



Assessment of Contamination Status of Heavy Metals in Sediment due to Gas Flaring at Esit Eket, South Eastern Nigeria

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Abstract

This study assessed the contamination status of heavy metals in sediment of Esit Eket, south eastern Nigeria due to gas flaring. Six sediment samples were collected into well labeled polyethylene bags with the use of a hand trowel at a depth of 10cm during the dry season in the month of February precisely in the intertidal zone at extremely low tide randomly from the flare point to a distance of about 250m away from the flare site. These samples were refrigerated for two days before transported to the laboratory to analyze for

heavy metals concentration using a particle induced x-ray emission (PIXE) technique. Heavy metals such as Titanium (Ti), Chromium (Cr), Manganese (Mn), Iron (Fe), Copper (Cu), Zinc (Zn), Rubidium (Rb), Strontium (Sr), Zirconium (Zr) and Lead (Pb) were analyzed. The mean concentration values of these metals were 4739.73, 83.94, 1782.28, 37519.54, 24.36, 134.68, 56.33, 112.80, 118.60 and 31.85 ppm respectively. The three pollution indices {enrichment factor (EF), geo-accumulation index (Igeo) and contamination factor (CF)} employed to assess the contamination status of heavy metals in sediment samples of the study area revealed the elemental trend to be in descending order in each area of this study Mn>Zn >Pb>Cu >Fe>Sr>Rb>Cr>Ti>Zr. Analysis of multi-variate statistics such as Pearson's Correlation coefficient and cluster analysis were also applied to ascertain the relationship and sources of investigated heavy metals. Both positive and negative correlations were observed among some heavy metals but at 0.05 levels, while the cluster analysis revealed three main clusters. The study

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concluded that the ecosystems in the flared sites region are vulnerable to bioaccumulation of heavy metals in the soil. The concentrations of Iron (Fe) in sediments are higher at the study area than every other elements but Manganese (Mn) poses more negative effects than others.

Keywords: Gas flare; Bioaccumulation; Intertidal; Enrichment factor (Ef), geo-accumulation index (Igeo); contamination factor (Cf); Vegetation

1.0 Introduction

The development of technology has led to the exploration of man's environment in a bid to increasing his standard of living. This exploration includes oil drilling which in turn leads to gas flaring. The drilling of crude oil and gas flaring in the oil-rich Niger Delta Region of Nigeria has continued to degrade the environment, affecting man, animals and plant lives. Even inanimate objects are affected (Steiner, 2010). The Niger Delta mangrove and rainforest belt is one of the most fragile ecosystems in the world. It is the most oil-impacted environment and polluted area in the world. Everywhere in the world, plant species are used for medicinal purpose, food, ornamentals; carbon sinks as well as building materials. In this vein, the essence of plants to man cannot be underscored. Plant species diversity is the measure of the number of different plant species present in an area with reference to their physical characteristics and genetics composition (Ugochukwu and Ertel, 2008). The plant species in the Niger Delta region are undergoing serious threats for more than forty years owing to the exploration and exploitation of oil and gas by multinational companies domiciled in the area. Though, natural gas is an important source of energy to man, its extraction has impacted negatively on the

environment. Flaring is adopted during the process of petroleum refining and chemical processing for safe disposal of waste gases, process upsets, plant start-up or shutdown and process emergencies (Akinro et al., 2008).

The exploitation and exploration of oil has been of great gain to Nigeria but the negative results emanating from such production processes have been very disastrous. One of such is gas flaring which locally and globally threatens the world ecosystem, global health, agriculture and water security through emission of toxins into the water, land and air (Edino et.al, 2010). Heat generated from gas flaring kills surrounding plant, suppresses the growth and flowering of some plants thereby reducing crop yield, induced soil degradation, destroys aquatic life and diminishes agricultural production (Odoemene, 2011).

The incidence of acid rain, Green House Gas Emissions (GHGE) has disrupted the economic lives of the people in Edo community in Esit-Eket Local Government Area, of Akwa Ibom State. Increase in temperature of the atmosphere, greenhouse effect, acid rain/acidification of aquatic environment, poor agricultural yields and changes in the ecosystem etc. have been mentioned as some of the adverse effects (Ekanim and Udoessien, 2013). The entry of these contaminants such as heavy metals into the environment can be due to human and natural activities which is the most serious issues facing most communities currently. Due to the industrial and economic growth and the production of a variety of compounds and chemicals by increased consumption, man makes some unwanted pollutants in the ecosystem which causes serious hazards to both the environment and livelihood (Eaton et al., 2015). The most important natural resources of environmental pollution are soil and rock weathering alongside natural events such as

