International Research Journal of Applied Sciences, Engineering and Technology
Vol.7, No.11; November-2021;
ISSN (1573-1405);
p –ISSN 0920-5691
Impact factor: 4.33

SPATIAL VARIATION OF HEAVY METALS IN BLUE CRAB *Calinectes amnicola* HARVESTED FROM THE WATER FRONT OF SOME FISHING COMMUNITIES IN RIVER STATE, NIGERIA.

[1]**Davies, I. C.,** [2]**Nkeeh, D. K.,** [3]**Akoko S. and** [4]**Ariri I. P.**

[1]Department of Fisheries, Faculty of Agriculture, University of Port Harcourt, Rivers State, Port Harcourt, Nigeria.
[2]World Bank Africa Centre of Excellence, Centre for Oilfield Chemicals Research,
University of Port Harcourt, Port Harcourt, Rivers State, Nigeria
[3]Department of Pharmacology, Faculty of Clinical Science, College of Health science, University of Port Harcourt, Port Harcourt, Rivers State, Nigeria.
[4]Deprtment of Biology, Federal College of Education Technology, Omoku, Rivers State, Port Harcourt, Nigeria.
*Corresponding Author: [1]**Davies, I. C.,**

Abstract: The aim of this study was to evaluate the spatial variation of the physicochemical parameters and heavy metals in surface water, sediment and swimming crab (*calinectes amnicola*) harvested from the water front of some fishing communities in river state, Nigeria. The physicochemical parameters were analylised using the in-situ multi-meter) while the heavy metals were analysed using Atomic Absorption Spectrophotometer. There was a spatial and temporal statistical difference ($p<0.05$) in all the parameters. The range for physicochemical parameters was as follows; temperature (27.6ºC-28.4ºC), pH (6.4-7.9), salinity (68µm/cm-131µm/cm), TSS (182.5mg/l-233mg/l) and DO (2.5mg/l-3.7mg/l). In surface waters, Iron and zinc were above EFA (2017) and WHO (2011) permissible limit of 3mg/kg for Zinc and 0.5mg kg^{-1} for Iron while in the tissues of *C. amnicola,* sediments and surface waters while coper was above the limit. The metals content in the different medium were in the following order; *C. amnicola* (Fe>Zn>Cu), Sediment (Fe>Zn>Cu), Surface water (Fe>Zn>Cu). There were significant differences observed in metal concentration in the tissues of *C. amnicola*, sediments and surface waters. Among the three tested mediums, the sediment recorded the highest metal concentration was reported followed by *C. amnicola* and the leas was in the surface water. The high level of non-essential metals recorded in this study indicates ingestion of this fish by human in the food chain could lead to a possible risk for neurological disorder hence need for further study, monitoring and mitigation to reduce the impact on human population through consumption.

Keywords: Heavy metal, physicochemical parameters, sediment and *C. amnicola.*

INTRODUCTION

The most often polluted phases of the environment are the aquatic system, especially the surface and interstitial water. This is because contaminants in air, soil or on land ultimately end up in the aquatic systems via local precipitation, surface water runoff and leaching of rocks and solid wastes (ISSA *et al.*, 2010). Aquatic ecosystems act as one of the major receptacles other than terrestrial ecosystem for various contaminants generated through the unregulated release of effluents from mines, smelters, industries, excessive usage of agrochemicals, and from aerial deposition (Nriagu and Pacyna, 1988; Kabata-Pendias 2010; Adriano 2001).

In Nigeria, the input of environmental pollutants in aquatic systems is a common phenomenon
(Okonkwo *et al.,* 2021). In the aquatic ecosystem, the uptake of heavy metals in fish was found to occur through absorption across the gill surface or through the gut wall tract. (Ezekiel *et al*., 2012) and some heavy metals like, Cd, Co, Cr, Cu, Hg, Ni, Pb, Se and Zn have been considered as major environmental pollutants and their toxicity is well established (Roesijadi,1994). Pollution of marine ecosystems by heavy metals is on the increase on a global scale. Trace metal contamination and the trophic transfer of metals in aquatic food chains has been a subject of concern for the past half century.

Shell and fin fishes have been widely used as bio-indicators to monitor heavy metals concentrations in the coastal environment, due to their wide range of distribution, and also their important position in the food chain (Akankali and Davies, 2020). Among the different kinds of pollutants, heavy metal pollution needs to be dealt with on top priority considering both its fast rate of accumulation in the aquatic medium and the impact of its toxicity on the organisms along the food chain and its biomagnification impacts.

Crabs are part of the aquatic ecosystem and they are consumed as food in many countries. In the Aquatic food products including crustacean shellfish have been praised for their health promoting characteristics. Crabs are nutritionally valuable sources of various minerals and high-quality proteins (Skongberg and Perkine, 2002; USDA, 2003). Also, seafood is generally accepted to be very important in a healthy, safe, nutrition and balance diet (WHO, 2006). They are important sources of valuable nutrients like, minerals (e.g., Calcium; Iron, Zinc, Iodine Selenium and Copper), vitamins, fatty acids and high-quality proteins.

The Sonbrayo River is among the important water resources in Asaro-Toru Local Government Area of Rivers state of Southern Nigeria; it is a vital part of the rapidly expanding oil city of Port Harcourt in Rivers State, Southern Nigeria. Most communities within this area are directly dependent on the river for their sea food, agricultural, and sometimes recreational activities. The river is subject to effluent discharge from Industries activities as it also serves as a minor shipping route for crude oil and other cargoes. Also, surface run-off resulting from illegal refinery locally known as bunkery, lumbering activities, forestry operations, dredging activities, and domestic sewage inputs may lead to wide scale contamination of the river.

The concentration of these metals in Nigerian coastal waters are of great concern which have warranted the need for periodic sampling and analyses of both water and water resources in around the creeks in order to monitor the pollution and productivity status of the marine ecosystem and compare the data with international standards and the study will provide necessary information that can help environmentalists and the law enforcement agencies to arrive at sustainable monitoring steps of this aquatic ecosystem and adjoining water bodies.

MATERIALS AND METHODS

STUDY AREA

Specifically, the study was carried out between the Tema, Opro-ama and Abalama water front, in Asari-Toru Local Government Area of Rivers State, Niger Delta (Figure 1). The Creeks are tributaries of the Sombreiro Estuary, which is one of the 21 estuaries in the Niger Delta geomorphic unit of Nigeria's extensive (approximately 853 km) coastline (NEDECO, 1961) Located Southeast of the Niger Delta between longitude N04^{0} 48' 14.0" and latitude E006^{0} 50' 16, the major Creeks consists of the mainly channel and associated feeder creeks linking Oproama, Sa-ama, Abalama, Tema and other fishing/ riparian communities. The mangrove vegetation of the area comprises *Rhizophora racemosa, R. harrisonii and R. mangle* (red mangrove). Other mangrove species in the area are *Avicennia germinans* (white mangrove), *Laguncularia racemosa* (black mangrove) and *Conocarpus erectus (*button wood*).* There is presence of mangrove associates such as *Acrostichum aureum* (mangrove fern) and *Paspalum vaginatum* (mangrove sedge). In terms of relative species abundance, the mangrove is typical of the broader Niger Delta mangrove composition, characterized by the dominance of *R. racemosa*. Sediments of the studied sites were uniformly consolidated spongy and highly fibrous "chicoco" peaty mud characteristic of many mangrove swamps of the Niger Delta (Zabbey *et al*., 2021; Omotosho *et al*., 2003).

