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Impacts of coastal activities on benthic sediments from qua Iboe river estuary, south-south, Nigeria using multivariate statistical techniques

George Ubong and Effiom Edak

Abstract

Studies on Impacts of Coastal Activities on Benthic Sediments from Qua Iboe River Estuary, South-South, Nigeria Using Multivariate Statistical Techniques was conducted between May 2015 and April 2016 with the aim of Understanding the current sources of contaminants concentration in the system and provide a model which allows policy-makers and local actors to design programs and policies to improve the existing practices and mitigate future problems. Sediment samples were collected monthly in five stations along the estuary and analyzed using standard procedures. Mean values of trace metals and other contaminants in sediment for wet and dry seasons were as follows: Cadmium (0.17 ± 0.08 and 0.22 ± 0.09 mg/kg), Chromium (0.32 ± 0.17 and 0.30 ± 0.14 mg/kg), Copper (1.25 ± 0.31 and 1.29 ± 0.33 mg/kg), Iron (124.39 ± 31.21 and 119.37 ± 30.58 mg/kg), Lead (0.55 ± 0.14 and 0.56 ± 0.15 mg/kg), Zinc (16.73 ± 4.89 and 16.88 ± 4.64 mg/kg), Total Hydrocarbon content (4.76 ± 1.22 and 4.61 ± 1.18 mg/kg), Total Organic Carbon (1.10 ± 0.26 and 1.83 ± 0.45 mg/kg) respectively. Vanadium, arsenic and cobalt were below detectable limits in the sediments. Trace metals concentrations in sediments were below the DPR target / intervention limit exception of iron. Analysis of variance and paired sample t-test revealed significant ($p = 0.05$) seasonal variations respectively. Correlation analysis revealed strong positive relationships amongst metal pairs. Multivariate analytical techniques (HCA and Time series analysis) imprinted that the estuary is a continuum in environmental block swayed by multiple contamination sources. However, the series of activities evident, coupled with the findings of this study further vindicate the need for proper monitoring and management of our indigenous water bodies.

Keywords: Impacts, Coastal Activities, Benthic Sediments, Qua Iboe River Estuary, Multivariate Statistical Techniques

1. Introduction

The negative impacts on the natural environment due to various coastal activities are becoming an increasing concern among stakeholders and the public at large. Coastal activities include fishing, farming, dredging, oil exploration and seismic activities, gas flaring and indiscriminate disposal of sewage and industrial wastes. Today the environment has become foul, contaminated, undesirable, and therefore harmful for the health of living organisms, including man due to the negative impact of coastal activities.

In different parts of Nigeria, rivers are used for disposal of refuse, human sewage, and waste waters from residential areas, abattoirs and industries (Fagade *et. al.*, 1993) ^[15]. Storm water runoffs and discharge of sewage into rivers are two common sources of nutrients in aquatic ecosystem that results in their pollution (Sudhira and Kumar, 2000; Adeyemo, 2003) ^[29, 1]. Rapid industrialization has direct and indirect adverse effects on our environment (Nasrullah *et. al.*, 2006) ^[21]. This has led to an increase in generation of industrial effluents which when discharged untreated, would result in water, sediment and seafood contamination (Wakawa *et. al.*, 2008) ^[33]. Environmental degradation, deterioration and underdevelopment are top public issues both at national and international levels (Ekweozor and Agbozu, 2001) ^[12].

Sediments reflect the current status of the environment as well as providing crucial information on the impact of pollution sources. Sediment is an integral component of aquatic ecosystem providing habitat, feeding, spawning and rearing areas for many aquatic organisms. Sediments plays vital role in the remobilization of contaminants in aquatic ecosystem under certain environmental conditions. The availability of metals in aquatic system is mediated by sediment - water exchange process that may result in the release or

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remobilization of pollutants from the sediment bed (Moses, *et. al*, 2015) [20]. Trace metals can be present in amounts several times higher than their natural background levels and pollute marine sediments in coastal regions near industrial areas (Bowen, 1979) [7]. Consequently, sediments enriched with trace metals may affect the health of marine organism and aquatic ecosystem.

High values of trace metals in sediments from Nigerian aquatic environment have been linked to industrialization, urbanization, agricultural activities, high human population and reworking of sediments by microorganisms (Obasahan, 2008) [22]. Information on trace metal distribution and enrichment in sediment is important in detecting, tracing and monitoring pollution sources in an aquatic system (Obasahan, 2008) [22].

It is therefore the aim of this study to evaluate the condition of the environment and examine the linkages between coastal activities and the observed status of the environment using multivariate statistical tool in modeling contaminants concentration which will help policy makers in the proper planning and monitoring in the event of pollution.