earthquakes and floods. Another entry point of these pollutants cause by man in the environment is through agricultural waste, industrial activities and municipal entry (Wogu et al., 2011). Although some of these metals are essential as micronutrients, their high concentration in the food chain can cause toxicity and environmental impacts and endanger aquatic ecosystems and their users (Obasohan, et. al., 2016). Particle induced X-ray emission (PIXE) technique used in this study has been proven to be an outstanding technique in the determination of the concentrations of various elements at parts per million (ppm) levels (Yawo and Akpan, 2021). PIXE is a multi-elemental analytical technique that can provide concentrations of many elements with atomic numbers between 11 and 92 (sodium and uranium) (Ho et al., 2010, Yawo and Akpan, 2021). Most of the other analytical techniques being used are destructive, while PIXE is a highly sensitive but relatively nondestructive technique (Steiner, 2010). In PIXE technique, the samples are bombarded with particles (Ho et al., 2010, Yawo and Akpan, 2021). Edo community in Esit Eket Local Government Area is open to industrial activities, runoff and municipal sewage from the oil company situated there; This is why the study is aimed at assessing the contamination status of heavy metals such as Titanium (Ti), Chromium (Cr), Manganese (Mn), Iron (Fe), Copper (Cu), Zinc (Zn), Rubidium (Rb), Strontium (Sr), Zirconium (Zr) and Lead (Pb) in the sediment of Esit Eket Local Government Area of Akwa Ibom State, Nigeria.

2.0 Materials and Methods

2.1 Description of study Area

Edo one of the gas flared sites is situated in Esit-Eket Local Government Area of Akwa Ibom State, Nigeria, as shown in Fig 1. Its

geographical coordinates are 4° 39' 20.22''North 8° 3' 46.39''East 4.655616°North 8.062886'' East. This city has a tropical climate. Edo has significant rainfall most months, with a short dry season that has a little impact. The average annual temperature in Edo Esit-Eket is 26.4°C. Precipitation here averages 3044 mm.

2.2 Sediment Samples Analysis

Sampling Technique and Analytical Tool

20grams of six sediment samples were collected into a well labeled polyethene bags with the use of a hand trowel at a depth of 10cm during the dry season in the month of February precisely in the intertidal zone at extremely low tide randomly from the flare point to a distance of about 250m away from the flare site following the method by Ugochukwu and Ertel (2008). These samples were refrigerated for two days before transported to the laboratory for analysis using a particle induced x-ray emission (PIXE) technique. The polythene bags were sealed to avoid contamination. Because sediments are a non-uniform mixture of different particle sizes, it is critical to maximize the homogeneity of sediment samples selected for analysis (Wogu and Okaka, 2011). The process of pulverization focuses on a thorough mixing of the samples. At the laboratory, an agate mortar and pestle were used for the grinding of those sediment samples and were rinsed for every sediment samples grinded using ethanol with toilet tissue. The fine sediment fraction ($< 0.2mm$) is particularly useful for estimating the relative degree of pollution and to distinguish between natural (geogenic) and anthropogenic sources which was used at the centre. Sample preparation was a straightforward pressing of a suitable quantity of homogenized powder of sediment samples in a die to produce a pellet using a pelletizing machine.

