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Ecotoxicological investigation of some metals in the surface sediment of a polluted river in Nigeria

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Abstract: **To carry out the ecotoxicological assessment, heavy metals collected from the sediments of River Orashi were analyzed every month for one year using Flame Atomic Absorption Spectrometry. The calculated Possible Environmental Pollution Indicator (PEPI) of the contaminated river at the sampling points showed that the metals assessed have low risk. The pollution of heavy metals was measured by comparing the Quality of Sediment Investigation Guide (QSIG) with the concentrations of the heavy metals measured. This was also used to measure the biological effects on the environment and the degree of contamination of sediment by the metals. The possible biological effects of heavy metals were also determined using the mean quotient for contaminants (mERMQ). The mERMQ values indicate a 12% probability of the investigated heavy metals being toxic in the sediment of the Orashi River at the sampling points. The degree of pollution of the environment and the poisoning of the living organisms were not severe as indicated by the calculated Modified Hazard Quotient (mHQ).**

Keywords: **sediment, ecotoxicological assessment, Possible Environmental Pollution Indicator (PEPI), Quality of Sediment Investigation Guide (QSIG), Modified Hazard Quotient (mHQ).**

1. INTRODUCTION

In marine ecosystems, contaminants are deposited in the sediments. Therefore, the quality of sediments is important to the health status of a marine ecosystem (Chiaia-Hernández et al., 2022).

River Orashi, a river of the lower Niger River basin and a tributary of the Oguta Lake in Nigeria (Verla et al, 2019), flows through many Nigerian towns, including Urualla, Ihiala, Oguta, Omoku, Obiakpo, Ebocha, Mbiama and Epie (Enetimi & Ebiotu, 2017). River Orashi has been subjected to anthropogenic activities and environmental degradation. Anthropogenic sources of pollution on River Orashi include local artisanal fishery industry, transportation of goods and human beings from one area to another in canoes and motorized river crafts, careless disposal of domestic waste by the communities along the river bank into the river without treatment, run-off discharges from companies, chronic oil spills from pipelines crossing the river at different points including some from local fabricated illegal crude oil distilleries, locally known as kpo-fire (Enetimi & Ebiotu, 2017).

Fractionation and ecotoxicological implications of potentially toxic metals in sediments of three urban rivers and the Lagos Lagoon, Nigeria, West Africa have been reported (Oyeyiola et al., 2014). The study suggested that, during the dry season, potentially toxic metals (PTM) may accumulate in sediments in relatively labile forms that are released and can potentially be transported or bioaccumulated in the rainy season. Application of risk assessment codes and Hankanson potential risk indices indicated that Cd was the element of greatest concern in the Lagos Lagoon system.

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Pollution of rivers with contaminants has become one of the most critical environmental problems of the century. Environmental concerns relative to the health and vitality of aquatic ecosystems have become an emerging issue in Nigeria (Howard et al., 2012). The principal reason for this is that many toxic compounds such as mineral hydrocarbons from a large number of input sources can accumulate to elevated concentrations in sediments (Asagbra et al., 2015).

In this study, the ecotoxicological investigation of some metals in the surface sediment of a polluted river in Nigeria, was studied using the Possible Environmental Pollution Indicator (PEPI) (Hakanson, 1980) and consensus-based Quality of Sediment Investigation Guide (QSIG) (Long and MacDonald, 1998).

Possible Environmental Pollution Indicator (PEPI) (Ma and Han, 2019):

PEPI is a precise measurement, to ascertain the synergetic ecological risk of heavy metals according to the sedimentary theory (Hákanson, 1980). This assessment takes into account the geological background conditions, environmental chemistry, biological toxicology, and ecological variability (Lim et al., 2021). In the PEPI concept, the standardized biological toxic-response factors (Trf) for the single pollutant in the surface sediment are adopted from the Hákanson (1980) theory, where Cu, Pb, Ni, Zn, Cr, and Cd are 5, 5, 5, 1, 2 and 30, respectively.

Contamination factor (Cf) (Hakanson, 1980; Ma and Han, 2019):

Cf = Ci/Cn

Where:

Cf = Contamination factor of substance i. Contaminants that could be included in this Cf include PCB, Hg, Ni, V, Mo, Co, Cu, Pb, Cr, Zn, and others. Fe, Mn, and P cannot be correctly measured because their concentrations are usually affected by the reactions in sediments.

