BIOACCUMULATION OF PERSISTENT ENVIRONMENTAL POLLUTANTS (PEPs) IN BLUE CRAB AND PRAWN FROM THE OGU CREEK, UPPER BONNY ESTUARY, RIVERS STATE, NIGERIA.

Elechi Eni Oko, Ogbuagu Dike Henry

Department of Environmental Management, Federal University Of Technology, Owerri, Nigeria.

Eneremadu Kingsley Enyinna

Department of Business Education, Alvan Ikoku Federal College of Education, Owerri, Nigeria.

Efugha Ifunanya

CCFN (Caritas Nigeria), No 24 Chief Iwuanyanwu Avenue, Area H, New Owerri-Imo State, Nigeria.

ABSTRACT

This study focused on Bioacummulation of Persistent Environmental Pollutants (PEPs) in Aquatic Organisms from the Ogu Creek, Upper Bonny Estuary, Nigeria. The specific objectives were to determine the presence and levels of trace elements and petroleum hydrocarbons in tissues of crab and prawn in the study area; determine spatial variations in concentrations of some trace elements and hydrocarbons in the organisms; comparison of the concentrations of the trace elements and hydrocarbons in the tissues of the organisms; and determination of Hazard/Toxicity Quotient (HQ/TQ) of selected trace elements and hydrocarbons in the organisms. The Analysis of Variance and Duncan Mighty Root Test were used to analyze tissue accumulation variations, student's t-test was used to analyze variations in the different organisms and correlationships between tissue accumulations and ambient water/sediment matrix was analyzed using Pearson's correlation at $p<0.05$. This study reveals that bioaccumulation of trace elements and hydrocarbons in the prawn, Macrobrachium malcolmsonii and blue crab, Callinectes sapidus occurred. Accumulations of the trace elements at p=0.05 (Zn=0.000, Cr=0.052, Cd=0.000, Pb=0.000, Fe=0.000 and Mn=0.000) and hydrocarbons (TPH=0.000, PAHs=0.000, and phenol=0.000) differed according to location and only (Cr=0.023 and Cd=0.048) differed in tissues sampled; with higher accumulations in impacted than reference locations, and in the head, internal organs, and digestive tissues, than in muscles and ovary. Accumulations of all the elements in many of the tissues sampled were above regulatory limits in edible aquatic foods. It is recommended that the environmental protection agencies for pollution control should ensure further bioaccumulation assessments on biota in water column and sediments of the creek.

Keywords : Bioaccumulation, Persistent Environmental Pollutants, Aquatic Organisms, Ogu Creek.

INTRODUCTION

The environment is perceived to be at risk from thousands of toxic substances and chemicals of both anthropogenic and natural origins. According to Ogeleka et al. (2010), when hazardous substances are released into the environment, an evaluation is necessary to determine the possible impact of these substances on human health and other biota. The natural aquatic systems may extensively be contaminated with heavy metals and other pollutants released from industrial and other anthropogenic activities. Metals are non-biodegradable and are considered as major environmental pollutants causing cytotoxic, mutagenic and carcinogenic effects in animals (Hayat et al., 2007; Hussain et al., 2011). Heavy metal contamination may have devastating effects on the ecological balance of the recipient environment and the diversity of aquatic organisms (Farombi et al., 2007; Tawari-Fufeyin and Ekaye, 2007; Yilmaz et al., 2007).

Bioconcentration refers to the absorption or uptake of a chemical from a medium to concentrations in the organism's tissues that are higher than that in the surrounding environment. The degree to which a contaminant would concentrate in an organism is expressed as a Bioconcentration Factor (BCF). BCF refers to the concentration of a chemical in an organism's tissues divided by the exposure concentration. It has been found that chemicals or substances displaying a half-life greater than 30 days, a BCF greater than 1000 or an octanol/water partition coefficient, log K_{ow} value greater than 4.2 tend to be persistent and bioaccumulate (Ezemonye et al., 2007). An important process through which chemical substances can affect living organisms is bioaccumulation. Bioaccumulation is a process by which chemicals or substances are taken up by an organism either directly from exposure to a contaminated medium or by consumption of food containing the chemical or substance. Bioaccumulation means an increase in the concentration of

a chemical or substance in a biological organism over time, compared to its concentration in the environment (Relyea and Diecks, 2008). Thus understanding the dynamics of bioaccumulation is very important in protecting human beings and other organisms from the adverse effects of chemical exposure and has become a critical consideration in the regulation of chemicals (DPR, 2002; OECD, 2003).

According to Osuji et al. (2004), hydrocarbons and heavy Metals from crude oil, apart from negatively affecting flora and fauna, biologically accumulate in plant cells and animal tissues. Biomarkers, including bioaccumulation offers an integrated measure on effects of pollutant exposure in wildlife and have been strongly recommended to be included in environmental monitoring programs (Jemec et al., 2010; Bejarano and Michel, 2016). The awareness and concern about the protection of the public from avoidable contamination and exposure to heavy metals (especially of Lead, Cadmium, Nickel and Chromium) from oil spillage and their attendant adverse effects on health have led to increase in strategies and methodologies for detecting their presence in the environment. One of such methods is by using non vertebrate wildlife species as bio-indicators (Ijeomah et al., 2013).

