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Potential Human Health Risk Assessment and Evaluation of Heavy Metals Contamination in Seafood from River Niger Across Ndoni Town in Onelga, Rivers State

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Abstract- Anthropogenic Sources tend to elevate level of heavy metals in the water bodies. The seafood bio accumulates these metals often times within their body system. This study evaluated the quantities of Lead (Pb), Cadmium (Cd), Chromium (Cr), Nickel (Ni), Copper (Cu), Iron (Fe), Zinc (Zn) and Mn from seafood specifically Periwinkle, Shrimp and Crab obtained from River Niger across Ndoni town in Rivers State. The result obtained was employed in assessing the human health risk. Ninety six samples comprising of Periwinkle, Shrimp and Crab were digested and tested using Flame (F-AAS).The result reflected that the levels of Pb, Cd, Cr, Ni, Cu, Fe, Zn, and Mn ranged from 0.040 ± 0.002to 0.817 ± 0.001 mg/kg; 0.002 ± 0.001 to 0.064 ± 0.001 mg/kg; 0.386 ± 0.005 to 3.422 ± 0.011 mg/kg; 0.670 ± 0.008 to 4.760 ± 0.015 mg/kg; 2.154 ± 0.003 to 9.108 ± 0.003 mg/kg; 5.120 ± 0.012 to 512.31 ± 0.006 mg/kg; 6.137 ± 0.009 to 18.337 ± 0.020 mg/kg; and 2.476 ± 0.029 to 8.322 ± 0.026 mg/kg correspondingly. The concentration of Cr surpassed the permissible values. The results of the human health risk assessment pointed out that it is safe and free from non-carcinogenic carcinogenic risks. However, Cr should be checked to prevent impending health risk from its accumulation in the body.

Index Terms- Heavy metals; seafood; potential; health, risk assessment; Ndoni.

I. INTRODUCTION

Water is essential for all forms of life. Seas and oceans contribute approximately 97%, while the freshwater resources consist only 3% of the entire water reserve of the earth. About 68.7% of the freshwater is locked up in glaciers and ice caps on poles, 30.1% in groundwater, 0.3% in surface water bodies and 0.9% in other forms (Gleick, 1996). So the amount of freshwater on Earth is limited, but its quality is always under suspect as reported by Global Analysis and Assessment of Sanitation. Now, water has a key role in sustaining ecological balance. Moreover, it is not only the main component of the biosphere but also a major part of the living organisms (Pandey, 2006). Life cannot be sustained more than few days without water, while an inadequate supply of water may change the pattern of distribution of organisms as well as of human beings. The widespread scarcity, the gradual destruction and the aggravated pollution of the water resources also lead to degradation of ecosystem. Nowadays, water quality issues are gaining recognition as river waters are getting heavily polluted at many places (Machiwa, 2010). Moreover, groundwater quality, at many places, is beginning to deteriorate to cause serious implications on the supply of water for drinking, irrigation and industrial use as all of them are important determinants of public health. The level of natural contaminants and chemical pollutants is high and also is increasing at several places. Environmental pollution became all the more hazardous as the urban life become more and more prevalent. Rather, it has increased parallel to the industrial development. In the second half of twentieth

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century, increasing environmental pollution due to rapid industrialization and population growth has caused natural resources to become more polluted so that destruction of ecosystem became an acute issue. The effluents discharged from the industries into the water bodies contain many toxic compounds like phenols, oils, pesticides, heavy metals, Xenobiotics and Poly-aromatic hydrocarbons. These effluents affect the physicochemical parameters of water such as temperature, pH, dissolved oxygen, total solids, dissolved solids and suspended solids. These parameters are often employed to assess the water quality (Machiwa, 2010).

In addition, the heavy metals form the core group of pollutants in the industrial and daily life activities. The exceeding contents of heavy metals like Cr, Mn, Fe, Co, Ni, Cu, Zn, Cd and Pb were also reported in several freshwater resources so that the available water has been rendered unsafe for domestic consumption, irrigation, and industrial needs. In a nut shell, this degradation of water quality has led to water scarcity for the human consumption (Machiwa, 2010). Therefore, this study aim to evaluate the concentration of heavy metals and human health risk assessment via the consumption of seafood obtained from River Niger running across Ndoni town in Ogba/Egbema/Ndoni Local Government Area, Rivers State, Nigeria.

II. MATERIALS AND METHODS

2.1 Study Area

Ndoni town, also known as Ndoni, is situated in the Ogba/Egbema/Ndoni Local Government Area of Rivers State, Nigeria. Geographically, it is located approximately at latitude 5.3856° N and longitude 6.7733° E. This places it in the southern part of Nigeria, within the Niger Delta region.

The town is nestled amidst the tropical rainforest biome, characterized by dense vegetation and a humid climate. It is positioned along the banks of the Niger River, which serves as a significant geographical feature in the area. Ndoni is surrounded by other communities within the Niger Delta, contributing to its cultural diversity and economic activities, including agriculture, fishing, and oil production, which are vital industries in the region.