Cf <1 - low contamination factor; 1<=Cf<3 – moderate contamination factor; 3< = Cf < 6, Considerable contamination factor; Cf >= 6 – very high contamination factor.

Ci = The measured value of the substance i

Cn = The preindustrial reference value of the substance (Hakanson, 1980; Pobi et al., 2019):

Substance	Preindustrial reference value
Cd	1.0 ppm
Zn	175 ppm
Pb	70 ppm
Cu	50 ppm
Cr	90 ppm
Fe	<1 ppm

Risk factor (Ecological) E:

E = T x C

Where:

E = Risk factor (Ecological) of metal i. E < 40 – low risk (Ecological); 40 <= E < 80 – moderate risk (Ecological); 80 <=E < 160 – considerable risk (Ecological); 160 <= E < 320, high risk (Ecological); E >= very high risk (Ecological)

T = is the "toxic response" factor for the given substance i. This is the sensitivity of organisms to the biological characteristics of the aquatic systems (Dauvalter and Kashulin, 2018). Bioproduction index (BPI) can be used to represent the sensitivity. It could be considered that there is a reference lake in which each substance's C value = 1.0, BPI = 5.0. (Ma and Han, 2019).

Possible Environmental Pollution Indicator (PEPI) for the river (PEPI):

PEPI = E1 + E2 + E3 ……… Ern.

PEPI < 150	Low risk
150 <= 300	Moderate risk
300<=PEPI < 600	Considerable risk
PEPI >=600	Very high risk

Quality of Sediment Investigation Guide (QSIG):

Effect Threshold (ET), Effect Probable (EP), Effect Low (EL), Effect Medium (EM), and Effect Severe (ES) were applied to evaluate the possible influence of metals estimated in the samples in sediment (Long and Mac Donald, 1998; Rahman et al, 2022; Patale and Tank, 2022).

EL/EM and EM/ET were used to assess the pollution of sediment. Probable ecotoxicological contamination of the recorded values of pollutants (Essien et al., 2009). At concentrations below ERs and ELs there is likelihood that there will be any effects on plants and animals on the sediment. At chemical concentrations above EM and EL, negative effects will probably occur (Long and MacDonald, 1998). There are two ways of carrying out comparison: Using EL and EM, calculation of the mean quotient calculated from two derived sets of QSIGs, and the consideration of the number of species limits that were exceeded (Essien et al., 2009).

There are three categories of chemical concentrations:

Category	Effect
<ET or EM	Rare adverse biological effects
>= ET or EL	Occasional adverse biological effects
>= EP or EM	Frequent adverse biological effects

The mean quotient for some contaminants can be calculated to know the possible biological effect of combined toxicants (Long et al., 1998).

$$mERMQ = (C1/ERM1 + C2/ERM2 + \ldots\ldots Cn/ERMn)/n$$

where C is the sediment concentration of metal, ERM is the ERM of the metal, and n is the number of metals.

mERMQ can be used to show the possibility that a substance will be toxic (Long and MacDonald 1998).

mERMQ of <0.1 = 12% probability of being toxic;

mERMQ of 0.11 – 0.5 = 30% probability of being toxic

mERMQ of 0.51 – 1.5 = 40% probability of being toxic

mERMQ of >1.50 = 74% probability of being toxic

Index of Risk of Toxicity (IRT) (Rahman et al., 2022):

The Index of Risk of Toxicity (IRT) indicates the risk of the metals to the biota in the aquatic environment. Two threshold values for SQGs (TEL and PEL standard) were used to calculate TRI.

$$IRT_i = \sqrt{((Ci/ETi)^2/(Ci/EPi)^2\ )/2}$$

Where Ci = concentration of the ith metal, EP = Effect Probable, ET = Effect Threshold. TRI<=5 is considered as no toxic risk, 5<TRI<=10 as low toxic risk, 10<TRI<=15 as moderate toxic risk, 15<TRI<=20 as considerable toxic risk, and TRI>20 as very high toxic risk.

Modified Hazard Quotient (mHQ)

The modified hazard quotient is a new technique for calculating the degree of risk that each metal poses to living organisms in a specific area. mHQ enables us to detect contamination by checking the concentration of the metal in a medium with ecological effects at different ETs, EPs, and ES.

$$mHQ = SQRT(Ci(1/ETi + 1/EPi + 1/ESi))$$

Where Ci = measured metal concentration.

