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Proximate, Mineral and Heavy Metal Compositions of some Seafood in Oil Producing Communities of Bayelsa State, Nigeria

SP Daworiye[*], SI Okorondu, IN Nwachukwu, W Braide[*]

Department of Microbiology, Federal University of Technology, P.M.B 1526, Owerri, Imo State, Nigeria

[*]**Corresponding author(s):** SP Daworiye, Department of Microbiology, Federal University of Technology, P.M.B 1526, Owerri, Imo State, Nigeria. Email: stephendaworiye@gmail.com

W Braide, Department of Microbiology, Federal University of Technology, P.M.B 1526, Owerri, Imo State, Nigeria. Email: wesley-braide2005@yahoo.com; braide.wesley@futo.edu.ng

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Abstract

Seafood serve as a major source of nutrients in the riverine oil producing communities of Bayelsa State, Nigeria. Oil exploration and exploitation activities over the years affects the proximate, mineral and heavy metal composition of seafood. Four different seafood samples from oil producing communities were analyzed for their proximate, mineral and heavy metal content. Results obtained for proximate and mineral analysis were significant for the chi-square test ($p<0.05$). Prawn samples showed higher mineral content compared to other samples. Cadmium for periwinkle (0.727 ppm/dw±0.281), zinc for oyster (122.990 ppm/dw±0.704) and copper for oyster (17.810ppm/dw±0.694) were significantly higher than recommended limits. Oil exploration activities have significant negative impact on the aquatic ecosystem affecting the nutritional, medicinal and market value of seafood that serve as a major source of nutrients. Regular monitoring of these factors in various seafood samples is important to reduce the incidence of consumption of seafood contaminated by heavy metals and of low nutritional value.

Keywords: Heavy Metals; Minerals; Proximate; Seafood

Introduction

Seafood serve as a vital source of food for man constituting over 40% of animal protein consumed by Nigerians [1]. Fishing is a major occupation in the Niger Delta region of Nigeria [2]. Seafood is also an important part of the diet in parts of Europe, North and South America and South East Asia [3,4]. Common edible seafood includes the fishes, shell fishes, crustaceans, molluscs, bivalves etc. The consumption of seafood may result in bacterial diseases due either to contamination at source or during the production and retail chain [5]. Bacteria in oceanic and coastal sediments constitute about 76% of global bacteria [6].

Seafood provide the main source of the Long Chain Length Fatty Acids (LCPUFA) with 20 or 22 carbon atoms commonly referred to as “good oil” or Omega-3 oils [7]. They also provide proteins, minerals and essential elements including the brain-selective minerals (iodine, iron, copper, selenium and zinc). [8]. Seafood consumption influence several cardiovascular risk factors due to the incorporation of Eicosapentanoic Acid (EPA) and Docosahaxaenoic Acid (DHA) into blood vessels where they are involved in cell membrane fluidity. Anti-arrhythmic effects are the predominant response of the heart to seafood intake reducing the risk of sudden (cardiac) death and Coronary Heart Disease (CHD) death. They are also associated with vision development and building of muscles and tissues.

Problems associated with seafood consumption in the Niger Delta region of Nigeria include microbiological, heavy metal and crude oil pollution due to anthropogenic activities mainly oil exploitation and exploration. As much as seafood provide a palatable and convenient source of nutrients, their consumption poses a threat of food borne illness and chronic diseases [7].

Bayelsa State is within the Niger Delta region lying in the Atlantic Coast of Southern Nigeria where the River Niger divides into tributaries and spans over 20,000 km^2 terminating at Imo River entrance with a coastline of about 450 km [9]. The Niger Delta, divided into four ecological zones (Coastal Inland Zone; Mangrove Swamp Zone; Freshwater Zone; and Lowland Rainforest Zone) is described as the richest wetland in the world but has emerged as one of the most ecologically sensitive regions in Nigeria due to oil production, seismic blasting and the discharge of untreated effluents directly into water bodies [10]. Oil exploration and exploitation activities results in increased levels of heavy metals in the aquatic environment [11]. These metals are transported along the food chain and they accumulate in seafood. Long term exposure to heavy metals in humans can result in carcinogenic, central and peripheral nervous system and circulatory effects [12].

