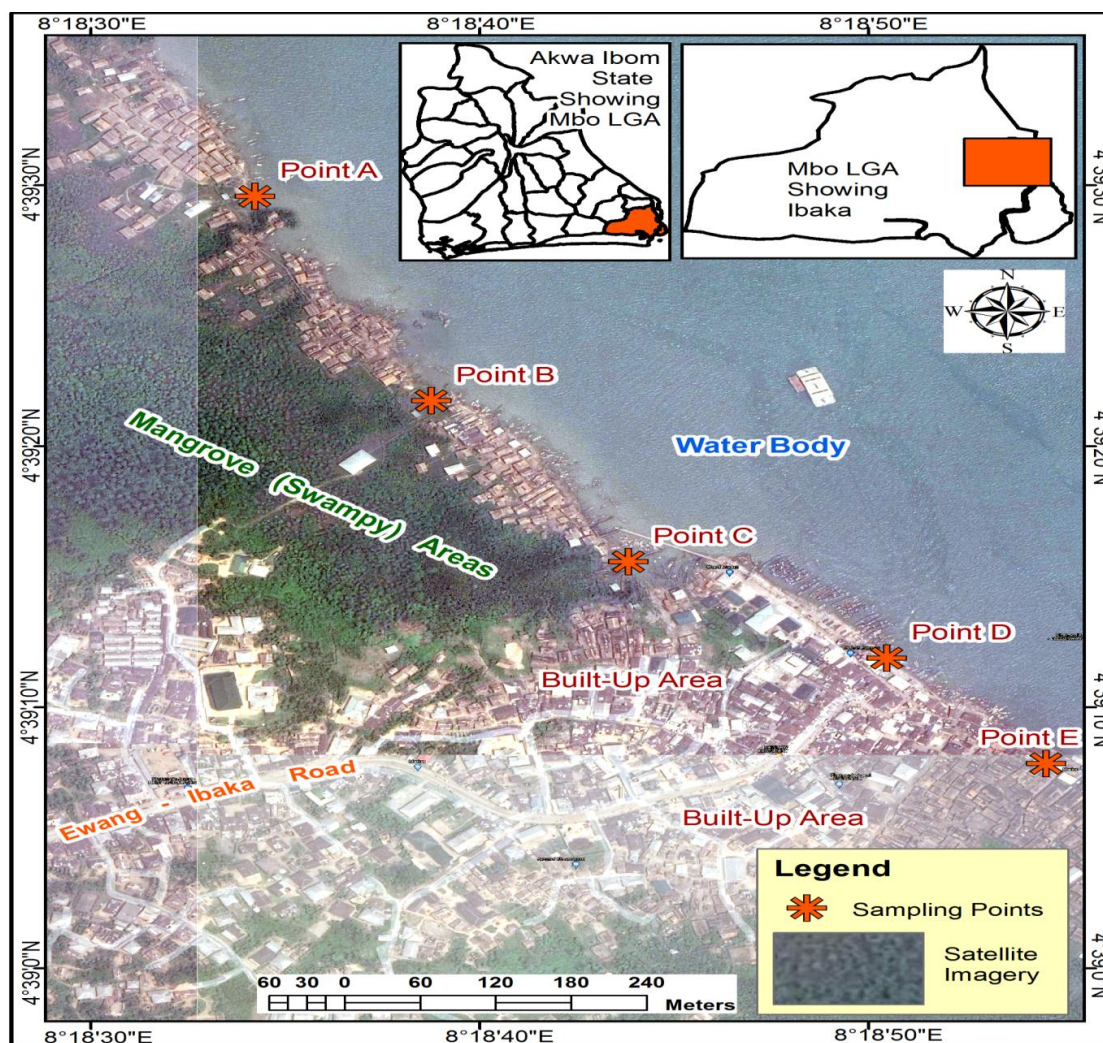


Figure 2.1: Location of sampling points along Ibaka River (Go to school limited, Uyo, 2016)