2. Materials and Methods

2.1 Study area

The Qua Iboe River Estuary lies within latitude $4^{\circ} 40' 30''$ N and longitude $7^{\circ} 57' 0''$ E on the South Eastern Nigeria Coastline. It is a meso-tidal estuary having tidal amplitude of 1m and 3m at neap and spring phases respectively (Uwah *et.al*. 2013) [32]. Sediments are brought into the estuary by long shore drift, tidal flow, waves and River transport. Coarse to medium-grained sand occurs mostly in the mouth of the estuary and middle of the main channels where the

tidal current are strong but most parts of the banks and creeks where the tidal current are weak are characterized by fine sand, silt and clay. The latter has high affinity for pollutants such as hydrocarbon and heavy metals (Uwah *et.al*. 2013) [32].

The climate of the area is characterized by a long wet season usually lasting from May to November and a short period of dry weather from December to April. The QIRE is comprised of tidal creeks (most notably Stubb creek and Douglas creek), lagoons, wetlands, and tributaries fringed with mangrove vegetation made up of species of *Avicennia*, *Rhizophora* and *Nypa*. The coastal vegetation of the area is mainly thick mangrove swamp.

The main occupation of the inhabitants include large scale fishing employing the use of fishing vessels, small scale fishing by artisanal fishermen employing the use of fishing boats, farming activities involving the use of agrochemicals, boat construction, sand excavation for commercial purposes as well as timber logging of mangrove vegetation as fuel wood (Ekwere, *et.al*. 1992) [13].

The sampling sites are made up of four examined sites located at the lower reach of the estuary and a control site located at Atabong. The global positioning system (GPS) coordinates of the different sites are: Iwuokpom ($4^{\circ} 32' N - 7^{\circ} 58' E$), Mkpanak ($4^{\circ} 34' 09.9'' N - 7^{\circ} 58' 32.8'' E$), Iwochang ($4^{\circ} 32' 50'' N - 7^{\circ} 55' 03'' E$), Eketai ($4^{\circ} 35' N - 7^{\circ} 54' E$), Atabong ($4^{\circ} 38' N - 7^{\circ} 54' E$). The control site (Atabong) is free from oil exploration and production activities and has less coastal activities compared to the examined sites. Figure 1 is a map of the study area indicating the sampling sites

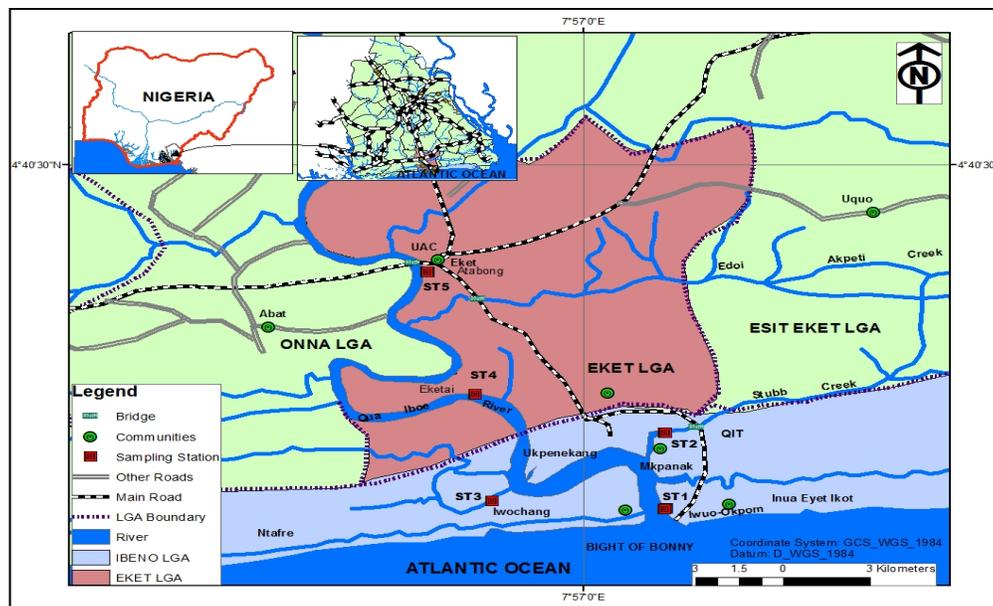


Fig 1: Map of the study area showing sampling stations in Qua Iboe River Estuary

2.2 Samples Collection

Sediments samples were collected monthly for one year (May 2015 and April 2016) period spanning the dry and wet seasons of the study area using Van Veen grab sampler. 5 grab samples were collected at each sampling station and were combined together into a stainless steel bowl to make a composite sample. A total of three hundred subsamples and

60 composite samples were collected, dried, ground and sieved.