Materials and Methods

Sample Collection

Seafood samples were collected from five different locations within Bayelsa State, Nigeria using standard procedures. Seafood samples were obtained from the markets and water bodies of selected locations using the methods described by Hewitt and Martin (1996) and Hoedt et al (2001) [13,14]. Seafood sample were preserved in ice blocks and taken to the laboratory for analysis. Samples were collected from the following locations;

A. Ox-bow Lake (Yenagoa) $4^0$55’N, $6^0$16’É)

B. Azuzuama ($4^0$43’N, $5^0$57’E)

C. Nembe ($4^0$32’N, $6^0$17’E)

D. Ogbia ($4^0$39’N, $6^0$16’E)

E. Brass ($4^0$18’N, $6^0$14’E)

Seafood samples collected for the study included the following;

3. Periwinkle

4. Prawn

5. Oyster

6. Crab.

Alphanumeric codes were used for the recording of collected seafood samples. The alphabet (A, B, C, D and E) represents the respective sample locations while the numbers (3, 4, 5, and 6) represents the respective seafood samples collected from the locations.

Sample Analysis

Proximate analysis for moisture, crude fibre, ash, crude protein, lipid and carbohydrate contents was carried out using the using the method described by Nielsen (2010) [15]. The determination of ash content and moisture content (or total solids) was combined for convenience using microwave drying [15,16]. The sample was heated to dryness and the loss of weight used to calculate moisture and ash content. Total fat content was made after extraction and gravimetric estimation using the Goldfish method [15]. Protein content was determined based on the Nitrogen content using the Kjeldhall method [15]. Total carbohydrate was obtained as residue after determining other contents while energy level in the samples were determined using the Atwater factors [17].

Mineral content of samples was determined using atomic absorption spectrophotometry [18]. Samples were digested in 6 ml Hydrochloric Acid (HCl) and made up to 30ml with distilled water. Filtration was carried out using acid wash filter paper and storing the filtrate in sample bottles. The filtrate was then analyzed in duplicates using a unicam Atomic Absorption Spectrophotometer (AAS) for the determination of Calcium, Iron, Potassium, Magnesium, Manganese and Sodium (Otitoju and Otitoju, 2013). Heavy metal content was determined for Zinc, Lead, Nickel, Copper, Cadmium and Chromium by Atomic absorption spectrophotometry [15].

Results and Discussion

The results of the proximate analysis of the samples are presented in Table 1. The results showed variations when compared to those obtained by Njinkoue et al. (2016) [18] in a similar previous study. Periwinkle samples, *Littorina littorea*, recorded the highest energy level (313.647-318.290 Kcal). Similar moisture content was recorded in Oysters, *Crassostrea rhizophorae*, (70.597-81.000%±0.651) compared to previous study of 76.17-78.24% while other samples recorded lower values. The highest percentage of crude fibre was recorded in the Prawn samples, *Macrobrachium rosenbergii*, (10.030-10.467%±10.231). Highest ash content (8.8.697-10.003%±0.473) was recorded in Periwinkle samples compared to 7.17-7.28% from previous study. Periwinkle samples also have the highest crude protein content of 75.000-76.597%±0.685. Compared to the previous study of 13.4-16.17%, the oyster samples recorded 10.233-20.844%±0.384. Prawn has the highest lipid content of 2.450-2.647% while the highest total carbohydrate was recorded in Crab samples, *Portunus* spp, with 4.903-6.133%±0.544. All the samples have high carbohydrate content compared to the previous study of 0.19-0.83%. The results were significant for the Chi-square analysis ($p<0.05$).