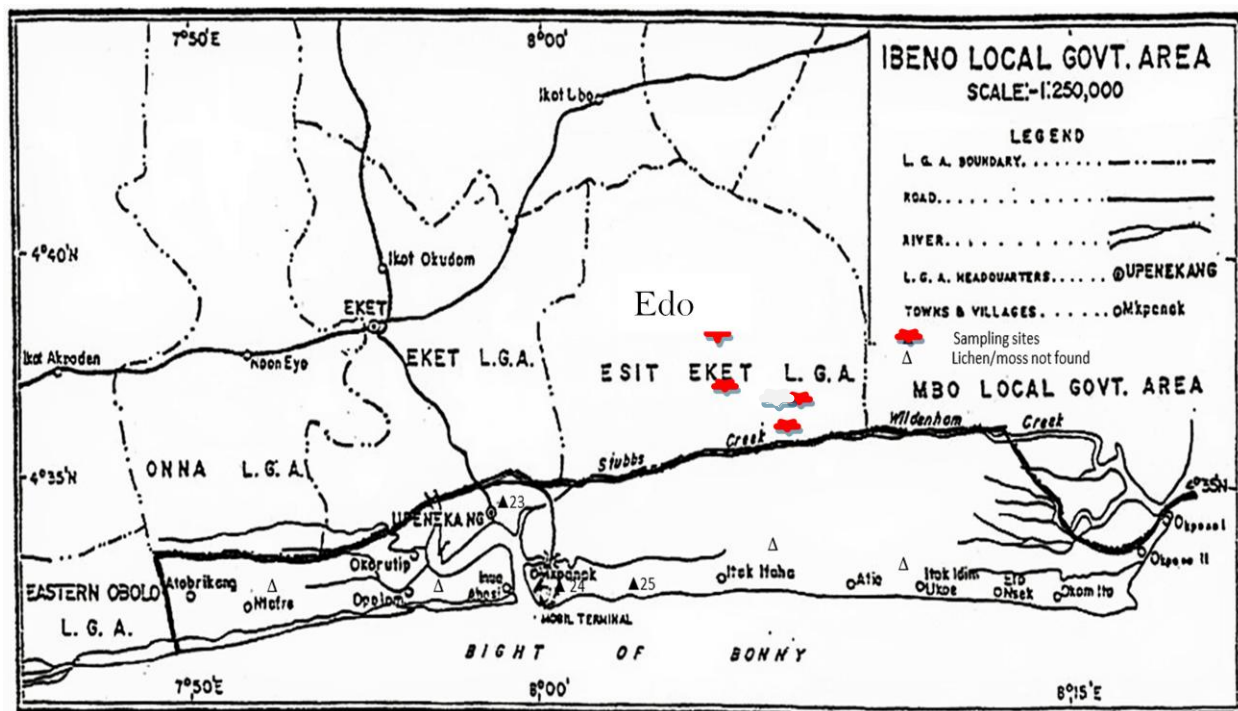


Figure 1: Map of Study Area (Esit Eket) showing the sampling locations

After which an ethanol was used to wash the die before inserting other samples to avoid contamination. Ten heavy metals concentration were analyzed for in the sediment which include Ti, Cr, Mn, Fe, Cu, Zn, Rb, Sr, Zr, and Pb. Three pollution indices namely, Enrichment factor (EF), geo-accumulation index (Igeo) and contamination factor (CF) were employed to assess the contamination status of those heavy metals.

As proposed by Akpan et al., (2013), Yawo and Akpan (2021), the enrichment factor was employed to assess the degree of contamination and to understand the distribution of the elements of anthropogenic origin from sites by individual elements in sediments. In this study, Fe is chosen as the normalizing element while determining EF-values as shown in equation 1 below, since in wetlands it is mainly supplied from sediments

and is one of the widely used reference element (Aghalino, et al., 2009; Dupont et al., 2000). Research by Steiner (2010) indicated that several researchers have also employed Al and Si as reference elements in the calculation of Enrichment factor (EF). According to Yawo and Akpan (2021) an element also qualifies as a reference one if it is of low occurrence variability and is present in the environment in trace amount. In this study, iron is also used as a conservative tracer to differentiate natural from anthropogenic components. According to Yawo and Akpan (2021) the metal (M) EF is defined in equation 1 as:

$$EF = \frac{[C_{metal}/C_{norm(Fe)}]_{sediment}}{[C_{metal}/C_{norm(Fe)}]_{backgroundsource}} \quad 1$$

where $[C_{\text{metal}}/C_{\text{norm}}(\text{Fe})]$ sediment and $[C_{\text{metal}}/C_{\text{norm}}(\text{Fe})]$ background source are the concentrations of metal and normalizer in the sediment samples and the background source respectively. In this approach, the normalizer is used to compensate for the differences in grain size and mineralogical composition between the sediment and the reference material (Obasohan, *et al.*, 2016). EF values were interpreted as suggested by Ho *et al.*, (2010), and Birch (2003), where $EF \leq 1$ indicates no enrichment; $1 < EF \leq 3$: minor enrichment; $3 < EF \leq 5$: moderate enrichment; $5 < EF \leq 10$: moderately severe enrichment; $10 < EF \leq 25$: severe enrichment; $25 < EF \leq 50$: very severe enrichment; $EF > 50$ is extremely severe enrichment. The background value (reference) is that of average shale (Ho *et al.*, 2010). Elements which are naturally derived have an EF value of nearly unity, while elements of anthropogenic origin have EF values of several orders of magnitudes. Index of geo-accumulation was used to assess heavy metal accumulation in sediments. This measure the degree of metal pollution in aquatic sediments studies (Dung *et al.*, 2008; Gerner *et al.*, 2004; Yawo and Akpan 2021) and is given in equation 2 as:

$$I_{\text{geo}} = \text{Log} 2 \left(\frac{C_m}{1.5 C_o} \right) \quad 2$$

where c_m in equation 2 is the measured concentration of the heavy metal in the sediment samples; and C_o is the concentration of the heavy metal in the background source; the factor 1.5 is used to compensate for possible variations of the reference data due to lithogenic effects (Dung *et al.*, 2008). Based on the I_{geo} value, the degree of heavy metal contamination is classified as follows: 1) $I_{\text{geo}} < 0$: unpolluted; 2) $0 \leq I_{\text{geo}} < 1$: unpolluted to moderately polluted; 3) $1 \leq I_{\text{geo}} < 2$:

moderately polluted; 4) $2 \leq I_{\text{geo}} < 3$: moderately to strong polluted; 5) $3 \leq I_{\text{geo}} < 4$: strongly polluted; 6) $4 \leq I_{\text{geo}} < 5$: strongly to very strongly polluted; 7) $I_{\text{geo}} \geq 5$: very strongly polluted.

Contamination factor parameter according to Ho *et al.*, (2010), and Birch (2003) is expressed in equation 3 as:

$$CF = C_{\text{metal}} / C_{\text{background}} \quad 3$$

where CF is the contamination factor, C_{metal} is the concentration of pollutant; $C_{\text{background}}$ is the background source value for the metal. The CF reflects the metal enrichment in the sediment. The CF was classified into four groups according to Dung *et al.*, (2008); Gerner *et al.*, (2004); Yawo and Akpan (2021). Where the contamination factor $CF < 1$ refers to low contamination; $1 \leq CF < 3$ means moderate contamination; $3 \leq CF \leq 6$ indicates high contamination and $CF > 6$ indicates very high contamination.