Corresponding author. Tel : 08034954293
Email address : eneremadukings@gmail.com

2.0 MATERIALS AND METHODS

2.1 Description of Study Area

The study area is Ogu Creek in Ogu-Bolo Local Government Area of Rivers State (Fig.1). It is one of the creeks close to the Ekerekana creek in Okrika Mainland, with its tributaries to Ogoloma River and Bonny River, readily accessible by a network of roads and footpaths and accessible to ships, boats, and canoes through the Bonny River and its tributaries. The study area is confined within the humid-hot equatorial climate, and lies between latitudes 4° 44' 00" to 4° 46' 10" N and longitudes 7° 5' 15" to 7° 6' 15"; occupying an area of 905.2sq.km with a population of over 150,000 (NPC, 2006). Weather conditions over the area are governed by the moist tropical maritime currents from the Atlantic Ocean wave fronts and dry wind and dust-laden tropical continental air mass from the northern part of Nigeria. Prevalent wind direction in the area is south-westerly, with speed ranging from 0.3 to 4.5m/s and north-easterly, with speed between 0.3 and 1.5m/s.

The area is known for having two main seasons, the dry season and the wet season. The dry season begins from November and ends in March, while the wet season stretches from mid-March to October. Fresh water is generally supplied by heavy precipitation estimated to have mean annual rainfall above 2600 mm. Mean annual rainfalls is variable, with maximum amounts estimated to be 4455 mm. The peaks of the rains occur in the months of June, July, September and October, and most significant factor that influences it within the area is the tropical marine air mass moisture. Relative humidity is usually above 85 percent in rainy season, but decreases to 45percent in dry season. Ambient air temperature ranges from 24.5 to 32^{o}C in rainy season and from 25 to 36^{o}C in dry season. Bonny River and its tributaries and creeks are accountable for the drainage

around the deltaic plain belt area. The dockyard creek in the south, Amadi and Okpoka creeks in the east, and the channel of Bonny River (Port Harcourt Harbour) by the west drain the area. These creeks flow in the N-S direction into the Bonny River, which eventually flow to the west. Each of the creeks that border Port Harcourt area can be subdivided into three sections, the head water (usually fresh water streams), the down streams (saline) and the brackish water (in between them) NPC (2006).

The vegetation of the area is predominated by the tropical rainforest regime, which is comparatively uniform throughout the proximity of the region to the Atlantic Ocean. The second vegetation type is the farmland/fallow mosaic regime that had been modified by agriculture and construction activities while the third is the mangrove forest which is a shrub or small tree that grows in coastal saline or brackish water.