Figure 1: Map of study area

2.2 Sample Collection

Random sampling technique was employed to collect the seafood samples of Shrimps (*Macurbrachium rosenbergii*), Crab (*Callinectes sapidus*) and Periwinkle (*Vincaminor*) around River Niger running across Ndoni in Ogba/Egbema/Ndoni local government area to obtain composite samples. The seafood was separated and samples were labelled accordingly.

2.3 Sample Preparation

In the laboratory, the collected samples were washed with distilled water to remove the mud, fouling substances or contaminated particles. Muscle tissue of the collected specimens (dorsal muscle), which considerd as the major target tissue for metal storage (Rejomon et al., 2010), was removed for metal analysis with a clean stainless steel knife. Tissues were cut and air-dried to a constant weight for removing the extra water and then stored at −20 °C. A wet digestion method was used and determination of metals was performed with a Solar ThermoElemental Flame Atomic Absorption Spectrometer (STEF-AAS) (Model S4-71096, Germany). Each sample was analyzed in triplicate and double-distilled deionised water was used throughout the study. Prior to use, the glassware and plasticware (Merck, Germany) were sanitized with 10% HNO3 followed by washing with deionised distilled water. One gram of each sample was carefully weighed in a conical flask. Two milliliter (2mL) of the mixed acid H2SO4: HNO3: HClO4 in the ratio of 40: 40: 20 was added and then digested in a hot plate under a fume cupboard until white fumes appeared. It was allowed to cool down, then transferred into a 100 ml volumetric flask and filled up to the 100 ml mark of the volumetric flask with distilled water.

2.4 Health Risk Assessment

Several toxicological indices as mentioned below were used to estimate the health risk as a consequence of seafood consumption. In this work, the health hazard, due to metals ingestion via fish consumption, were based on heavy metal evaluation and records according to EPA guidelines (2004).

2.5 Estimated Daily Intake (EDI)

EDI is related to metals in seafood and water was calculated for adults and children by the following formula (US EPA, 2004; USEPA, 2011)

$$\text{EDI (mg/kg/day)} = \frac{\text{C} \times \text{IR}}{\text{BW}}$$

Where:

C = concentration of the metal in seafood (mg/kg);

IR = ingestion rate for seafood (0.038 kg/day for adults and 0.023 kg/day for children);

BW = average body weight (70 kg for adults and 24 kg for children)

2.6 Non-Carcinogenic Health Effect

2.6.1 Target Hazard Quotient (THQ)

Non- carcinogenic hazard estimation of heavy metals intake was determined using THQ values. THQ is a ratio of the determined dose of a pollutant to a reference level which was taken into consideration. THQs were calculated consistent with the technique defined by the Environmental Protection Agency (EPA) in the USA (USEPA, 1989; Singh et al., 2010; USEPA, 2011).

THQ = EDI/RfD

Where:

EDI is estimated daily intake

RfD is reference dose of the metals

2.6.2 Hazard Index (HI)

Human health risks due to the intake of metal contaminated seafood was assessed by determining the Hazard Index (HI). If the value of HI is below 1, then the uncovered populace is probably not going to encounter evident antagonistic impacts. While HI value above 1 means that there is a possibility of non-carcinogenic effect, with an increasing probability as the value increases. The Supposing cumulative effects, HI was calculated as follows:

Total Hazard Index (HI) = Sum of THQ (THQ_{Pb} + THQ_{Cd} + THQ_{Cr} + THQ_{Cr}…….)

Where:

THQ is target hazard quotient

2.7 Carcinogenic Health Effect

2.7.1 Lifetime Cancer Risk (LCR)

USEPA distinguishes between the cancer-causing agents by the load of proof characterization of the compound. The evaluated every day portion and the malignant slope factor were multiplied together to determine the lifetime cancer chance presented by the metal hazard. Malignancy slope factors are evaluations of cancer-causing intensity and are utilized to relate every day portion of a substance over a lifetime. Ingestion malignancy incline factors are communicated in units of (mg/kg/day).

Lifetime likelihood of reaching disease due to the cancer-causing synthetic substances is determined as follows:

Lifetime Cancer Risk = EDI x CSFing

Where:

EDI is the estimated daily intake of each heavy metal (mg/kg/day)

CSFing is the ingestion cancer slope factors $(\text{mg/kg/days})^{-1}$

USEPA in 2011 stated that 10^{-6} (1 of every 1,000,000) to 10^{-4} (1 out of 10,000) is a range of passable anticipated lifetime dangers for cancer-causing agents. Metals for which the hazard factor falls underneath 10-6 might be disposed of from further thought as a compound of concern. The hazard related with the cancer-causing impact of target metal is communicated as the abundance likelihood of reaching malignant growth over a lifetime of 70years.

2.8 Statistical Analysis

The data was analysed using statistical package for social science version 16.0 (SPSS Inc., Chicago, IL, USA). The mean and the standard deviation error were obtained to compare the variation between groups of same sample.