Multivariate analysis such as Pearson's correlation coefficients and Cluster analysis were also employed to determine the sources and relationships of those heavy metals. This refers to multiple advanced techniques for examining relationships among multiple variables at the same time. It has been proved to be an effective tool for providing suggestive information regarding heavy metal sources and pathways (Eugenio, 2003; and Abdulkareem, 2005). Some of which are employed in this study are cluster analysis and Pearson's correlation coefficient. The most use of cluster analysis is classification. That is, subjects are separated into groups such that each subject is more similar to other subjects in its group than to subjects outside the group. Cluster analysis (CA) classifies the studies of heavy metals in terms of their similarity and

difference. Cluster analysis was performed on the data set using average linkage between groups (rescaled distance cluster) to visualize elemental groupings in the studied sediments. The results are illustrated in the dendrogram on Hierarchical cluster analysis. Elements belonging to the same cluster are likely to have originated from a common source (Ho et al., (2010), Birch (2003) and Yawo and Akpan (2021).

Pearson's correlation coefficient is a statistical measure of the strength of a linear relationship between paired data. In a sample, it is denoted by r and is by design constrained as follows:

$$-1 \leq r \leq 1 \quad 4$$

such that

- Positive values denote positive linear correlation;
- Negative values denote negative linear correlation;
- A value of 0 denotes no linear correlation;
- The closer the value is to 1 or -1, the stronger the linear correlation.

3.0 Results and Discussion

The concentrations of heavy metals in sediments of Esit Eket as shown in Table 1 show variations in different stations. The mean enrichment factor (EF) values of heavy metals in sediment samples of Esit Eket sites (EET) on table 2 follow the sequential trend as follows; Mn>Zn>Pb>Cu>Fe>Sr>Rb>Cr>Ti>Zr. The mean geo-accumulation index (Igeo) values of heavy metals in sediment samples of Esit Eket local government, Akwa Ibom State are in Table 2. On the basis of the mean values of Igeo, sediment samples of Esit Eket sites (EET) are enriched with heavy metals in the following sequential trend; Mn> Zn >Pb> Cu>Fe >Sr >Rb> Cr> Ti> Zr. The mean contamination factor (CF) values of heavy metals in the sediment samples shows in

Table 2 also follow the same sequential trend of Mn> Zn >Pb> Cu>Fe >Sr >Rb> Cr> Ti> Zr. Following the sequential trends of these heavy metals in the study site it is observed that Manganese (Mn) concentration is higher than other metals while Zirconium (Zr) is the lowest. The differences in the concentrations of heavy metals based on pollution indices as shown in Figures 2, 3, 4 and 5 revealed the extent of toxicity and effects of these heavy metals to the environment. Tables 3, 4 and 5 shows the concentrations of these three pollution indices: enrichment factor (EF), geo- accumulation index (Igeo) and contamination factor (CF) respectively.

Pearson's correlation coefficient matrix for heavy metals in sediments of Esit Eket flared site shows both positive and negative significant correlations of heavy metals as shown in Table 6. Correlation matrix of heavy metals in Esit Eket LGA as presented in Table 6 shows the relationship among heavy metals concentrations. Correlation at these site shows both positive and negative significant correlation, but at $p < 0.05$ level. For instance, Copper (Cu) correlated positively with Chromium (Cr) at $p < 0.05$ level ($r = 0.824$) which indicate same source. Rubidium (Rb) correlated negatively with Zinc (Zn) at $p < 0.05$ level ($r = -0.898$) indicating different source. Strontium (Sr) shows only positive relationship with Titanium (Ti) and Iron (Fe) at $p < 0.05$ level ($r = 0.916$ and $.905$ respectively). This indication shows that they emanate from same source. The result of Hierarchical clustering of elements in sediments of Esit Eket L.G.A. in Akwa Ibom State (Fig. 6.) shows only 3 main clusters. Cluster 1 consists of (Cu, Pb, Rb, Zn, Sr and Cr), Cluster 2 consists of (Mn and Ti), and Cluster 3 consists of (Zr and Fe). This statistical analysis illustrates their relationships

and sources. Figure 7 shows a comparison of and standard limit by PEC. heavy metals concentrations between study site

Table 1: Concentration (ppm) of heavy metals in sediment samples of Esit Eket (EET)

Element	EET1	EET2	EET3	EET4	EET5	EET6
Ti	5348.2 ± 2.1	6873.23 ±8.2	4118.31 ± 1.32	2187.67 ± 4.3	5526.8 ± 18.2	4384.18 ± 18.4
Cr	79.32 ±3.10	48.34 ± 2.1	101.21 ± 5.8	68.13 ± 2.1	98.76 ± 1.8	108.12 ± 4.8
Mn	2170.3 ±11.6	1874.87 ± 15.1	1374.16 ± 11.2	1194.89 ± 6.12	897.68. ± 9.3	3181.78 ± 1.9
Fe	34320.9 ±11.21	61324.18 ± 6.2	21118.8 ± 1.81	4384.63 ± 11.2	82134.52 ± 6.3	21834.19 ± 3.8
Cu	14.3 ±1.8	9.67 ± 32.1	23.31 ± 1.8	18.49 ± 0.6	42.18 ± 1.2	38.21 ± 1.8
Zn	103.34 ±8.7	143.48 ± 71.6	99.38 ± 1.2	128.18 ± 4.2	174.82 ± 1.8	158.87 ± 4.8
Rb	61.72 ±38.10	48.32 ± 1.8	87.31 ± 8.1	58.97 ± 1.8	32.67 ± 3.2	48.98 ± 2.7
Sr	124.6 ±11.8	132.32 ± 6.7	97.11 ± 4.8	69.18 ± 1.4	142.81 ± 1.6	110.81 ± 3.4
Zr	181.7 ±7.9	119.62 ± 3.1	98.14 ± 1.2	73.18 ± 2.4	169.14 ± 4.6	69.83 ± 1.3
Pb	30.12 ±1.21	46.11 ± 1.8	60.11 ± 1.1	23.72 ± 1.8	11.23 ± 0.8	19.81 ± 1.7