2.3 Laboratory Analysis

2.3.1 Determination of Trace Metals

1 g of air - dried sediment was weigh accurately and passed through (2 mm sieve) with foil paper and transfer to a 250 ml conical flask. A measured volume of well - mixed acid,

Perchloric acid, nitric acid and sulphuric acid in the ratio 1 : 2 : 2 was transfer into the flask containing the sediment sample in the fume hood. Sample was heated for about (15 - 20 minutes) in the hot plate until a white fume was observed. The digestion was stop and allowed to cool. After cooling, 20 ml of distilled water was added and boil to bring the metal into solution. The solution was filtered through Whatman 42 filter paper in a 100 ml volumetric flask and makes to mark with distilled water and then transfer to 100 ml plastic can for AAS analysis. Heavy metals were determined using Atomic Absorption Spectrophotometer (model GBC scientific AASGF 3000) according to APHA, (1998) [3].

2.3.2 Determination of Total Hydrocarbon in Sediment Sample

5g of air - dried sediment samples was weigh into a conical flask and 25 ml of n - Hexane was added and shakes vigorously for 10 minutes. The organic layer was siphon into a clean and dry beaker. Another portion of 25 ml n-Hexane was added to the sample and shakes for 10 minutes. Venting was done to avoid pressure build up. The organic layer was siphon into a 100 ml beaker for UVS analysis. The absorbance was read at 410 nm using a UV - spectrophotometer. Total hydrocarbon was determined using Ultra Violet Spectrometer (model HACH DR 4000 U)

according to APHA, (1998) [3]. A calibration graph was plotted to check its acceptance by calculating the Correlation Coefficient (R^2 value should be ≥ 0.995). The Concentration of THC in the sediment sample was obtained from the regression equation.

2.3.3 Determination of Total Organic carbon in Sediment Sample

Total organic carbon content of the sediment was determined using the Walkey-black method of ASTM (1996) and APHA (1995) [2]. This method is based on the theory that the color of a sediment sample determines the organic carbon content of that sediment. 0.5 g of sediment samples was sieved through a 2 mm mesh-size sieve and weighed into 250 ml conical flask. 10 ml of potassium dichromate ($K_2Cr_2O_7$) and 20 ml H_2SO_4 was added and left to stand for 30 minutes on asbestos after intermittent swirls. 100 ml of distilled water (spectator ion) was added. To this mixture was added 3 - 4 drops of ferrous indicator and titrated with 0.5 N $FeSO_4 \cdot 7H_2O$. The sediment sample rich in organic carbon assumed a greenish cast on adding all reagents and indicators but in the absence of organic carbon assumed an orange color. Upon titration, an organic carbon rich sediment goes from green to light green and finally to maroon red or brown; that is the end point. Total organic carbon was calculated thus:

$$\text{Organic Carbon (\%)} = \frac{\text{Titre value} - \text{Titre Value} \times 0.195 \text{ (factor) of blank of sample}}{\text{Weight of sediment sample (g)}}$$

2.4 Data Analysis

Statistical package for Social Sciences (SPSS) version 20 was employed to compute Mean, variance and standard error in the data. Also, one-way analysis of variance (ANOVA) and Least Significant Difference (LSD) test were employed to separate significant differences in mean values computed for stations while paired sample t-test was used to compare seasons. The probability level was set at $p = 0.05$. Correlation analysis tested the association between various parameters along sampling stations. Hierarchical cluster analysis was used for stations classification and source apportionment while principal component analysis was employed to ordinate environmental variables into factor components. Heavy metals, Total hydrocarbon and Total organic carbon concentrations were modeled using Time series options of MINITAB analytical software.

3. Results

3.1 Trace Metal Concentrations in Sediments

The range of cadmium values obtained for wet and dry season were 0.02 - 0.49 mg / kg and 0.03 - 0.57 mg / kg respectively. The mean cadmium values recorded for wet and dry season were 0.22 mg / kg \pm 0.09 and 0.17 mg / kg \pm 0.08 (Table 1). Seasonal variation between the dry and wet season shows significant difference at $p = 0.05$. Lowest cadmium value was recorded at station 5 in the month of June, 2015 while the highest cadmium value was recorded at station 4 in the month of October, 2015. Within the five sampling stations, the spatial variation of cadmium shows no significant difference at $p = 0.05$ during the study period. Chromium values obtained for wet and dry season ranged between 0.03 - 0.93 mg / kg and 0.04 - 0.75 mg / kg and the mean values were 0.32 mg / kg \pm 0.17 and 0.30 mg / kg \pm 0.14 respectively (Table 1). There was significant variation between the dry and wet seasons ($p = 0.05$). Lowest