Sample	Code	Energy (Kcal)	Moisture (%)	Crude fibre (%)	Ash (%)	Crude protein (%)	Lipid (%)	Total carbohydrate (%)
Periwinkle	A3	318.290±2.026	11.613±0.651	0.843±0.022	9.400±0.473	76.597±0.685	1.143±0.089	0.403±0.159
	B3	313.647±2.026	13.143±0.651	0.887±0.022	9.233±0.473	75.000±0.685	1.340±0.089	0.397±0.159
	C3	317.740±2.026	12.680±0.651	0.847±0.022	8.697±0.473	76.087±0.685	1.327±0.089	0.363±0.159
	D3	314.857±2.026	12.033±0.651	0.887±0.022	10.003±0.473	75.097±0.685	1.310±0.089	0.670±0.159
	E3	314.820±2.026	12.993±0.651	0.853±0.022	9.157±0.473	75.397±0.685	1.367±0.089	0.233±0.159
Prawn	A4	126.610±1.599	60.047±0.583	10.540±0,231	0.823±0.030	22.723±0.844	2.450±0.079	3.417±0.362
	B4	124.967±1.599	61.110±0.583	10.087±0.231	0.820±0.030	21.563±0.844	2.607±0.079	3.813±0.362
	C4	123.213±1.599	61.533±0.583	10.030±0.231	0.883±0.030	20.647±0.844	2.600±0.079	4.307±0.362
	D4	122.500±1.599	61.337±0.583	10.467±0.231	0.880±0.030	20.887±0.844	2.647±0.079	3.783±0.362
	E4	124.150±1.599	61.227±0.583	10.167±0.231	0.857±0.030	20.897±0.844	2.630±0.079	4.223±0.362
Oyster	A5	67.133±3.388	80.733±1.016	2.433±0.163	2.133±0.247	10.300±0.384	1.667±0.076	2.733±0.644
	B5	69.200±3.388	80.067±1.016	2.367±0.163	2.600±0.247	10.800±0.384	1.867±0.076	2.300±0.644
	C5	70.633±3.388	79.500±1.016	2.200±0.016	2.767±0.247	10.300±0.384	1.700±0.076	3.533±0.644
	D5	66.000±3.388	81.000±1.016	2.033±0.163	2.633±0.247	10.233±0.384	1.733±0.076	2.367±0.644
	E5	74.667±3.388	78.467±1.016	2.367±0.163	2.667±0.247	11.100±0.384	1.733±0.076	3.667±0.644
Crab	A6	112.037±3.372	70.597±0.874	0.113±0.013	1.860±0.040	20.833±0.467	0.463±0.020	6.133±0.544
	B6	114.333±3.372	70.033±0.874	0.107±0.013	1.893±0.040	21.267±0.467	0.493±0.020	6.207±0.544
	C6	108.767±3.372	71.467±0.874	0.140±0.013	1.793±0.040	20.080±0.467	0.473±0.020	6.047±0.544
	D6	105.427±3.372	72.333±0.874	0.130±0.013	1.813±0.040	20.313±0.467	0.507±0.020	4.903±0.544
	E6	110.627±3.372	71.000±0.874	0.117±0.013	1.860±0.040	20.460±0.467	0.507±0.020	6.057±0.544

Table 1: Proximate composition of seafood samples.

Proximate component and minerals contribute to the low caloric density, nutritive value, economic value and organoleptic characteristics of shell fish [19]. Proteins from fish and seafood have high biological value due to a good proportion of essential amino acids [20]. The poly unsaturated amino acids present in seafood play a vital role in human nutrition with curative and preventive effects on human diseases. Proximate composition determines nutritional and medicinal value of products [18].

Analysis of the mineral content of the seafood samples are presented in Table 2. The results showed that the Prawn samples had the highest calcium (1,660.093-1,777.810 mg/100g±54.241), phosphorus (1,777.703-1,995.605 mg/100g±83.421) and magnesium (876.162-896.657 mg/100g±0.492) content. The Crab samples had the highest mineral content for iron (91.780-97.733 mg/100g±2.653), potassium (360.967-377.300 mg/100g±6.111), manganese (90.967-101.160 mg/100g±3.969) and sodium (403.607-443.927 mg/100g±14.853). The mineral content of seafood's is shown in Figures 1-4. The bars indicate that the differences are not statistically significant. With the exception of the prawn samples, the analysis of mineral content for the seafood samples were significant for the chi-square test at ($p<0.05$).

