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Health Risk Assessment of Toxic Metals on Five Aquatic Biotics in Isaka and Marine Base Creeks in Rivers State, Nigeria

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Abstract

Pollution of the environment with toxic metals can lead to the possible contamination of aquatic biotics. Evaluation of the levels of As, Cd, Hg, Mn and Pb in five aquatic biotics (fish, periwinkle, crab, oyster, prawn), collected from two selected creeks in Rivers State, was done and their health risk estimated. Mean concentrations of 0.001±0.00mg/kg in As and Cd, and 0.0005±0.00mg/kg in Hg were observed in the five aquatic biotics of both creeks. Mn has varying concentrations of 0.99±0.02mg/kg, 11.92±0.02mg/kg, 11.293±0.03mg/kg, 8.527±0.01mg/kg, and 3.140±0.02mg/kg in fish, periwinkle, crab, oyster, and prawn respectively in Isaka creek; while that of Marine Base was 10.107±0.001mg/kg, 0.669±0.00mg/kg, 15.758±0.00mg/kg, 7.012±0.00mg/kg, and 5.098±0.00mg/kg. Pb equally has varying concentrations of 0.01±0.00mg/kg, 0.0074±0.00mg/kg, 0.012±0.0mg/kg, 0.012±0.00mg/kg, and 0.001±0.00mg/kg in fish, periwinkle, crab, oyster, and prawn respectively in Isaka creek and 0.873±0.002mg/kg, 0.001±0.00mg/kg, 0.02±0.00mg/kg, 0.012±0.00mg/kg, 0.001±0.00mg/kg in Marine Base Creek. The cumulative Hazard Quotient or Chronic Hazard Index of the toxic metals in the various biotics indicated significant risk of non-carcinogenic effect on humans upon consumption. The Total Cancer Risk values of metals in the biotics were within the various acceptable limit as such there was no risk of cancer. However, there is the need of creating awareness on the existence of these toxic metals in the biotics of both creeks, and the public health implications. Laws be enacted by policy makers on the need to prevent environmental pollution through the help of the community leaders to guarantee that aquatic biotics are safe for human consumption and avoid damages to human health through community education and policy implementation strategies.

Keywords: *Toxic Metals, Aquatic Biotics, Creek, Consumption, Human Health Risk.*

1. Introduction

Toxic metal is any chemical element with a relatively high density and toxic at minimal amount. As a result of their toxicity even at low concentrations, capability to enter food chains, and ability to be concentrated by aquatic animals, toxic metals are considered to be major contaminants of aquatic biosystems (Adewumi *et al*., 2014). They are regarded as the most precarious ecosystem contaminants considering their tendency for bioaccumulation and toxicity. Their contamination may have disastrous impacts on the recipient environment's ecological balance as well as a variety of aquatic creatures (Nesreen *et al*., 2014). Considering the large accumulation of substantial metals in their bodily tissues, aquatic species might suffer detrimental effects from toxic metals as well, which poses a threat to man health when ingested (Adewumi *et al*., 2014; Zhuang *et al*., 2013).

2. Materials and Methods

2.1 Description of the Study Area

The study was conducted in Isaka and Marine Base creeks in Okrika and Port Harcourt LGAs, Rivers State. Isaka creek is a salty H_2O body located in Isaka, Okrika L.G.A of Rivers State, Nigeria. It is an armlet of the National Ports Authorities highway-sea that lies between Latitude 4°73 North and Longitude 6°99 East. The river is decked by mangrove vegetation by the sides.
However, the entropy originating from dumped boats, open bathrooms and a lot of municipal trashes escalate the unhealthy status of the creek.
Marine base is situated in Port Harcourt at Latitudes 04^0 43^0 and 04^0 57^0 North of the Equator and between Longitudes 06^0 53^0 and 07^0 58^0 East of the Greenwich Meridian and is bounded by the Dockyard creek, Bonny River and Amadi creek, of the Niger Delta, at an elevation of about 12m above sea level. It is roughly 60km from the crest up stream of the Bonny River. Marine base is located in the coastal area of Port Harcourt, were loading and off-loading of crude oil and other petroleum products by ships, cargo oil tankers occur. The marine base surrounding is not free from contaminants from petrol products, effluents from industries and garbage migrating via drains from hinterland. Thus, has a direct impact on the inhabitant H_2O organisms such as mudskippers, periwinkles, oysters and crabs as well as the consumers.