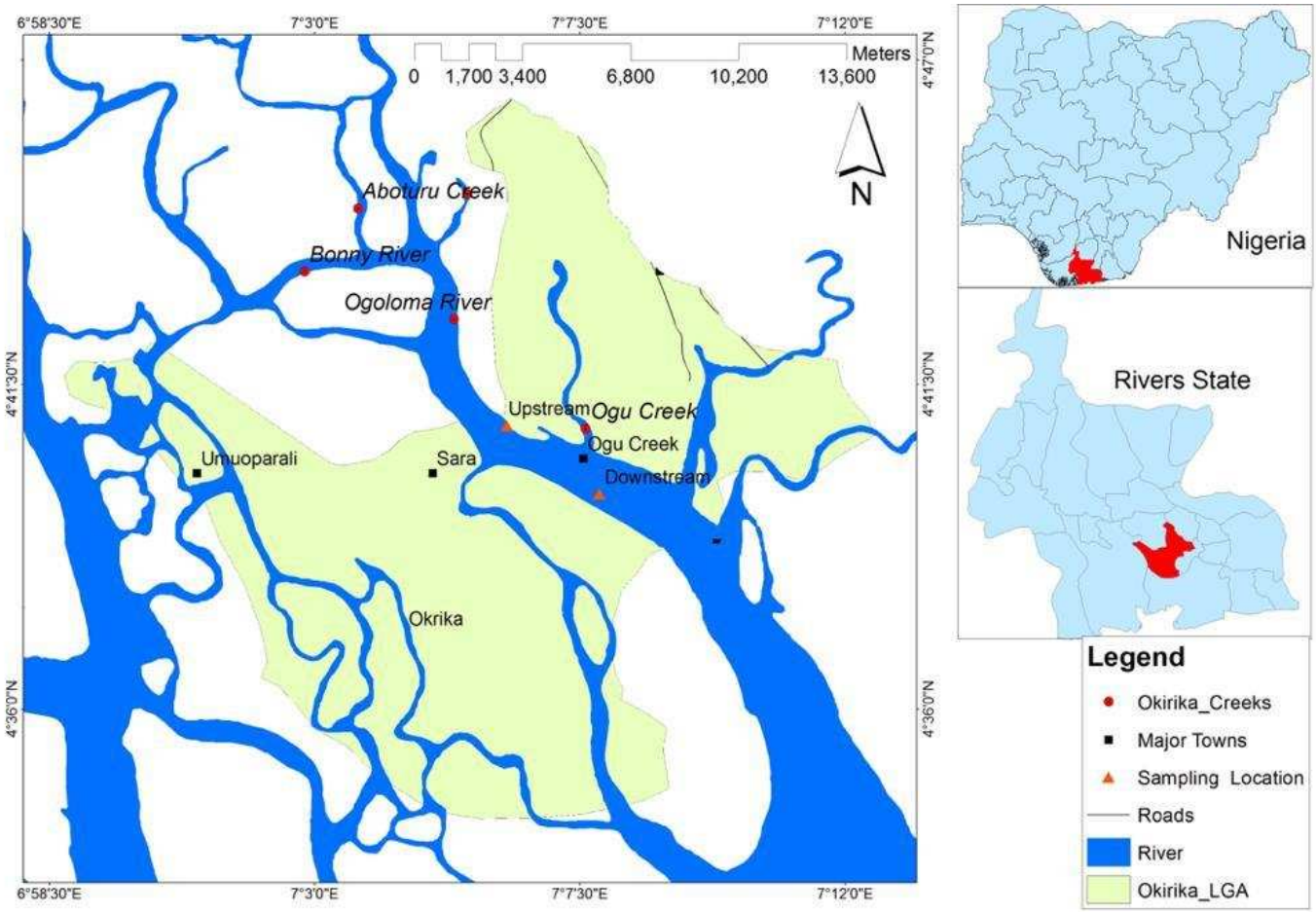

Fig. 1. Map of the study area showing sampling points(National Space Research and Development Agency, 2013)

2.2 Field Sample Collection

2.2.1 Sampling Collection

The sample of blue crab (Callinectes sapidus) and prawn (Macrobrachium malcolmsonii) were collected from the Ogu creek with fishing drag net.

2.2.2 Water and Sediment Sample Collection

Water Sample Collection

Water samples for the determination of heavy metals were collected in 250 mL glass containers and fixed with concentrated HNO_3, while those for the determination of hydrocarbon concentrations (TPHs, PAHs, MAHs) were fixed with concentrated H_2SO_4 each in the ratio of 2:500. Samples were subsequently taken to the laboratory for analyses.

Sediment sample Collection

Sediment samples were collected with 10 x 12 cm Eckman Grab and transferred to the laboratory in labelled polythene bags.

2.2.3 Animal Sample Collection

Sampling was carried out in accordance with the recommendation of UNEP reference method for marine pollution studies. Each prawn and crab was properly cleaned by rinsing with distilled water to remove debris, plankton and other external adherent. It was then drained under folds of filter, weighed, wrapped in aluminum foil and then frozen at 10^oC prior to analysis.

2.3 Laboratory Methods

2.3.1 Water and Sediment Sample Analyses

Analysis of Hydrocarbons in Water and Sediment

The analytical procedure was in keeping with standard methods of APHA (1998) and Fetzer (2000). In sediments, sample extraction procedure involved weighing out 5g each of sediment samples into a beaker and adding 10 mL of analytical grade hexane to the samples. The mixture was shaken for 5 minutes and filtered; and filtrates used for Gas Chromatography (GC) analysis.

For water samples, 50 mL of a sample was measured into 1 liter separating funnel, a drop of concentrated H_2SO_4 was added to the sample in the separating funnel to release the hydrocarbon components and 5 mL of analytical grade N-hexane (as solvent) was subsequently added. Samples were vigorously shaken for 5mins and allowed to stand for another 20mins. Layers were formed that separated the extract (the top layer) from the lower layer which was discarded and the extract collected in a glass vial for analysis. A column chromatography was set up using silica gel and a glass wool. Extracts were passed through the column to clean and remove biogenics, and then collected for GC analysis.

GC was calibrated using commercially prepared external standards having 16 components of PAHs with concentration of 1000 ppm per component. The GC parameters used included helium as carrier gas, air and hydrogen as fuel gases, nitrogen as back-up gas, detector temperature of 35 ^oC, in-let temperature of 25 ^oC, initial oven temperature of 5 ^oC, final oven temperature of 300 ^oC, hydrogen flow rate of 30 mL/mins., air flow rate of 300 mL/mins., nitrogen flow rate of 30 mL/mins., and helium flow rate of 30 mL/mins. The GC parameters were set and a PAH extract loaded using a micro-syringe to prompt the GC interphased with Flame Ionization Detector (GC-FID) to run for a period of about 41minutes.

Analyses of Heavy Metal contents in Water and Sediments

Exactly 250 mL of water sample was filtered and digested with 10 mL concentrated analytical grade HNO_3. The solution was evaporated in a crucible to approximately 5 mL, then filtered into 20 mL standard flask and made up to the mark with distilled water.

Sediment sample was extracted with concentrated HNO_3 in the ratio/proportion of 2g of sediment sample to 5 mL of acid. The mixture was gently heated in a water bath at a temperature of 150 ^{0}C until the sediment became bleached. The mixture was diluted to 20 mL with distilled water, decanted and filtered for analysis.

The extracts from water and sediment samples were analyzed for heavy metals with the Perkin Elmer (Analyst 2000 Version 6.0) Atomic Absorption Spectrophotometer (AAS).