2.2.1 Determination of THC

According to **Ikpe *et al.* (2019)** Total hydrocarbon content (THC) was determined from blue crabs using gas chromatography fitted with flame ionization detector (GC-FID). Each of the fresh crab samples were cut into pieces using the stainless steel knife and then crushed with the help of a porcelain mortar and pestle. 10 gram (10 g) of each of the crushed samples was weighed into a 100 ml beaker and 60 ml of THC extraction mixture (Dichloromethane and Acetone – 1:1) was then added. The beaker with its content was placed on a magnetic stirrer (with heater), shaken for about 15 minutes at 70 °C and decanted. Thereafter, five grams (5 g) of anhydrous sodium sulphate was used to remove water from the extract. The extract was concentrated to 1ml with rotary

evaporator maintained at 20 °C. 1.5 ml of the concentrated extract was loaded on a silica gel column (prepared by loading a 2 g glass wool followed by a 30 g chromatography silica gel, onto a chromatography column of 2 cm internal diameter and 10 cm long). The extract was eluted through the conditioned column with 30 ml high performance liquid chromatography (HPLC) hexane and 30 ml dichloromethane to obtain the aliphatic and aromatic hydrocarbon compounds respectively in the sample. Two grams (2 g) of anhydrous sodium sulphate was added to remove any traces of water left in the extract. The extract was re-concentrated using rotary evaporator to about 2 ml and stored in a refrigerator at a temperature of -4 °C until GC analysis.

2.2.2 Determination of Heavy Metals

The *Callinectes sapidus* (blue crab) were digested after drying at a temperature of 105 °C for 25 hrs (AOAC, 2018). The level of Pb, Cd, Zn, Cr and Cu was determined using Buck scientific model through 210VGP (variable Giant pulse) atomic absorption spectrophotometer with different hollow cathode lamp at different wavelengths. All reagents used were of analytical grade and deionized water was added in all preparation except otherwise stated. The samples were ground using three molar (3M) nitric acid pre-washed mortar and pestle. The pulverized samples were sieved into well labeled transparent plastic containers by passing them through a 1mm mesh, 1g of each of the sieved samples (fauna) were accurately weighed into different digestion flask, well clamp to a retort stand. Ten (10 ml) of nitric (HNO₃) and perchloric (HClO₄) acid mixture (10:1 ratio) was added to the sample in each of the clamped digestion flask. This was then swirled and allowed for few minutes for any reaction to subside. The digestion flask was mounted on a heating mantle, and heating began gradually until appearance of whitish dense fumes with a clear solution obtained. The digestion flask was removed and allowed to cool. Fifty ml (50 ml) of deionized water was added to the digest filtered (using Whatman's filter paper no. 1) and made up to mark of 100 ml standard volumetric flask with deionized water. The analysis of heavy metals using the atomic absorption spectrophotometer (AAS) was then achieved.

2.3 Determination of Proximate Composition

Proximate composition includes moisture, crude protein, ether extract, crude fibre, ash and nitrogen free extract. The Moisture Content was determined by oven dehydration method at 105 °C up to the constant weight. Crude protein was determined using Kjeldhal method (AOAC,

2018). The crude fat was determined by ether extraction method using Soxhlet apparatus. Crude fiber was determined by acid and alkali digestion method. Ash Content was determined in muffled furnace at 500°C for six (6) hours. For all these determination powdered sample were used in triplicate in accordance with AOAC (2018). Nitrogen free extract (NFE) was calculated by difference method, after obtaining the values of organic matter, protein, lipid and ash.

2.4.1 Moisture

Water or moisture in the fauna sample was determined by drying a known weight (1g) in an oven to a constant weight at a suitable temperature of 105 °C. The loss in weight was regarded as being due to moisture loss (Olufemi *et al.*, 2022) and was calculated in terms of percentage weight of the samples which was 1g of the fresh sample. The formula can be given as:

$$\text{Percentage moisture content (\%)} = \frac{\text{loss in weight due to drying}}{\text{initial weight of sample}} \times 100 \quad (1)$$

2.4.2 Ash Content Determination

The ash content of the sample (fauna) were determined by burning the dry samples in an enclosed muffled furnace at temperature of 500°C, for 4hrs until the samples turned to ash and the value expressed in terms of dry weight of the samples (AOAC 2018). The organic matter was obtained by subtracting the amount of the ash from the dry samples.

2.4.3 Determination of Crude Fibre Content

This was carried out according to the methods proposed by AOAC (2018) and Tagatz *et al.* (2010). Crude fiber content determination involved boiling the dried sample with tetraoxosulphate (VI) acid (H₂SO₄) and Sodium hydroxide (NaOH). This was followed by washing of insoluble residue obtained at the

different stages with distilled water. The following basic procedures were involved during estimation of crude fibre content.

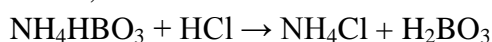
(a) defating of the sample, (b) Acid digestion, (c) Base digestion and (d) Ignition process

2.4.4 Lipid Content Determination

Petroleum ether (B.P 60 - 80 °C) was used to extract lipid exhaustively for six hours, using Soxhlet apparatus and weighing the lipid after evaporating the solvent.