chromium value was recorded at station 1 in the month of June, 2015 while the highest chromium value was recorded at station 4 in the month of March, 2016. Within the five sampling stations, the spatial variation of chromium shows no significant difference at $p = 0.05$ during the study period. Copper concentration recorded for wet and dry season ranged from 0.01 - 1.69 mg / kg and 0.01 - 1.74 mg / kg respectively. The mean values recorded for wet and dry season were 1.25 mg / kg \pm 0.31 and 1.29 mg / kg \pm 0.33 (Table 1). Significant variation was observed between the dry and wet seasons ($p = 0.05$). Lowest concentration was recorded at station 5 in the month of May, August, September, November, 2015, January and April, 2016 respectively while the highest concentration was recorded at station 1 in the month of December, 2015. Within the five sampling stations, the spatial variation of copper shows no significant difference at $p = 0.05$ during the study period. Iron values obtained for wet and dry season were 0.45 - 169.58 mg / kg and 0.48 - 172.53 mg / kg and the mean values were 124.39 mg / kg \pm 31.21 and 119.37 mg / kg \pm 30.58 respectively (Table 1). Seasonal variation between the dry and wet season shows significant difference at $p = 0.05$. Lowest value was recorded at station 5 in the month of September, 2015 and April, 2016 respectively while the highest value was recorded at station 4 in the month of March, 2016. There was no significant spatial variation ($p = 0.05$) during the study period.

The mean range values for lead recorded for wet and dry season were 0.01 - 0.85 mg / kg and 0.02 - 0.90 mg / kg respectively. Mean values recorded for wet and dry season were 0.55 mg / kg \pm 0.14 and 0.56 mg / kg \pm 0.15 (Table 1). Seasonal variation between the dry and wet season shows no significant difference at $p = 0.05$. Lowest lead value was recorded at station 5 in all the month except for December, 2015 and was below detectable (BDL) in the month of June

and July 2015 while the highest lead value was recorded at station 4 in the month of February, 2016. Within the five sampling stations, the spatial variation of lead shows no significant difference at $p = 0.05$ during the study period.

Zinc values recorded for wet and dry season ranged between 0.28 – 29.95 mg / kg and 0.32 – 28.68 mg / kg and the mean values were 16.73 mg / kg \pm 4.89 and 16.88 mg / kg \pm 4.84 respectively (Table 1). Seasonal variation between the dry and wet season shows no significant difference at $p = 0.05$. Lowest zinc value was recorded at station 5 in the month of June, 2015 while the highest zinc value was recorded at station 4 in the month of March, 2016. Within the five sampling stations, the spatial variation of zinc shows no significant difference at $p = 0.05$ during the study period.

Total hydrocarbon ranged between 0.13 – 6.83 mg / kg and 0.15 – 6.49 mg / kg for wet and dry season respectively. The mean total hydrocarbon values recorded for wet and dry season were 4.76 mg / kg \pm 1.22 and 4.61 mg / kg \pm 1.18 (Table 1). There was significant variation between the dry and wet seasons ($p = 0.05$). Lowest total hydrocarbon value was recorded at station 5 in the month of May, 2015 and April, 2016 respectively, while the highest total hydrocarbon value was recorded at station 1 in the month of December, 2015. Within the five sampling stations, the spatial variation of total hydrocarbon shows no significant difference at $p = 0.05$ during the study period.

The range values recorded for total organic carbon for wet and dry season were 0.03 – 1.48 mg / kg and 0.13 – 2.62 mg / kg respectively. The mean total organic carbon values recorded for wet and dry season were 1.10 mg / kg \pm 0.26 and 1.83 mg / kg \pm 0.45 respectively (Table 4). There was significant variation between the dry and wet seasons ($p = 0.05$). Lowest total organic carbon value was recorded at station 5 in all the month except for February and March, 2016 respectively while the highest total organic carbon value was recorded at station 4 in the month of March, 2016 (Figure 29). Within the five sampling stations, the spatial variation of total organic carbon shows no significant difference at $p = 0.05$ during the study period.

Vanadium, arsenic and cobalt were below detectable limit (BDL) throughout the study period (Table 1).

3.2 Correlation matrix and hierarchical cluster dendrogram based on heavy metals in sediment

3.2.1 Correlation matrix and hierarchical cluster dendrogram based on heavy metals in sediment (wet season)

During the wet season, significant positive correlation was observed between the following metal pairs: Cadmium - Chromium ($r = 0.992$); Copper - Iron ($r = 0.994$), Copper - Lead ($r = 0.953$), Copper - Zinc ($r = 0.906$); Iron - Lead ($r = 0.963$), Iron - Zinc ($r = 0.888$) and Lead - Zinc ($r = 0.926$) (Table 2). Hierarchical cluster analysis (HCA) was used in the classification of the contaminants and sampling stations based on source and concentration gradient respectively. Figure 2 represents a cluster dendrogram which reflect source apportionment for different contaminants whereas Figure 3 assort the station in line with salinity gradient and proximity to the Sea.

3.2.2 Correlation and hierarchical cluster dendrogram based on heavy metals in sediment (dry season)

During the dry season, significant positive correlation was observed between the following metal pairs: Copper - Iron ($r = 0.980$), Copper - Lead ($r = 0.928$), Copper - Zinc ($r = 0.913$); Iron - Lead ($r = 0.969$), Iron - Zinc ($r = 0.952$) and Lead - Zinc ($r = 0.967$) (Table 3). Again, hierarchical cluster analysis (HCA) was used in the classification of the contaminants and sampling stations based on source and concentration gradient respectively. Figure 4 represents a cluster dendrogram which reflect source apportionment for different contaminants whereas Figure 5 assort the station in line with salinity gradient and proximity to the Sea.