III. RESULTS

3.1 Heavy Metals Concentration in Seafood

Seafood samples comprising of periwinkle, shrimps and crab from River Niger running across Ndoni town were analysed for lead (Pb), cadmium (Cd), chromium (Cr), nickel (Ni), copper (Cu), iron (Fe), zinc (Zn) and manganese (Mn). The mean levels and standard error of Ni in the sea foods varied between 0.670 ± 0.008 to 4.760 ± 0.015 mg/kg with crab from site A recording the highest concentration of Ni. However, the lowest concentration was seen in shrimp from Site B.

The concentration of Cu in the sea foods collected from the different sites was from 2.154 ± 0.003 to 9.108 ± 0.003 mg/kg. The highest concentration of Cu was recorded in periwinkle from Site B; while the lowest concentration was seen in shrimp from Site C.
The mean levels and standard error of mean of Fe in the sea foods were from 5.120 ± 0.012 to 512.31 ± 0.006 mg/kg with crab from site A recording the highest concentration. The lowest concentration was observed in shrimp from Site D.

The concentration of Zn in the sea foods collected from the different sites was from 6.137 ± 0.009 to 18.337 ± 0.020 mg/kg. The highest concentration of Zn was recorded in crab from Site A; meanwhile the lowest concentration was seen in crab from Site D.

The mean levels and standard error of mean of Mn in the sea foods varied from 2.476 ± 0.029 to 8.322 ± 0.026 mg/kg with crab from site B recording the highest concentration. The lowest concentration was observed in periwinkle from Site D.

Table 3.1: Concentration (mg/kg) of Heavy Metals in Sea foods from four Points in River Niger across Ndoni in Ogba/Egbema/Ndoni LGA, Rivers State, Nigeria

Points	Sample/Metals	Pb	Cd	Cr	Ni	Cu	Fe	Zn	Mn
A	Periwinkle (A)	0.360 ± 0.005	0.013 ± 0.001	1.803 ± 0.014	3.437 ± 0.011	8.215 ± 0.003	9.536 ± 0.006	13.070 ± 0.025	2.494 ± 0.014
	Shrimp (A)	0.083 ± 0.003	0.005 ± 0.001	0.890 ± 0.004	1.693 ± 0.022	3.156 ± 0.002	8.126 ± 0.003	6.262 ± 0.020	5.133 ± 0.018
	Crab (A)	0.174 ± 0.001	0.046 ± 0.001	2.041 ± 0.006	4.760 ± 0.015	5.429 ± 0.002	12.31 ± 0.006	18.337 ± 0.020	7.132 ± 0.023
B	Periwinkle (B)	0.628 ± 0.002	0.007 ± 0.001	1.424 ± 0.003	2.417 ± 0.003	9.108 ± 0.003	7.191 ± 0.008	9.344 ± 0.012	4.900 ± 0.017
	Shrimp (B)	0.040 ± 0.002	0.002 ± 0.001	0.386 ± 0.005	0.670 ± 0.008	5.184 ± 0.001	10.64 ± 0.005	8.159 ± 0.010	6.426 ± 0.020
	Crab (B)	0.106 ± 0.001	0.037 ± 0.001	2.382 ± 0.012	4.295 ± 0.004	7.645 ± 0.002	8.519 ± 0.005	12.069 ± 0.039	8.322 ± 0.026
C	Periwinkle (C)	0.414 ± 0.001	0.017 ± 0.001	1.164 ± 0.005	2.872 ± 0.010	4.110 ± 0.002	9.397 ± 0.008	10.534 ± 0.023	3.919 ± 0.021

	Shrimp (C)	0.128 ± 0.001	0.003 ± 0.001	3.422 ± 0.011	1.383 ± 0.010	2.154 ± 0.003	5.433 ± 0.009	9.139 ± 0.023	5.967 ± 0.018
	Crab (C)	0.817 ± 0.001	0.016 ± 0.001	2.616 ± 0.007	3.617 ± 0.002	3.524 ± 0.003	8.295 ± 0.014	7.159 ± 0.023	4.196 ± 0.014
D	Periwinkle (D)	0.303 ± 0.002	0.064 ± 0.001	1.156 ± 0.009	2.140 ± 0.002	8.633 ± 0.005	5.730 ± 0.006	8.123 ± 0.009	2.476 ± 0.029
	Shrimp (D)	0.061 ± 0.001	0.003 ± 0.001	0.734 ± 0.004	0.812 ± 0.002	6.724 ± 0.003	5.120 ± 0.012	9.646 ± 0.018	6.140 ± 0.026
	Crab (D)	0.246 ± 0.001	0.060 ± 0.002	1.863 ± 0.006	4.524 ± 0.005	4.652 ± 0.012	6.042 ± 0.032	6.137 ± 0.009	3.050 ± 0.029
Turkish (TFC, 2002)		1.0	0.1			20		50	20
EU (2006) (crustacean) mg/kg/bw	mg/kg	0.5	0.5	0.5		5		50	
WHO/FAO, 2001 mg/kg					0.02	5		50	
Institute of Medicine (IOM, 2003) mg/kg							40-45	40	

3.2 Estimated Daily Intake of Heavy (EDI)

Table 3.2 is a representation of the Estimated Daily Intake (EDI) of Lead (Pb), Cadmium (Cd), Chromium (Cr), Nickel (Ni), Copper (Cu), Iron (Fe), Zinc (Zn) and Manganese (Mn) in periwinkle, shrimp, and crabs derived from four points in River Niger running across Ndoni in Ogba/Egbema/Ndoni Local Government Area, Rivers state, Nigeria.