2.3.2 Tissue Analyses

For analysis, the blue crab (Callinectes sapidus) and prawn (Macrobrachium malcolmsonii) sample were defrosted for 2hr, weighed into a pre-weighed petri-dish, and then dried at 80 ºC in Gallenkamp hot box oven. The dried samples were weighed at intervals of 4 hours until a constant weight was obtained. The dried samples of crab and prawn were put in a cleaned dried mortar separately, grounded to fine particles and sieved using a sieve of particle size 0.02 mm. Exactly 0.5 g each of samples was measured into clean, dried 100 ml beaker, 5ml of aqua regia (HCl) and HNO_3 (3:1) was then added to the sample for digestion. The samples were stirred in the acid by stirring with a glass rod and then the beaker was placed on the gas burner. The digested sample was filtered into a graduated cylinder and the filtrate made up to 50 ml using distilled water. The Atomic Absorption Spectrophotometer (Model 200; Perkin Elmer) was used to analyse the concentration (µg/g) of Hydrocarbon and trace elements in the samples of crab and prawn.

2.4 Statistical analysis

SPSS V.23.0 and MS Excel 2017 tools were used to analyze the data. The differences in trace elements and hydrocarbon concentration between the mainstream (impacted) and the upstream(reference) locations was assessed using the spatial variation and one-way analysis of variance (ANOVA) with P-value of $p<0.05$. ANOVA and Duncan Mighty Root Test were used to analyze tissue accumulation variations, student's t-test was used to analyze variations in the different organisms with T-value of $t=0.05$. Correlation between tissue accumulations and ambient water/sediment matrix was analyzed using Pearson's correlation. In all cases, treatments were considered significantly different if $p<0.05$.

3.0 RESULTS AND DISCUSSION

3.1. RESULTS

3.1.1. Persistent Environmental Pollutants in Water and Sediments

Table 1 shows the concentrations of the heavy metals and hydrocarbon pollutants in water column and sediments of the Ogu Creek during the sampling period. In water column, Zn, Cd, Cr, Pb, Fe and Mn varied from 0.020-0.037 (0.029±0.005), 0.001-0.004 (0.002±0.001), 0.001-0.002 (0.001±0.00), 0.000-0.001 (0.001±0.000), 5.250-6.200 (5.817±0.289), and 0.000-0.002 (0.001±0.001) mg/L respectively. Total Petroleum Hydrocarbons (TPHs) and Polynuclear Aromatic Hydrocarbons (PAHs) varied from 35.40-45.20 (40.23±2.83) and 5.10-9.40 (7.60±1.29) mg/L respectively.

However, in sediments Zn varied from 20.40-24.80 (22.10±1.37) mg/kg, Cd varied from 1.90-2.05 (1.98±0.04) mg/kg, Cr varied from 2.00-2.30 (2.13±0.09) mg/kg, Pb varied from 4.00-5.90 (4.80±0.57) mg/kg, and Fe varied from 21.60-26.00 (24.03±1.29) mg/kg. TPH and PAHs varied from 65.30-76.00 (70.93±3.10) and 25.10-37.80 (29.80±4.02) mg/kg respectively.

The One-way Analysis of variance (ANOVA) test revealed that mean tissue accumulations of Cd, Pb, Fe, Mn, TPHs, PAHs, MAHs, and phenol differed significantly between the impacted and reference locations ($Sig.F_{values}=0.000$ each) at $p<0.05$ level, even as that of Cr differed at $p=0.05$ ($Sig.F_{value}=0.052$) (Appendix 2).