2.4.5 Crude Protein Determination

Crude Protein Content determination was done by analyzing the samples for nitrogen by a protein factor (6.25). This process began with the digestion of 1g of the sample with concentrated H₂SO₄, which converts nitrogen component in the sample into ammonium sulphate. Ammonia is subsequently liberated from ammonium salt by heating with sodium hydroxide. The ammonia generated is collected in an excess of boric acid and the nitrogen was estimated by titration of the ammonium borate produced with standardized 0.1 M HCl acids (AOAC 2018), according to the equation shown below;



2.4.6 Estimation of Carbohydrate Content

Carbohydrate content was obtained by subtracting the values obtained for fat and protein from organic matter. The percentage of organic matter was calculated by subtracting the percentage of ash from one hundred percent (100%) (Onwuka, 2015).

2.4.7 Determination of pH

The pH analysis was done using Jenway digital pH meter, based on the difference in activity of hydrogen ion in and out of the electrode. The pH meter was calibrated with buffer solution of pH 4.0, 7.0 and 9.0 respectively. 50 ml of deionized water was added to 10 g of

pulverized fresh samples and stirred in a 100 ml beaker. After allowing standing for equilibration, the pH values were read by immersing the meter electrode into the mixture and (Tsai *et al.*, 2012); (Gisieli *et al.*, 2022).

3.0 Result and Discussion

The result of the analysis carried out on *Callinectes sapidus* (blue crab) from Ibaka River in five sampling points are presented below.

3.1 Proximate Analysis

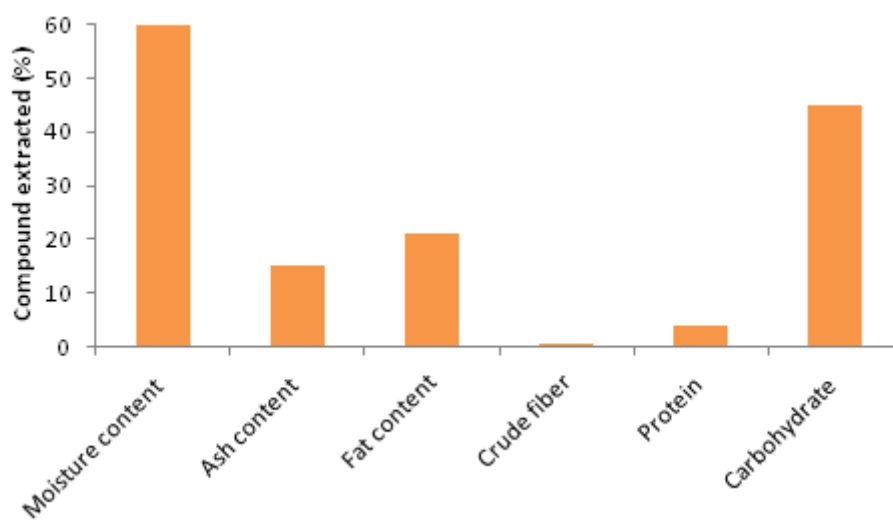
Proximate Analysis is a partitioning of compound in a feed into six categories based on chemical composition of the compounds (Akpabio and Ikpe, 2013). The six categories are moisture, ash, crude protein, crude lipid, crude fibre and nitrogen free-extract (digestible carbohydrate).

3.1.1 Moisture

Moisture content of samples is of great importance as a number of biochemical, chemical and physiological changes in food and other related substances depends very much on moisture content. The result of the percentage moisture in *Callinectes sapidus* analyzed in this study is 59.99 ± 0.310 % (Table 3.1). This value indicates a low shelf life of the fresh sample implying that long storage would result to spoilage, due its vulnerability to microbial attack (Akpabio & Ikpe, 2013; Kircham & Kircham, 2017). This informs the need for their storage in dry form by users in Ibaka community. The higher moisture content in this study corresponds with the findings of other studies (Elegbede & Fashina-Bombata, 2013; Enyeribe *et al.*, 2014 and Onwuka, 2015). However, the moisture content is lower than the studies of Gokoolu & Yerlikaya (2013) and Zotti *et al.* (2016) whose study sites were in Italy and Turkey, respectively.