2.2 **Sampling method and procedure**.

The sampling method for collection of the biotics in each of the three locations within the creeks is a simple random method, where homogenous species of each of the biotics (fish, crayfish, crab, periwinkle, and oyster) were selected at three different locations per creek on different days.

The samples were collected in three different basins containing water from each of the creeks. These samples were then taken to the laboratory and a portion of each of the biotics analyzed for the toxic metals (Lead, Mercury, Cadmium, Arsenic and Manganese) using Atomic Absorption Spectrophotometer.

2.3 Materials and Reagents

- Atomic absorption spectrophotometer (AAS), burner, conical flask, funnel, filter paper, measuring cylinder, volumetric flask, weighing balance.
- Deionized-distilled water, Conc.HNO_3, Hydrogen peroxide, Stock metal solutions, Standard metal solution, fuel, and oxidant.

2.4 Digestion procedure of the collected samples

1g of Biota, was transferred into 100ml conical flask for digestion. 10ml 1:1 of HNO_3 and hydrogen peroxide was added to the sample in fume hood. It was brought to a slow boiling by heating at 95^0C on a hot plate. Additional 2ml of water and 3ml of hydrogen peroxide was introduced, covered and heated until effervescence subsides. It was then cooled and filtered into a measuring container and make up 100ml.
A portion of this solution is then taken for required metal and cations determination.

The values of metal concentration are read directly from the extrapolated calibration curve in the system.

2.5 Data Interpretation

Descriptive statistics was adopted to depict the average, range, mean and standard deviations (SD) of the assayed noxious elements in the aquatic biotics specimens. The test of significance and one-way ANOVA were also employed to depict the causes of PAHs in the studied site, the contamination dynamics and potential linkage among established variables. Statistical analysis was done using IBM SPSS 23 software.

2.6 Health Risk Analysis to Humans

2.6.1 Chronic daily intake (CDI) indices:

The Chronic daily intake of toxic metals through biotics ingestion was deduced from the equation

$$CDI_{Ingestion} = CS \times IRS \times EF \times ED \times CF / BW \times AT \quad \ldots\ldots (1)$$

Where:
CDI = chronic day-by-day intake; CS = metal concentration in the biotics (mg/kg); EF = frequency of exposure = 35 d/a; ED = duration of exposure = 30 a; AT = averaging time for non-carcinogens = 365 × ED d; AT = averaging time for carcinogens = 365 × 70 d; BW = body weight = 70 kg (USEPA, 1992); CF = units conversion factor = 10^{-6} mg·kg^{-1}; IRS = Ingestion Rate = 100 mg·d^{-1}

2.6.2 Hazard quotient (HQ) indices: The HQ for non-carcinogenic menace was arrived at by the equation:

$$HQ = CDI / RfD \quad \ldots\ldots (2)$$

where, the non-cancer hazard quotient (HQ) is the ratio of exposure to perilous substances, and RfD is the chronic reference dose of the toxicant ($mgkg^{-1}d^{-1}$).
According to database (USEPA, 2009b), the oral toxicity indication dose values (RfD) for As, Cd, Pb, Hg. and Mn are, 0.0005, 0.001, 0.004,0.0005 and - mg/kg correspondingly. The exposed population is assumed to be safe when HQ < 1 and unsafe when HQ ≥ 1 (Khan *et al*., 2008).

2.6.3 Chronic hazard index (HI)

Chronic Hazard Index (CHI / CHQ) = Σ^{k}_{i} CDI_K /RfD_K ……………………………… (3)
Where:
CHI is the aggregate of more than 1 HQ for multi-substances or exposure routes, CDIk is the day-by-day intake of a noxious element (k) and RfDk is the chronic indication dose for the noxious element k. HI values ≥ 1 shows that there is a chance that non-carcinogenic risk may emanate and when HI < 1 the turnaround is the case.

2.6.4 Cancer risk (CR)

Cancer risk can be deduced from:
Cancer risk (CR) = CDI×SF ……………………………… (4)
where:
Cancer risk (CR) depicts the prospect of self's lifetime health menace from carcinogens; CDI is the chronic day-by-day carcinogens intake ($mg\cdot kg^{-1}\cdot d^{-1}$); SF is the slope factor of perilous substances ($mg\cdot kg^{-1}\cdot d^{-1}$). Slope factor values for the carcinogens As and Cd are given as 1.5, and 15 (EPA, 2009). Mn, Hg and Pb, being non-carcinogens, have no assigned value for slope factor (SF).