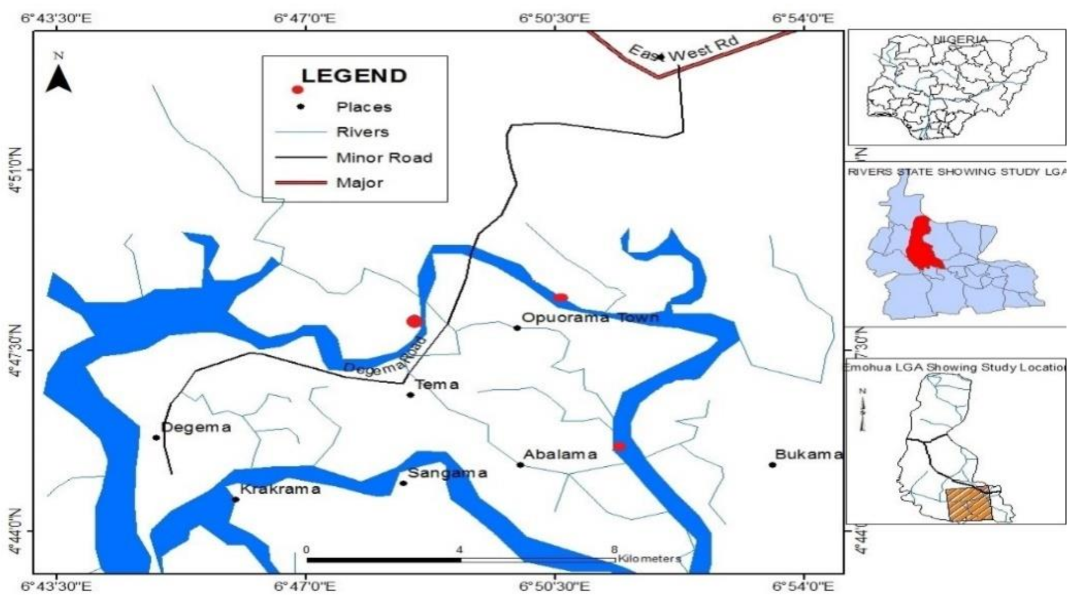

Figure 1: Showing the Sampling Location

SAMPLE AND SAMPLING TECHNIQUES

Sampling was carried out once in a month at low tide (January-June 2020) and a composite sampling technique was used in the three sample stations along the creeks. During this period, all research followed the basic minimal COVID-19 protocol while working on this research in the laboratory.

Sampling Procedure

The sampling stations are shown in figure 1. A total of three stations were chosen and were at least 1000 meters apart along the creek. Based on the peculiarities and features observed around the study area of this creek, three sampling stations were selected within the creek to reflect different activities in the areas: Station I (Tema), Station II (Abalama) and Station III (Oproama). Samples collected for analysis include water, sediment and Swimming crab. All sites were geo-referenced using a handheld global positioning system (GPS) receiver unit (Magellan GPS 315) to generate geographic coordinates of the sampling area.

SWIMMING CRAB (*Callinectes amnicola*)

The Swimming crab was collected once in a month for six months from the local fishermen at the different sample stations and stored in an ice pack to maintain the freshness and later transported to the laboratory. *Callinectes amnicola* was identified using the striking taxonomic features of their widened and arched carapace described by Arimoro and Idoro (2007)

International Research Journal of Applied Sciences, Engineering and Technology
Vol.7, No.11; November-2021;
ISSN (1573-1405);
p –ISSN 0920-5691
Impact factor: 4.33

SEDIMENT

The sediments were also collected once in a month for six months in a form of composite from three different stations using an 'Ekman grab' sampler and kept in a plastic container which had been previously treated with 10% nitric acid for 24 hours and rinsed with de-ionized water. The samples were then transported to the Laboratory and stored frozen. In the laboratory, samples were stored at 20°C until further treatment and analysis using the Atomic Absorption Spectrophotometric Machine (API-RP 45).

WATER

Surface water samples were collected in Schott glass bottles. The sampling bottles were cleaned using detergent then rinsed with tap water and soaked in 50% hydrochloric acid (HCl) for 24 hours before sampling. The bottles were washed with tap water and rinsed with triple distilled water before sampling. The bottles were cleaned to ensure that they were not contaminated with metal residue before sampling and to prevent adhering of metals to glass surface, since acidification of the glass ensures metals to go into solution. Samples were then transported in an ice pack to the laboratory and analysis using the Atomic Absorption Spectrophotometric Machine (API-RP 45).

PHYSICOCHEMICAL PARAMETERS ANALYSIS

Surface water samples were collected using a Schott glass bottles. The pH, temperature, salinity, total suspended solids (TSS) of the water were measured in-situ using Laboratory Bench-top meter (860033 model) while the Dissolved Oxygen (DO) was measured using Winkler's method.

Data were analyzed using ANOVA and Duncan's multiple range and results were tested statistically with significant differences at the 0.05% level of probability.

DETERMINATION OF BIOACCUMULATION QUOTIENT (BQ)

The Quotient (BQ) which is expresses the ability of the fish to accumulate of heavy metals above the biota environment was determined using the equation according to Adams *et al*. (1980) and Moslen and Miebaka (2017).) as follows;

$$BQ = \frac{\text{Metals in Fish organs or tissues}}{\text{Metals in water}}$$

Transfer factor (TF) in fish tissue from the aquatic environment (water or bottom sediment) was determined according to Kim *et al*. (2012) and Farooq *et al.* (2008) as follows;

$$TF = \frac{\text{Metals concentration in fish}}{\text{Metals in sediment}}$$

It is determined using dry weight concentrations (Kwok *et al*., 2013).

DETERMINATION OF HEAVY METALS IN WATER SAMPLE

Metal analysis such as Cu, Fe, and Zn, (mg/L) was carried out using a computer controlled Atomic Absorption Spectrophotometer (Buck Scientific 210/211 VGP Model). Sample preparation was by acid digestion, followed by filtration through a 0.45-micron membrane filter. Then aliquots of the filtrate were used to analyses for the various metals. The instrument setting and operational conditions were done in accordance with the manufacturers' specifications.

STATISTICAL ANALYSIS

Statistically data was analyzed using a one-way ANOVA and Duncan's multiple range tests to compare the mean values of the samples and to avoid error inherent in performing multiple *t*-tests. Results were tested for statistically significant differences at the 0.05 level.

RESULTS

PHYSICOCHEMICAL PARAMETERS

Data for these study are presented in Tables 1. The highest value of hydrogen iron concentration (pH) was (7.9±0.27) in June and least value (6.4±0.27) was observed in February. Temperature was highest (28.4±0.01ºC) was recorded in the month of February while the least (27.6±0.01ºC) was observed in January, March, April, May and June. The highest salinity value (1115±0.27‰) was in February and the least (68±0.27‰) in April. The month of March recorded the highest value (228±0.03mg/L) of Total suspended solids (TSS) while the least (182±0.03mg/L) was observed in the month of in June. The Dissolved oxygen (DO) was maximum (3.7±0.11mg/L) in January and February while the least value was recorded in (2.5±0.11mg/L) in June. Generally, all the physicochemical parameters were significant difference(P<0.05) across the months.

Table 1. Mean monthly values of physicochemical parameters.