The EDI of Pb in the seafoods ranged from 0.005 to 0.097 mg/kg/bw with crab from site C recording the highest EDI of Pb. However, the lowest EDI was seen in shrimp from Site B.

The EDI of Cd in the seafoods ranged from 0.000 to 0.064 ± 0.008 mg/kg/bw with periwinkle from site D recording the highest EDI. The lowest was observed in shrimp from Site B.

The EDI of Cr in the seafood collected from the different sites was from 0.046 to 0.406 mg/kg/bw. The highest and lowest EDI of Cr was recorded in shrimp from Site C and A respectively.

The EDI of Ni in the sea foods varied between 0.079 to 0.564 mg/kg/bw with crab from site A recording the highest EDI of Ni. However, the lowest EDI was seen in shrimp from Site B.

The EDI of Cu in the seafood collected from the different sites was from 0.255 to 1.080 mg/kg/bw. The highest EDI of Cu was recorded in periwinkle from Site B; while the lowest was seen in shrimp from Site C.

The EDI of Fe in the seafood were from 0.607 to 1.460 mg/kg/bw with crab from site A recording the highest EDI. The lowest EDI was observed in shrimp from Site D.

The EDI of Zn in the seafood collected from the different sites was from 0.728 to 2.174 mg/kg/bw. The highest EDI of Zn was recorded in crab from Site A; meanwhile the lowest EDI was seen in crab from Site D.

The EDI of Mn in the sea foods varied from 0.294 to 0.987 mg/kg/bw with crab from site B recording the

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highest EDI. The lowest EDI was observed in periwinkle from Site D.

Table 3.2: Estimated Daily Intake (mg/kg/BW/day) of Heavy Metals in Adult Population via Seafood Consumption from four Points in River Niger across Ndoni in Ogba/Egbema/Ndoni LGA, Rivers State, Nigeria

Sample/Metals	Pb	Cd	Cr	Ni	Cu	Fe	Zn	Mn
Periwinkle (A)	0.043	0.002	0.214	0.408	0.974	1.131	1.550	0.296
Shrimp (A)	0.010	0.001	0.106	0.201	0.374	0.964	0.742	0.609
Crab (A)	0.021	0.005	0.242	0.564	0.644	1.460	2.174	0.846
Periwinkle (B)	0.074	0.001	0.169	0.287	1.080	0.853	1.108	0.581
Shrimp (B)	0.005	0.000	0.046	0.079	0.615	1.262	0.967	0.762
Crab (B)	0.013	0.004	0.282	0.509	0.906	1.010	1.431	0.987
Periwinkle (C)	0.049	0.002	0.138	0.341	0.487	1.114	1.249	0.465
Shrimp (C)	0.015	0.000	0.406	0.164	0.255	0.644	1.084	0.708
Crab (C)	0.097	0.002	0.310	0.429	0.418	0.984	0.849	0.498
Periwinkle (D)	0.036	0.008	0.137	0.254	1.024	0.679	0.963	0.294
Shrimp (D)	0.007	0.000	0.087	0.096	0.797	0.607	1.144	0.728
Crab (D)	0.029	0.007	0.221	0.536	0.552	0.716	0.728	0.362
Reference Dose	0.0035	0.0005	1.5	0.02	0.04	0.007	0.3	0.14

Singh et al., (2010)

3.3 Target Hazard Quotient (THQ) and Hazard Index of Heavy Metals in Adult Population via Seafood Consumption

Table 3.3 is a representation of the target hazard quotient (THQ) and hazard index (HI) of Lead (Pb), Cadmium (Cd), Chromium (Cr), Nickel (Ni), Copper (Cu), Iron (Fe), Zinc (Zn) and Manganese (Mn) in periwinkle, shrimp, and crabs derived from four different locations in River Niger across Ndoni town in Ogba/Egbema/Ndoni Local Government Area, Rivers state, Nigeria.

The THQ of Pb in the sea foods ranged from 0.0014 to 0.0277 with crab from site C recording the highest THQ of Pb. However, the lowest THQ was seen in shrimp from Site B.

The THQ of Cd in the sea foods ranged from 0.0005 to 0.0152 with periwinkle from site D recording the highest THQ. The lowest was observed in shrimp from Site B.

The THQ of Cr in the sea foods collected from the different sites was from 0.0000 to 0.0003. The highest

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and lowest THQ of Cr was recorded in shrimp from Site C and B respectively.

The THQ of Ni in the sea foods varied between 0.0040 to 0.0282 with crab from site A recording the highest THQ of Ni. However, the lowest THQ was seen in shrimp from Site B.

The THQ of Cu in the sea foods collected from the different sites was from 0.0064 to 0.0270. The highest THQ of Cu was recorded in periwinkle from Site B; while the lowest was seen in shrimp from Site C.