The cumulative CR will be deduced from:
Total Cancer Risk (TCR) = $\Sigma^{k}_{i=1}$ CDI x SF ……………………………… (5)
where:
CDIk is the chronic day-by-day intake ($mg\cdot kg^{-1}\cdot d^{-1}$) of a single toxic element k;
SFk is the slope factor for the toxic element k ($mg\cdot kg^{-1}\cdot d^{-1}$).
The endurable maximum limit for TCR, for regulatory purpose, is between 10^{-6} - 10^{-4} (USEPA, 2001).

3.0. Results and Discussions

3.1 Results of Recovery Analysis

Table 3.1.1 Concentration of Toxic Metals in Aquatic Biotics, Isaka Creek.

Parameters and Units (mg/kg)	Fish	Periwinkle	Crab	Oyster	Prawn
Arsenic (As)	0.001±0.00	0.001±0.00	0.001±0.00	0.001±0.00	0.001±0.00
Cadmium (Cd)	0.001±0.00	0.001±0.00	0.001±0.00	0.001±0.00	0.001±0.00
Mercury (Hg)	0.0005±0.00	0.0005±0.00	0.0005±0.00	0.0005±0.00	0.0005±0.00
Manganese (Mn)	0.99±0.02	11.92±0.02	11.293±0.03	8.527±0.01	3.140±0.02

Lead (Pb)	0.01±0.00	0.0074±0.00	0.012±0.00	0.012±0.00	0.001±0.00

The result of Table 3.1.1 above is the Concentration of Toxic Metals in Aquatic Biotics, in Isaka Creek. The toxic metals under study were Mercury (Hg), Arsenic (As), Cadmium (Cd), Manganese (Mn), and Lead (Pb) in the five biotics of Fish, Periwinkle, Crab, Oyster, and Prawn. The result obtained from the experimentation showed Arsenic and Cadmium having concentrations of 0.001±0.00mg/kg in all the five biotics. Similarly, the concentration of Mercury was found to be 0005±0.00mg/kg in all the five biotics.

Meanwhile, there was variation in the Manganese Concentrations in the five biotics. The conc. of manganese in fish was found to be 0.99±0.02mg/kg, while that of periwinkle was 11.92±0.02mg/kg. Crab, oyster, and prawn were found to have concentrations of 11.29±0.003mg/kg, 8.527±0.001mg/kg and 3.140±0.002mg/kg respectively.

For Lead, 0.01±0.00 mg/kg concentration was found in fish; while 0.012±0.00mg/kg was found in both crab and oyster; 0.0074±0.00mg/kg and 0.001±0.00mg/kg concentrations were found in periwinkle and prawn respectively.

Table 3.1.2 Concentration of Toxic Metals in Aquatic Biotics, Marine Base Creek

Parameters and Units (mg/kg)	Fish	Periwinkle	Crab	Oyster	Prawn
Arsenic (As)	0.001±0.00	0.001±0.00	0.001±0.00	0.001±0.00	0.001±0.00
Cadmium (Cd)	0.001±0.00	0.001±0.00	0.001±0.00	0.001±0.00	0.001±0.00
Mercury (Hg)	0.005±0.00	0.005±0.00	0.005±0.00	0.0005±0.00	0.0005±0.00
Manganese (Mn)	10.107±0.001	0.669±0.00	15.758±0.00	7.012±0.00	5.098±0.00
Lead (Pb)	0.873±0.002	0.001±0.00	0.02±0.00	0.012±0.00	0.001±0.00

The result of Table 3.2 showed Arsenic and Cadmium having concentrations of 0.001±0.00mg/kg in all five biotics in Marine Base creek. Mercury was found to be of the same concentration of 0005±0.00mg/kg in fish, periwinkle, and crab, but of a conc. of 0.0005±0.00 $mgkg^{-1}$ in both oyster and prawn. The concentration of Manganese was found to be 10.107±0.00$mgkg^{-1}$ in Fish, 0.669±0.00mg/kg in periwinkle, 15.758±0.00mg/kg in crab, 7.0124±0.00mg/kg in oyster, and 5.098±0.00mg/kg in prawn. The concentration of Lead was found to be 0.873±0.002mg/kg in fish, 0.02±0.00mg/kg in crab, 0.012mg/kg in oyster, and 0.001mg/kg in both periwinkle and prawn.