Table 3.1: Proximate analysis (%) of *Callinectes sapidus*

Compound extracted	Percentage (%)
Moisture content	59.99 ±0.31
Ash content	15.03±0.53
Fat content	21.07± 0.01
Crude fiber	0.43 ± 0.07
Protein	3.88 ± 0.02
Carbohydrate	45.04 ± 0.20

**Fig. 3.1:** Chart showing proximate analysis of *Callinectes sapidus*

3.1.2 Ash Content

The ash content signifies the index of mineral elements present in a sample; its amount is useful in assessing the mineral available in a sample. Incineration of materials above 500 °C in a furnace results in the oxidation of organic constituents to volatile materials, such as carbon (IV) oxide and sulphur (IV) oxide etc. Table 3.1 indicates that the sample has an ash content of 15.03%, which confirms the availability of mineral elements. This finding corroborates with a similar study undertaken by Elegbede & Fashina-Bombata (2013); Esemefade & Akpogheli (2015) but is in variance with Gokoolu & Yerlikaya (2013) ; Oramidike & Kolade (2015) and Zotti *et al.* (2016) that recorded lower ash content.

3.1.3 Fat content

Fat and oil are insoluble hydrophobic substances of vegetable and animal origin; they constitute of glycerol esters of fatty acid called triglycerides. Crude fats or lipids can provide a very good source of energy; it aids in transport of fat soluble vitamins, insulates and protects the internal tissues, as well as contributing to important cell processes (Pamela *et al.*, 2015). The crude fat obtained from the crab was 21.07%, aligning with a similar study reported by Ikpe (2020). It can be concluded that the *Callinectes sapidus* is a good source of fat, which can aid to the body metabolic activities.

3.1.4 Crude Fibre

The crude fibre composition was determined because of the recent interest in the potential role of dietary in human nutrition. Fibre helps to maintain the health of gastrointestinal tracts,

in excess may bind trace elements leading to deficiencies of iron and Zinc. More so, fibre lowers the body cholesterol level and consequently decreases the cardiovascular disease (Onwuka, 2015). Table 3.1 indicates a crude fibre composition of 0.43%, which confirms the availability of crude fibre in the crab. This corroborates a similar study undertaken by Esemefafe and Akpogheli (2015).

3.1.5 Crude protein

Table 3.1 reveals a crude protein content of 3.88 %, indicating that the sample is a good source of protein, which aids human metabolic activity. Proteins are made up of polypeptide chains, which range from a single chain, like in myoglobin, to several chains. Proteins are found in all living systems as structural components and as biologically important substances such as hormones, enzymes and pigments. Protein in our food can be divided into first class protein and second class protein. First class protein contains essential amino-acids and is mainly of animal origin, such as meat, fish, egg, milk and cheese. Second class proteins are mainly vegetable proteins, which are found in vegetables like peas and beans (Pamela *et al.*, 2015). The protein content of *Callinectes sapidus* in this study is low, compared to Gokoolu & Yerlikaya (2013),

Elegbede & Fashina-Bombata (2013); Oramadike & Kolade (2015) and Zotti *et al.* (2016).

3.1.6 Carbohydrate

The high percentage of carbohydrate in sample is a signal that it can be used to regulate various metabolic processes in the body as vital molecules in the central metabolic pathway of the body. Carbohydrate serves as stored form of energy in the form of glycogen in liver and muscles. It also provides most important source of energy and response for breakdown fatty acids and preventing ketosis as reported by (Pamela *et al.*, 2015). The result (Table 3.1) shows a carbohydrate content of 45.04%, which confirms the availability of carbohydrate in *Callinectes sapidus* used in this study. This correlates with a similar study undertaken by Onwuka (2015). However, Elegbede & Fashina-Bombata (2013) recorded a lower amount of carbohydrate (5.40%) in another crab species, *Callinectes pallidus*, obtained from the Badagry Creek in Lagos, Nigeria..

3.2 Heavy Metals Concentration

Table 3.3 indicates mean concentration, standard error (S.E) of heavy metals in *Callinectes sapidus* used in the study obtained from five different sites along Ibaka River, Akwa Ibom State, Nigeria.

