Toxicological Evaluation of Selected Seafoods and Water from Akpajo, Rivers State

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Abstract
This study evaluated the toxicological indices of heavy metals in selected seafoods and water from Ogugu River in Eleme Local Government Area of Rivers State. Seafoods (*Tilapia guineensis (Tilapia Fish),Callinectes sapidus* (Blue crab) and *Matacostraca decapoda* (cray fish)), and water samples were obtained from Ogugu River. They were taken to the laboratory under aseptic conditions and were analyzed for Lead (Pb), Cadmium (Cd), Nickel (Ni), Arsenic (As) and Mercury (Hg) contents with the aid of an Atomic Absorption Spectrophotometer. The results obtained shows; Pb ranging from 0.235±0.001(in Water) to 5.172±0.012 (in *Matacostraca decapoda* (cray fish)), Cd 0.044±0.03 (in water) to 0.464±0.058 (in *Matacostraca decapoda*), Ni 0.179±0.193 (in water) to 2.212±0.065 (in *Matacostraca decapoda* (cray fish)), while As and Hg were shown to be below detectable limits. The Health risk evaluation was done using Chronic Daily Intake (CDI), Target Hazard Quotients (THQ) and TLCR. These indices revealed that adult and children population exposed to these samples could be highly at risk as obtained values where above the probable USEPA risk free limit (10^{-6} to 10^{-4}). The Pb THQ was in the order *Matacostraca decapoda* (cray fish) > *Tilapia guineensis*, (Tilapia Fish) > *Callinectes sapidus* (Blue crab) > Water, with Cd *Matacostraca decapoda* (cray fish) > *Callinectes sapidus* (Blue crab) > water > *Tilapia guineensis*, (Tilapia Fish), while Ni is in the order *Matacostraca decapoda* (cray fish) > *Tilapia guineensis*, (Tilapia Fish) > water > *Callinectes sapidus* (Blue crab). The obtained HI is in the order *Matacostraca decapoda* (cray fish) > *Tilapia guineensis*, (Tilapia Fish) > *Callinectes sapidus* (Blue crab) > Water, The TLCR values was shown in the order *Matacostraca decapoda* (cray fish) > *Tilapia guineensis*, (Tilapia Fish > *Callinectes sapidus* (Blue crab) >Water. Results from this study hence arouses public health concerns and apt policies are needed to curtail further accumulation of these heavy metal in the samples.

Keywords: *Tilapia guineensis*, *Callinectes sapidus*, *Matacostraca decapoda,* Heavy metals, Risk Assessment, Fish Toxicity, Water Safety
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1 Introduction

Seafoods as food has become an important source of livelihood (Abubakar et al., 2015). Interest in several sea foods species have increased daily, they are notable source of protein and income to respective consumers and farmers (Fagbenro et al., 2005). Reports shows that these seafoods contributes above 40% of dietary protein hence becoming vital protein source in developing countries (Louka et al., 2004). It is notably a preferred protein source when compared to chicken and goat meat (Astawan and Ikan, 2004). This makes it healthier and safer for consumption (Astawan and Ikan, 2004). Quest for wealth, urbanization and industrialization have lead to high environmental pollution (Olua *et al.,* 2018; Nyimone *et al*., 2023) this no doubt has pose a major threat to the sea food consumption as the aquatic environment; the major niche for these sea foods in most cases are heavily polluted (Ighariemu *et al.,* 2023). These sea foods seen within the aquatic habitat are substantial bio-indicator of toxic substances such as heavy metals, as they have been seen to be viable bio-accumulator of inorganic and organic pollutants (King and Jonathan, 2003).