3.1.3 Comparison of data of toxic metals in Aquatic Biotics from both creeks with worldwide standards and similar studies

Table 3.3 Worldwide comparison of data of Toxic Metals in Aquatic Biotics (mg/kg)

Biota	As	Cd	Hg	Mn	Pb
Fish	0.05	0.5 (EU Reg.)	0.5 (EU Reg.)	NR	0.5 (EU Reg.)

Periwinkle	NR	NR	NR	1 [FAO/FEPA 2003]	0.05 (WHO)
Crab	NR	0.1/0.2 (WHO/FAO)	2 (WHO)	1	0.3/0.2 [WHO/FAO]
Oyster	NR	0.05	NR	NR	0.2 (FAO)
Prawn	NR	0.2 (WHO/FAO)	NR	NR	0.3 (FAO/WHO 2011)

NR implies no records yet for comparison.

As can be seen from the world comparison table for aquatic biotics, the various values of concentration of toxic metals apart from Manganese, from Isaka creek, are all higher than the values derived from the study under review.

The concentrations of Manganese in prawn, periwinkle, crab, and oyster are witnessed to be much greater than the highest permissible limit of 1mg/kg (FAO/FEPA 2003). This may have a negative effect on the aquatic organisms due to high accumulation in their body tissues and consequently can cause a human health risk when these organisms are consumed (Adewumi *et al*., 2014; Zhuang *et al*., 2013).

For Marine base creek, concentration of Arsenic, Cadmium, and Hg are all lower than the max. tolerable limits. The conc. of Pb metal in Periwinkle, Crab, oyster, and prawn were also observed to be lower than the tolerable amount in the tissues of the biotics. However, the content of Pb in fish was witnessed to be greater than the maximum tolerable amount which may pose health issues to man. Manganese in the biotics was also observed to be higher than the maximum tolerable quantity, which may equally lead to public health challenges.

3..2 Human Health Risk Index from consumption of toxic metals via the biotics

Table 3.2.1. Human HRI from consumption of toxic metal in Fish, Isaka Creek

Toxic Metal	**Mean Conc. (mg/kg)**	***CDI***	***RfD***	***HQ***	***Safety***	**SF**	**CR**
As	0.001	0.00002857	0.0003	0.095	Safe	1.5	4.29×10^{-5}
Cd	0.001	0.00002857	0.001	0.2857	Safe	15	8.14×10^{-5}
Hg	0.0005	0.00001428	0.0005	0.02857	Safe	-	-
Mn	0.99	0.0282857	0.14	0.2020	Safe	-	-
Pb	0.01	0.0002857	0.004	0.0714	Safe	-	-

$\Sigma HQ = 0.683$; $\Sigma CR = 1.243 \times 10^{-4}$

From tables 3.2.1, the non-CR or HQ for As, Cd, Hg, Mn, and Pb were below one (1) in fish. No possibility of having non-carcinogenic health issues upon continuous consumption of fish from the creek of Isaka. The CR is within the permissible range, as such no likelihood of cancer risk.

Table 3.2.2. Human HRI from consumption of toxic metal in Periwinkle, Isaka Creek

Toxic Metal	Mean Conc. (mg/kg)	CDI	RfD	HQ	Safety	SF	CR
As	0.001	0.00002857	0.0003	0.095	Safe	1.5	4.29×10^{-5}
Cd	0.001	0.00002857	0.001	0.2857	Safe	15	4.29×10^{-4}
Hg	0.0005	0.00001428	0.0005	0.02857	Safe	-	-
Mn	11.92	0.34097	0.14	2.4355	Unsafe	-	-
Pb	0.0074	0.000211	0.004	0.052857	Safe	-	-

$\Sigma HQ = 2.897$; $\Sigma CR = 4.72 \times 10^{-4}$

From tables 3.2.2, the total non-CR or HQ for As, Cd, Hg, Mn, and Pb was above one (1) in periwinkle. There is possibility of having non-carcinogenic health issues upon continuous consumption of periwinkle from the creek. The cancer risk is within the permissible range, as such no likelihood of cancer risk.