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mHQ	Interpretation
>3.5	Severe Contamination (Extreme)
3.0 <= mHQ < 3.5	Severe Contamination (Very high)
2.5 <= mHQ < 3.0	Severe Contamination (High)
2.0 <= mHQ < 2.5	Contamination (Considerably severe)
1.5 < = mHQ < 2.0	Contamination (Moderately severe)
1.0 <= mHQ < 1	Contamination (Low Severity)
mHQ < 0.5	Contamination (Nil to very low severity)

2. MATERIALS AND METHOD

Study Area:

Orashi River is a river of the lower Niger River basin and a tributary of the Oguta Lake in Imo state, Nigeria. It started from the Ezeama community of Dikenafi through Urualla, Akokwa, Okija, Orsu, Ukpor, Ihiala, Uli, Oguta, Osemotor in Imo State, Omoku, Obiakpo, Ebocha, Ukodu, Okarki, Mbiama in Rivers State, and Epie in Bayelsa State. The river forms tributaries along its flow, from Imo through Anambra, Rivers to Bayelsa, before emptying onto the Altlantic (Enetimi & Ebiotu, 2017).

Description of sampling sites

Sampling station 1: Located at the waterfront of Odieke Ugbobi, before the meander loop as shown in Figure 1. Human activity was minimal in a way that did not affect water quality negatively. Usual human activities include washing, fishing, and recreation

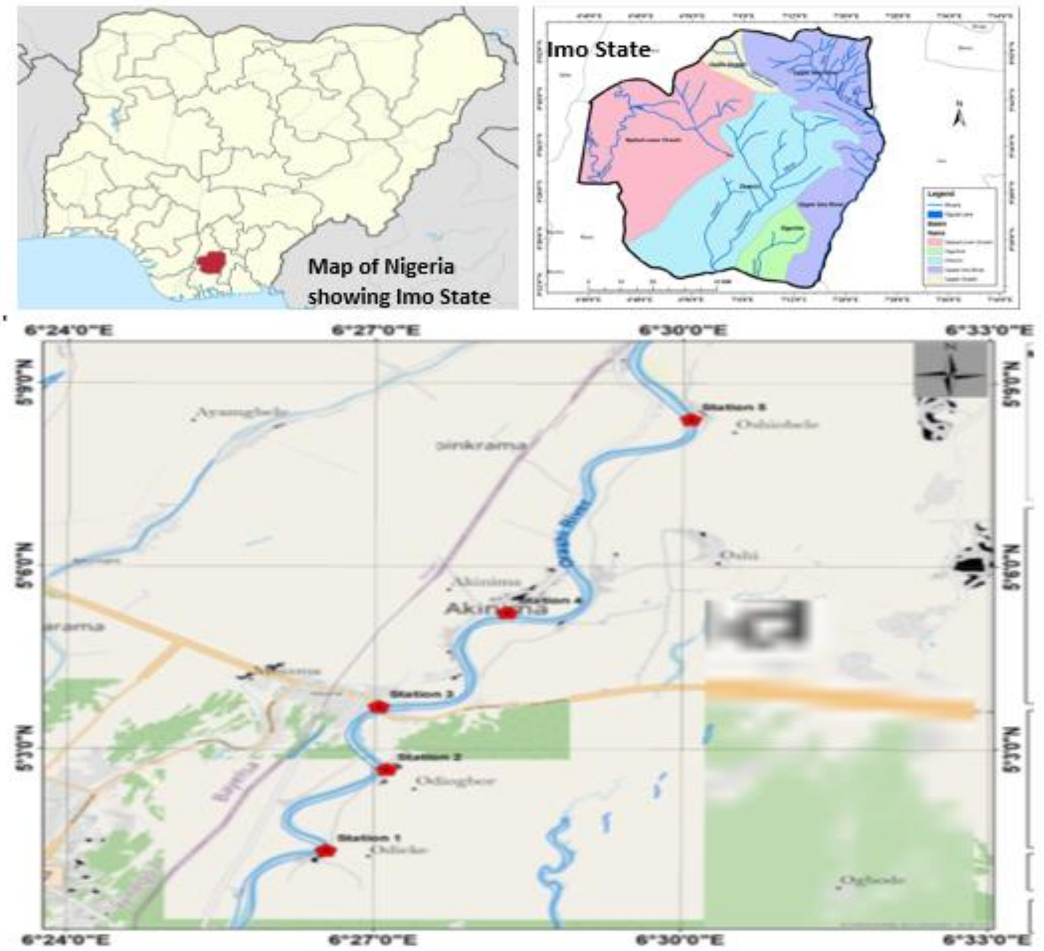

Figure 1: Orashi River showing the sampling points

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Sampling station 2: Situated at Odiobor waterfront just a little bit upstream after the community (Figure 1). This was an area with high human activities such as sand dredging, bunkering, illegal artisanal crude oil refineries, and waste dump areas.