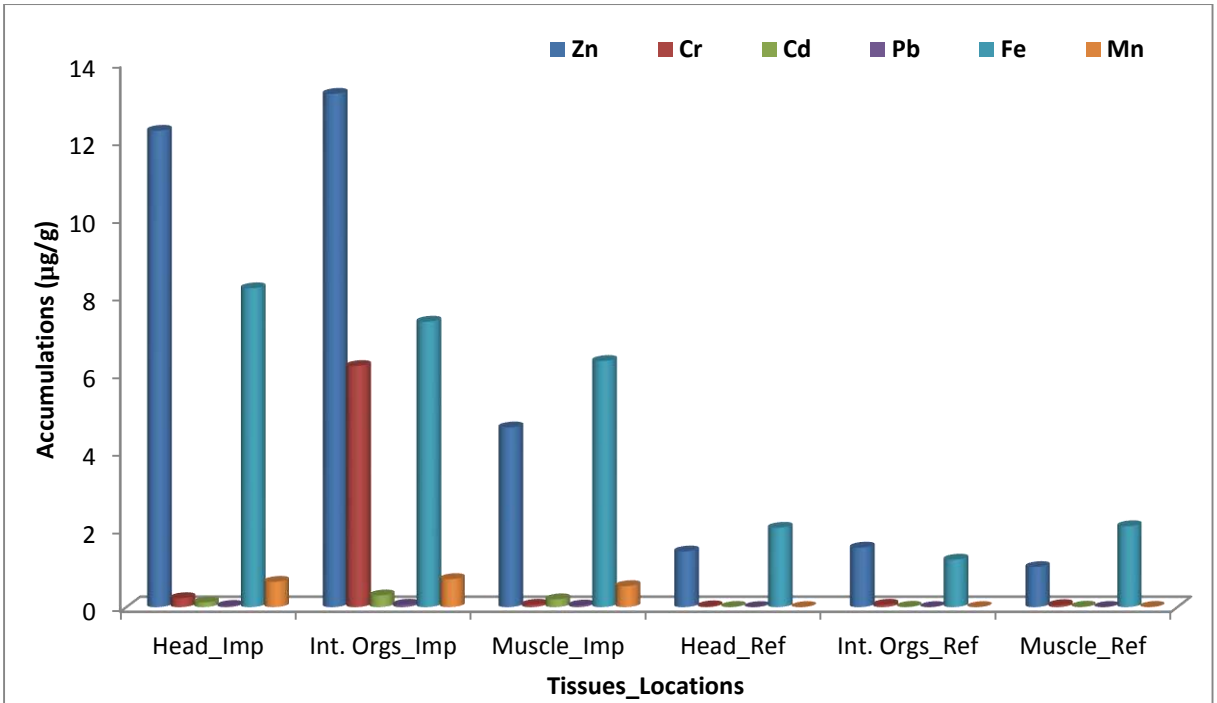

Fig. 2. Mean accumulations of trace elements in tissues of prawn (*Macrobrachium malcolmsonii*) at the sampling locations in Ogu Creek

Description of abbreviation.

i. **Imp ----- impacted location**

ii. **Int. orgs ----- internal organs of crab and prawn.**

iii. **Ref ------- Referenced location.**

3.1.2. Spatial Variations of PEPs accumulation in Macrobrachium malcolmsonii

In M. malcolmsonii tissues, mean accumulations (±SE) of Zn, Cr, Cd, Pb, Fe, and Mn at the impacted location were 22.25 (±12.65), 2.16 (±1.01), 0.22 (±0.08), 0.043 (±0.005), 7.29 (±0.27),

and 0.64 (±0.03) µg/g respectively in the tissues (Fig. 4.1). However, at the reference location, their respective accumulations were 1.33 (±0.08), 0.04 (±0.02), 0.008 (±0.002), 0.001 (±0.000), 1.78 (±0.14), and 0.003 (±0.001) µg/g.

At the impacted location, TPHs, PAHs, BTEX, and phenol accumulations in the tissues were 4.41 (±0.26), 0.163 (±0.019), 0.053 (±0.007), and 0.0037 (±0.001) µg/g respectively. At the reference location their accumulations were 0.003 (±0.001), 0.001 (±0.000), 0.0003 (±0.0002), and 0.0003 (±0.0002) µg/g respectively in the tissues.

On the basis of tissues accumulations and in irrespective of sampling locations, highest mean accumulations of Zn (25.70±19.64 µg/g), Cr (3.13±1.37 µg/g), Cd (0.15±0.07 µg/g), Pb (0.03±0.01 µg/g), and Mn (0.36±0.16 µg/g) were recorded in the internal organs of M. malcolmsonii, least accumulations of 2.83±0.80, 0.05±0.004, 0.06±0.03, 0.02±0.01, and 0.27±0.12 µg/g for the respective metals were recorded in the muscle, muscle, head, head, and muscle tissues of the organism respectively (Fig. 4.1). However, highest mean accumulation of Fe (5.12±1.38 µg/g) was recorded in the head, and the least accumulation of 4.28±1.37 µg/g was recorded in the internal organs (Fig. 4.1). Mean maximum accumulations of TPHs (2.58±1.15 µg/g), PAHs (0.12±0.05 µg/g), MAHs (0.035±0.016 µg/g) and phenol (0.003±0.001 µg/g) were all recorded in tissues of the internal organs, and their least accumulations of 1.71±0.76, 0.05±0.02, 0.016±0.007, and 0.002±0.001 µg/g were recorded in the head, head, muscle, and muscle tissues respectively (Fig. 4.2).