3.3 Contaminants concentration (mg/kg) in Qua Iboe River Estuary as a Function of Time (Month)

Time series analysis reflected unique non-linear patterns which were stations and contaminant specific. However, the mean concentrations of contaminants in Qua Iboe River Estuary in the wet and dry seasons computed for the five stations were: Cadmium (0.17 and 0.22), Chromium (0.32 and 0.30), copper (1.25 and 1.29), iron (124.39 and 119.37), lead (0.55 and 0.56), zinc (16.73 and 16.88), total hydrocarbon (4.76 and 4.61) and total organic carbon (1.10 and 1.83) respectively (Fig. 6 – 10). The results of contaminants concentration in Qua Iboe River Estuary using time series reflect a trend that can be used by policy makers in proper monitoring and planning in the event of pollution

Table 1: Seasonal range, mean variation, standard error of contaminants (mg/kg) measured in sediment of Qua Iboe River Estuary for wet and dry season (May, 2015 – April, 2016)

Parameter	Units	Range (Wet Season)	Range (Dry Season)	Mean \pm S.E (Wet Season)	Mean \pm S.E (Dry Season)	DPR Target limit (mg / kg)	DPR Intervention limit (mg / kg)
Cadmium	mg/kg	0.02 – 0.49	0.03 – 0.57	0.17 \pm 0.08	0.22 \pm 0.09	0.8	12
Chromium	mg/kg	0.03 – 0.93	0.04 – 0.75	0.32 \pm 0.17	0.30 \pm 0.14	100	380
Vanadium	mg/kg	BDL	BDL	BDL	BDL	100	120
Arsenic	mg/kg	BDL	BDL	BDL	BDL	1.0	10
Copper	mg/kg	0.01 – 1.69	0.01 – 1.74	1.25 \pm 0.31	1.29 \pm 0.33	36	190
Iron	mg/kg	0.45 – 169.58	0.48 – 172.53	124.39 \pm 31.21	119.37 \pm 30.58	4.7	-
Lead	mg/kg	0.01 – 0.85	0.02 – 0.90	0.55 \pm 0.14	0.56 \pm 0.15	85	530
Cobalt	mg/kg	BDL	BDL	BDL	BDL	20	240
Zinc	mg/kg	0.28 – 29.95	0.32 – 28.68	16.73 \pm 4.89	16.88 \pm 4.84	140	720
Total Hydrocarbon	mg/kg	0.13 – 6.83	0.15 – 6.49	4.76 \pm 1.22	4.61 \pm 1.18	50	5,000
Total Organic carbon	mg/kg	0.03 – 1.48	0.13 – 2.62	1.10 \pm 0.26	1.83 \pm 0.45	-	-

Where: S.E = Standard Error, DPR = Department of Petroleum Resources, BDL = Below Detectable Limit

Table 2: Pearson’s correlation matrix of trace metals in sediment from Qua Iboe River Estuary (wet season)

Heavy Metal	Cadmium	Chromium	Copper	Iron	Lead	Zinc
Cadmium	1					
Chromium	.992**	1				
Copper	.478	.463	1			
Iron	.524	.519	.994**	1		
Lead	.641	.649	.953*	.963**	1	
Zinc	.676	.641	.906*	.888*	.926*	1

* - Significant at P = 0.05

** - Significant at P = 0.01

Table 3: Pearson’s correlation matrix of trace metals in sediment from Qua Iboe River Estuary (dry Season)

Heavy Metal	Cadmium	Chromium	Copper	Iron	Lead	Zinc
Cadmium	1					
Chromium	.852	1				
Copper	.530	.354	1			
Iron	.670	.522	.980**	1		
Lead	.796	.609	.928*	.969**	1	
Zinc	.791	.524	.913*	.952*	.967**	1