Sampling station 3: This site is close to the Mbiama East/West road bridge crossing the Orashi River (Figure 1). Anthropogenic activities were much higher at this site. Lots of dredging activities take place here. It was near the site where illegally refined crude oil products were landed and sold to marketers.

Sampling station 4: This is located upstream of Akinima, Ahoada West L.G.A headquarters (Figure 1). The area has shallow and straight water courses. It is one of the major fishing communities in the area, where serious fishing activity and trading is done. Anthropogenic activity was very high upstream about 2 kilometers away, and illegal bunkering and crude oil theft were obvious around this point. Oil pipelines and creeks cross this section of the river and vandals often damage pipes and steal crude oil that they use for illegal refineries. After that, the waste is dumped into the Orashi River to pollute the water.

Sampling station 5: This sample point is located between Oshiobele and Joinkrama communities (Figure 1). This section is the shallowest, widest, and fastest-flowing water current in the area. It is quiet with less anthropogenic activity. More fishing is done in this section than in other areas.

Sample Collection:

The sample was collected every month from October 2018 to September 2019. The upper 10 cm of surface sediment samples were collected with Ekman grab randomly and composited as one sample at each sampled point.

Preparation of samples:

The procedures involve oven drying of sediment at a specific temperature and time for trace metals. The oven-drying sediment for trace metals was placed on a clean sheet of paper in the oven and dried at 1030C temperature for 24 hours. The dried samples were crushed with a mortar sieved through a 2 mm mesh screen was stored in a plastic container for analysis.

Determination of heavy metals in sediment

Heavy metal determination in sediment samples used the Flame AAS (FAAS) (ASTM, 1981; IITA, 1979)

The dried sediment sample at room temperature was homogenized by grinding and sieving the sample through a 2mm mesh sieve. Then exactly 5 grams (5g) of the prepared sample was transferred and contained into a 100 ml glass beaker, while a mixture of 2 ml concentrated nitric acid (HNO3), 10 ml of concentrated hydrochloric acid (HCL), and about 20 ml of distilled water was added and properly mixed.

The cooled sample solution was filtered and quantitatively transferred into a 50ml standard volumetric flask for the test of metals.

The total metal concentrations were reported in units of ppm (parts per million), mg (milligram) per kg (kilogram) of sediment and calculated as:

Total metal concentration = (DxRxV)/W

Where: D = serial dilution,

R = concentration reading (PPM or mg/l)

V = final volume of acid during digestion (ml).

W = Sample weight (dry) (g)

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3. RESULTS

Table 1: Average Concentration of heavy metals in sediment of Orashi River at Odieke (2018 - 2019)

Heavy Metal	Concentration (C)		Preindustrial Ref. Value (Cn) (Wang et al., 2022)	Contamination factor (C)	Toxic Response Factor (T)	Risk Factor (Ecological (E)	Possible Environmental Pollution Indicator (PEPI)
	Average (mg/kg)	Std. Dev.					
Cd	0.001	0.001	1	0.001	30	0.030	
Cr	0.326	1.130	90	0.004	2	0.007	
Fe	18.020	4.320	NA		6	0.000	
Zn	9.830	4.580	175	0.056	1	0.056	
Pb	1.376	4.760	70	0.020	5	0.098	0.192

Table 2: Potential ecotoxicological effects of the metals in sediment of River Orashi at Odieke (2018 - 2019) Using Sediment Quality Guidelines (SQGs) (MacDonald et al., 2000; Toby et al. 2019)