Sample	Code	Ca (mg/100g)	P (mg/100g)	Fe (mg/100g)	K (mg/100g)	Mg (mg/100g)	Mn (Mg/100g)	Na (mg/100g)
Periwinkle	A3	42.877±1.002	29.897±1.250	3.323±0.139	39.230±0.400	173.013±6.357	0.443±0.028	98.600±3.821
	B3	41.270±1.002	30.700±1.250	3.337±0.139	39.707±0.400	178.203±6.357	0.480±0.028	91.060±3.821
	C3	41.030±1.002	31.093±1.250	3.337±0.139	39.963±0.400	170.287±6.357	0.460±0.028	93.497±3.821
	D3	42.127±1.002	33.220±1.250	3.100±0.139	40.317±0.400	170.457±6.357	0.440±0.028	99.667±3.821
	E3	43.360±1.002	30.713±1.250	3.060±0.139	39.683±0.400	161.363±6.357	0.403±0.028	98.840±3.821
Prawn	A4	1700.948±54.241	1886.128±83.421	5.831±0.271	190.300±3.994	891.221±7.822	1.025±0.075	204.322±13.066
	B4	1660.093±54.241	1995.605±83.421	5.884±0.271	198.575±3.994	892.211±7.822	1.106±0.075	220.889±13.066
	C4	1772.408±54.241	1841.663±83.421	5.200±0.271	189.308±3.994	876.162±7.822	1.125±0.075	222.510±13.066
	D4	1777.810±54.241	1777.713±83.421	5.625±0.271	191.142±3.994	886.304±7.822	0.987±0.075	211.075±13.066
	E4	1777.464±54.241	1818.366±83.421	5.583±0.271	188.767±3.994	896.657±7.822	0.952±0.075	238.748±13.066
Oyster	A5	100.337±2.171	33.593±2.192	0.120±0.084	10.253±0.807	10.103±0.492	0.173±0.009	44.807±1.768
	B5	101.030±2.171	34.040±2.192	0.253±0.084	11.660±0.807	10.103±0.492	0.173±0.009	45.893±1.768
	C5	97.593±2.171	30.740±2.192	0.217±0.084	11.090±0.807	10.993±0.492	0.187±0.009	44.167±1.768
	D5	103.483±2.171	36.133±2.192	0.307±0.084	11.430±0.807	11.130±0.492	0.193±0.009	47.930±1.768
	E5	99.363±2.171	31.273±2.192	0.113±0.084	12.463±0.807	10.803±0.492	0.180±0.009	48.030±1.768
Crab	A6	400.767±9.532	49.327±1.533	96.200±2.653	364.633±6.111	188.000±8.404	98.267±3.969	433.000±14.853
	B6	400.000±9.532	50.847±1.533	97.733±2.653	367.233±6.111	185.133±8.404	99.943±3.969	424.667±14.853
	C6	426.000±9.532	53.393±1.533	91.780±2.653	377.300±6.111	187.807±8.404	90.967±3.969	430.167±14.853
	D6	408.233±9.532	51.230±1.533	94.700±2.653	365.820±6.111	177.877±8.404		403.667±14.853
	E6	411.153±9.532	50.107±1.533	91.780±2.653	360.967±6.111	168.300±8.404	98.297±3.969	443.927±14.853

Ca: Calcium; P: Phosphorus; Fe: Iron; K: Potassium: Mg: Magnesium; Mn: Manganese; Na: Sodium; Mg/100g: Milligrams Per 100g.

Table 2: Mineral content of seafood samples.

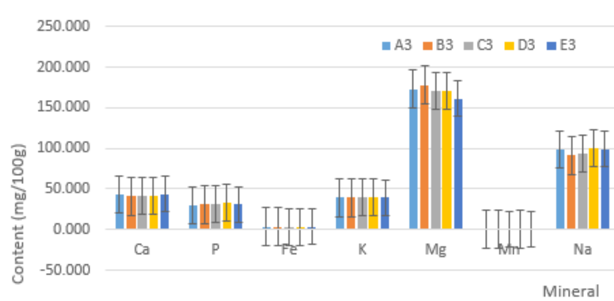

Figure 1: Mineral content of Periwinkle showing error bars.

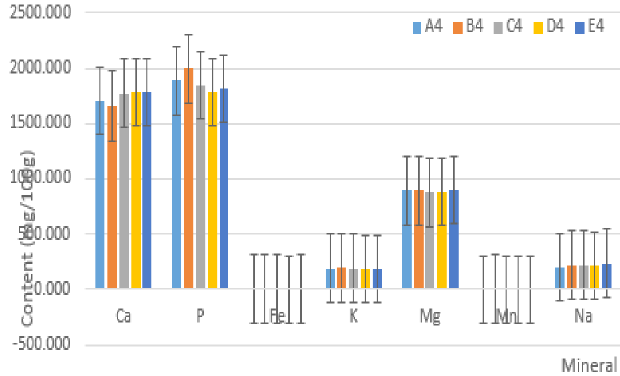

Figure 2: Mineral content of Prawn showing error bars.