Parameter	Jan	Feb	Mar	Apr	May	Jun	WHO 2011
P^H	7.3±0.27 ^a	6.4±0.27^b	6.7±0.27 ^b	6.6±0.27 ^b	6.5±0.27 ^b	7.9±0.27^a	6.5-8.5
Tempt	27.6±0.01^b	28.4±0.01^a	27.6±0.01^b	27.6±0.01^b	27.6±0.01^b	27.9±0.01^b	24.8-30
Salinity	97±0.27 ^c	115±0.27^b	110.5±0.27^b	68±0.27^d	90.1±0.27 ^c	131±0.27^a	120
T SS	203±0.03^b	233±0.03^a	228±0.03^a	207±0.03 ^b	189.5±0.03^c	182±0.03^c	500
DO	3.7±0.11^a	3.7±0.11^a	3.4±0.11^ab	2.7±0.11^b	2.7±0.11^b	2.5±0.11^c	6

* Rows with a common letter are not significantly different (P>0.05)
* Rows with different letter are significantly different (P<0.05)

HEAVY METALS

From table 2, Copper (Cu) concentration in *C. amnicola* was highest in the month of May (1.9±0.24mg/kg), and least (0.2±0.43mg/kg) in June. Zn was highest (10±0.04mg/kg) in the month of January while the least value (5.1±0.01mg/kg) was observed in June. The highest value (13±0.02mg/kg) of Zn was June and the least (7.2±0.02mg/kg) was recorded in January. There was significant difference (P<0.05) in the Metal concentrations in the fish across the months (Figure 2).

In the sediment, Copper (Cu) was highest (3.4±0.01mg/kg) in the months of February and May while the least value (0.2±0.01mg/kg) was observed in June. The maximum value (7.4±0.03mg/kg) of zinc (Zn) was recorded in the month of May while the least (3.2±0.03mg/kg) was observed in March. The value (9.5±0.04mg/kg) of Iron (Fe) was highest in the month of February and the least (3.8±0.04mg/kg) was recorded in June. There was significant difference (P<0.05) in the metal concentrations in the sediment across the months (Figure 3).

The maximum value (1.5±0.01mg/kg) of copper (Cu) in the surface water was observed in the months of January and February while the least (0.1±0.01mg/kg) was reported in May. The concentration of Zinc was highest (8.7±0.03mg/kg) in the month of May and the least (4.5±0.03mg/kg) was recorded in January. The Iron (Fe) concentration was (9.1±0.02mg/kg) was highest in the month of February while least (3.9±0.02mg/kg) was observed in January. There was significant difference (P<0.05) in the metal concentrations in the surface water across the months (Figure 4).

International Research Journal of Applied Sciences, Engineering and Technology
Vol.7, No.11; November-2021;
ISSN (1573-1405);
p –ISSN 0920-5691
Impact factor: 4.33

Table 2. Mean monthly values of heavy metals.

Media	Metals	Jan	Feb	Mar	Apr	May	June	WHO (2011)	EPA (2017)
	Cu	1.5±0.01[a]	0.3±0.43[c]	1.9±0.24[a]	1.2±0.01[b]	1.2±0.24[b]	0.2±0.43[c]	2.0	3.0
C. amnicola	Zn	10±0.04[a]	9.4±0.01[a]	5.6±0.01[b]	8.1±0.01[a]	5.9±0.01[b]	5.1±0.01[c]	0.1	3.0
	Fe	7.2±0.02[c]	9.4±0.02[b]	8.9±0.02[b]	9.8±0.02[b]	10±0.02[ab]	13±0.02[a]	0.3	0.5
	Cu	1.5±0.01[b]	3.4±0.01[a]	1.2±0.02[b]	3.1±0.01[a]	3.4±0.02[a]	0.2±0.01[c]	2.0	3.0
Sediment	Zn	5.5±0.03[b]	3.5±0.03[c]	3.2±0.03[c]	6.8±0.03[a]	7.4±0.03[a]	6.6±0.03[a]	0.1	3.0
	Fe	8.1±0.04[a]	9.5±0.04[a]	5.3±0.04[b]	4.9±0.04[b]	4.5±0.04[bc]	3.8±0.04[c]	0.3	0.5
Surface	Cu	1.5±0.01[ab]	1.5±0.01[ab]	1.2±0.04[b]	1.2±0.01[b]	0.1 ±0.01[b]	0.2±0.43[a]	2.0	3.0
water	Zn	4.5±0.03[bc]	2.8±0.03[c]	8.7±0.03[a]	5.7±0.03[b]	5.2±0.03[b]	6.1±0.03[b]	0.1	3.0
	Fe	3.9±0.02[c]	9.1±0.02[a]	7.8±0.02[a]	6.5±0.02[b]	5.8±0.02[b]	5.6±0.02[b]	0.3	0.5

* Rows with a common letter are not significantly different (P>0.05)

* Rows with different letter are significantly different (P<0.05)

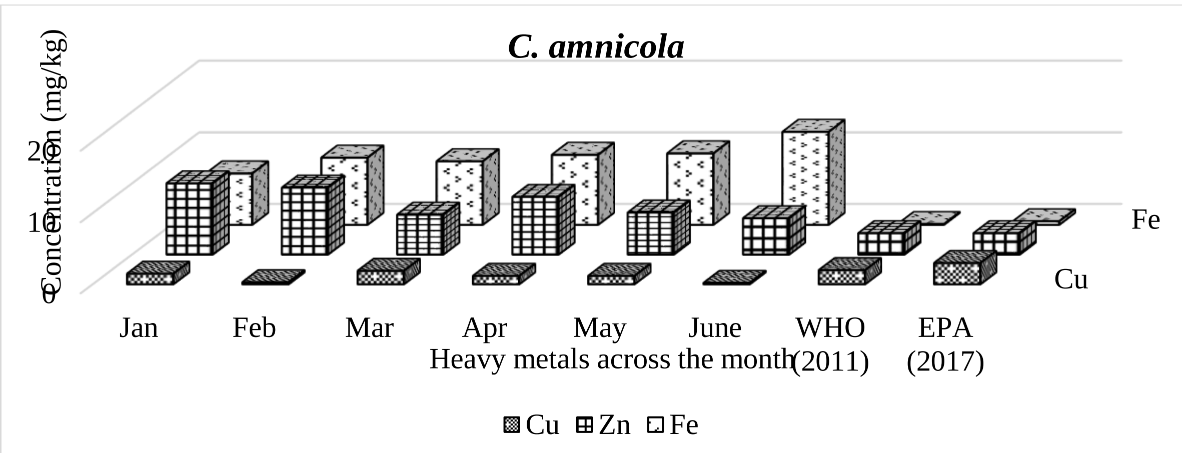

Figure 2: Heavy Metal Concentrations in *C. amnicola* across the month.

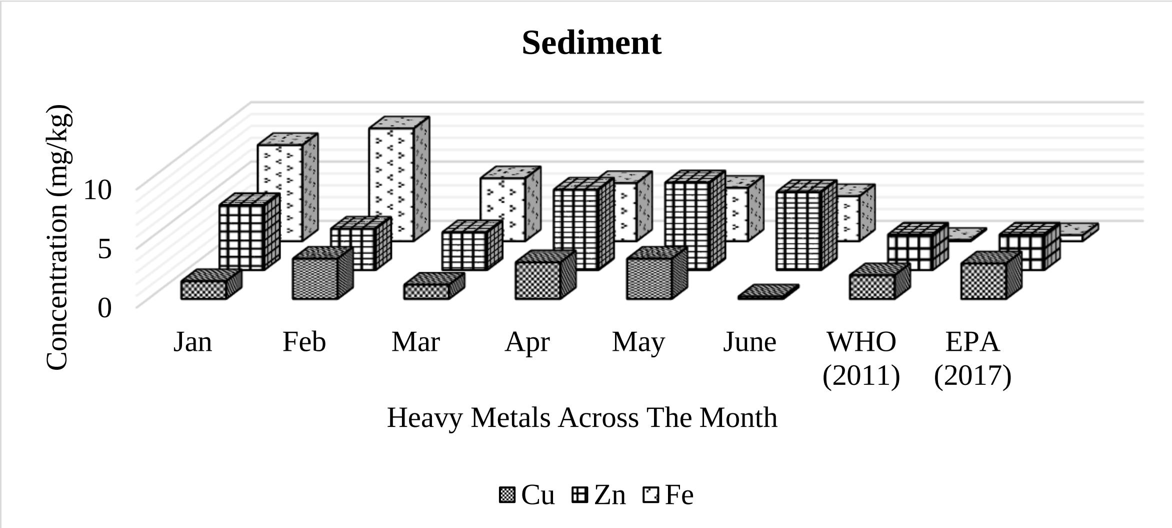

Figure 3: Heavy Metal Concentrations in the Sediment across the month.