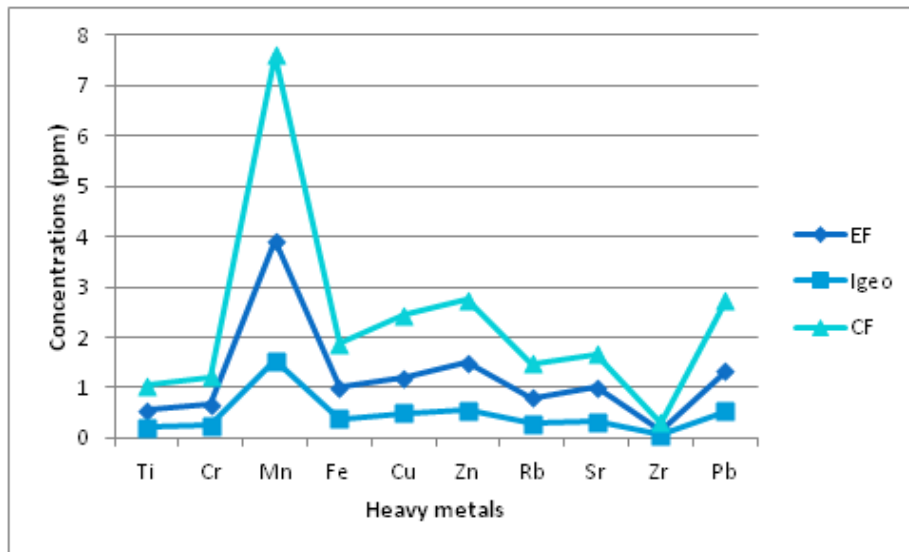


Fig 2: Spatial variation of mean values of EF, Igeo and CF of elements in sediment samples of Esit Eket L.G.A., Akwa Ibom State.

Table 2: Mean, average shale, EF, Igeo and CF of heavy metals in sediment samples of Esit Eket

Heavy metals	Mean Conc.(ppm)	Average shale(ppm)	EF	Igeo	CF
Ti	4739.73	4560.0	0.56	0.21	1.04
Cr	83.98	69.3	0.67	0.24	1.21
Mn	1782.28	234.5	3.92	1.53	7.60
Fe	37519.54	20080.2	1.00	0.38	1.87
Cu	24.36	10.0	1.20	0.49	2.44
Zn	134.68	48.9	1.49	0.55	2.75
Rb	56.33	38.0	0.79	0.29	1.48
Sr	112.80	68.0	1.00	0.33	1.66
Zr	118.60	378.6	0.16	0.06	0.31
Pb	31.85	11.7	1.33	0.54	2.72

Table 3: Enrichment Factor (EF) of Heavy Metals in Esit Eket Sediments

Stations	Ti	Cr	Mn	Fe	Cu	Zn	Rb	Sr	Zr	Pb
1	0.69	0.67	5.25	1.00	0.80	1.25	0.95	1.33	0.28	1.50
2	0.49	0.29	2.58	1.00	0.40	0.96	0.42	0.65	0.10	1.33
3	0.86	1.67	5.42	1.00	2.20	1.96	2.16	1.35	0.24	4.67
4	2.19	4.43	22.75	1.00	10.5	14.5	6.50	5.33	0.89	5.00
5	0.29	0.33	0.92	1.00	1.00	0.87	0.21	0.5	0.11	0.17
6	0.88	1.40	12.17	1.00	3.6	3.04	1.16	1.50	0.17	1.50

Table 4: Geo-accumulation Index (Igeo) of Heavy Metals in Esit Eket Sediments

Stations	Ti	Cr	Mn	Fe	Cu	Zn	Rb	Sr	Zr	Pb
1	0.23	0.23	1.86	0.34	0.29	0.42	0.33	0.37	0.09	0.52
2	0.30	0.14	1.60	0.61	0.19	0.59	0.26	0.39	0.06	0.79
3	0.18	0.29	1.18	0.21	0.47	0.41	0.46	0.29	0.05	1.03
4	0.09	0.19	1.02	0.05	0.37	0.53	0.31	0.20	0.04	0.41
5	0.24	0.29	0.77	0.82	0.85	0.72	0.17	0.42	0.09	0.19
6	0.19	0.31	2.72	0.22	0.77	0.65	0.26	0.33	0.04	0.34