Table 3.2.3. Human HRI from consumption of toxic metal in Crab, Isaka Creek

Toxic Metal	Mean Conc. (mg/kg)	CDI	RfD	HQ	Safety	SF	CR
As	0.001	0.00002857	0.0003	0.095	Safe	1.5	4.29×10^{-5}
Cd	0.001	0.00002857	0.001	0.2857	Safe	15	4.29×10^{-4}
Hg	0.0005	0.00001428	0.0005	0.02857	Safe	-	-
Mn	11.2934	0.322657	0.14	2.30469	Unsafe	-	-
Pb	0.012	0.000342	0.004	0.0857	Safe	-	-

$\Sigma HQ = 2.799$; $\Sigma CR = 4.72 \times 10^{-4}$

From tables 3.2.3, the total non-CR or HQ for As, Cd, Hg, Mn, and Pb was above one (1) in crab. There is possibility of having non-carcinogenic health issues upon continuous consumption of crab from the creek. This issue will specifically be related to accumulation of manganese in the human system. The cancer risk is within the permissible range, as such no likelihood of cancer risk.

Table 3.2.4. Human HRI from consumption of toxic metal in Oyster, Isaka Creek

Toxic Metal	Mean Conc. (mg/kg)	CDI	RfD	HQ	Safety	SF	CR
As	0.001	0.00002857	0.0003	0.095	Safe	1.5	4.29×10^{-5}
Cd	0.001	0.00002857	0.001	0.2857	Safe	15	4.29×10^{-4}
Hg	0.0005	0.00001428	0.0005	0.02857	Safe	-	-

Mn	3.140	0.089714	0.14	0.64081	Safe	-	-
Pb	0.001	0.00002857	0.004	0.00714	Safe	-	-

ΣHQ =1.057; ΣCR = 4.72 x10^{-4}

From tables 5.2.4, the non-CR or HQ for As, Cd, Hg, Mn, and Pb was above one in oyster. There is the possibility of having non-carcinogenic health issues upon continuous consumption oyster from the creek. The cancer risk is within the permissible range, as such no likelihood of cancer risk.

Table 3.2.5. Human HRI from consumption of toxic metal in Prawn, Isaka Creek

Toxic Metal	Mean Conc. (mg/kg)	CDI	RfD	HQ	Safety	SF	CR
As	0.001	0.00002857	0.0003	0.095	Safe	1.5	4.29 x 10^{-5}
Cd	0.001	0.00002857	0.001	0.2857	Safe	1.5	4.29 x 10^{-4}
Hg	0.0005	0.00001428	0.0005	0.02857	Safe	-	-
Mn	8.527	0.2436285	0.14	0.2436	Safe	-	-
Pb	0.012	0.000342	0.004	0.0857	Safe	-	-

ΣHQ =0.734; ΣCR = 4.72 x10^{-4}

From the table above, the non-CR or HQ for As, Cd, Hg, Mn, and Pb were less than one in prawn. No possibility of having non-carcinogenic health issues upon continuous consumption of prawn from the creek. The cancer risk is within the permissible range, as such no likelihood of cancer risk.

Table 3.2.6. Human HRI from consumption of toxic metal in Fish, Marine Base Creek

Toxic Metal	Mean Conc. (mg/kg)	CDI	RfD	HQ	Safety	SF	CR
As	0.001	0.0000285	0.0003	0.095	Safe	1.5	4.28x10^{-5}
Cd	0.001	0.0000285	0.001	0.0285	Safe	15	4.28x10^{-4}
Hg	0.0005	0.0000142	0.0005	0.0284	Safe	-	-
Mn	10.107	0.2887	0.14	2.062143	Unsafe	-	-
Pb	0.873	0.0249	0.004	6.225	Unsafe	-	-

ΣHQ = 8.439; ΣCR = 4.70x10^{-4}

From tables 3. 2.6, the total non-CR or HQ for As, Cd, Hg, Mn, and Pb was above one (1) in the biotics. This implies that continues consumption of fish from the creek directly or indirectly may cause non-carcinogenic health issues.

Sum CR obtained for deadly metals in the fish of marine base creek was observed to be within tolerable limit of 10^{-6} - 10^{-4} showing impossibility of cancer risk.

Table 3.2.7. Human HRI from consumption of toxic metal in Periwinkle, Marine Base Creek

Toxic Metal	Mean Conc. (mg/kg)	CDI	RfD	HQ	Safety	SF	CR
As	0.001	$2.85x10^{-5}$	0.0003	0.095	Safe	1.5	$4.28x10^{-5}$
Cd	0.001	$2.85x10^{-5}$	0.001	0.0285	Safe	15	4.2810^{-4}
Hg	0.0005	$1.42x10^{-5}$	0.0005	0.0284	Safe	-	-
Mn	0.669	0.019	0.14	0.1365	Safe	-	-
Pb	0.001	$2.85x10^{-5}$	0.004	0.007	Safe	-	-

ΣHQ = 0.2886; ΣCR = $4.70x10^{-4}$

From tables 3.2.7, the total non-CR or HQ for As, Cd, Hg, Mn, and Pb was below one in the biotics. This implies that continues consumption of periwinkle from the creek directly or indirectly may not cause non-carcinogenic health issues.