Heavy Metal	Concentration (C)		ET (Effect Threshold)	EP (Effect Probabe)	EL (Effec tLow)	EM (Effect Medium)	ES (Effect Severe)	Mean Quotient	Index of Risk of Toxicity (IRT)	Modified Hazard Quotient (mHQ)
	Averag e (mg/kg)	Std. Dev.								
Cd	0.001	0.001	0.99	4.9800	3.53	9	10		3.557	0.036
Cr	0.326	1.130	52.3	160.4000	81	370	110		2.169	0.106
Fe	18.020	4.320			Nil	Nil	Nil			
Zn	9.830	4.580	124	271.0000	150	410	820		1.545	0.357
Pb	1.376	4.760	30.2	112.2000	46.7	218	250	0.0313	2.627	0.252

Table 3: Average Concentration of heavy metals in sediment of Orashi River at Odiobor (2018 - 2019)

Heavy Metal	Concentration (C)		Preindustrial Ref. Value (Cn) (Wang et al., 2022)	Contamination factor (C)	Toxic Response Factor (T)	Risk Factor (Ecological (E)	Possible Environmental Pollution Indicator (PEPI)
	Average (mg/kg)	Std. Dev.					
Cd	0.001	0.001	1	0.001	30	0.030	
Cr	2.334	8.080	90	0.026	2	0.052	
Fe	21.080	5.200	NA		6	0.000	
Zn	12.070	8.120	175	0.069	1	0.069	
Pb	2.218	7.680	70	0.032	5	0.158	0.309

Table 4: Potential ecotoxicological effects of the metals in sediment of River Orashi at Odiobor (2018 - 2019) Using Sediment Quality Guidelines (SQGs) (MacDonald et al., 2000; Toby et al. 2019)

Heavy Metal	Concentration (C)		ET (Effect Threshold)	EP (Effect Probable)	EL (Effect Low)	EM (Effect Medium)	ES (Effect Severe)	Mean Quotient	Index of Risk of Toxicity (IRT)	Modified Hazard Quotient (mHQ)
	Average (mg/kg)	Std. Dev.								
Cd	0.001	0.001	0.99	4.9800	3.53	9	10		3.557	0.036
Cr	2.334	8.080	52.3	160.4000	81	370	110		2.169	0.284
Fe	21.080	5.200			Nil	Nil	Nil			
Zn	12.070	8.120	124	271.0000	150	410	820		1.545	0.396
Pb	2.218	7.680	30.2	112.2000	46.7	218	250	0.0460	2.627	0.320

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Table 5: Average Concentration of heavy metals in sediment of Orashi River at Mbiama (2018 - 2019)

Heavy Metal	Concentration (C)		Preindustrial Ref. Value (Cn) (Wang et al., 2022)	Contamination factor (C)	Toxic Response Factor (T)	Risk Factor (Ecological (E)	Possible Environmental Pollution Indicator (PEPI)
	Average (mg/kg)	Std. Dev.					
Cd	0.001	0.001	1	0.001	30	0.030	
Cr	1.559	5.400	90	0.017	2	0.035	
Fe	24.010	16.720	NA		6	0.000	
Zn	15.350	9.910	175	0.088	1	0.088	
Pb	1.568	5.430	70	0.022	5	0.112	0.264

Table 6: Potential ecotoxicological effects of the metals in sediment of River Orahi at Mbiama (2018 - 2019) Using Sediment Quality Guidelines (SQGs) (MacDonald et al., 2000; Toby et al. 2019)

Heavy Metal	Concentration (C)		ET (Effect Threshold)	EP (Effect Probable)	EL (Effect Low)	EM (Effect Medium)	ES (Effect Severe)	Mean Quotient	Index of Risk of Toxicity (IRT)	Modified Hazard Quotient (mHQ)
	Average (mg/kg)	Std. Dev.								
Cd	0.001	0.001	0.99	4.9800	3.53	9	10		3.557	0.036
Cr	1.559	5.400	52.3	160.4000	81	370	110		2.169	0.232
Fe	24.010	16.720			Nil	Nil	Nil			
Zn	15.350	9.910	124	271.0000	150	410	820		1.545	0.446
Pb	1.568	5.430	30.2	112.2000	46.7	218	250	0.0490	2.627	0.269

Table 7: Average Concentration of heavy metals in sediment of Orashi River at Akinima (2018 - 2019)