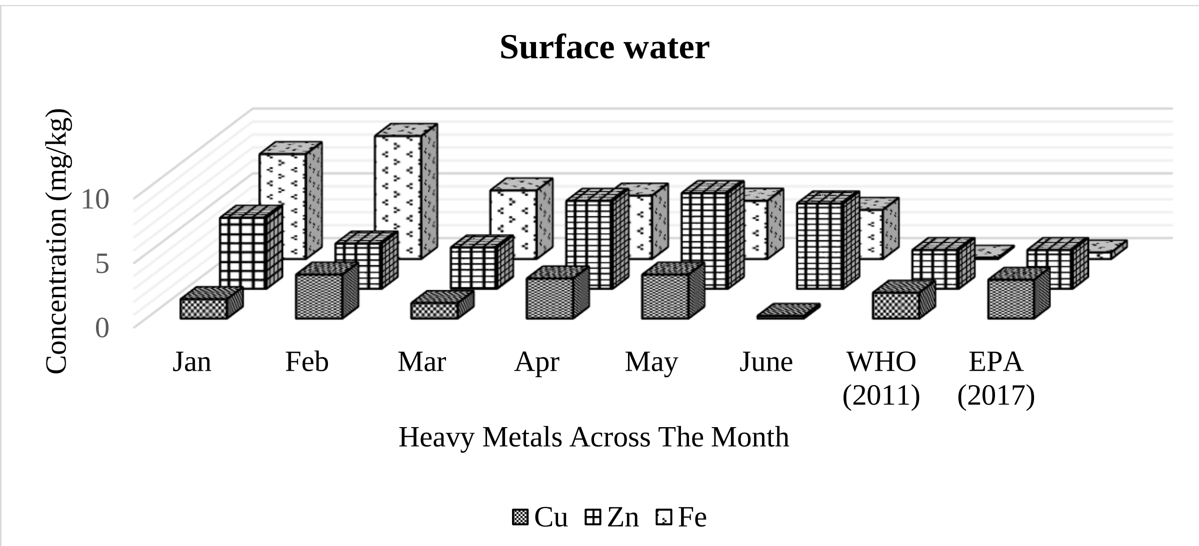

Figure 4: Heavy Metal Concentrations in the Surface water across the month.

From table 3, the bioaccumulation and transfer factor in the fish from Water (BFS) show that the value of Cu across the months were in the order of March > January = May = April = June > February. The concentration of Zn across the months were in the order of February >January > April > May > June > March while the concentration of Fe across the months were in the order of June > January > May > April > March >February respectively (Figure 5-7).

The bioaccumulation and Transfer factor in the fish from sediment (BFS) show that the value for Cu across the months were in the order of March > January = June > February > May> April. The concentration of Zn across the months were in the order of February >January > March >

International Research Journal of Applied Sciences, Engineering and Technology
Vol.7, No.11; November-2021;
ISSN (1573-1405);
p –ISSN 0920-5691
Impact factor: 4.33

April > May > June while the concentration of Fe across the months were in the order of Fe= June > May > April > March >February >January (Figure 5-7).

Table 3: Spatial Bioaccumulation and Transfer Factor in *C. amnicola*

Metals	**Jan**		**Feb**		**Mar**		**Apr**		**May**		**June**	
(mg/kg)	BFS	BFW	BFS	BFW	BFS	BFW	BFS	BFW	BFS	BFW	BFS	BFW
Cu	1	1	0.09	0.2	1.58	1.58	0.39	1	0.34	1	1	1
Zn	1.82	2.22	2.68	3.36	1.75	0.64	1.19	1.42	0.79	1.13	0.77	0.84
Fe	0.89	1.84	0.89	1.03	1.70	1.14	2	1.51	2.22	1.72	3.42	2.32

**BFW: Heavy metal concentration in fish tissue by from the water.*
**BFS: Heavy metal concentration in fish tissue by from the sediment.*
**When the value of the metal is < 1, it implies that they are excluders, when the metals are > 1, it implies that they are accumulators and when they are = 1, it implies that they have no influence.*

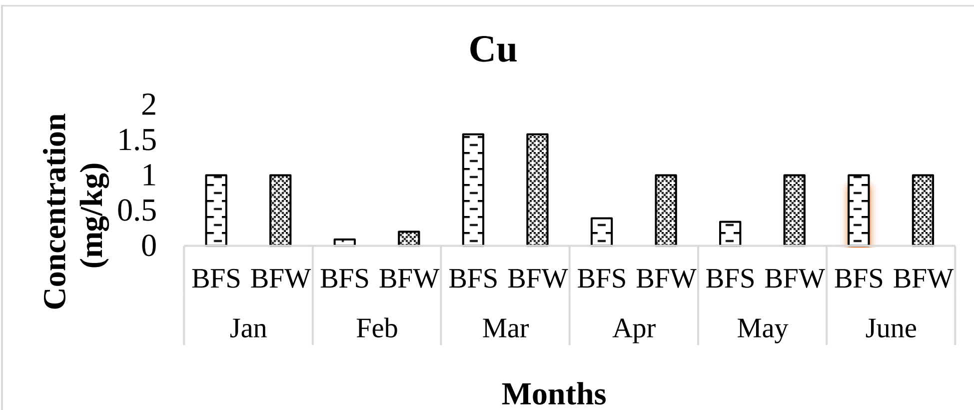

Figure 5: Bio-accumulation of Cu in tissue from Water and Sediment and across months

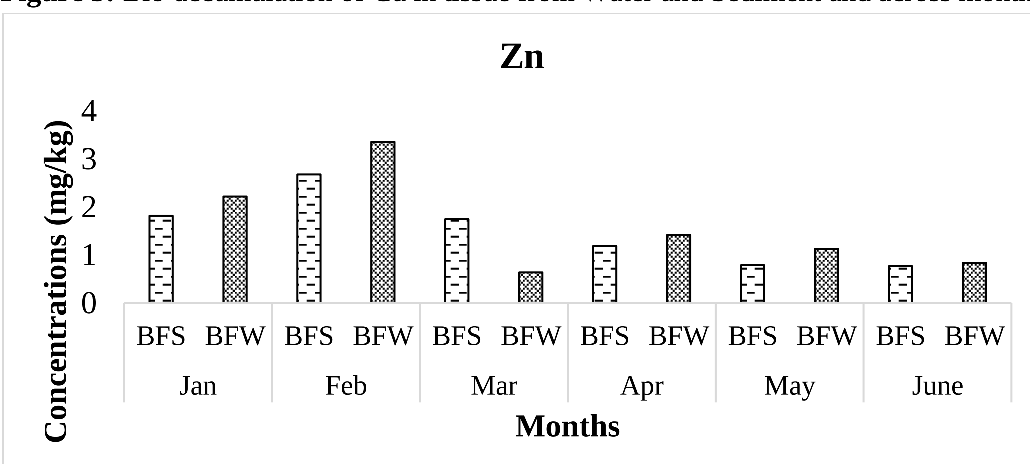

Figure 6: Bio-accumulation of Zn in tissue from Water and Sediment and across months