* - Significant at P = 0.05

** - Significant at P = 0.01

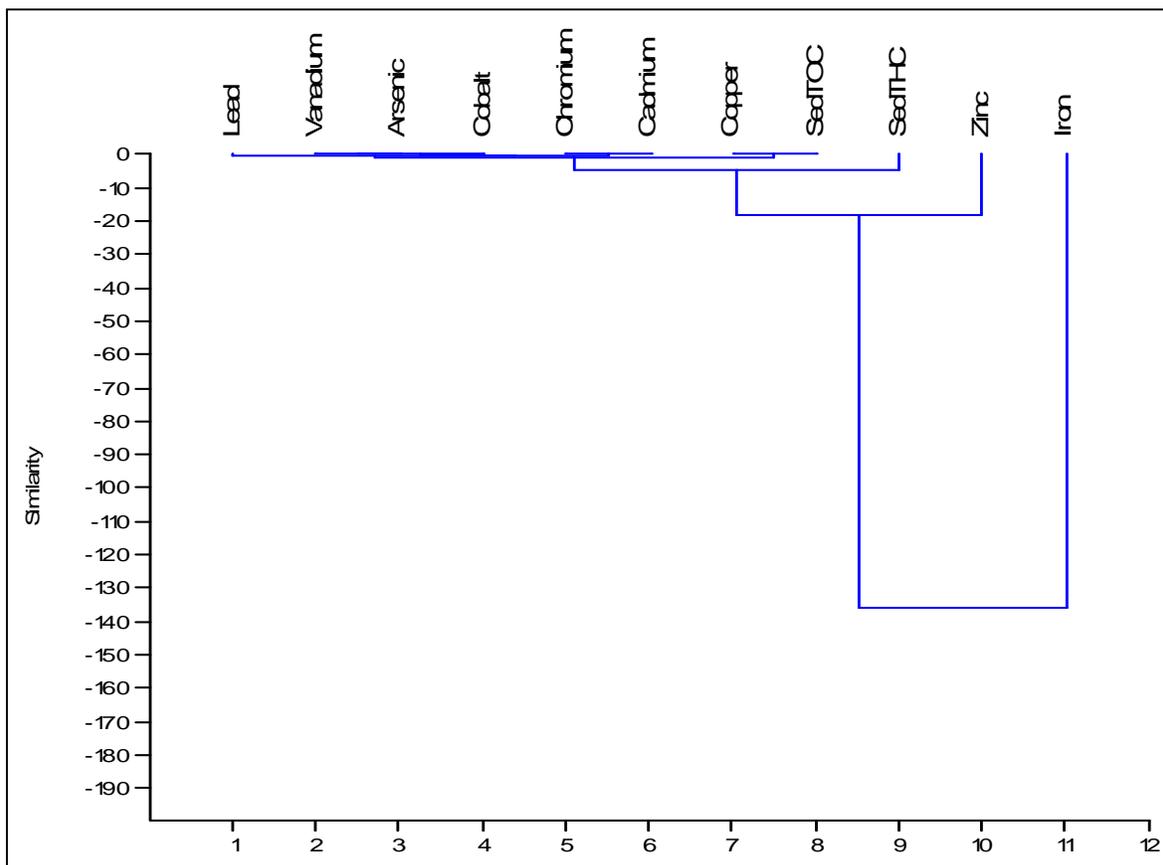


Fig 2: Dendrogram showing source apportionment in sediment of Qua Iboe River Estuary (wet season)