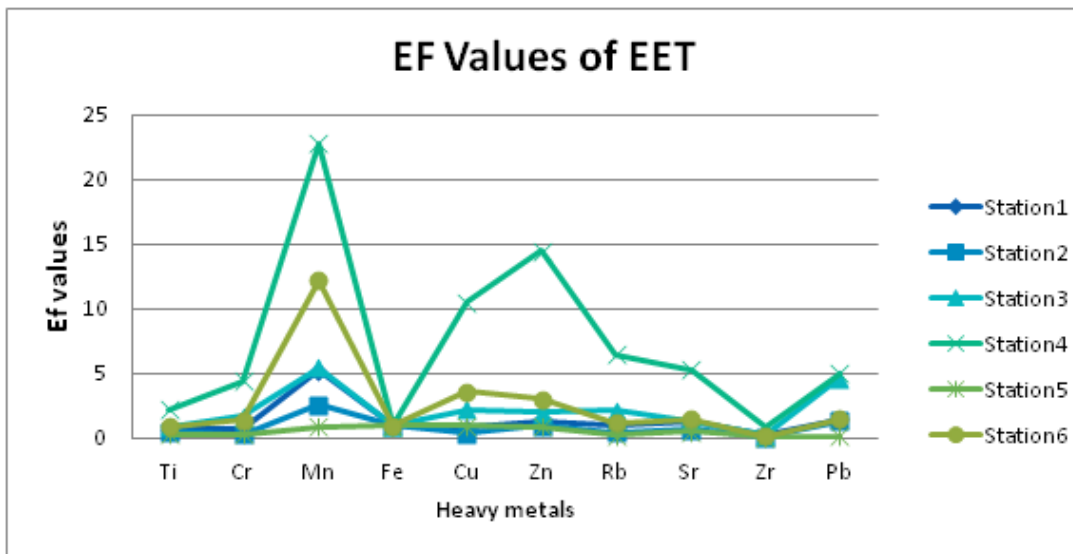


Fig 3: Spatial variation of Enrichment factor (EF) of elements in sediment samples of Esit Eket L.G.A., Akwa Ibom State

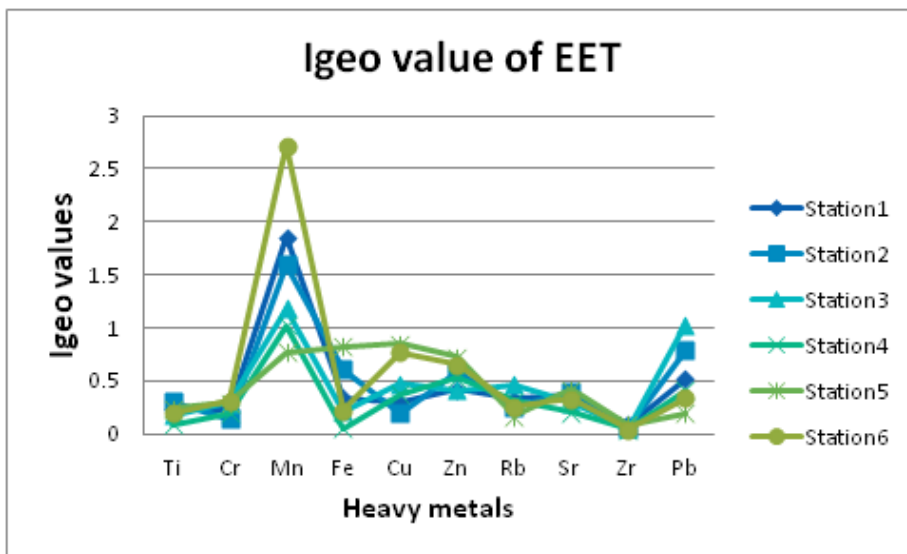


Fig 4: Spatial variation of Geo accumulation Index (Igeo) of elements in sediment samples of Esit Eket L.G.A., Akwa Ibom State

Table 5: Contamination factor (CF) of Heavy Metals in Esit Eket Sediments

Stations	Ti	Cr	Mn	Fe	Cu	Zn	Rb	Sr	Zr	Pb
1	1.17	1.14	9.26	1.71	1.43	2.11	1.62	1.83	0.48	2.57
2	1.51	0.69	7.99	3.05	0.97	2.93	1.27	1.95	0.32	3.94
3	0.90	1.46	5.86	1.05	2.33	2.03	2.29	1.43	0.26	5.13
4	0.48	0.98	5.09	0.22	1.85	2.62	1.55	1.02	0.19	2.03
5	1.21	1.03	3.83	4.09	4.22	3.58	0.86	2.10	0.45	0.96
6	0.96	1.56	13.57	1.09	3.82	3.25	1.29	1.63	0.18	1.69