Table 3.2: Comparison of proximate analysis data of current study with some previous studies

Proximate parameter (%)	Current study	Zoffi <i>et al</i> 2016	Gokoolu & Yerlikaya 2013	Oramadike & Kolade 2015
Moisture content	59.99	80.12	82.34	77
Ash content	15.03	1.63	1.64	2.3
Fat content	21.07	-	-	0.7
Crude fiber	0.43	-	-	-
Protein	3.88	15.13	14.86	20.2
Carbohydrate	45.04	-	-	-

Table 3.3: Result of Heavy Metals Analysis

(mg/k)	Site 1	Site 2	Site 3	Site 4	Site 5
Pb	1.398 ± 0.030	0.741 ± 0.050	0.701 ± 0.000	1.568 ± 0.400	1.048 ± 0.080
Cd	0.003 ± 0.050	0.010 ± 0.100	0.088 ± 0.000	0.050 ± 0.250	0.081 ± 0.010
Cu	10.011 ± 0.080	10.001 ± 0.000	0.003 ± 0.010	0.016 ± 0.720	0.057 ± 0.040
Zn	0.960 ± 0.010	0.073 ± 0.300	0.093±0.700	0.061 ± 0.000	0.045 ± 0.000
Cr	1.074 ± 0.000	1.070 ± 0.020	1.061 ± 0.900	1.065 ± 0.000	0.081 ± 0.060
THC	801.543 ± 12.550	627.706 ± 2.16	154.82 ± 7.000	323. ± 3.590	233.6 ± 8.700

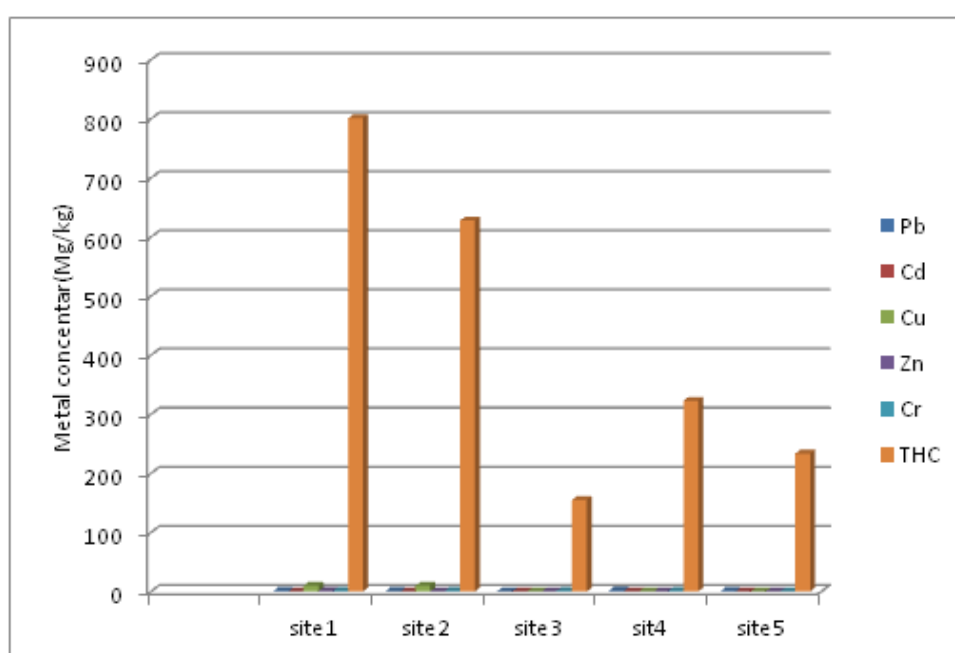


Fig 3.2: chart showing results of heavy metals and THC analysis.

3.3.1 Cadmium (Cd)

There was a significant concentration of Cd in the samples (Table 3.3), with the highest found in site 2 (0.10 mg/kg) and the least recorded in site 1 (0.003 mg/kg). The presence of Cd in the crab samples could be attributed to atmospheric deposition from natural or anthropogenic sources, as well as from run-off of cadmium containing fertilizer, cadmium-nickel battery and sewage sludge into the river. Cadmium, when ingested by humans accumulates in the intestine, liver and kidney (Norcross, 2018). The health effects of chronic exposure of Cd include proximal tubular disease. Long term

exposure to cadmium is associated with renal dysfunction. Cadmium is bio persistence and once absorbed remains resident for many years. High exposure can lead to obstructive lung diseases and has been linked to lungs cancer. Cadmium may also cause bone defect in humans and animals. With reference to the maximum permissible limit of Cd (0.01 mg/kg) by WHO (2016), it can be inferred that *Callinectes sapidus* obtained from the study sites is polluted with cadmium (with the exception of site 1), and not recommended for frequent consumption. Therefore, dwellers of Ibaka community that consume the sample are

liable to suffer from ailment attributed to cadmium, such as severe kidney, liver damage and bone weakness in the near future due to bioaccumulations.