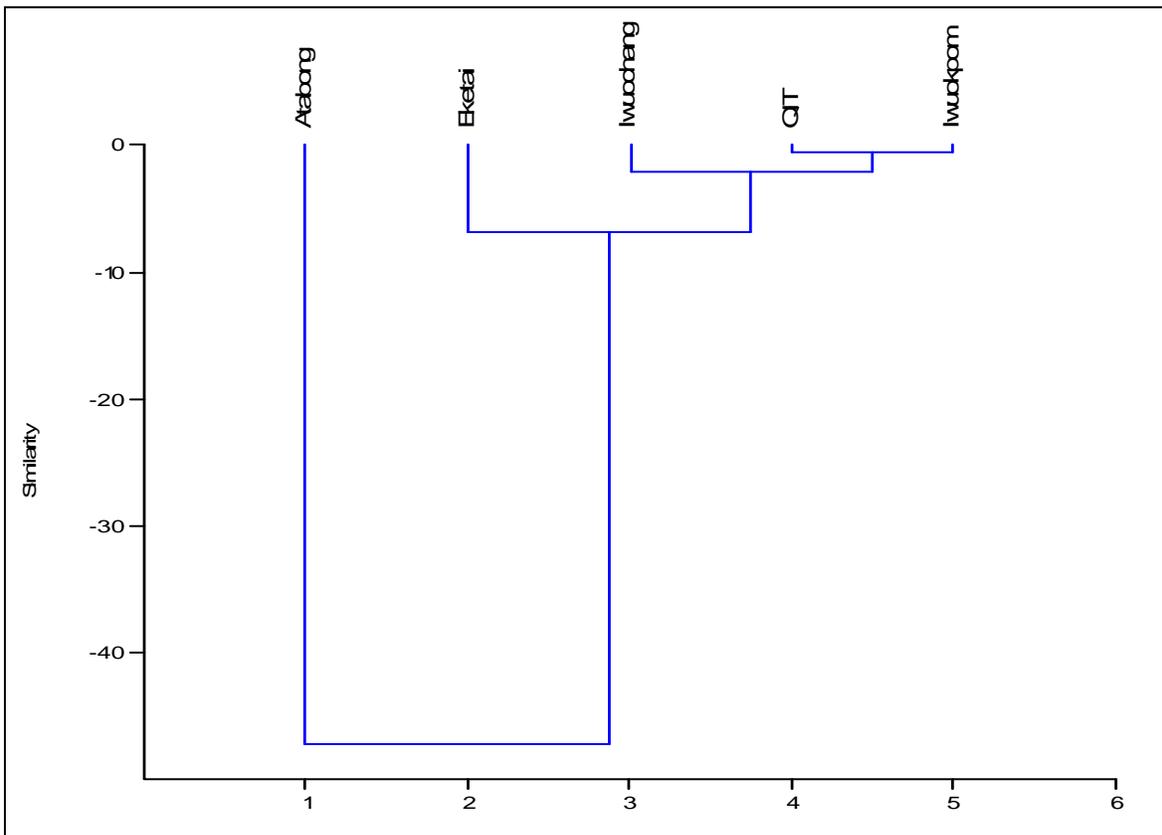


Fig 3: Dendrogram showing spatial distribution of contaminants in sediment of Qua Iboe River Estuary (wet season)

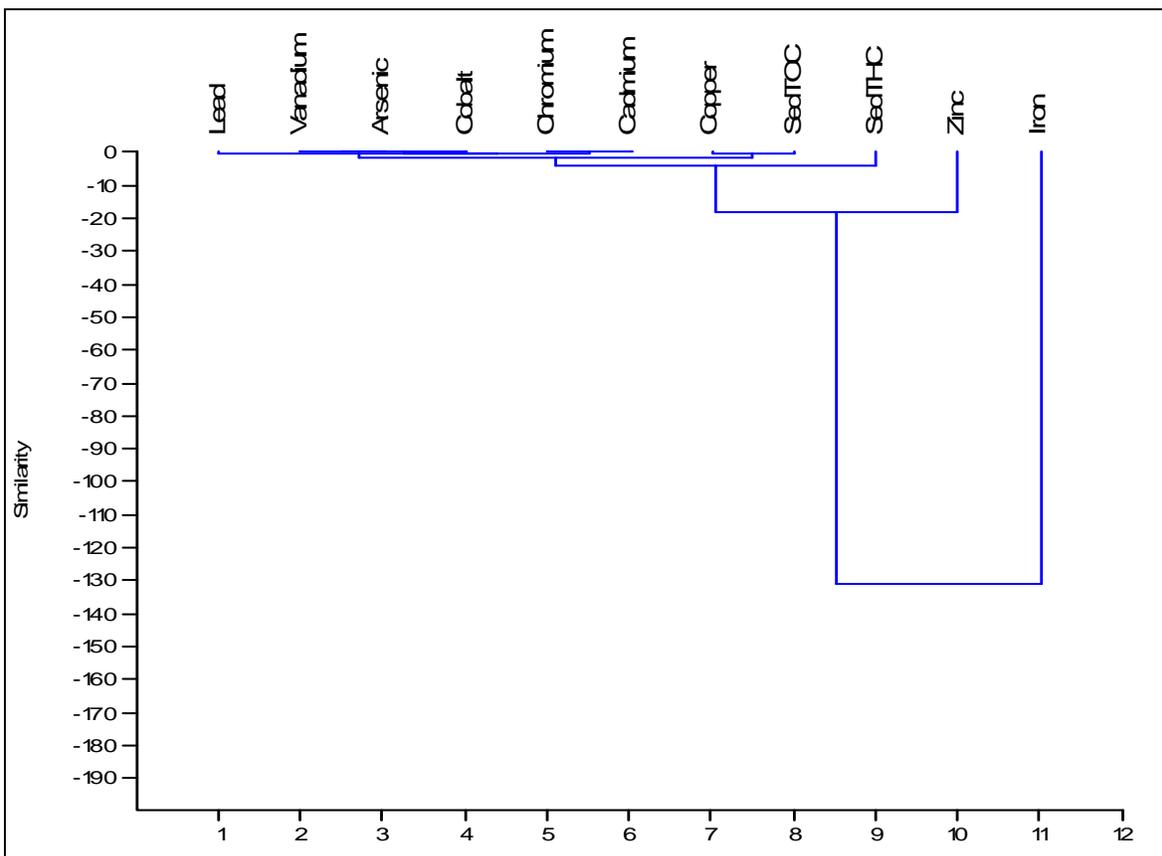


Fig 4: Dendrogram showing source apportionment in sediment of Qua Iboe River Estuary (dry season)