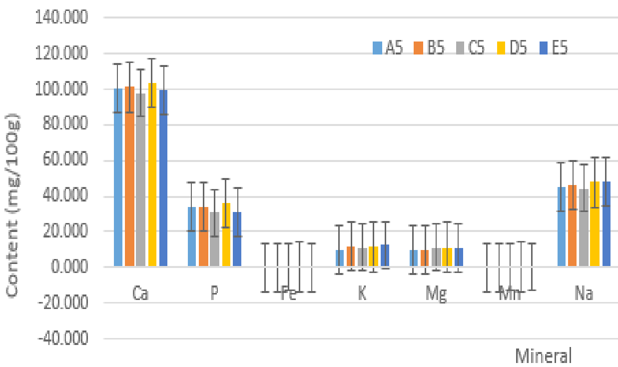

Figure 3: Mineral content of Oyster showing error bars.

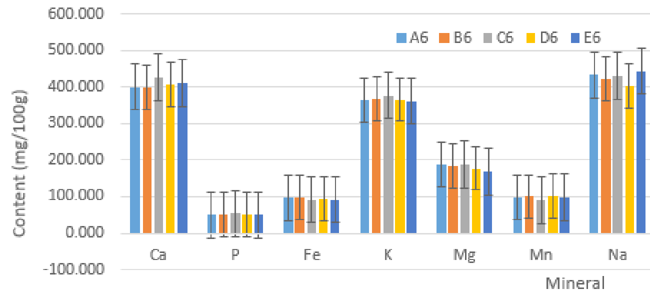

Figure 4: Mineral content of Crab showing error bars.

The results of the analysis of heavy metal content of the samples are presented in Table 3. The Zinc (Zn) content was highest in oyster samples in the range of 121.070-122.990 ppm/dw±0.704. Oysters were also highest for Lead (Pb) with 0.096-0.794 ppm/dw 0.338. Lead was not detected in any of the prawn samples as well as crab samples from 2 locations. Nickel (Ni) was not detected in periwinkle, prawn and crab samples from all the locations. Only oyster sample from two locations had nickel content (0.062-0.082 ppm/dw±0.040). Highest Copper (Cu) content was recorded in oyster samples (16.067-17.810 ppm/dw±0.694). Highest Cadmium (Cd) content was recorded in periwinkle (0.010-0.727 ppm/dw±0.281) and crab (0.021-0.459 ppm/dw±0.003) samples. Oyster samples also recorded the highest Chromium content of 0.201-0.212 ppm/dw±0.007. Figures 5-8 shows the heavy metal content of the respective seafood samples compared to the FAO/WHO minimum permissible limits. Heavy metal content above the MPL were recorded for zinc (periwinkle), copper (oyster) and cadmium (oyster).

Sample	Code	Zn (ppm/dw)	Pb (ppm/dw)	Ni (ppm/dw)	Cu (ppm/dw)	Cd (ppm/dw)	Cr (ppm/dw)
Periwinkle	A3	0	0.030±0.011	0.001	0.023±0.006	0.563±0.281	0.003±0.025
	B3	0.001	0.010±0.011	0	0.010±0.006	0.533±0.281	0.043±0.025
	C3	0	0.007±0.011	0	0.023±0.006	0.640±0.281	0.057±0.025
	D3	0.001	0.013±0.011	0	0.013±0.006	0.727±0.281	0.020±0.025
	E3	0	0.000±0.011	0	0.013±0.006	0.010±0.281	0.000±0.025
Prawn	A4	0.002±0.001	0	0	0.022±0.050	0.022±0.011	0.017±0.009
	B4	0.002±0.001	0	0	0.032±0.050	0.016±0.011	0.020±0.009
	C4	0.001±0.001	0	0	0.130±0.050	0.024±0.011	0.021±0.009
	D4	0	0	0	0.041±0.050	0.029±0.011	0.021±0.009
	E4	0.001±0.001	0	0	0	0	0.001±0.009

Oyster	A5	121.603±0.704	0.092±0.338	0.082±0.040	16.277±0.694	0.560±0.036	0.201±0.007
	B5	122.990±0.704	0	0	16.067±0.694	0.601±0.036	0.218±0.007
	C5	122.307±0.704	0	0	17.067±0.694	0.609±0.036	0.204±0.007
	D5	121.907±0.704	0.794±0.338	0.062±0.040	16.637±0.694	0.647±0.036	0.203±0.007
	E5	121.070±0.704	0.096±0.338	0	17.810±0.694	0.647±0.036	0.212±0.007
Crab	A6	0.003±0.001	0.007±0.003	0	0.001±0.001	0.007±0.003	0
	B6	0.002±0.001	0.006±0.003	0	0.002±0.001	0.006±0.003	0
	C6	0	0.004±0.003	0	0.001±0.001	0.004±0.003	0
	D6	0.001±0.001	0	0	0.003±0.001	0	0
	E6	0	0	0	0	0	0
Zn: Zinc; Pb: Lead; Ni: Nickel; Cu; Copper; Cd: Cadmium; Cr: Chromium; Ppm/Dw: Parts Per Million Per Dry Weight.							