The THQ of Fe in the sea foods were from 0.0867 to 0.2085 with crab from site A recording the highest THQ. The lowest THQ was observed in shrimp from Site D.

The THQ of Zn in the sea foods collected from the different sites was from 0.0024 to 0.0072. The highest THQ of Zn was recorded in crab from Site A; meanwhile the lowest THQ was seen in crab from Site D.

The THQ of Mn in the sea foods varied from 0.0021 to 0.0070 with crab from site B recording the highest THQ. The lowest THQ was observed in periwinkle from Site A

Table 3.3: Target Hazard Quotient (THQ) of Heavy Metals in Adult Population via Seafood Consumption from four Points in River Niger across Ndoni in Ogba/Egbema/Ndoni LGA, Rivers State, Nigeria

Sample/Metals	Pb	Cd	Cr	Ni	Cu	Fe	Zn	Mn	HI
Periwinkle (A)	0.0122	0.0031	0.0001	0.0204	0.0244	0.1615	0.0052	0.0021	0.23
Shrimp (A)	0.0028	0.0012	0.0001	0.0100	0.0094	0.1376	0.0025	0.0043	0.17
Crab (A)	0.0059	0.0109	0.0002	0.0282	0.0161	0.2085	0.0072	0.0060	0.28
Periwinkle (B)	0.0213	0.0017	0.0001	0.0143	0.0270	0.1218	0.0037	0.0042	0.19
Shrimp (B)	0.0014	0.0005	0.0000	0.0040	0.0154	0.1694	0.0032	0.0054	0.20
Crab (B)	0.0036	0.0088	0.0002	0.0255	0.0227	0.1443	0.0048	0.0070	0.22
Periwinkle (C)	0.0140	0.0040	0.0001	0.0170	0.0122	0.1592	0.0042	0.0033	0.21
Shrimp (C)	0.0043	0.0007	0.0003	0.0082	0.0064	0.0920	0.0036	0.0051	0.12
Crab (C)	0.0277	0.0038	0.0002	0.0214	0.0104	0.1405	0.0028	0.0036	0.21
Periwinkle (D)	0.0103	0.0152	0.0001	0.0127	0.0256	0.0971	0.0032	0.0036	0.17
Shrimp (D)	0.0021	0.0007	0.0001	0.0048	0.0199	0.0867	0.0038	0.0052	0.12
Crab (D)	0.0083	0.0142	0.0001	0.0268	0.0138	0.1023	0.0024	0.0026	0.17
Reference Value	1	1	1	1	1	1	1	1	1

3.4 Carcinogenic Risk (CR) of Heavy Metals in Adult Population via Seafood

Table 3.3 is a representation of the Carcinogenic Risk (CR) of Lead (Pb), Cadmium (Cd), Chromium (Cr), Nickel (Ni), Copper (Cu), Iron (Fe), Zinc (Zn) and Manganese (Mn) in periwinkle, shrimp, and crabs derived from four different locations in River Niger across Ndoni in Ogba/Egbema/Ndoni LGA, Rivers State, Nigeria.

The CR of Pb in the sea foods ranged from 4.0E-08 to 8.2E-07 with crab from site C recording the highest CR of Pb. However, the lowest CR was seen in shrimp from Site B.

The CR of Cd in the sea foods ranged from 3.6E-06 to 1.1E-04 with crab and periwinkle from site D recording the highest CR. The lowest CR was observed in shrimp from Site B.

The CR of Cr in the sea foods collected from the different sites was from 2.3E-05 to 2.0E-04. The highest and lowest CR of Cr was recorded in shrimp from Site C and B respectively.

The CR of Ni in the sea foods varied between 7.2E-05 to 5.1E-04 with crab from site A recording the highest CR of Ni. However, the lowest CR was seen in shrimp from Site B.

NOTE: Copper (Cu), Fe, Zn, and Mn have no Cancer slope factor for the carcinogenic calculations, hence; have no CR emanating from them

Table 3.4: Carcinogenic Risk (CR) of Heavy Metals in Adult Population via Sea foods Consumption from four Points in River Niger across Ndoni in Ogba/Egbema/Ndoni LGA, Rivers State, Nigeria

Sample/Metals	Pb	Cd	Cr	Ni	Cu	Fe	Zn	Mn
Periwinkle (A)	3.6E-07	2.3E-05	1.1E-04	3.7E-04	-	-	-	-
Shrimp (A)	8.4E-08	8.9E-06	5.3E-05	1.8E-04	-	-	-	-
Crab (A)	1.8E-07	8.2E-05	1.2E-04	5.1E-04	-	-	-	-
Periwinkle (B)	6.3E-07	1.2E-05	8.4E-05	2.6E-04	-	-	-	-
Shrimp (B)	4.0E-08	3.6E-06	2.3E-05	7.2E-05	-	-	-	-
Crab (B)	1.1E-07	6.6E-05	1.4E-04	4.6E-04	-	-	-	-
Periwinkle (C)	4.2E-07	3.0E-05	6.9E-05	3.1E-04	-	-	-	-
Shrimp (C)	1.3E-07	5.3E-06	2.0E-04	1.5E-04	-	-	-	-
Crab (C)	8.2E-07	2.8E-05	1.6E-04	3.9E-04	-	-	-	-
Periwinkle (D)	3.1E-07	1.1E-04	6.9E-05	2.3E-04	-	-	-	-
Shrimp (D)	6.1E-08	5.3E-06	4.4E-05	8.8E-05	-	-	-	-