Heavy metals are regarded as serious pollutants within the terrestrial and aquatic ecosystems due to their non-biodegradeability, bioacummulation, biomagnification and toxicity effects even at low levels (El-Nagger et al., 2009; Shirlin, 2014; Olua *et al.,* 2021a, Olua *et al.,* 2021b). Hence they are top in the list hazardous environmental pollutants (Al-Attar, 2005, Olua *et al.,* 2018). Heavy metal contents in sea foods may vary according to the surrounding environment (Ambedkar and Muniyan, 2011; Sen et al., 2011). Several studies have shown presence of heavy metals in sea foods caught within some Rivers in the Niger Delta (Abowei and Ogamba, 2013; Alinnor and Obiji, 2010; Ighariemu *et al.,* 2023). Akpajo is one of the major communities in Eleme Local Government Area of Rivers State with high industrial activities which have impacted negatively to the surrounding land and water. Reports of environmental contaminations of even surrounding dusts within Akpajo have been noted (Olua, *et al.,* 2018). Akpajo is amongst communities that host the Indorama Petrochemical Industry, a huge chemical company with several plants such as Fertilizer, Poly-propylene, Poly-ethylene and ethanol respectively. Ogugu river, with high number of brackish water. (located within this same community which is highly industrialized), is most vulnerable river, receiving most effluents from the activities of the chemical industry. Further risks to the aquatic life is exacerbated by illicit tapping ("bunkering") of oil pipelines, which can release significant amounts of crude oil into the environment. It is therefore expedient to understudy the toxicity of selected common sea foods and water from Ogugu River in Eleme LGA of Rivers State.

2 Materials and Methods

2.1 Materials/Reagents

Flame AAS **model:S4=71096**, Graphical display and recorder, Burner, Pressure reducing valves, Hollow cathode lamps. All reagents were of analytical grade. Air, Aluminium nitrate solution Acetylene, Metal free water (H_2O), potassium chloride solution, Stock metal solution, H_2SO_4), Trioxonitrate (v) acid (HNO_3), Perchloric acid ($HClO_4$).

2.2 Sample collection

Water (H_2O) and three selected samples of sea foods namely; tilapia, Crabs, and Crayfish were obtained/collected from Ogugu River in Eleme LGA Rivers State. The samples were preserved appropriately and was taken to the laboratory for analysis.

2.3 Heavy Metal Analysis and Risk Assessment

The heavy metals Pb, Cd, Ni, As, Hg, weres analyzed using Atomic Absorption Spectrophotometer as described by Nyimone *et al.,* (2023). The health risk assessment was evaluated using Chronic Dietary Intake (CDI), Target Hazard Quotient (THQ), Hazard Index (HI) for the non-carcinogenic risk evaluation. While Life cancer Risks and Total Life Cancer Risks were used to evalute the probable carcinogenic risks the exposed adult and children population are prone to. These risk assessments were evaluated using methods described by Nyimone *et al.,* 2023 and Ighariemu *et al.,* 2023)

2.4 Data Analysis

The obtained data were analyzed using SPSS Version 23.0. A one-way analysis of variance (ANOVA) was done at 95% degree of confidence at n=3.

3.0 Results and Discussion

3.1 Heavy Metals in Sampled Sea Food and Water

The heavy metal contents in sampled Fish (*Tilapia guineensis*, (Tilapia Fish), *Callinectes sapidus* (Blue crab), *Matacostraca decapoda* (cray fish)), and water from the sampled site of Ogugu river is as shown in tables 1. Heavy metals such as Pb,Cd,Ni, As, Hg were assayed having noted the high industrialization notable within Eleme LGA and possible pollution from anthropogenic sources.

Lead is the most abundant metal in all samples, followed by Nickel then Cadmium, Arsenic and Mercury were below detectable limits. Lead (ranging 0.235±0.001(in Water) to 5.172±0.012 (in *Matacostraca decapoda* (cray fish)). The Pb contents were found to be high, exceeding standards by WHO/FAO, EC/CODEX and EU.

Cadmium (0.044±0.03(in water) to 0.464±0.058 (in *Matacostraca decapoda*)) and Nickel (Ni 0.179±0.193 (in water) to 2.212±0.065 (in *Matacostraca decapoda* (cray fish)) have values above EC/CODEX and EU recommended standards. However, these values are seen to be significantly different across the various samples at $p>0.05$

Therefore, individuals within Akpajo in Eleme LGA who rely on these sources of food are indirectly consuming high load of heavy metals which with time keep bioaccumulating and biomagnifying these heavy metals.