Heavy Metal	Concentration (C)		Preindustrial Ref. Value (Cn) (Wang et al., 2022)	Contamination factor (C)	Toxic Response Factor (T)	Risk Factor (Ecological (E)	Possible Environmental Pollution Indicator (PEPI)
	Average (mg/kg)	Std. Dev.					
Cd	0.001	0.001	1	0.001	30	0.030	
Cr	0.868	3.000	90	0.010	2	0.019	
Fe	17.890	6.010	NA		6	0.000	
Zn	12.990	3.780	175	0.074	1	0.074	
Pb	1.609	5.570	70	0.023	5	0.115	0.238

Table 8: Potential ecotoxicological effects of the metals in sediment of River Orashi at Akinima (2018 - 2019) Using Sediment Quality Guidelines (SQGs) (MacDonald et al., 2000; Toby et al. 2019)

Heavy Metal	Concentration (C)		ET (Effect Threshold)	EP (Effect Probable)	EL (Effect Low)	EM (Effect Medium)	ES (Effect Severe)	Mean Quotient	Index of Risk of Toxicity (IRT)	Modified Hazard Quotient (mHQ)
	Average (mg/kg)	Std. Dev.								
Cd	0.001	0.001	0.99	4.9800	3.53	9	10		3.557	0.036
Cr	0.868	3.000	52.3	160.4000	81	370	110		2.169	0.173
Fe	17.890	6.010			Nil	Nil	Nil			
Zn	12.990	3.780	124	271.0000	150	410	820		1.545	0.411
Pb	1.609	5.570	30.2	112.2000	46.7	218	250	0.0415	2.627	0.272

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Table 9: Average Concentration of heavy metals in sediment of Orashi River at Oshiobele (2018 - 2019)

Heavy Metal	Concentration (C)		Preindustrial Ref. Value (Cn) (Wang et al., 2022)	Contamination factor (C)	Toxic Response Factor (T)	Risk Factor (Ecological (E)	Possible Environmental Pollution Indicator (PEPI)
	Average (mg/kg)	Std. Dev.					
Cd	0.001	0.001	1	0.001	30	0.030	
Cr	0.884	3.060	90	0.010	2	0.020	
Fe	20.070	7.570	NA		6	0.000	
Zn	14.610	5.380	175	0.083	1	0.083	
Pb	0.801	2.770	70	0.011	5	0.057	0.190

Table 10: Potential ecotoxicological effects of the metals in sediment of River Orashi at Oshiobele (2018 - 2019) Using Sediment Quality Guidelines (SQGs) (MacDonald et al., 2000; Toby et al. 2019)

Heavy Metal	Concentration (C)		ET (Effect Threshold)	EP (Effect Probable)	EL (Effect Low)	EM (Effect Medium)	ES (Effect Severe)	Mean Quotient	Index of Risk of Toxicity (IRT)	Modified Hazard Quotient (mHQ)
	Average (mg/kg)	Std. Dev.								
Cd	0.001	0.001	0.99	4.9800	3.53	9	10		3.557	0.036
Cr	0.884	3.060	52.3	160.4000	81	370	110		2.169	0.174
Fe	20.070	7.570			Nil	Nil	Nil			
Zn	14.610	5.380	124	271.0000	150	410	820		1.545	0.435
Pb	0.801	2.770	30.2	112.2000	46.7	218	250	0.0418	2.627	0.192

4. DISCUSSION

The calculated Risk Factors (Ecological) (E) for Cd, Cr, Fe, Zn, and Pd at the Odieke are in Table 1. Table 3 shows the E for the metals at the Odiobor. Table 5 shows the E for the metals at Mbiama. Table 7 shows E for the metals at Akinima. Table 9 shows the E for the metals at Oshiobele. The calculated Risk Factor (Ecological) (E) for Cd, Cr, Fe, Zn, and Pd at the locations were also lower than 40 at the stations which shows low risk factor (Ecological) of the metals.

The calculated Possible Environmental Pollution Indicator (PEPI) of Orashi River at the Odieke sampling point was 0.192 shown in Table 1. The calculated PEPI for Orashi River at Odiobor was 0.309 as shown in Table 3. The calculated PEPI for Orashi River at Mbiama was 0.264 as shown in Table 5. The calculated PEPI for Orashi River at Akinima was 0.238 as shown in Table 7. The calculated PEPI for Orashi River at Oshiobele was 0.190 as shown in Table 9. PEPIs calculated in decreasing order are 0.309 at Odiobor > 0.264 at Mbiama > 0.238 at Akinima > 0.192 at Odieke > 0.190 at Oshiobele. The calculated PEPIs are less than 150, which shows that the heavy metals have a low possible environmental pollution indicator of River Orashi. Orashi River had the highest calculated Possible Environmental Pollution Indicator (PEPI at Odiobor due to high human activities such as dredging, bunkering, and waste dump, while the lowest calculated PEPI was 0.190 at Oshiobele because the sampling point was quiet with less anthropogenic activities.