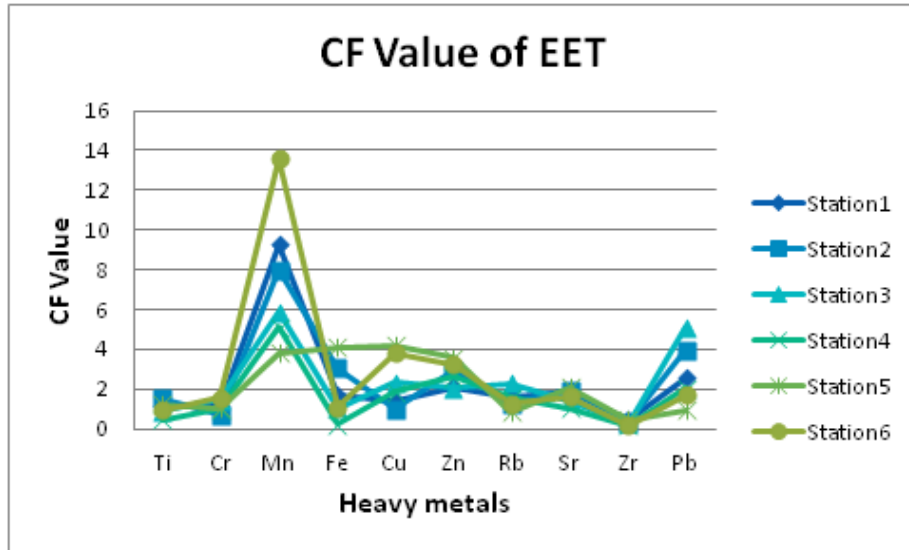


Fig 5: Spatial variation of Contamination factor (CF) of elements in sediment samples of Esit Eket L.G.A., Akwa Ibom State

Table 6: Correlation coefficient of heavy metals in sediment samples of EET

Correlations										
	Ti	Cr	Mn	Fe	Cu	Zn	Rb	Sr	Zr	Pb
Ti	1									
Cr	-.253	1								
Mn	.152	.188	1							
Fe	.804	-.093	-.287	1						
Cu	-.122	.824*	.041	.249	1					
Zn	.256	.146	.042	.577	.663	1				
Rb	-.385	.107	-.029	-.659	-.423	-.898*	1			
Sr	.916*	.021	.082	.905*	.213	.446	-.568	1		
Zr	.598	-.072	-.271	.678	-.044	-.014	-.288	.733	1	
Pb	.144	-.230	-.063	-.222	-.595	-.690	.788	-.176	-.175	1

*. Correlation is significant at the 0.05 level (2-tailed).

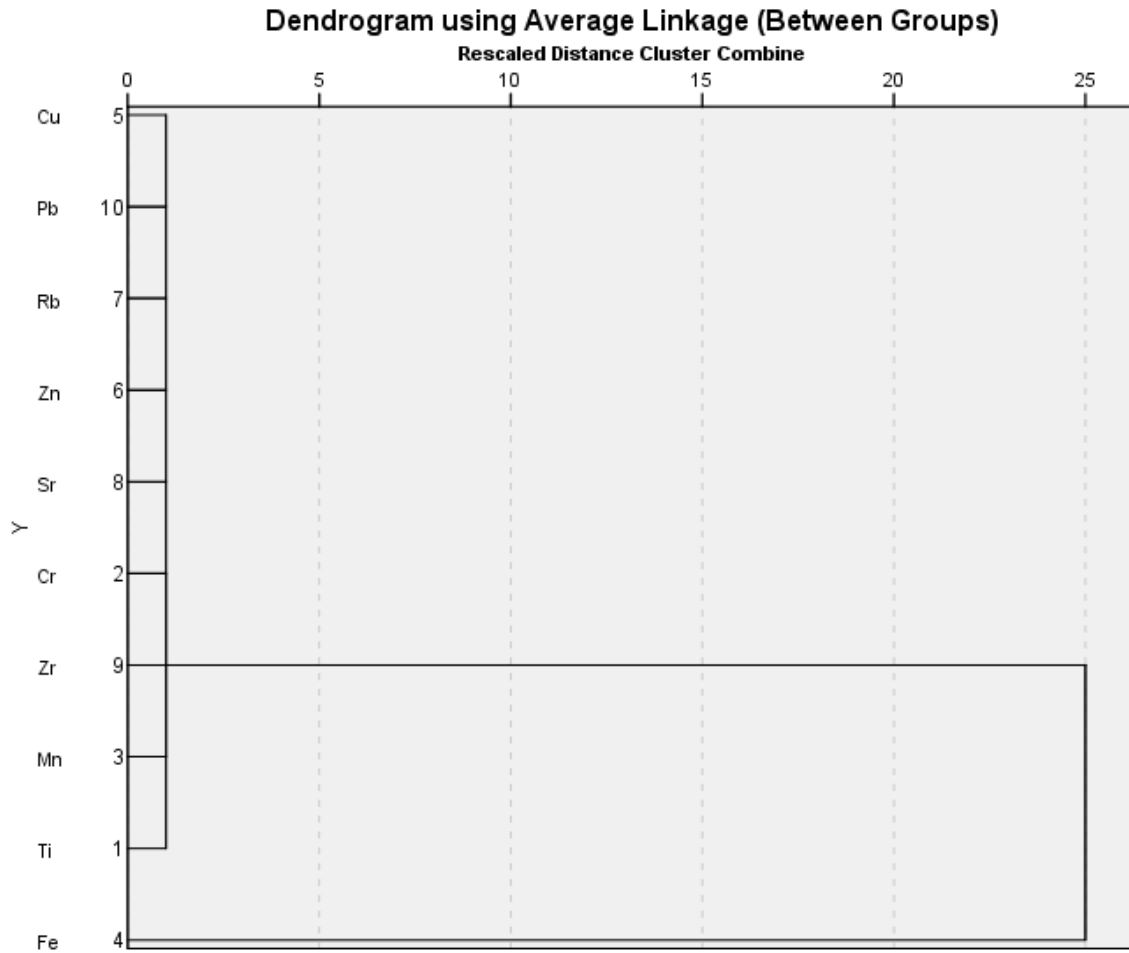


Fig 6: Hierarchical Clustering results (dendrogram) for element in sediment samples of Edo community in Esit Eket L.G.A., Akwa Ibom State