Lead known to be from environmental sources such as agrochemicals and industrial wastes may be deleterious to living organisms as their level exceeds standards values (Aydinalp and Marinova, 2009), thereby increasing their ability to cause adverse health effects such as; inhibiting enzyme activities which may lead to water imbalance and altering membrane permeability, mineral nutrition disturbance and hormonal status alterations, (Seregin, and Ivaniov, 2001). Pb could also affect and or damage the Liver, central nervous system, kidneys, etc (Ademoroti, 1996; Rudolph *et al.,*2003).

Table 1: Mean Concentration of Heavy Metals in Samples

Sample	Pb(mg/kg)	Cd(mg/kg)	Ni(mg/kg)	As(mg/kg)	Hg(mg/kg)
Tilapia guineensis, (Tilapia Fish)	3.964±0.002[a]	0.392±0.001[a]	1.96±0.006[a]	0	0
Callinectes sapidus (Blue crab),	3.1±0.058[a]	0.432±0.012[a]	1.664±0.009[a]	0	0
Matacostraca decapoda (cray fish)	5.172±0.012[a]	0.464±0.058[a]	2.212±0.065[a]	0	0
Water	0.235±0.001[a]	0.044±0.03[a]	0.179±0.193[a]	0	0
WHO/FAO	2	1	-		
EC	0.3	0.2			
EU	0.3	0.2			

Values are Mean±SEM, Means in the same column with same superscript alphabet are significantly different at $p \leq 0.05$, n=3,

(EU. 2001; EC. 2006;. FAO/WHO, 1984)

Cadmium enters the environment via anthropogenic activities linked to industrial processes such as; refining, extraction etc. (Flower, 2006). It relatively devoid of beneficial effects known and could be harmful to living organisms at levels exceeding set values (Gough *et al.,* 1979; Aydinalp and Marinova, 2009). Cadmium is notably toxic even on low absorption by via ingestion; high Cd ingestion in food on chronic exposure could causes bone disorders (Obata and Umebayashi, 1997; Asia *et al.,* 2008; Luevano and Damodaran, 2014).

Ni toxicity could result to loss of body weight and liver damage on long term exposure. Pb, Cd and Ni, has been proved to be possible carcinogen (IARC,2012; ATSDR, 2015).

3.2 Health Risk Assessment of the Heavy Metal Contents, Present in the Sampled Seafoods, and Water

The heavy metal level was further evaluated for level of risks (risk assessment) on exposure, using toxicological indices which includes;

3.2.1 Chronic Daily Intake (CDI)

The Chronic daily intake via ingestion for fish and water was evaluated and results are presented in Table 2. the results revealed high CDI levels which were above the reference doses (RFD) as recommended by USEPA, (USEPA, 2011). The results obtained gave CDI_{ingest} value for Pb ranging from 0.007 $mgkg^{-1}day^{-1}$ (in water) to 0.0168 $mgkg^{-1}day^{-1}$ (*Matacostraca decapoda* (cray fish)) and 1.79E-03 $mgkg^{-1}day^{-1}$ (in water) to 0.039$mgkg^{-1}day^{-1}$ (*Matacostraca decapoda* (cray fish)) for adult and

Table 2 Chronic Daily Intake Dose (CDI_{ingest}) ($mg\ kg^{-1}day^{-1}$) for Seafoods, Vegetables and Water

SAMPLE	Pb		Cd		Ni		As	
	Adult	Child	Adult	Child	Adult	Child	Adult	Child
Tilapia guineensis, (Tilapia Fish)	0.0129	0.030126	0.0013	0.002979	0.006356	0.014896	-	-
Callinectes sapidus (Blue crab),	0.0101	0.02356	0.0014	0.003283	0.005396	0.012646	-	-
Matacostraca decapoda (cray fish)	0.0168	0.039307	0.0015	0.003526	0.007173	0.016811	-	-
Water	7.39E-03	1.79E-03	1.38E-03	3.34E-04	5.63E-04	1.36E-04	-	-
RFD	0.0035	0.0035	0.001	0.001	0.02	0.02		