Table 3: Heavy metal content of seafood samples.

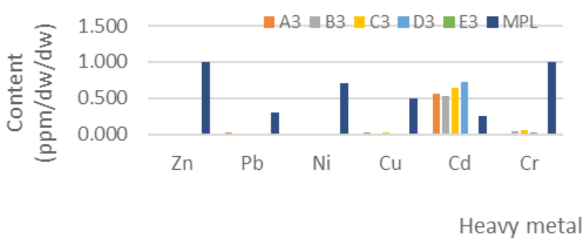

Figure 5: Heavy metal content of Periwinkle compared to FAO/WHO Minimum Permissible Limit (MPL).

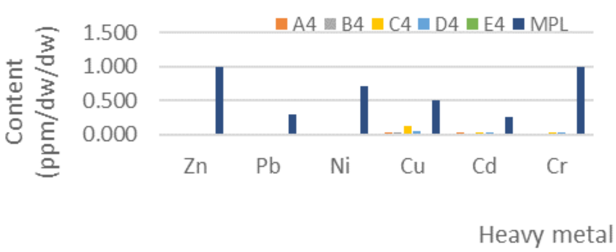

Figure 6: Heavy metal content of Prawn compared to FAO/WHO Minimum Permissible Limit (MPL).

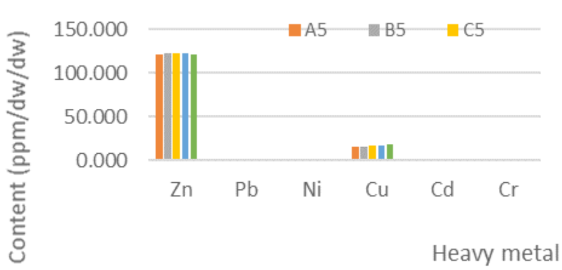

Figure 7: Heavy metal content of Oyster compared to FAO/WHO Minimum Permissible Limit (MPL).

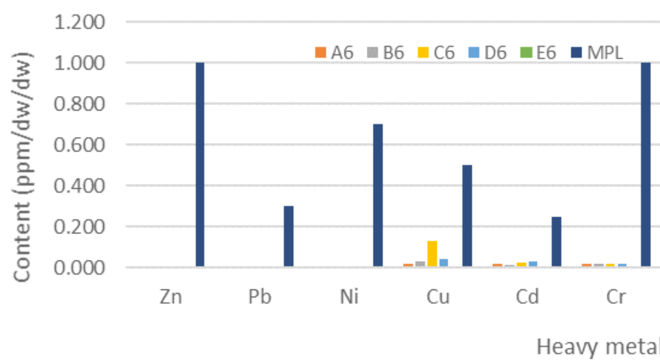

Figure 8: Heavy metal content of Crab compared to FAO/WHO Minimum Permissible Limit (MPL).

Heavy metals have highly varied chemical properties and biological functions. Their dietary intake through the consumption of contaminated seafood have long term detrimental effects on human health [12]. Chinedu and Chukwuemeka (2018) [11] identified oil spillage as a source of heavy metal contamination of aquatic environments in oil producing regions. At toxic levels, heavy metals cause specific harmful effects in humans from mild effects to potentially fatal effects e.g. organ damage and mortality. Chinedu and Chukwuemeka (2018) [11] also reported substantial amounts of heavy metals due to oil spills.

Conclusion

The heavy metal content from all the sample locations indicated that the oysters have the highest heavy metal content. The presence of heavy metals in seafood consumed by the local populace is of significance since heaviest metals are able to induce diseases [21]. Cadmium level was comparatively high above the WHO/FAO (2011) [22] Maximum Permissible Limits (MPL) in periwinkle samples, similar to results obtained by [23]. The content for Zinc and Copper was above the acceptable limit for Oyster samples. All other metals in the various samples analyzed were within the acceptable limits. The co-exposure of more than one heavy metal produce effects more dangerous to human health than those caused by individual metals [24]. The activities involved in oil exploration and exploitation are associated with more than one heavy metal. It is therefore necessary to regularly monitor the levels of these metals in the aquatic ecosystem in these areas and the seafood will serve as effective bio indicators.

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