International Research Journal of Applied Sciences, Engineering and Technology
Vol.7, No.11; November-2021;
ISSN (1573-1405);
p –ISSN 0920-5691
Impact factor: 4.33

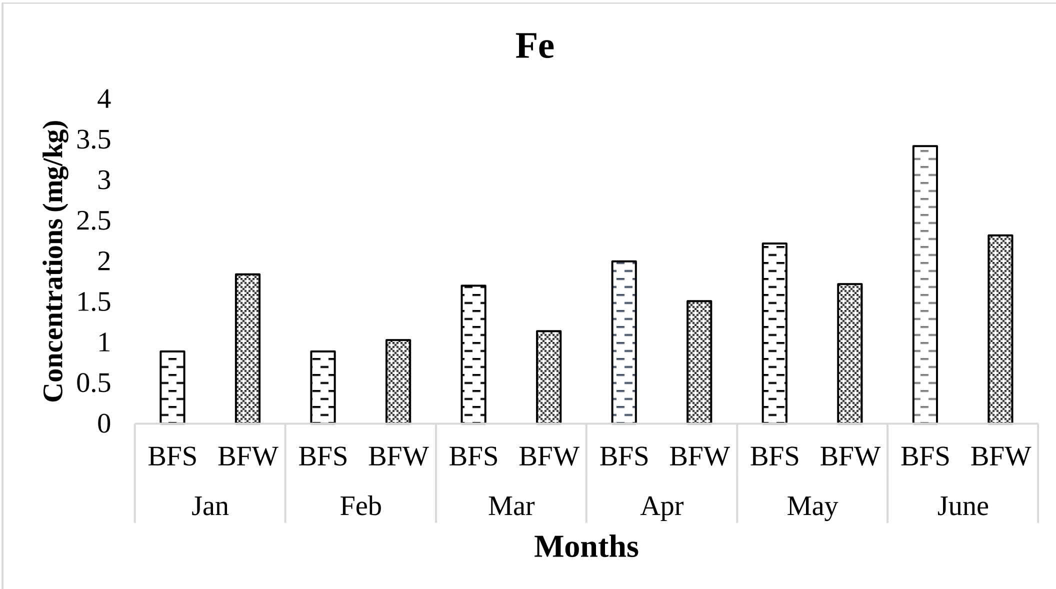

Figure 7: Bio-accumulation of Fe in tissue from Water and Sediment and across months

DISCUSSION

PHYSICOCHEMICAL PARAMETERS

Temperature is an important parameter that plays a major role in determining chemical reaction that takes place in any aquatic environment (Okonkwo *et al.*, 2021). The increase in temperature could directly affects the pH and dissolved oxygen level available to aquatic life (Davies and Ekperusi, 2021). The temperature (27.6ºC to 28.4ºC) reported in our study across the months which is within the acceptable limit for freshwater bodies, was similar to those reported in different water bodies in southern Nigeria. The six (6) month mean monthly temperatures which variation agrees with the seasonal pattern in the Niger Delta (Odokuma and Okpokwasili, 1996). These variations could be due to the effect of precipitation and the abundant vegetation cover observed around the creek. This agrees with Zabbey *et al.* (2021) who stated that high elevation, lack of vegetation cover and sun (sunlight) are factors that can bring about increase in temperature. This could also be attributed to the length of time of exposure of intertidal flat during low tide which can also affects the temperature of the study area (Okonkwo *et al.*, 2021).

The Hydrogen ion concentration (pH) is an important environmental parameter that has strong bearing with the physiology of many aquatic fauna (Boltovskoy and Wright, 1976). The pH values reported in this study ranges from 6.4 -7.9 and were within permissible limits (6.5-8.5) of WHO (2011), tends towards the alkalinity of the surface water body. This is expected where rivers have some interaction with saltwater bodies particularly from the mangrove swamp ecosystem in the Niger Delta region (Davies and Ekperusi, 2021). The values are in agreement with records on other water bodies in the Niger Delta as reported by Akankali and Davies (2021), Iloba and Ruejoma (2014) and Asibor (2016) and Fianko *et al.* (2013). The values reported for the parameters were in conformity with other reported outside the Niger Delta by Edokpayi and Osimen (2001) and Arimoro (2009) reported lower values for pH and temperature at Ibiekum River, Ekpoma and Adofi River. Jaji *et al.* (2007) and Asibor (2016) reported lower temperature and pH in Ogun River and Asejire Reservoir. These values ultimately represent, to a large extent, interstitial conditions as fluxes in ecological variables between interstitial and overlying water column may attain stability with time due to exchanges at the water-sediment interface. According to Spiff and Horsfall (2004), the variation could be attributed to the diffusion at the sediment-water boundary layer in either direction depending on the skewed ambient conditions at the time. Dublin-Green (1987) reported pH values between 6.7 and 7.7 in wet saline soils (chicoco mud) in experimental ponds in Buguma, Rivers State, Nigeria. She stated that the area contained acid sulphate materials which released acids into the pond waters causing low pH values. Zabbey *et al*. (2010) reported in Bodo Creek that the interstitial pH of the creek was maintained due to high flushing rates by tidal waters.

The concentration of the total suspended solids in an aquatic environment in addition to the biochemical and chemical oxygen demand, nitrate, sulphate, phosphate, chloride and ammonia are all pollution indicators in surface water system (Davies and Ekperusi, 2021). From this study, the total suspended solids which ranges from 182-233mg/L. The increased levels of these parameters could indicate a growing level of degrading water quality and pollution presence in a water body. Although the values were within the WHO (2011) permissible limits freshwater ecosystems. Sikoki and Anyanwu (2013) reported elevated physicochemical parameters such as total suspended solids total alkalinity, total hardness, conductivity, nitratenitrogen, turbidity, biochemical oxygen demand, temperature and phosphate-phosphorus etc. The total suspended solids also confirm that the direct relationship between TSS and turbidity Oluyemi *et al.* (2010). According to Edorie *et al.* (2019), an increase in suspended solid particles in water medium, results in an increase in the level of turbidity of the water. There is a direct relationship between TSS and turbidity. According to Edorie *et al*. (2019), an increase in suspended solid particles in water medium, results in an increase in the level of turbidity of the water.

The Dissolved oxygen is a primary parameter in all pollution studies (Okere *et al.*, 2021). Dissolved oxygen regulates the existence, diversity, behavioural, and physiological of aquatic organisms (Okoro *et al.*, 2021). High Dissolve oxygen value is an indicator of a good aquatic life (Davies and Okonkwo, 2021). The amount of dissolved oxygen recorded in this study ranges between 2.50 to 3.7ppm). The mean value of dissolved oxygen was recorded in this study varied between 2.5 to 4.7mg/L which was lower than the W.H.O standard of 65mg/L. The low level of dissolved oxygen of recorded in the study indicate a high level of organic pollution as time went by. This could be attributed to the high temperature and addition of sewage and other waste might have been responsible for low value of DO (Davies and Okonkwo, 2021). Depletion of dissolve oxygen in water could also be due to high temperature and increased microbial activity (Davies and Okonkwo (2021). Onojake *et al.,* (2017) attributed the variation to the fact that the oxygen is dissolved more during the period of active photosynthesis. This further shows an inverse relationship between dissolved oxygen and temperature. This agrees with an earlier by Zabbey (2012), that showed the relationship between dissolved oxygen (DO) and temperature. This was also in line with the DO values reported by Chindah (2004) for a similar aquatic body (Estuary) which were within the Niger Delta region. Akankali and Davies (2021) reported similar value in the Upper Reaches of Bonny River, Niger Delta, Nigeria. Davies *et a1*. (2021) also reported that dissolved oxygen can be reduced in water when it is used up by gradual degradation of organic matter there by reducing the water size. In addition, Onojake *et al.,* (2011) comfirms by saying dissolved oxygen can also be eaten by nitrogen bio oxidation in water.