3.3.2 Lead (Pb)

The level of Pb concentration in the study is high, when compared with the permissible limit. The presence of Pb could be attributed to the high volume of boat traffic in the area, since the anticorrosive and primer chemicals used on fishing boats contain lead. Moreover, it is envisaged that metal construction work, iron bending and welding of metal for the boat making within the area could be contributing factors. Bioaccumulation of Pb definitely led to the elevated metal concentration in the crab samples, which had resulted in high Pb concentration range of 0.701 - 1.0912 mg/kg in the study sites; this is above the WHO permissible limit of 0.5 mg/g. However, the range of Pb concentration in this study were found to be lower than the Tunde *et al.* (2021), who recorded a Pb mean value of 7.87 mg/kg in crab species in Ojo River, Lagos, Nigeria but slightly agreed with Abu & Nwokoma (2016) of range 1.03 – 1.63 mg/kg in *Callinectes amnicola* obtained in Bodo creek, Niger delta, Nigeria.

3.3.3 Copper (Cu)

Cu is known to be one of the active ingredients in antifouling composition, which is commonly used on the fishing boats. This would imply a high exposure of the aquatic ecosystem to copper. From the result (Table 3.3), it is observed that *Callinectes sapidus* under study showed Cu concentration ranging from 0.003 mg/kg (Site 3) to 10.011 mg/kg (Site 1). By comparison, it is observed that only Site 1 (10.011 ± 0.08 mg/kg) and Site 2 (10.001 ± 0.000 mg/kg) exceed the FAO (2011) standard of 0.2 mg/kg, making the crabs obtained unfit for human consumption. However, Cu concentration in this study was generally lower

than Tunde *et al.* (2021) of 18.26 – 33.26 mg/kg in Ojo River, Lagos, Nigeria.

3.3.4 Zinc (Zn)

Zinc ranged from 0.045 mg/kg (Site 5) to 0.96 mg/kg (Site 1), which were below the Food and Agriculture Organization (FAO, 2011) and WHO (2011) acceptable limit of 50 µg/g. Zinc being an essential micro-nutrient is paramount in the development of aquatic life, hence the level reveals that Zn poses less danger for human consumption. Oguzie and Okhagbuzo (2010) reported that zinc is sourced from industries involved in smelting, electro-galvanizing, mining, metallurgy, production of pesticides, rubber plastics and various alloys. Zinc is detrimental to humans when found in excess quantity above the WHO permissible limit, causing vomiting, abdominal pains, cramps, renal damage, hemorrhagic pancreation and death (Nazanim *et al.* 2013).

3.3.5 Chromium (Cr)

Chromium present in the sample fell within the range of 1.061 – 1.074 mg/kg, which is above the NESREA (2014) permissible limit (0.001 mg/kg). According to Satya *et al.*, (2008) and Ikpe (2019), Chromium can be used in the preparation of various types of chrome steel and alloys. Interestingly, examples of such chrome steels are stainless steel, chrome steel, chrome vanadium steel, chrome-nickel steel etc. Consequently most of these steels are being used by the operating oil companies in construction of their platform and for oil exploration/exploitation activities, which may introduce Cr into the water bodies and sediments. This development leads to bioaccumulation by seafood, like crabs, which will later affect human through food chain. Chromium present in the samples could also be attributed to chrome pigment containers, dysfunctional boilers in which chromium is used as anti-corrosive agents when washed into the river through runoff water during wet

season. As supported by Qing and Bozhi (2022), that Heavy metals in watershed ecosystems are difficult to be degrade and characterized by strong concealment, resulting a lasting harm and difficult to removal.

3.3.6 Total Hydrocarbon Content

Total Hydrocarbon Content (THC) was determined using gas chromatography fitted with flame ionization Detector (GC-FID). Results indicate that all the study sites recorded THC values that exceed the permissible limit in food. However, it was observed that the THC was highest in sites 1 and 2; the high THC can be attributed to fuel discharged from fishing boats into the river, resulting in its pollution with a range of hydrocarbon compounds. The source of the THC can also be linked to crude oil exploration activities and oil spillage, since Ibaka located in the oil producing area of Nigeria. Numbere (2019) has indicated a high concentration of THC in a crab species (*Goniopsis pelii*) in the same oil producing Niger delta region of Nigeria. The study stated that the size, sex, and body parts of crabs are important aspect of bioaccumulation of THC, as large-sized male crabs and internal parts show the highest THC concentration. According to Kuppusamy *et al.* (2020), hydrocarbons have a strong impact on mental health and induce physical/physiological effects, and they are potentially toxic to genetic, immune, and endocrine systems. Thus, their alarming concentration in this study should be a cause for major concern for the exposed populace.