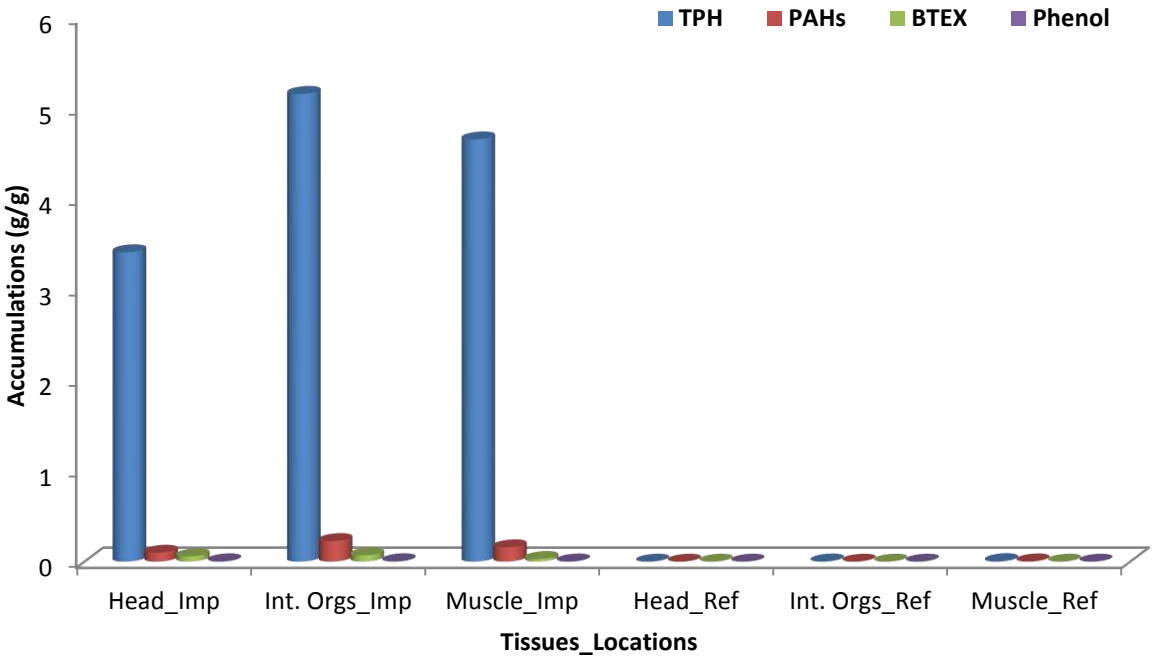

Fig. 3. Mean accumulations of hydrocarbons in tissues of prawn (*Macrobrachium malcolmsonii*) at the sampling locations in Ogu Creek

3.1.3. Spatial Variations of PEPs accumulation in Callinectes sapidus

In C. sapidus, mean accumulations ± SE of Zn, Cr, Cd, Pb, Fe and Mn were 7.97 ± 1.39, 0.117 ± 0.025, 0.043 ± 0.015, 0.023 ± 0.005, 5.153 ± 0.281 and 0.030 ± 0.006 µg/g respectively at the impacted location, and at the reference location they were 1.17 ± 0.05, 0.020 ± 0.004, 0.005 ± 0.000, 0.005 ± 0.002, 1.053 ± 0.009, and 0.003 ± 0.001 µg/g respectively. Mean accumulations of TPHs were 2.827 ± 0.432 µg/g (impacted location), and 0.004 ± 0.001 µg/g (reference location); PAHs were 0.057 ± 0.011 µg/g (impacted location) and 0.002 ± 0.001 µg/g (reference location); MAHs were 0.013 ± 0.003 µg/g (impacted location) and 0.001 ± 0.000 µg/g (reference location) and phenol were 0.002 ± 0.001 µg/g (impacted location) and 0.000 µg/g (reference location).

Irrespective of sampling locations, mean tissue accumulations of Zn (6.10±2.19 µg/g), Cr (0.115±0.043 µg/g), Cd (0.052±0.02 µg/g), Pb (0.022±0.009 µg/g), Fe (3.590±1.123 µg/g), and Mn (0.028±0.010 µg/g) were all recorded in the head tissues of C. sapidus (Fig. 4.3). However, their least mean accumulations of 1.70±0.31, 0.035±0.004, 0.008±0.003, 0.010±0.004, 2.605±0.691 and 0.006±0.003 µg/g were all recorded in the muscle tissues of the organism. Mean tissue accumulations of the TPHs, PAHs, MAHs, and phenol were highest in the head (2.073±0.924 µg/g), head (0.047±0.019 µg/g), internal organs (0.010±0.005 µg/g) and head (0.002±0.001 µg/g) respectively (Fig. 4.4). Their least accumulations of 0.602±0.267, 0.011±0.005, 0.0055±0.0033, and 0.000±0.000 µg/g were all recorded in the muscle tissues of the organism.

The One-way ANOVA test revealed that only mean accumulations of Cr in M. malcolmsonii (Sig. F_{value}=0.023) and Cd in Callinectes sapidus (Sig. F_{value}=0.048) differed significantly in the tissues sampled (Table 3).

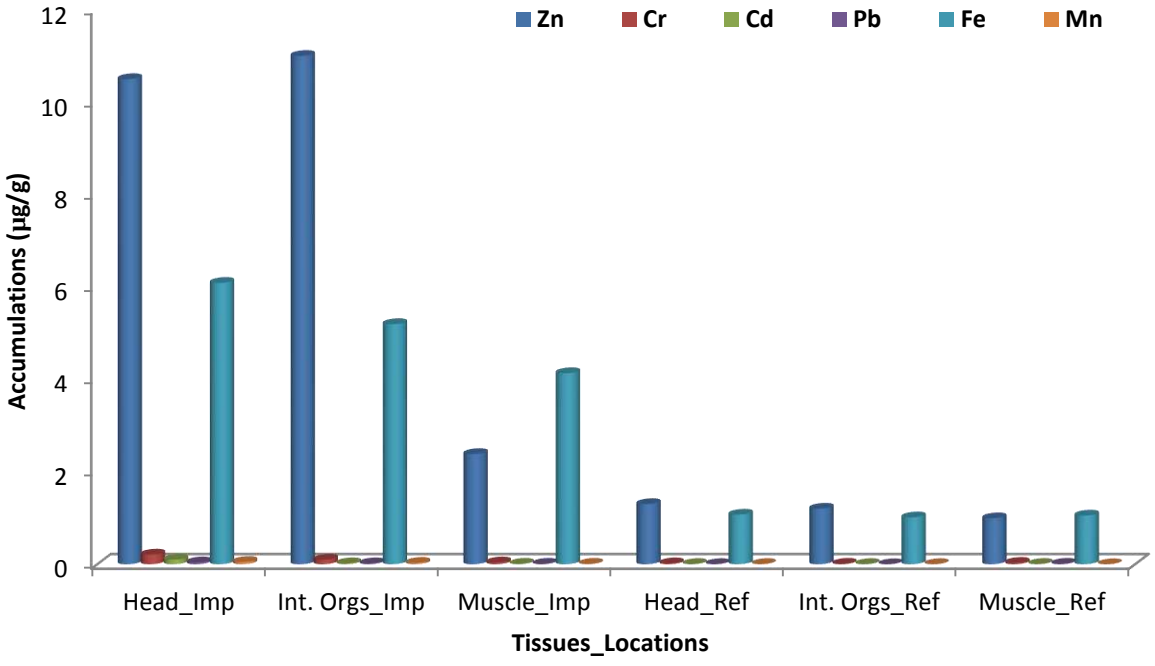

Fig. 4. Mean accumulations of trace elements in tissues of blue crab (*Callinectes sapidus*) at the sampling locations in Ogu Creek