The Quality of Sediment Investigation Guide (QSIG) at the Odieke sampling point are shown in Table 2. The QSIG s at Odiobor are shown in Table 4. The QSIG s at Mbiama are shown in Table 6. QSIG at Akinima is shown in Table 8. The QSIGs at Oshiobele are shown in Table 10. QSIGs comparative study can be used to monitor plan design, historical data interpretation, remedial investigations, and developing sediment quality remediation objectives. The calculated mean quotient (mERMQ) was used to determine the biological contamination of the heavy metals. The mERMQ values obtained in decreasing order were Mbiama (0.0490) > Odiobor (0.0460) > Oshiobele (0.0418) > Akinima (0.0415) > Odieke (0.0313). The m-ERM-Q values were less than 0.1 which indicates a 12% probability of the metals (Cd, Cr, Fe, Zn, Pb) being toxic in the sediment of Orashi River at Mbiama, Odiobor, Oshiobele, Akinima and Odieke.

The risk of the metals to the biota in the aquatic environment was assessed with the Toxic Risk Index (TRI). TRI of the heavy metals at the Odieke sampling point is shown in Table 2. The TRI of the metals at Odiobor is shown in Table 4. The TRI at Mbiama is shown in Table 6. TRI at Akinima is shown in Table 8. The TRI at Oshiobele is shown in Table 10. The highest TRI calculated was 3.557 for Cd while the lowest TRI calculated was 1.545 for Zn. These calculated values were less than 5 which is considered as no toxic risk of the metals investigated to the biota on Orashi River at Mbiama, Odiobor, Oshiobele, Akinima, and Odieke.

The hazard quotient (HQ) of the heavy metals at the Odieke sampling point is shown in Table 2. The HQ of the metals at Odiobor is shown in Table 4. The HQ at Mbiama is shown in Table 6. HQ at Akinima is shown in Table 8. The HQ at Oshiobele is shown in Table 10. The highest HQ calculated was 0.446 for Zn while the lowest HQ calculated was 0.036 for Cd. These calculated values were less than 0.5 which indicates a very low severity of contamination of living organisms on Orashi River at Mbiama, Odiobor, Oshiobele, Akinima, and Odieke by the metals investigated.

5. CONCLUSION

Ecotoxicological assessment was carried out at the sampling points at Odieke, Odiobor, Mbiama, Akinima, and Oshiobele. Apart from the Mbiama sampling point where significant anthropogenic activities were observed, other sampling points were quiet with little or no activities. The calculated PEPI of Orashi River at Odieke, Odiobor, Mbiama, Akinima, and Oshiobele showed the risk of contamination of the sediment of River Orashi by the heavy metals were low.

The mERMQ values indicate 12% probability of the investigated heavy metals being toxic in the sediment of Orashi River at Mbiama, Odiobor, Oshiobele, Akinima and Odieke

REFERENCES

[1] Asagbra, M.C., Adebayo, A.S., Anumudu, C.l. and Ugwumba, A.A. (2015). Polycyclic aromatic hydrocarbon in water, sediment and fish from the Warri River at Ubeji, Niger Delta, Nigeria. Afr. J. of Aquatic Sci. 40(2),1-7

[2] Chiaia-Hernández A. C., Günthardt B. F., Frey M. P., J. Hollender (2017) Unravelling contaminants in the anthropocene using statistical analysis of liquid chromatography–high-resolution mass spectrometry nontarget screening data recorded in lake sediments. Environ. Sci. Technol. 51:12547–12556

[3] Chiaia-Hernández, A.C., Casado-Martinez, C., Lara-Martin, P. and T. D. Bucheli (2022). Sediments: sink, archive, and source of contaminants. Environ Sci Pollut Res 29, 85761–85765. https://doi.org/10.1007/s11356-022-24041-1

[4] Dauvalter V. A. and Kashulin N. A (2018) Assessment of the ecological state of the Arctic Freshwater system based on concentrations of heavy metals in the bottom sediments. Geochemistry International, 56:842-856.