4.0 Conclusion

This study provides analysis of the bioaccumulation of heavy metals and THC in crab (*Callinectes sapidus*) samples from Ibaka River, Akwa Ibom State, Nigeria. Proximate analysis was also carried out in this study. The results showed a significant concentration of THC and heavy metals in the samples analyzed.

It was found that the concentration of THC and metals in the samples largely exceeded the recommended permissible limit, with the exception of zinc. Generally, the heavy metal concentration in the samples under investigation recorded the following trend; Cu > Pb > Cr > Zn > Cd. The result of this study has revealed that the *Callinectes sapidus* obtained from Ibaka River has some health challenges and is unfit for human consumption. Therefore, there is need for sensitization of the exposed populace on the dangers of consuming this seafood and intermittent monitoring should be encouraged.

References

- Abu Onisokyetu, M. G. and Nwokoma, G. C. (2016). Bioaccumulation of Selected Heavy Metals in Water, Sediment and Blue Crab (*Callinectes amnicola*) from Bodo Creek, Niger Delta, Nigeria - Journal of FisheriesSciences.com
- Akpabio, U. D. and Ikpe, E. E. (2013). Proximate composition and nutrient analysis of *Aneilema acquinotiale* leaves. *Asian Journal of plant science and research*. 3(2): 55-61.
- AOAC (2018), Official method of Analysis, 17th edition, Association of Analytical Chemist. Gaithersburg, MD, USA. 624-642.
- Besage, J. E. and Gleave, J. T. (2013). The detection of spatial pattern in plant communities. *Bulletin of the international institute*, 45: 153-158.
- DPR (2011) Department of petroleum Resources, Environmental guidelines and standards for the petroleum industry in Nigeria [EGASPIN] Revised edition.
- Elegbede, I. O. and Fashina-Bombata, H. A. (2013). Proximate and Mineral Compositions of Common Crab Species [*Callinectes pallidus* and *Cardisoma*

- armatum*] of Badagry Creek, Nigeria. *Poult. Fish. Wildl. Sci.*, 2, 1-5
- Enyeribe, C., Oparah, E.N., Akawa, J., Kutman, N.A., Obadahun, J. and Ibrahim, M.Y. (2014). Proximate and chemical composition of *Helianthus annuus* (sunflower).
- Esemedafe, J. U and Akpoghelie, J. O (2015). proximate analysis of buck wheat groat of different villages in Enugu state, Nigeria proceeding of 37th Annual International conference, workshop and exhibition chemical society of Nigeria (CSN) vol.II.
- Ezeokonkwo, M. A., Okoro, U. C., Godwin-Nwakwasi, E. U. and Okpala, K. M. (2014). Proceedings of 37th Annual International conference. Workshop and exhibition of chemical society of Nigeria (SCSN) Vol. II.
- FAO/WHO (2011). Joint Food Standards Program Codex Committee on contaminants in foods. Fifth session. the Hague, the Netherlands, 21 – 25 March.
- Gisiela, K., Waterloo, P., Rafael, D. (2022). Performance and Validation of water surface temperature estimates from landsat 8 of Itaipu Reservoir, state of Parana Brazil. *Springer nature Switzerland. AG.*
- Go to School Limited, Uyo (2016). WWW.gotoschool.ng. Akwa Ibom State.
- Gokoolu, N. and Yerlikaya, P. (2013). Determination of proximate composition and mineral contents of blue crab (*Callinectes sapidus*) and swim crab (*Portunus pelagicus*) caught off the Gulf of Antalya, *Food Chem.*, 80, 495-498.
- Ikpe, E. E. Akpakpan, A. E., Nsi, E. W. and Ekanem, A. N. (2020). Determination of the level of petroleum hydrocarbon in water, fishes and plant from part of River Ethiopia, Oghara in Delta State, Nigeria. *Internal journal for research in applied chemistry*, 2(8).
- Ikpe, E. E., Ekwere, I. O, Etiowo, G. U., James, O. E. and Okon, E O. (2019) . Evaluation of the levels of heavy metals, Total Petroleum hydrocarbon and total hydrocarbon content in Tympariotomus fuscatus and sediment, Qua Iboe River, Akwa Ibom State Nigeria. *Chemical Science International Journal*, 27(4): 1-17.
- Jibril, M., Fowler, D. L. and Van Den Avyle, M.J. (2018). Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Mid-Atlantic) - Blue crab. *US Fish Wild Serv Biol Rep* 82(11.100), US Army Corps of Engineers, TR EL-82-4, 18 pp.
- Kirchmann, G. and Kirchmann, J. (2017). Nutritional Almanac, McGraw Hill, London, pp 115 – 116.
- Kuppusamy, S., Naga Raju, M., Mallavarapu, M. and Kadiyala, V. (2020). Impact of Total Petroleum Hydrocarbons on Human Health. 10.1007/978-3-030-24035-6_6.
- Nazanin, R., Richard H., Roy, K., Rainer, S. (2013). Zinc and its Importance for Human Health, An Integrative Review. *Journal of Research in Medical Sciences*, 18(2), 144 – 157.
- NESREA [2014]. National Environment Standard and Regulations Enforcement Agency, Lagos, Nigeria.
- Norcross, B. L. and Shaw, R. F. (2018). Oceanographic and estuarine transport of fish eggs and larvae: a review. *Trans. Am. Fish. Soc.*, 113, 153–165.