3.1.4. Comparison in accumulations of PEPs in organisms

A pair-wise comparison in accumulations of the Persistent Environmental Pollutants (PEPs) in M. malcolmsonii and C. sapidus using the Student's t-test of significance shows that the accumulations of Cd (Sig. t_{value}=0.007), Fe (Sig. t_{value}=0.000), Mn (Sig. t_{value}=0.001), TPHs (Sig. t_{value}=0.039), PAHs (Sig. t_{value}=0.009), MAHs (Sig. t_{value}=0.003), and phenol (Sig. t_{value}=0.003) in combined tissues M. malcolmsonii and C. sapidus differed significantly at $p<0.05$ level (Table 4).

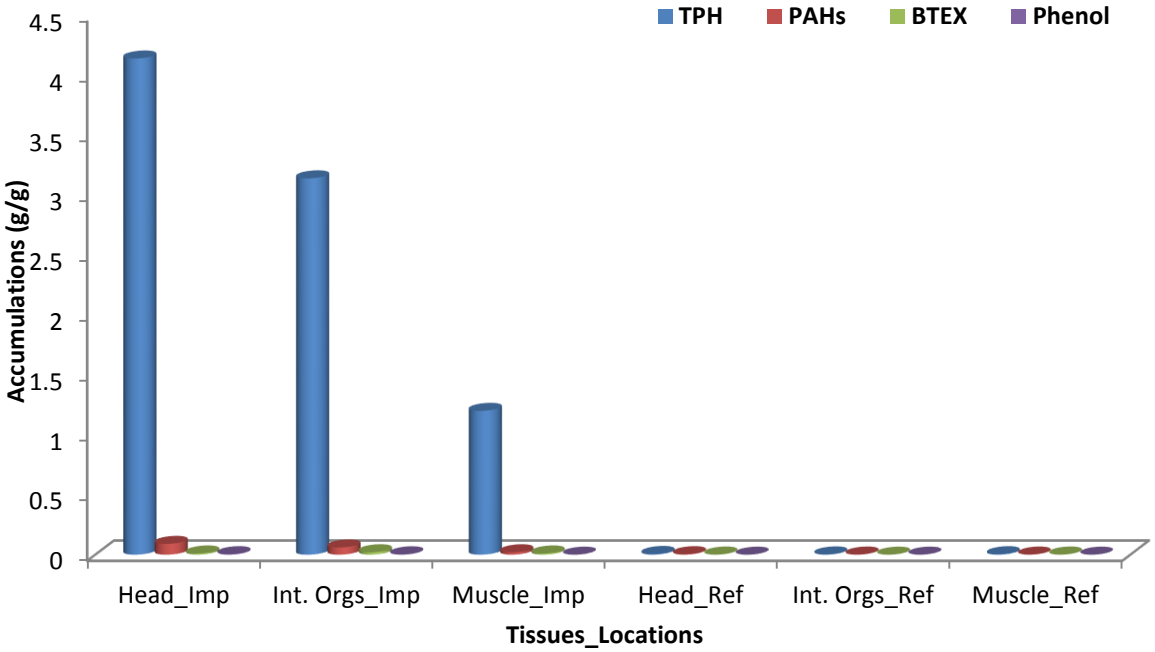

Fig. 5. Mean accumulations of hydrocarbons in tissues of blue crab (*Callinectes sapidus*) at the sampling locations in Ogu Creek

3.2. Discussion

Aquatic ecosystems serve as repository for wastes generated by industries and domestic homes. The detectable presence of the persistent environmental pollutants studied in both water column and sediments of the Ogu Creek, impacted by a poorly treated oil refinery and artisanal refinery effluents clearly shows that these activities contributed this class of pollutants in the coastal water body.

The presence of persistent pollutants, including trace metals and hydrocarbons in the tissues of fish sampled from the Ogu creek indicates the presence of pollutants from industrial and domestic effluents, as well as waste in water from the adjoining areas of the creek. Both local (Olowu et al., 2010; Oladele and Jenyo-Oni, 2015) and foreign researchers (Ikem et al., 2003; Alam et al., 2012) have observed that contaminants are introduced into aquatic ecosystems through many routes and sources such as industrial, domestic, municipal run-offs and leachates. Alam et al. (2012) and Akan et al. (2012) had also reported that effluents generated by various processes in factories and discharged untreated into nearby water bodies may affect water quality and may result in dramatic changes in the chemical quality of the water.

The effluents from the nearby petroleum industry to the creek and from other artisanal refining activities obviously contained a variety of pollutants ranging from organic pollutants, through metals, to hydrocarbons. Although many of these metals are essential for the growth of organisms at lower concentrations, they are essentially poisons when their concentrations exceed certain levels.