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Crab (D)	2.5E-07	1.1E-04	1.1E-04	4.9E-04	-	-	-	-
Reference Value	$10^{-6} – 10^{-4}$	$10^{-6} – 10^{-4}$	$10^{-6} – 10^{-4}$	$10^{-6} – 10^{-4}$	$10^{-6} – 10^{-4}$	$10^{-6} – 10^{-4}$	$10^{-6} – 10^{-4}$	$10^{-6} – 10^{-4}$

IV. DISCUSSION

The concentration of Heavy metals in periwinkle, shrimp, and crab from four different sites obtained from River Niger across Ndoni town in Ogba/Egbema/Ndoni Local Government Area, Rivers state, Nigeria is given in Table 3.1. The distribution of the heavy metal concentrations in periwinkle was Zn > Fe > Cu > Ni > Mn > Cr > Pb > Cd whereas in Shrimp was Fe > Zn > Mn > Cu > Ni > Cr > Pb > Cd, and Crab was Zn > Fe> Mn > Cu > Ni > Cr > Pb > Cd respectively. In general, the concentration orders of heavy metals were found to be Crab > Periwinkle > Shrimp for the studied sea food species. Heavy metals can accumulate in fish and shrimp tissues, which are generally found in the last zone of the aquatic food chain and they could have adverse effects on human health when consumed. Metals are usually taken from food and water in fish and shrimp, distributed by circulation and eventually accumulated in target organs. In the present study, the highest concentrations of heavy metals were found in the liver and gill tissues in all species in every season. The liver and gill are metabolically active tissues with tendency to accumulate high levels of heavy metals (Kargin and Çogun, 1999).

It was observed from the result of the present study that most of the seafood analysed for Pb were below the 1.0 and 0.5 mg/kg permissible limit recommended by Turkish (TFC, 2002) and European Union (EU) (2006). Only periwinkle and crab obtained from sites B and C respectively exceeded the 0.5 mg/kg recommended by EU, 2006 which may indicate that periwinkle and crab obtained from sites B and C may be contaminated as a result of excess accumulation of Pb in them. However, all the sea foods across all sites were within the recommended 1.0 mg/kg BY Turkish (TFC, 2002) guideline which is suggestive that they may not be contaminated with heavy metals as suggested by the Turkish guideline. This shows that the sea foods have a considerable Pb values in them which may not result to Pb poisoning to the exposed populace via consumption of the sea foods which serve as food. The low concentration of Pb in the examined organisms might be because of proper regulation and monitoring of the aquatic environment from waste dumping, curbing of illegal bunkering and the protection of the pipelines within the water vicinities. Contaminants in water system water, ranch soil (ranch site) debased by unrefined petroleum from oil investigation and misuse or because of contamination from the interstate traffic are the major cause of Pb elevation in the water bodies (Qui *et al.,* 2000; Baird, 2002). Furthermore, low concentration of Pb could be as a result of decrease in mobile metal fraction of Pb and high low level of oil exploitation (Siebe, 1995).

The Pb values obtained from the present study were comparable to the values reported by Abu and Nwokoma (2016) on the bioaccumulation of selected Heavy metals in water, sediment and blue crab (*Callinectes amnicola*) from Bodo creek, Niger Delta, Nigeria. However, the present study disputed with the study of Farombi*et al*., (2007) who reported higher Pb, Cd, and Fe are major heavy metals associated with Nigerian crude oils. Also antifouling paints which are employed to stop or reduce the germination of marine organism in boats tend to culminate Pb as an important component. Subsequently, the concentrations of Pb gotten from the present examination corroborated with that obtained from the investigation announced by Agwu*et al*., (2018). The present examination discovered lower estimations of Pb. Moreover, the concentrations of Pb got from this investigation was not in tandem with the study of Turkmen and Ciminli, (2007) in sea foods items from Turkey which went between (0.09 to 6.95 mg/kg) which reported higher level of Pb in the examination titled 'Determination of metals in fish and mussel species by inductively coupled pasma-atomic emission spectrometry'. Furthermore, the level of Pb got from the present examination were comparable to the study reported by Gorur*et al*., (2012) in the investigation titled 'Radioactivity and densemetal levels of some commercial fish species expended operating at a profit ocean locale of Turkey which has Pb fixations running between (< 0.001 to 0.06 mg/kg).