- Numbere, A. O. (2019). Bioaccumulation of Total Hydrocarbon and Heavy Metals in Body Parts of the West African Red Mangrove Crab (*Goniopsis pelii*) in the Niger Delta, Nigeria. *International Letters of Natural Sciences*, 75, 1-12.
- Oguzie, F. A. and Okhagbuzo, F. A. (2010). Concentration of Heavy Metals in Effluent Discharges Downstream of Ikpoba River in Benin City, Nigeria. *African Journal of Biotechnology*, 9 (3), 319 – 325.
- Olufemi, O. A., Elizabeth, O.O., Aniekanabasi, J. O. (2022). The dynamics of household water security and treatment practices: a population-based, cross sectional study in Osun state, southwest Nigeria. Springer nature Switzerland. AG. Part of springer nature.
- Onwunka, G. I. (2015). Food analysis and instrumentation theory and practice. Naphthalic prints, Lagos, Nigeria, pp. 219-230.
- Oramadike, C. and Kolade, O. (2015). Microbial and Proximate Composition of Blue Crab *Callinectes sapidus* from Agbalata Market Badagry Lagos West, Nigeria. Published 2015 Biology.
- Pamela, C. C., Richard, A. H. and Denis, R. F. (2015). Lippincotts illustrated Reviews .biochemical 3rd, Lippincott William and Wilkins Philadelphia, pp. 335 - 388.
- Qing, X., and Bozi R. (2022). Pollution and risk assessment of heavy metals in Rivers in Antimony capital of Xikuashan. *Scientific reports*.
- Satya, P., Tuli, G. D., Basu, S. K., Madan, R. D. (2008). Advanced Inorganic Chemistry Vol. II Ram Nagar, New Delhi – 110 055.
- Tagatz, M. E. (2010). Growth of Juvenile blue crab, *Callinectes sapidus* Rathbun, St Johns River, Florida. *Fishery Bulletin*, U.S., 67:281-288.
- Tsai, D. E., Chen, H. C. and Tsai, C. F. (2012). Total lipid and cholesterol content in the blue crab, *Callinectes sapidus* Rathbun. *Comparative Biochemistry and Physiology*, B, 78(1):27-31.
- Tunde, Olusegun S., Ezeokoli, Abigail C., Kehinde, Fadimu O., Abolore, Badmus W., Temidayo , Olatunde A., Olubunmi , Osundiya M. (2021). Bioaccumulation of Heavy Metals in Crab and Prawn Tissue from Ojo River, Ojo-Lagos, *Advances in Analytical Chemistry*, 11 (1), 9-12. doi: 10.5923/j.aac.20211101.02.
- WHO (2011). Guideline for Drinking Water Quality Criteria, 2nd World Health Organization, Geneva. 2:281 – 308.
- WHO (2016). Guidelines for drinking Water quality. Greeva 2:281-308.
- Williams, A. B. (2014). Shrimps, lobsters, and crabs of the Atlantic coast of the eastern United States, Maine to Florida. Washington, DC: Smithsonian Institution Press. 550.
- Zotti, M., Coco, L. D., De Pascali, S. A., Migoni, D., Vizzini, S., Mancinelli, G. and Fanizzi, F. P. (2016). Comparative analysis of the proximate and elemental composition of the blue crab *Callinectes sapidus*, the warty crab *Eriphia verrucosa*, and the edible crab *Cancer pagurus*. *Heliyon*, 2(2), ISSN 2405-8440, <https://doi.org/10.1016/j.heliyon.2016.e00075>.