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children population respectively. Cd ranging from 0.001 $mgkg^{-1}day^{-1}$ (in water) to 0.0015 $mgkg^{-1}day^{-1}$ (in *Matacostraca decapoda* (cray fish)) and 0.0003 $mgkg^{-1}day^{-1}$ (in water) to 0.0035 $mgkg^{-1}day^{-1}$ (in *Matacostraca decapoda* (cray fish)) for adult and children population respectively with Ni ranging 5.63E-04 $mgkg^{-1}day^{-1}$ (in water) to 0.0035 $mgkg^{-1}day^{-1}$ (in) and 1.36E-04 $mgkg^{-1}day^{-1}$ (in water) to 0.016$mgkg^{-1}day^{-1}$ (in *Matacostraca decapoda* (cray fish)), for adult and children populations respectively.

The study reveal that oral route (ingestion) is a notable exposure route to heavy metal contamination. This corroborates the works earlier done by Zheng *et al.,* (2010); Junhua and Wichitra, (2012) and Olua *et al*., 2018 on dusts and soil samples.

3.2.2 Target Hazard Quotient and Hazard Index

Tables 3 presents the THQ and HI values on exposure to heavy metal contents in sampled fish, and water for the adult and children population.
The results depict that same trend as the CDI was observed in THQ and HI. The THQ ingest in Pb was in the order *Matacostraca decapoda* (cray fish) > *Tilapia guineensis*, (Tilapia Fish) > *Callinectes sapidus* (Blue crab) > Water, in Cd we obtained *Matacostraca decapoda* (cray fish) > *Callinectes sapidus* (Blue crab) > water > *Tilapia guineensis*, (Tilapia Fish), while Ni is in the order *Matacostraca decapoda* (cray fish) > *Tilapia guineensis*, (Tilapia Fish) > water > *Callinectes sapidus* (Blue crab). The results shows that THQ ingest values for Pb, and Cd were higher than 1

Table 3: Target Hazard Quotient (THQ_{ingest}) and Hazard Index for Seafoods, Vegetables and Water

SAMPLE	Pb		Cd		Ni		As		HI	
	Adult	Child	Adult	Child	Adult	Child	Adult	Child	Adult	Child
Tilapia guineensis,	**3.67E+00**	**8.61E+00**	**1.27E+00**	2.98E+00	3.18E-01	7.45E-01	-	-	5.26E+00	1.23E+01
Callinectes sapidus	**2.87E+00**	**6.73E+00**	**1.40E+00**	3.28E+00	2.70E-01	6.32E-01	-	-	4.54E+00	1.06E+01
Matacostraca	**4.79E+00**	**1.12E+01**	**1.50E+00**	3.53E+00	3.59E-01	8.41E-01	-	-	6.66E+00	1.56E+01
Water	0.2E+01	0.5E+00	1.383	3.34E-01	2.81E-01	6.80E-02	-	-	3.77E+00	9.13E-01

in all samples. while in Ni gave THQ values below 1. This result entails that consumption of sampled fish, and water could cause adverse non-carcinogenic health effects for the exposed adult and children populations. The obtained HI is in the order *Matacostraca decapoda* (cray fish) > *Tilapia guineensis*, (Tilapia Fish) > *Callinectes sapidus* (Blue crab) > Water, with all values obtained greater than one these values are above the standard values as set by USEPA (2011) . This shows that the sample fish and vegetables could have probable adverse health effects which is attributable to the high industrial activities within this region leading to high anthropogenic sources of contaminants.