Lead is not useful for fish, and increased exposure can cause decreases in the sustenance of life, and growth rates, as well as development and metabolism, in addition to increased mucus formation. Lead likewise bio accumulates in the human body over long periods of eating these foods. The bioaccumulation after some time is the significant test as higher levels of Pb can irreversibly harm the brain (Bakare-Odunola MT, 2005; WHO, 2008; Lawrence W, 2014). Lead is a commutative toxin and a potential human cancer-causing agent. It might likewise cause the advancement of autoimmunity where an individual's insusceptible framework assaults its own cells. This can prompt joint sicknesses and illness of the kidneys, circulatory framework and neurons (Bakare-Odunola MT, 2005). Lead can trigger both intense and ceaseless manifestations of poisoning. Intense Inebriations happen through ingestion of huge single dosages of solvent lead salts while ceaseless inebriations can emerge through ingestion of subtle Pb doses. Kids are especially in danger of lead toxicity, especially at birth, since they retain lead more quickly than grown-ups. Neurologic problems in children are the principal concern of chronic Pb exposure (Goyer and Clarkson, 2001). As indicated by Parkin *et al*., 2010, there is an increase in malignant growth cases, disabled neurological issue, and lack of healthy sustenance among youngsters in Uganda. Be that as it may, dietary commitment particularly of debased meats and meat contributing to these malignant growths remains obscure.

The findings from this study showed that all of the sea food analyzed for Cd recorded concentrations below the 0.1 and 0.5 mg/kg permissible limits recommended by Turkey (TFC, 2002) and EU, 2006 respectively. Generally, there was no increase level of Cd in the analyzed sea food. The lower value of Cd may be attributed to low usage of fertilizer in cultivation. This is because fertilizers may be washed into the river which tends to elevate the Cd concentration in water which is further accumulated by the tissues of fishes, since we are devoid of fertilizers , there may be reduced Cd accumulation the seafoods.

The low concentrations of Cd observed in this study does not concur with the study by Farombi*et al*., (2007) who reported high concentrations of Cd in Scylla serrata sample. These low levels of Cd obtained is owed to the antifouling paints which were mainly employed to stop the germination of marine organisms in boat. Furthermore, the concentrations of Cd levels disagree with that reported by Nkpaa *et al*., (2013) which reported higher Cd level compared to the present study. Exposure to Cadmium has been accounted for to contribute to kidney damage and hypertension (Yujun Y *et al*., 2011; Sivaperumal P *et al*., 2007; Lawrence, 2014). Humans are exposed to cadmium through food and the average daily intake for adults has been estimated to be approximately 50 mg (Calabrese *et al*., 1985). The limit for intense cadmium poisoning is accounted for to be a complete ingestion of 3-15 mg. Serious dangerous manifestations are accounted for to happen with ingestions of 10-326 mg. Lethal ingestions of cadmium, causing shock and intense renal failure, happen from ingestions surpassing 350 mg (NAS-NRC, 1982; NAS-NRC, 1974; NAS-NRC, 1975). Genuine wellbeing side effects could radiate from the admission of Compact disc and side effects have been accounted for Cd esteems running from 10-326 mg g–1 (EPA, 2004). Deadly admission of Cd brings about shock and intense renal damage and can occur from consumption above 350 mg g–1. (Obrien *et al*., 2003).

It was observed from the study that all the sea food samples analyzed for Cr exceeded the 0.5 mg/kg permissible limit by EU, (2006). Consequently, this shows that, the concentrations of Cr in the analysed sea food samples were high and may lead to health risk through the frequent consumption of the sea food by the populace of the study area. Khandanker*et al*., (2015) reported lower level of Cr which ranged between < 0.001 to 0.73 mg/kg when compared with the Cd concentration of the present study. The high concentrations of Cr in the present study may be attributed to the increased level of crude oil exploration, exploitation and pipeline destruction which results to spillage that tend to be leached into the water bodies thereby increasing the level of Cr in the water bodies which are in turn bio accumulated by the sea foods.

Chromium is an essential trace element but has been reported as a known carcinogen if ingested at a daily dose greater than 0.5 mg kg^{-1} of body weight (Rashed, 2001). Chromium is an essential metal in humans and some animals, but the occurrence of excessive levels of it is regarded as a potential hazard which can endanger both fish and human health. Furthermore, Cr can be said to be an essential trace element (Mertz, 1969) and the biologically usable form of chromium plays an essential role in glucose metabolism. It has been estimated that the average human requires nearly 1g/day. Deficiency of chromium results in impaired growth and disturbances in glucose, lipid, and protein metabolism.

The concentration of Ni in the all the sea food analyzed in the present study exceeded the 0.02 mg/kg permissible limit recommended by WHO/FAO, 2001. This is an indication that there may be contamination of the sea foods emanating from Ni, this could be an impending health danger that may awaits the populace of this studied area. The concentration of Ni obtained from this studied disputed the report of Iwuanyanwu, *et al*., 2020 who reported lower Ni concentrations. This high Ni attainable from the present study may be as a result of excessive bush burning, vehicular and motor bike movements which generates smokes that get into the water bodies and settle in water thereby elevating the level of Ni in water bodies. The report of Chien*et al*., 2002 was not in tandem with the level of Ni from this present study which reported higher Ni concentrations. Inhaled Ni carbonyl, a carcinogenic gas that results from the action of nickel with heated carbon monoxide from cigarette smoke, car exhaust, and some industrial wastes is very toxic and Ni allergy can also cause systematic reactions (WHO, 2004).