From the study, the salinity varied from 68 - 131‰ Salinity gradient of the tidal flats was not in conformity with the situation obtainable in brackish waters where by WHO

2011. The concentration of salt increases downstream as a result of oceanic waters and decreasing influence of river- and runoff-derived freshwater (Davies and Ekperusi, 2021). Akankali and Davies (2020) stated that longer time of exposure of intertidal flat as related to the temperature could explains the high salinity of the study area. An earlier study by Zabbey (2012) also reported a deviation in salinity from the usual downstream increase in salinity in brackish water. Studies on other water bodies in the Niger Delta also reports similar trend in the salinity variations (Yakubu *et al*., 1998; Mansi, 1997). Onojake *et al.* (2015) recorded seasonal change with high dry season value than wet season values and attributed it to a higher rate of surface water evaporation due to extreme sunshine, which in the dry season made it saltier and saltier. Mclusky (1989) claimed that precipitation could cause estuarine waters to dilute and thereby reduce salinity at different time interval.

HEAVY METALS CONCENTRATIONS IN FISH, WATER AND SEDIMENT ACROSS THE MONTHS:

Table 2 and Figure 2-4 show the variations of the heavy metals in Crab (*C. amnicola*), water and sediments from January to June 2021.

The major routes by which metals are released into aquatic environment are industrial effluents, municipal and domestic sewage discharges, ship breaking and agriculture activities, exploration and production of oil/gas, and petroleum refinery etc. (Ra *et al.,* 2014). From the study The Copper, Zinc and Iron concentration in the *C. amnicola* range between 0.2-1.9 mg/kg, 5.1-10mg/kg and 7.2 -13mg/kg respectively and were above the WHO/EPA acceptable limit for heavy metals in fish except for Copper that was within the standard. The higher concentration of Zinc and Iron in *C. amnicola* could be as a result of the bioaccumulation of heavy these metals in the test organism as time went by (Obire *et al*., 2006).

The Copper, Zinc and Iron concentration in the Sediment ranges between 0.2-3.4mg/kg, 3.2-7.4mg/kg and 3.8-9.5mg/kg respectively were above the WHO/EPA acceptable limit for heavy metals in sediment except for Copper that varied slightly above at some point and were within the standard at some months.

The Copper, Zinc and Iron concentration in the Surface water range between 0.1-1.5mg/kg, Zn 2.8-8.7mg/kg and 3.9-9.1mg/kg respectively and were above the WHO/EPA acceptable limit for heavy metals in water except for Copper that was within the standard. The presence of less heavy metal concentration in the surface water could be attributed to the effect of dilution from precipitation, on the concentration of heavy metal (Davies *et al.*, 2021). This agrees with Davies and Okonkwo (2021) in their previous study on heavy metal from Ajegunle creek in Lagos showing the same seasonal pattern in metal concentration. The variations in the heavy metals in the different test media show that the value of Cu, Zn and Fe were in the order of *C. amnicola* > Sedimen> Suface Water across the months. Sediment shows the higher accumulation of the metals while the least was observed in the fish. There was minimum heavy metal concentration in *C amnicola* against the higher concentrations in surface water and sediment as reported by Akankali and Davies (2018). Higher concentration of heavy metal in sediment shows that most of the heavy metal present in the surface water settles at the bottom of the water body (Akankali *et al.,* 2019). This could also be attributed to high level of anthropogenic activities observed around the water body. This agrees with Davies and Ekperusi, 2021 who reported that heavy metals in surface waters and sediment in the Niger Delta are largely associated with effluents or spill from the oil and gas industry or from similar anthropogenic factors within the region (Ekperusi *et al*., 2016). This also affirms the report by Akankali and Davies (2021) who stated that sediment act as a sink for contaminants in the aquatic ecosystem and could be an avenue for the recontamination of the water column as a result of turbulence or bioturbation (Akankali and Davies 2021). The levels of chemical distribution in surface waters influence the diversity of life present or adapted to the water column (Akankali *et al.*, 2019).

Although *C. amnicola* may not to be an active site for bio-accumulation, the findings in this study may imply that at chronic exposures in minute concentrations, the carb tissues might bioaccumulation higher concentrate heavy metals that may exceed the permissible limits for human consumption with severe health implications. The effects of these metals (Cu, Zn and Fe) on the health of humans have been shown in nephrotoxicity, neurotoxicity and acute toxicity (Stift *et al*., 2000; Katz and Salem, 1993).

BIOACCUMULATION FACTOR

The values of the metal Bioaccumulation and Transfer factor for the studied heavy metal varied significantly across the months in the fish. Bioaccumulation and transfer factor value of Cu was (> 1) highest in the month of March and least (<1) during in the month of February. Zn was also higher (>) in the month of January to Apri land lower (<1) in the months of May to June. Fe was higher in the months of March to June and lowest in January and February. This is an indication that Cu, Zn and Fe bio-accumulated in *C. amnicola* at different time interval during the period of study which shows that *C. amnicola* bio-accumulated more heavy metals from the sediment than water. This could be because the crab (*C. amnicola*) are mostly found on the sediment during low tide thereby takes up more of the heavy metals while feeding and burrowing (Abdul *et al.*, 2009). This agrees with Eja *et al.*, (2003); Chindah and Braide (2003). However, low BAF could be attributed to assimilation and excretion rate of heavy metals in the organism examined (Moslen and Miebaka, 2017). This potential should qualify the *C. amnicola* to be categorized in the league of some well-known bioindicator species such as the bivalves, mudskipper and shrimps identified as standard bioindicators of aquatic pollution owing to their capability to bioaccumulate and bioconcentrate organic pollutants in tissues in addition to target organs at levels higher than background concentrations (MacFarlane *et al.*, 2000). The variations in the concentration of Cu, Zn and Fe explain the spatiotemporal changes of water body status (Akankali and Davies, 2021). The relationship between the metals and their interaction with the physicochemical parameters of the water can be relation to statement by Davies and Okonkwo (2021) to reported that environmental conditions of an area largely determine the bioavailability, mobility and toxicity of metals. Sharifuzzaman *et al.*, (2016) reported that once metals incorporated into sediments, they are not readily available to aquatic habitats, but changes in physicochemical conditions like pH, temperature, salinity, dissolved oxygen, total suspended solids and organic ligand concentrations can help dissolution of metals from a solid phase and readily available for bioaccumulation.

CONCLUSION

The assessment of the fish, surface water and sediment harvested from the water front of some fishing communities in river state has given an insight into the changing chemical composition and contaminants fluxes of the aquatic environment in Asari-Toru local government area of Rivers state. Most of the physicochemical parameters were within the acceptable limit for freshwater ecosystem except for salinity. The increased heavy metals such as Cu, Zn and Fe were above the recommended limits which could be an indication of a deteriorating water condition in the river. The heavy metals concentration in sediments were higher for all metals compared to the concentration observed in surface waters and crab. This is an indication of the bio-accumulative and elevated metals deposition into sediments which has been reported as sink for contaminants in aquatic ecosystems. The increased uptake of metals reported in the tissues of the crab is a signal that activities along the river could be introducing contaminants which including metals in the food chain. Overtime ingestion of this fish by human in the food chain could lead to a possible risk for neurological disorder hence need for further study and attention for the protection of the aquatic environment, biodiversity and health of the community dwellers.