Sum CR obtained for noxious metals in the periwinkle of marine base Creek was observed to be within tolerable limit of 10^{-6} - 10^{-4} showing impossibility of cancer risk.

Table 3.2.8. Human HRI from consumption of toxic metal in Crab., Marine Base Creek

Toxic Metal	Mean Conc. (mg/kg)	CDI	RfD	HQ	Safety	SF	CR
As	0.001	$2.85x10^{-5}$	0.0003	0.095	Safe	1.5	$4.28x10^{-5}$
Cd	0.001	$2.85 x10^{-5}$	0.001	0.0285	Safe	15	$4.28x10^{-4}$
Hg	0.0005	$1.42 x10^{-5}$	0.0005	0.0284	Safe	-	-
Mn	15.758	0.45	0.14	3.214286	Unsafe	-	-
Pb	0.02	0.000571	0.004	0.14275	Safe	-	-

ΣHQ =3.509; ΣCR = $4.70x10^{-4}$

From table 3.2.8 above, the total non-CR or HQ for As, Cd, Hg, Mn, and Pb was above one in the biotics. This implies that continues consumption of crab from the creek directly or indirectly may cause non-carcinogenic health issues.

Sum CR obtained for noxious metals in the crab of marine base creek was observed to be within tolerable limit of 10^{-6} - 10^{-4} showing impossibility of cancer risk.

Table 3. 2.9. Human HRI from consumption of toxic metal in Oyster, Marine Base Creek

Toxic Metal	Mean Conc. (mg/kg)	CDI	RfD	HQ	Safety	SF	CR
As	0.001	$2.85X10^{-5}$	0.0003	0.095	Safe	1.5	$4.28x10^{-5}$
Cd	0.001	$2.85x10^{-5}$	0.001	0.0285	Safe	1.5	$4.28x10^{-5}$
Hg	0.0005	$1.42x10^{-5}$	0.0005	0.0284	Safe	-	--
Mn	7.012	0.2	0.14	1.428571	Unsafe	-	-
Pb	0.001	$2.85x10^{-5}$	0.004	0.007125	Safe	-	-

ΣHQ =1.586; ΣCR = $4.70x10^{-4}$

From table 4.44, the total non-CR or HQ for As, Cd, Hg, Mn, and Pb was above one in the biotics. This implies that continues consumption of oyster from the creek directly or indirectly may cause non-carcinogenic health issues.
The sum CR obtained for poisonous metals in the oyster of marine base creek was observed to be within tolerable limit of 10^{-6} - 10^{-4} showing impossibility of cancer risk.

Table 3.2.10. Human HRI from consumption of toxic metal in Prawn., Marine Base Creek

Toxic Metal	Mean Conc. (mg/kg)	CDI	RfD	HQ	Safety	SF	CR
As	0.001	$2.85x10^{-5}$	0.0003	0.095	Safe	1.5	$4.28 x10^{-5}$
Cd	0.001	$2.85x10^{-5}$	0.001	0.0285	Safe	15	$4.28 x10^{-4}$
Hg	0.0005	$1.42x10^{-5}$	0.0005	0.0284	Safe	-	-
Mn	5.098	0.1457	0.14	1.040714	Unsafe	-	-
Pb	0.001	$2.85x10^{-5}$	0.004	0.007125	Safe	-	-

ΣHQ =1.199; ΣCR = $4.70x10^{-4}$

From shown, the total non-CR or HQ for As, Cd, Hg, Mn, and Pb were above one in the biotics. This implies that continues consumption of prawn from the creek directly or indirectly may cause non-carcinogenic health issues.
The sum CR obtained for lethal metals in the prawn of marine base creek was observed to be within tolerable limit of 10^{-6} - 10^{-4} showing impossibility of cancer risk.

4.0 Conclusions

The concentration of the toxic metals in most of the aquatic biotics of both creeks were found to be of a risk upon consumption by man, which implies that the major sources of these pollutants within the creeks must be checked to forestall serious public health issues.

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