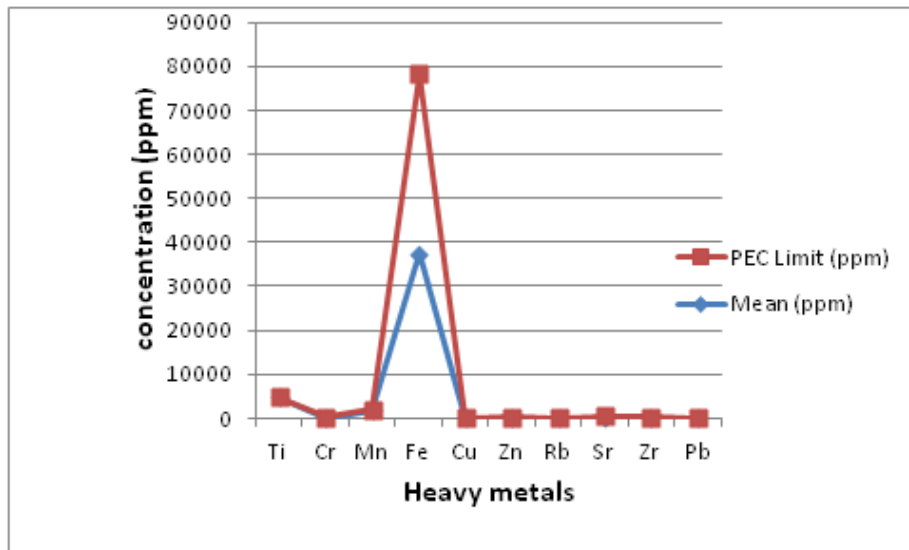


Fig 7: Comparison of Heavy metals concentrations between study site and standard limit by PEC

Discussion

Heavy metals contamination in sediments may impact functional disorders of soils, retarded plant growth and even harm the health of humans through contamination of food chain. These heavy metals or metalloids do not undergo microbial and chemical degradation and may persist in the soil for longer duration (Aggarwal et al., 2011). Heavy metals are poorly soluble in water, so they predominantly sorb to suspended particles and settle in sediment through precipitation, ion exchange, adsorption, complexation and many others (Abdulkareem, 2005). Heavy metals concentrations in the study area were both above and below the standard limit by World Bank (2002).

The following heavy metals concentrations (ppm) were below or slightly below the standard limit recommended; Cr (83.94), Cu (24.36), Rb (56.33), Zr (118.60), and Sr (112.80) while Fe (37519.54), Ti (4739.73), Mn (1782.28), Zn (134.68), and Pb (31.85) were above the standard limit recommended. The higher concentrations of Manganese can cause both toxicity and deficiency symptoms in plants. It can also cause swelling of cells walls, withering of leafs and brown spots on leaves (Hongta et al., 2008). Severe zinc contamination tends to be confined to areas near emission sources and tend to seep into the groundwater and causes stunting of shoot, curling and rolling of young leaves and thereafter lead to death of leaf tips and chlorosis. Without Iron, plants would not be able to produce chlorophyll (chlorosis) which gives plants oxygen and its healthy green color, but high concentrations of iron can wilt, brown, hinder growth or even kill plants by direct cellular damage or harming fats and proteins, thereby decreasing roots ability to grow (Eaton

and Franson, 2015).

High concentration of iron in sediment tend to lower soil Ph. Titanium is considered as a beneficial element for plant growth and development and is economically friendly because it can be easily recycled but high concentration has the potential to harm marine lives either plants or animals.

One of the sources of Lead in the environment is through direct discharge of waste streams to water bodies and mining. Elevated lead in the environment can result in decreased growth and reproduction in plants and animals, and neurological effects in vertebrates.

Strontium occurs naturally throughout the environment and are found in soil and water. It is only toxic to aquatic life at high concentrations. Exposure to high levels of radioactive strontium may cause cancer (Akpan and Thompson, 2013). Leukemia and cancers of the bone, nose, lung and skin are as a result of high strontium concentration.

Conclusion

This research provides the comprehensive assessment of the contamination status of the heavy metals present in the sediments of Edo community in Esit Eket, Southeastern Nigeria. The employment of the pollution indices such as the enrichment factor (EF), geo-accumulation index (Igeo) and contamination factor (CF) revealed from the mean concentration values that the sediments in the study area is significantly polluted with certain heavy metals such as Mn, Zn, Pb, Cu and Fe and are moderately enriched with heavy metals such as Sr, Rb, Cr, Ti and Zr. The multivariate statistical analyses applied in this work revealed both positive and negative

correlation of some heavy metals such as Cu, Mn, Sr, Ti, and Fe for positive which shows similar sources and Rb and Zn for negative which shows different sources.

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