[5] Enetimi, I. S. & Ebiotu P. K. (2017). Diversity and Levels of Bacteriological Contamination in Orashi River, Mbiama Community, River State, Nigeria. *Journal of Advances in Microbiology*, 4(3), 1-6.

[6] Essien, J. P., Antai S. P. and A. A. Olajire (2009), Distribution, Seasonal Variations and Ecotoxicological Significance of Heavy Metals in Sediments of Cross River Estuary Mangrove Swamp, Water Air Soil Pollut, 197:91–105. DOI 10.1007/s11270-008-9793-x

[7] Hakanson, L., (1980), An ecological risk index for aquatic pollution control.a sedimentological approach, Water Research, Volume 14, Issue 8: 975-1001, ISSN 0043-1354, https://doi.org/10.1016/0043-1354(80)90143-8.

[8] Howard, I.C, Briggs, A.O. and Uzomba, N.I. (2012). Total hydrocarbon level of surface sediment and water from the upper reaches of sobreiro river, Niger Delta, Nigeria. Journal of Nigeria Environmental Society7(3), 16-22.

[9] Lim, K. Y., Zakaria N. A. and K. Y. Foo (2021). Geochemistry pollution status and ecotoxicological risk assessment of heavy metals in the Pahang River sediment after the high magnitude of flood event, Hydrology Research, 51 (1): 107-124.

[10] Long, E. R. and MacDonald, D. D. (1998) Recommended uses of empirically derived, sediment quality guidelines for marine and estuarine ecosystem. Human and Ecological Risk Assessment 4, 1019–1039.

[11] Ma, L. and C. Han (2019), Water Quality Ecological Risk Assessment with Sedimentological Approach, Water Quality – Chapter 5, IntechOpen, Kelvin Summers, doi: 10.5772/intechopen.88594, url: https://doi.org/10.5772/intechopen.88594

[12] MacDonald, D. D., Ingersoll, C. G. & Berger, T. A. (2000), Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystem. Archives of Environmental Contamination and Toxicology 39, 20–31.

[13] Oyeyiola, O. A., Davidson C. M., Olayinka K. O. and B. I. Alo (2014), Fractionation and ecotoxicological implication of potentially toxic metals in sediments of three urban rivers and the Lagos Lagoon, Nigeria, West Africa, Environmental Monitoring and Assessment, 186:7321–7333

[14] Patale, V and Tank J. G. (2022), Ecological assessment of heavy metals accumulation in sediments and leaves of Avicennia marina along the Diu coast of the northeast Arabian Sea, Oceanologia, 64(2): 276-286

[15] Pobi K. K., Satpati S., Dutta, S., Nayek S., R. N. Saha and S. Gupta (2019), Sources evaluation and ecological risk assessment of heavy metals accumulated within a natural stream of Durgapur industrial zone, India, by using multivariate analysis and pollution indices, Applied Water Science, 9:58

[16] Rahman, R. S., Zia A.,, Sirajum, M. S, Rafiul Alam, Abu Reza Md Towfiqul Islam, Tasrina Rabia Choudhury, Bilkis Ara Begum, Abubakr M. Idris, 2022, Assessment of heavy metal contamination in sediment at the newly established tannery industrial Estate in Bangladesh: A case study, Environmental Chemistry and Ecotoxicology, 4: 1-12

[17] Toby, S. C., Duller, R. A., De Angelis, S.,& Straub, K. M. (2019). A stratigraphic framework for the preservation and shredding of environmental signals. Geophysical Research Letters,46,5837–5845. https://doi.org/10.1029/2019GL 082555https://www.scirp.org/(S(lz5mqp453ed%20snp55rrgjct55))/reference/referencespapers.aspx?referenceid =1643054. Available: 6 Nov. 2023.

[18] Verla A. W., Enyoh C. E., Verla E. N., Peter N. O. & Shirish S. P. (2019), Chemometric Assessment of Orashi River after Confluence with Oguta. Indonesian Journal of Fundamental and Applied Chemistry, 4(3), 91-103.

[19] Wang J, Gough WA, Yan J, and Z. Lu, 2022, Ecological Risk Assessment of Trace Metal in Pacific Sector of Arctic Ocean and Bering Strait Surface Sediments. Int J Environ Res Public Health, 19(8):4454. doi: 10.3390/ijerph190 84454. PMID: 35457322; PMCID: PMC9031188.