REFERENCES

Abdul, RW; Wan, VL; Harun, A (2009). Accumulation and Depuration of Heavy Metals in the Hard Clam (*Meretrix meretrix*) under Laboratory Conditions; *Tr. L. Sci. Res.* 20(1):17-24.

Adams, T. G., Atchison, G. J., & Vetter, R. J. (1980). The impact of an industrially contaminated lake on heavy metal levels in its effluent stream. *Hydrobiologia*, *69*(1), 187-193.

Adriano, D. C.: 2001, Trace Elements in Terrestrial Environments: Biogeochemistry, Bioavailability, and Risks of Metals, *Springer*, *New York*, 864 pp.

Akankali, J.A. and Davies, I.C. (2021). Heavy Metals and Physicochemical Parameters Evaluation in the Upper Reaches of Bonny River, Niger Delta, Nigeria. J. Appl. Sci. Environ. Manage. Vol. 25 (8) 1341-1348.

Akankali, J.A. and Davies, I.C. (2020). Analysis of heavy metals concentration in different media of Iwofe Creek, Niger Delta, Nigeria; *International Journal of Scientific and Research Publications*, 10(04): 2250-3153.

Akankali J.A., Davies I.C. and Kpaniku, N. (2019). Assessment of heavy metals concentrations in the upper reaches of Bonny River, Niger delta, Nigeria. African *Journal of Agriculture Technology and Environment*, 8(1): 62-73.

Akankali J.A. and Davies I.C. (2018). Assessment of Heavy Metal Pollutants (Zn & Pb) in New

Calabar River, Niger Delta, Nigeria. *International Journal of Fisheries and Aquatic Studies*. Vol. 6(2): 436-441.

Arimoro, F. O., & Idoro, B. O. (2007). Ecological studies and biology of Callinectes amnicola (Family: Portunidae) in the lower reaches of Warri River, Delta State, Nigeria. World journal of Zoology, 2(2), 57-66.

Asibor IG. 2016. Assessment of heavy metals associated with bottom sediment of Asejire Reservoir, Southwest Nigeria. *International Letters of Natural Sciences*, 55:9-16.

Boltvosky, E. & Wright, R. (1976). *Recent Foraminifera*. The Hague. Junk Publishers.

Chindah, A. C., Braide, A. S. and Sibeudu, O. C. (2004). Distribution of hydrocarbons and tracemetals in sediment and a crustacean (*Penaeus notialis*) from the Bonny River/New Calabar River Estuary, Niger Delta. *African Journal of Environmental Assessment and Management*, 9:1-17.

Chindah, A. C. (2004). The physicochemical quality and phytoplankton community of tropical waters: a case of 4 biotopes in the lower Bonny River, Niger Delta, Nigeria.

Chindah, A. C., Braide, A. S. & Sibeudu, O. C. (2004). Distribution of hydrocarbons and heavy metals in sediment and a crustacean (shrimps: *Penaeus notialis*) from the Bonny/New Calabar River Estuary, Niger Delta. *African Journal of Environmental Assessment and Management*, *9*, 1-17.

Chindah, A. C., Hart, A. I., Braide, S. A., & Amadi, A. (1993). The epibenthic algal community of the Bonny estuary, Niger Delta, Nigeria. *Acta Hydrobiologica*, *4*(35), 307-320.

Davies, I. C., Agarin, O. J., and Onoja C. R. (2021). Study On Heavy Metals Levels and Some Physicochemical Parameters of a Polluted Creek Along the Tin Can Island in Lagos. *International Journal of Environment and Pollution Research.*Vol.9, No.2 pp.25-39,

Davies I C. and Ekperusi A. O. (2021). Evaluation of Heavy Metal Concentrations in Water, Sediment and Fishes of New Calabar River in Southern Nigeria. *Journal of Limnology and Freshwater Fisheries Research* 7(3): 207-218.

Davies, I. C. and Okonkwo, S. E. (2021). Analyses of Some Heavy Metal and Nutrients of Water

Samples from Ajegunle Creek in Lagos. *International Journal of Environment and Pollution Research*.Vol.9, No.1 pp.7-26.

Dublin-Green, C. O. (1990). Seasonal variations in some physiochemical parameters of the Bonny estuary,Niger delta.

Edokpayi CA, Osimen CO. 2001. Hydrobiological Studies on Ibiekuma River at Ekpoma, Southern Nigeria, after Impoundment: The Faunal Characteristics. Afr J Sci Tech.2(1):72-81.

Eja, M. E., Ogri, O. R. A., & Arikpo, G. E. (2003). Bioconcentration of heavy metals in surface sediments from the great Kwa rivers estuary, Calabar, South Eastern Nigeria.

Ekperusi OA, Aigbodion IF, Iloba BN, Okorefe S. 2016. Assessment and bioremediation of heavy metals from crude oil contaminated soil by earthworms. EthiopianJ Environ Stud Managem. 9(2):1036-1046.

Edori, O. S., Kieri, B. S. I. and Festus, C. (2019). Physicochemical Characteristics of Surface

Water and Sediment of Silver River, Southern Ijaw, Bayelsa State, Niger Delta, Nigeria. *American Journal of Environmental Science and Engineering*, 3(2):39-46.

Ezekiel, O. A., Benedict, O. O. and Fidelis, B. A. (2012). Heavy metal profile of water, sediment and freshwater cat fish, *Chrysichthys nigrodigitatus* (Siluriformes: Bagridae), of Cross River, Nigeria. *Revista de Biologia Tropical*, 60(3).

Farooq, S., Hashmi, I., Qazi, I. A., Qaiser, S., & Rasheed, S. (2008). Monitoring of coliforms and chlorine residual in water distribution network of Rawalpindi, Pakistan. *Environmental monitoring and assessment*, *140*(1), 339-347.

Fianko, J. R., Laar, C., Osei, J., Anim, A. K., Gibrilla, A., & Adomako, D. (2013). Evaluation of some heavy metal loading in the Kpeshi lagoon, Ghana. *Applied Water Science*, *3*(1), 311-319.

Horsefall, M. and Spiff, A. I. (2002). Distribution and partitioning of trace metals in sediments of the lower reaches of the New Calabar River, Port Harcourt, Nigeria. *Environmenatl Management and Assessmen*t, 78:309-326.

Horsfall, M. J., Spiff, A. I., & Abia, A. A. (2004). Studies on the influence of mercaptoacetic acid (MAA) modification of cassava (Manihot sculenta Cranz) waste biomass on the adsorption of Cu 2+ and Cd 2+ from aqueous solution. *Bulletin of the Korean Chemical Society*, *25*(7), 969-976.

Jaji MO, Bamgbose O, Odukoya OO, Arowolo TA. 2007. Water quality assessment of Ogun River, South West Nigeria. Environ Monit Assess. 133:473-482.

Katz and Salem, 1993). Heloecius cordiformis: bio-indication potential for heavy metals in estuarine systems. *Aq. Tox. 50*(3), 153-166.

Kabata-Pendias, A. (2010). Trace Elements in Soils and Plants. Expl. Agr. 47(4):548.

Katz, S. A. and Salem, H. (1993). The toxicity of chromium with respect to its chemical speciation: A review. *Journal of Applied Toxicology,* 13:217-224.

Kim, J. Y., Lee, J. H., Kunhikrishnan, A., Kang, D. W., Kim, M. J., Yoo, J. H., ... & Kim, W. I. (2012). Transfer factor of heavy metals from agricultural soil to agricultural products. *Korean Journal of Environmental Agriculture*, *31*(4), 300-307.