The high levels of trace elements in the water can be attributed mainly to industrial and other anthropogenic sources. Consequently, findings from this current work corroborated the one earlier

conducted in Ijaw areas of Delta State in Nigeria by Gbaruko and Friday (2007), wherein they reported accumulation of trace elements such as mercury, lead, zinc, copper and nickel in the fauna and flora. Since fishes and other aquatic lives live in close contact with, and are dependent on aquatic environment, effect of the pollutants in water may be acute or chronic on them. Zinc, chromium, lead, Iron and manganese were all high in the tissues, especially in the head and internal organs of prawn and crab in the current work. Adeolu and Afolabi (2010) had also observed high levels of industrial pollutants, including heavy metals in effluents of industries in Lagos, Nigeria.

There was also the presence of trace metals in the reference location of the current work, away upstream from the points of discharge of industrial effluents. This must have been transported by tides causing mixture of the pollutants further upstream and from the surrounding lands. According to Adedeji and Okocha (2011), runoffs from urban areas during the rainy season are rich in certain trace metals such as chromium and zinc. Observations have also been made by Meyer et al. (2015) that mixture of organic materials, trace metals and hydrocarbons resulted to high toxicity which affected the ecosystem drastically.

Wogu and Okaka (2011) researched on the heavy metals species in surface water of Warri river, Delta State and their potential distributions in aquatic biotopes. Their results compare favourably with the current research, especially in the mean accumulations of trace elements.

The mean value of zinc recorded in the present study was different from that recorded by Esinulo et al. (2016) in seven spatially located markets in Asaba (Oshimili South Local Government Area), Oleh (Isoko South Local Government Area), Ekpan (Uvwie Local Government Area), Ogwashi-Uku (Aniocha North Local Government Area), Okere (Warri South Local Government Area), Ughelli (Ughelli North Local Government Area) and Abraka (Ethiope East Local Government Area) of Delta State. Values from the current work far exceed those of the earlier work cited.

Result from the work of Aladesanmi et al. (2014) on the determination of concentrations of trace elements (Pb, Cr, Fe and Mn) in mud catfish (C. gariepinus) and the health risk associated with trace elements in fish at selected fish pond, water and sediments in Osun State, Nigeria, differed from the current result.

However the value of Zn recorded in this study is above the Food and Agricultural Organization's acceptable levels for Zn in edible fish (0.03 mg/g dry weight) (EFSA, 2010). Values of Zn were also above the 0.04 mg/g permissible limits for Zn in fish by the World Health Organization (WHO, 2003). The value of Pb and Cd exceeded the CODEX (EFSA, 2010), which have a permissible value of 0.0003 mg/g. The mean value of Cd, Cr and Pb exceeded the International/National Standards for trace elements in Food, (Meyer et al., 2005) which have permissible limits of 0.002 mg/g, 0.001 mg/g, and 0.006 mg/g respectively. The value of phenol exceeded the Agricultural Food and Veterinary Authority (AFVA, 1992) permissible value of 0.0005mg/g.

The head and internal organs of Macrobrachium malcolmsonii and digestive tissues and muscle of Callinectes sapidus accumulated more trace elements and petroleum hydrocarbons than the muscle and ovary respectively. Metals and hydrocarbons accumulations could be due to physiological affinities to lipophilic sites in the bodies of the organisms. Metals and hydrocarbons accumulations in body tissues usually reflect their bioavailability in high enough concentrations in water (Olowu et al., 2010; Oladele and Jenyo-Oni, 2015). It is well known that the muscles do not actively accumulate trace metals and seems to have a very fast decontamination rate. However, the muscles are the main site where Persistent Organic Pollutants (POPs) such as pesticides, PAHs,

PCBs, etc. accumulate the most. Therefore, these tissues are used in studies regarding human health and food poisoning (Wangboje and Ikhuabe, 2015).

Trace metals and hydrocarbons have been noted to cause persistent health implication such as cancer, respiratory disease, body fatigue, headache, and other health condition when they get incorporated into the food chain and consumed by higher organisms.

Among these trace elements, Zn and Cr are mentioned in the list of potent carcinogens (EFSA, 2010; IPCS, 1994; Environment Canada, 2010). In the study, Cr showed high cancer risk to the exposed population. Like toxicity/hazard quotient (TQ/HQ), the estimated lifetime cancer risk (TR) is also not a specific estimate of expected cancers. Rather, it is apparently an upper limit of the probability that the individuals may have cancer sometime in his/her lifetime following exposure to that toxicant (ATSDR, 1994). Incidents of endocrine disruption and carcinogenicity from heavy metals and hydrocarbon pollutants have severally been indicated (ATSDR, 1994; US EPA, 1998; Brooks et al., 2004; Giri and Singh, 2014; Martin, 2018).

4.0 CONCLUSION

The current work revealed the trace elements and hydrocarbons accumulated to toxic levels in tissues of prawn and blue crab sampled from the Ogu creek in Rivers State. The detectable presence of the persistent environmental pollutants studied in both water column and sediments of the Ogu Creek, impacted by a poorly treated oil refinery and artisanal refinery effluents clearly shows that these activities contributed this class of pollutants in the coastal water body.

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