3.2.3 Life Cancer Risks and Total Life Cancer Risks

Tables 4 shows estimated/calculated carcinogenic risks results from exposure to sampled fish and water within Ogugu River in Akpajo, Eleme LGA of Rivers State. The life cancer risks (LCR) and the total life cancer risks were calculated. The $LCR_{ingest}$was used to estimate the carcinogenic risk on exposure to the sampled fish, and water. USEPA (2011) denoted values within 10^{-6} to 10^{-4}

Table 4: Life Cancer Risks (LCR) and Total Life Cancer Risks (TLCR) for Seafoods, Vegetables and Water

SAMPLE	Pb		Cd		Ni		As		TLCR	
	Adult	Child	Adult	Child	Adult	Child	Adult	Child	Adult	Child
Tilapia guineensis, (Tilapia Fish)	1.09E-04	2.56E-04	4.83E-04	1.13E-03	1.08E-02	2.53E-02	-	-	1.14E-02	2.67E-02
Callinectes sapidus (Blue crab)	8.54E-05	2.00E-04	5.32E-04	1.25E-03	9.17E-03	2.15E-02	-	-	9.79E-03	2.29E-02
Matacostraca decapoda (cray fish)	1.43E-04	3.34E-04	5.72E-04	1.34E-03	1.22E-02	2.86E-02	-	-	1.29E-02	3.03E-02
Water	6.28E-05	1.30E-06	5.25E-04	1.19E-03	4.73E-03	9.79E-05	-	-	5.31E-03	1.10E-04

as tolerable range. While 10^{-4} is the upper tolerable limit and 10^{-6} the lower tolerable limit (USEPA, 2011). Observed values for adult and children population on consumption of the assayed sample gave figures which exceeds the upper tolerable limit of 10^{-4}.

The LCR levels obtained for Pb in all samples ranged from 6.28E-05 (in water) to 1.43E-04 (in) and 1.30E-06 (in water) to 3.34E-04 (in), Cd from 4.83E-04 (in *Tilapia guineensis*, (Tilapia Fish)) to 5.72E-04 (in *Matacostraca decapoda* (cray fish)) and 1.13E-03 (in *Tilapia guineensis*, (Tilapia Fish)) to 1.34E-03 (in *Matacostraca decapoda* (cray fish)), Ni from 4.73E-03 (in water) to 1.22E-02 (in *Matacostraca decapoda* (cray fish)) and 9.79E-05(in water) to 2.86E-02(in *Matacostraca decapoda* (cray fish)), for adult and children populations respectively. The TLCR values is in the order

Table 5 Reference Values and Standards for Risk Assessments

Exposure variable	Unit	Adult	Child
Exposure frequency (EF)	dayyear^{-1}	365	365
Exposure duration (ED)	year	70	6
Body weight(BW)	kg	70	15
Fish ingestion rate ($IR_{ingestion}$)	mgday^{-1}	0.227	0.114
Water ingestion rate ($IR_{ingestion}$)	mlday^{-1}	2.2	0.114
Life span (AT) Average	day	70 ×365 =25,550, 0.03 mg/cm^2	70 ×365 =25,550, 0.03 mg/cm^2
maximum acceptable risk level (RL)	(dimensionless)	10^{-5}	10^{-5}

USEPA, 2001; Wei *et al*., 2010 and Wang *et al*., 2011, USEPA,2011, 2007, 2002, 1989,

Matacostraca decapoda (cray fish) > *Tilapia guineensis*, (Tilapia Fish > *Callinectes sapidus* (Blue crab) >Water. These values has shown that the samples has high potency for carcinogenic risks as maximum as postulated by USEPA (2011). With the obtained results it is observed that the exposed adult and children population could be highly at risk.

4.0 CONCLUSION

This study determined the Toxicological potentials of heavy metals contents of sampled seafoods, and water. The obtained results showed presence of heavy metal at levels notably higher than guidelines set by the European Commission Regulation (EC), WHO/FAO, and European Union. This no doubt calls for urgent measures to curtail further accumulation of these heavy metal in the samples.

The Health Risk assessment of the heavy metal contents, present in the sampled seafoods, and water were also evaluated. The calculated CDI, THQ, HI, LCR and TLCR, gave values which depicts high risk potency for both carcinogenic and non-carcinogenic adverse health effects. As HI levels were seen to be notable above 1, while the LCR and TLCR on exposure to the level of heavy metals present in the assayed sample gave values higher than the upper tolerable limit of 10^{-4}, as such their usage should be discouraged as the safety of these products is not guaranteed due to the level of pollution and contamination seen within Ogugu River in Eleme LGA.

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