Kwok, C. K., Liang, Y., Wang, H., Dong, Y. H., Leung, S. Y., & Wong, M. H. (2014). Bioaccumulation of heavy metals in fish and Ardeid at Pearl River Estuary, China. *Ecotoxicology and Environmental Safety*, *106*, 62-67.

MacFarlane, GR; Booth, DJ; Brown, KR (2000). The semaphore crab, Heloecius cordiformis: bio-indication potential for heavy metals in estuarine systems. *Aq. Tox. 50*(3), 153-166.

Mansi, S.E. (1997). An ecological survey of the benthic macroinvertebrate communities after dredging activities in an intertidal mangrove swamp of the Niger Delta. M.Sc. thesis, University of Port Harcourt, Rivers State, Nigeria.

Moslen, M., & Miebaka, C. A. (2016). Temporal Variation of Heavy Metal Concentrations in *Periophthalmus SP* Obtained from Azuabie Creek in the Upper Bonny Estuary, Nigeria. *Current Studies in Comparative Education, Science and Technology*, *3*, 136-147.

McLusky, D. S. (1989). The estuarine ecosystem. Blackie & Son, Glasgow and London. of consumption of fish (Sarotherodon melanotheron) from an Estuarine Creek in the Niger Delta, Nigeria. *IOSR J Env Sci, Toxicol Food Technol*, *11*, 68-73.

NDES (1997). The Niger Delta Environmental Survey. Environmental and Socio-Economic Characteristics. Lagos, Nigeria: Environmental Resources Managers Limited.

NEDECO (Netherlands Engineering Consultants) (1961) The Waters of the Niger Delta.

NEDECO, The Hague, The Netherlands.

Nriagu, J.O. and Pacyna, J.M., 1988, Quantitative assessment of worldwide contamination of air, water and soils by trace metals: Nature, 333, 134-139.

Obire, O., Tamuno, D. C. and Wemedo, S. A. (2003). Physico-chemical quality of Elechi Creek in Port Harcourt, Nigera. *Journal of Applied Science and Environmental Management.* 7:43-49.

Odokuma, L.O. & Okpokwasili, G.C. (1996). Seasonal influences of the organic pollution monitoring of the New Calabar River, Nigeria. *Environ. Mon. Assess*. 45:43-56.

Okere, M. C., Davies, I. C., Onyena, A. P. (2021). Variation of The Physico-Chemical Parameters, Nutrients and Some Selected Heavy Metals Around the Waters of the Tincan Island in Lagos, Nigeria. *British Journal of Environmental Sciences* Vol.9, No.4, pp. 1-17.

Okonkwo, S. E; Davies I. C; Okere M.C**.** (2021): Assessment of Physico-Chemical Characteristics and Phytoplankton of a Polluted Tidal Creek in Ajegunle, Lagos. *British Journal of Environmental Sciences* 9(1): 51-69, 2021

Onojake, M. C., Sikoki, F. D., Omokheyeke, O., & Akpiri, R. U. (2017). Surface water characteristics and trace metals level of the Bonny/New Calabar River estuary, Niger delta, Nigeria. *Applied Water Science*, *7*(2), 951-959.

Onojake, M. C., Ukerun, S. O., & Iwuoha, G. (2011). A statistical approach for evaluation of the effects of industrial and municipal wastes on Warri Rivers, Niger Delta, Nigeria. *Water Quality, Exposure and Health*, *3*(2), 91-99.

Okpokwasili, G. C., & Odokuma, L. O. (1996). Tolerance of Nitrobacter to toxicity of hydrocarbon fuels. *Journal of Petroleum Science and engineering*, *16*(1-3), 89-93.

Oluyemi EA, Adekunle AS, Adenuga AA, Makinde WO. (2010). Physico-chemical properties and heavy metal content of water sources in Ife North Local Government Area of Osun State, Nigeria. Afr J Environ Sci Technol. 4(10):691-697.

Ra, K; Kim, JK; Hong, S.H; Yim, UH; Shim, WJ; Lee, SY; Kim, KT (2014). Assessment of pollution and ecological risk of heavy metals in the surface sediments of Ulsan Bay, Korea. *Ocean. Sci. J*. *49*(3), 279-289.

Roesijadi G (1994) Metallothionein induction as a measure of response to metal exposure in aquatic animals. Environ Health Perspect 102:91–96.

Sam, K., Coulon, F. and Prpich, G. (2017). A multi-attribute methodology for the prioritisation of oil contaminated sites in the Niger Delta Sci. Total Environ., 579:1323-1332.

Sharifuzzaman, SM; Rahman, H; Ashekuzzaman, SM; Islam, MM; Chowdhury, SR; Hossain, MS (2016). Heavy metals accumulation in coastal sediments. In *Environ. Remed. Techn. for metal-cont. soils.* (pp. 21-42). Springer, Tokyo.

Sikoki FD, Anyanwu IN. 2013. Spatial and Temporal Variations of Physicochemical Variables in a Small Pristine Stream in Niger Delta, Nigeria. J Fish Aquat Sci.8 (1):129-135.

Simeon, E. O., Idomo, K. B. S., & Chioma, F. (2019). Physicochemical Characteristics of Surface Water and Sediment of Silver River, Southern Ijaw, Bayelsa State, Niger Delta, Nigeria. *American Journal of Environmental Science and Engineering*, *3*(2), 39-46.

Skonberg, D.I. *&* Perkins, B.L. (2002). Nutrient composition of green crab (*Carcinus maenus*) leg meat and claw meat. *Food Chemistry*, 72, 401–404.

Stift, A., Friedl J., Langle, F., Berlakorich, G., Steininger, R. and Muhlbacher, F. (2000). Successful treatment of a patient suffering from severe acute potassium dichromate poisoning with liver transplantation. *Transplantation*, 69: 2454-2455.

USDA *(*2003*).* National Nutrient Database for Standard Reference, *Release 16. Nutrient Data Laboratory Home Page. Available* http://www.nal.usda.gov/fnic/foodcomp/search

Wootton, R.J. (1992). *Fish ecology*. New York. Chapman and Hall

Yakubu, A.F., Sikoki, F. D. & Horsfall, M. Jr. (1998). An investigation into the physicochemical conditions and planktonic organisms of the lower reaches of the Nun River, Nigeria. *J. Appl. Sc. Environ. Mgt*., 1: 28 – 42.

World Health Organization (2011). Guidelines for drinking-water quality. *WHO chronicle*, *38*(4), 104-108.

World Health Organization (2006). Guidelines for drinking water quality. 3rd ed. vol. 1. Geneva. Addendum: World Health Organization, 23-48.

Yakubu, A. F., Sikoki, F. D., & Horsfall, M. (1998). An investigation into the physicochemical conditions and planktonic organisms of the lower reaches of the Nun River, Nigeria. *Journal of Applied Science and Environmental Management*, *1*(1), 38-42.

Zabbey, N., Hart, A. I., & Wolff, W. J. (2010). Population structure, biomass and production of the West African lucinid Keletistes rhizoecus (Bivalvia, Mollusca) in Sivibilagbara swamp at Bodo creek, Niger Delta, Nigeria. *Hydrobiologia*, *654*(1), 193-203.

Zabbey, N. (2012). Spatial temporal variability in interstitial water quality of soft- bottom flats at Bodo Creek, Eastern Lower Niger Delta, Nigeria. *Tropical Freshwater Biology*, 21(1): 83-103.

Zabbey, N., Ekpenyong, I.G., Nwipie, G.N., Davies, I.C. and Sam, K. (2021): Effects of fragmented mangroves on macrozoobenthos: a case study of mangrove clearance for powerline right-of-way at Oproama Creek, Niger Delta, Nigeria, *African Journal of Aquatic Science,* 1-11.