The findings in this study shows that the concentrations of Cu in all the analyzed sea food samples were below the 20 mg/kg required permissible limits by Turkey (TFC, 2002). However, some the samples notably periwinkle from sites A, B and D, crab obtained from sites A and B, and shrimp from site D were more than the 5.0 mg/kg permissible limit by EU (2006). The mean concentration of Cu in this study were more than the values reported by Agwu*et al.,* (2018) and Usero*et al*., (2003) which has Cu ranged of 0.4 to 1.5 mg/kg.

Copper is an essential metal so is needed in high quantity in the body so this is an indication that the concentration of Cu in the analyzed sea food samples were within the recommended permissible limit by WHO/FAO (1989) and USEPA (Mishra *et al*., 2007). Copper is an essential trace element. It facilitates iron uptake and serves as a constituent of respiratory enzyme complexes in the human body.

The concentration of Fe from the current study showed that all the analyzed sea food samples fall below the permissible limit of 40 – 45 as recommended by Institute of Medicine (IOM, 2003). Iron is an essential metal so is needed in higher quantity in the body system reason for its high permissible limit; however it may become toxic if it exceeds the permissible required limit in the body.

Iron is essential for the synthesis of chlorophyll and activates a number of respiratory enzymes in plants. The deficiency of Fe results in severe chlorosis of leaves in plants. High levels of exposure to Fe dust may cause respiratory diseases such as chronic bronchitis and ventilation difficulties.

The concentration of Zn from this study showed that the sea food samples were lower than the 50, 50, and 40 mg/kg permissible limit by Turkey (TFC, 2002) , EU, (2006), and Institute of Medicine (IOM, 2003) respectively. Since Zn is an essential metal, it is required in high quantity so the analyzed sea food samples indicate that there may not be toxicity resulting from Zn, since the concentration of Zn were within the recommended permissible limit by the various health bodies.

From this analysis, the concentrations of Zn are lower than those reported by Nkpaa*et al*., (2013). Zinc is an important trace component that results in delayed development, loss of taste, dermatitis, alopecia, hypogonadism and reduced fertility (EPA, 2004). Excessive intake of Zn can lead to acute toxicity

The concentration of Mn from the present study was lower than the permissible limit recommended by Turkey (TFC, 2002). This is an indication that the sea food samples may not be

Contaminated as a result of Mn. The report of Mahmood and Malik, 2014 corroborated with the result of the present study who reported similar Mn concentration as compared with the present study. Generally, the result of this present study shows that there may not be contamination of the sea foods emanating from Mn.

The Estimated Daily Intake (EDI) of metals in the adult population was compared with the Reference oral dose of the individual metals. The EDI of Pb, Ni, Cu, Fe, and Zn analyzed in this present study exceeded the recommended reference dose (RfDo) (Singh *et al*., 2010). This simply intake that the populace may be in danger of developing health risk as a result of excessive and frequent ingestion of these sea foods that have bio accumulated these metals which in turn get into the body system and accumulate thereby exposing the populace to various diseases. In addition, over 20 % of the EDI of Cd exceeded the RfDo of Cd notably crab from sites A and D and periwinkle from site D which may be a point of health concern emanating from Cd toxicity. The EDI of Cr and Mn were below their respective oral reference dose (RfDo) (Singh *et al*., 2010) which is an indication that there may not be health danger resulting from Cr and Mn toxicity as a result excess ingestion of these sea foods into the body system.

The THQ of Pb, Cd, Cr, Ni, Cu, Fe, Zn and Mn were below 1 (THQ < 1).
This simply indicates that the population of the study area may not be exposed to a noncarcinogenic health risk due to the ingestion of the metals analyzed by sea food consumption

Likewise, the HI of Pb, Cd, Cr, Ni, Cu, Fe, Zn and Mn for adults were all below 1 (THQ<1) suggesting that there may be no risk or toxicity associated with non-carcinogenic ingestion of these metals by sea food intake.

The U.S. Environmental Protection Agency reported that 10^{-6} to 10^{-4}
is the range of allowable lifetime risk expected for ca rcinogens.The LCR of Pb, Cd, and Cr was within the range of allowable expected lifetime risk for carcinog ens in the adult population of the study area. This indicates that there may not be lifetime risk of developing cancer over time due to the ingestion of Pb, Cd, and Cr. Generally, from the point of collection of samples as the result has suggested, there may not be carcinogenic risk over time from metals consumption in the sea foods.

CONCLUSION

The result from the concentrations of metals showed that Cr exceeded its permissible limit an indication that there may be contamination of the sea foods as a result of Cr. Furthermore, all the analyzed metals (Pb, Cd, Cr, Ni, Cu, Fe, Zn, and Mn) have their THQ and HI less than 1 showing there may not be non-carcinogenic risk gotten by gradual eating of the seafood. In addition, the LCR of Pb, Cd, and Cr were normal, therefore may not be any resultant cancer risk as a result of carcinogenic consumption of foods over time.

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