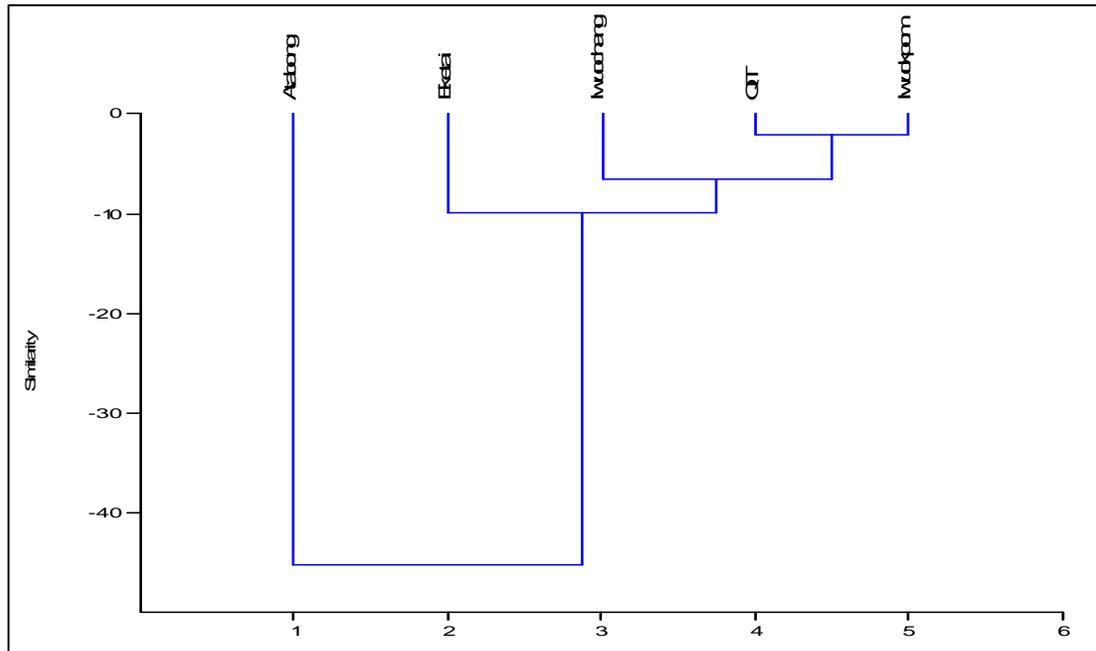


Fig 5: Dendrogram showing spatial distribution of contaminants in sediment of Qua Iboe River Estuary (dry season).

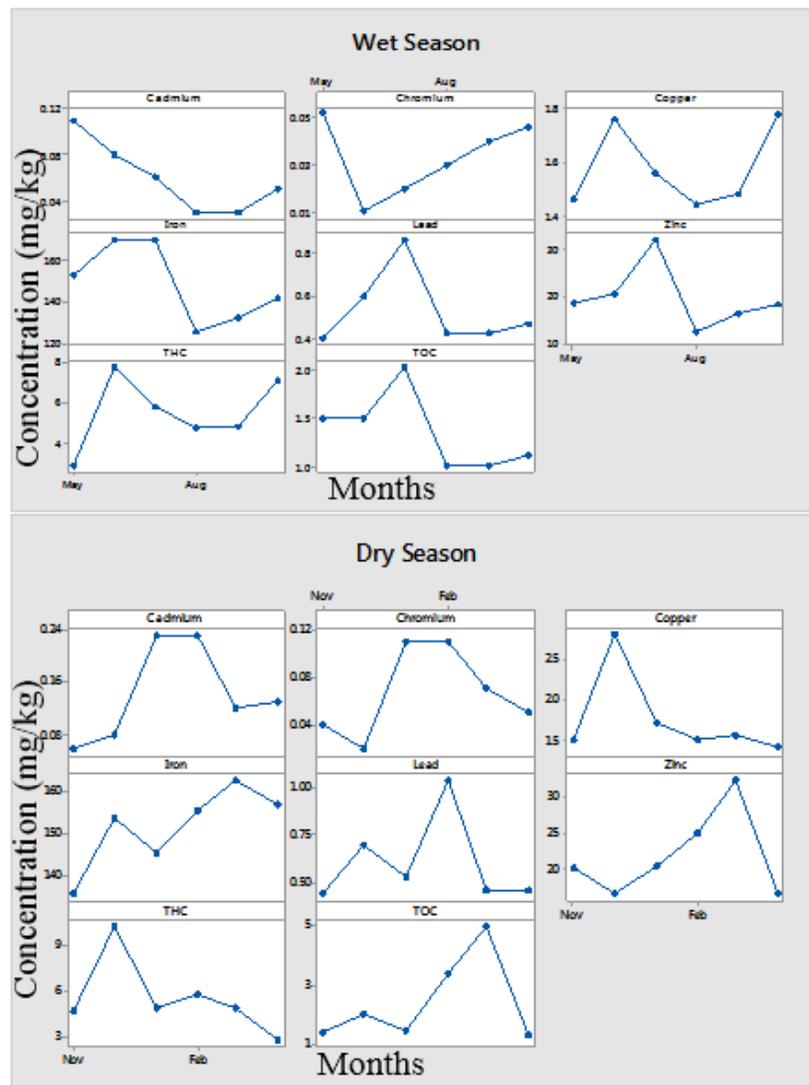


Fig 6: Contaminants concentration trend in the sediment of Qua Iboe River Estuary (Iwuokpom)

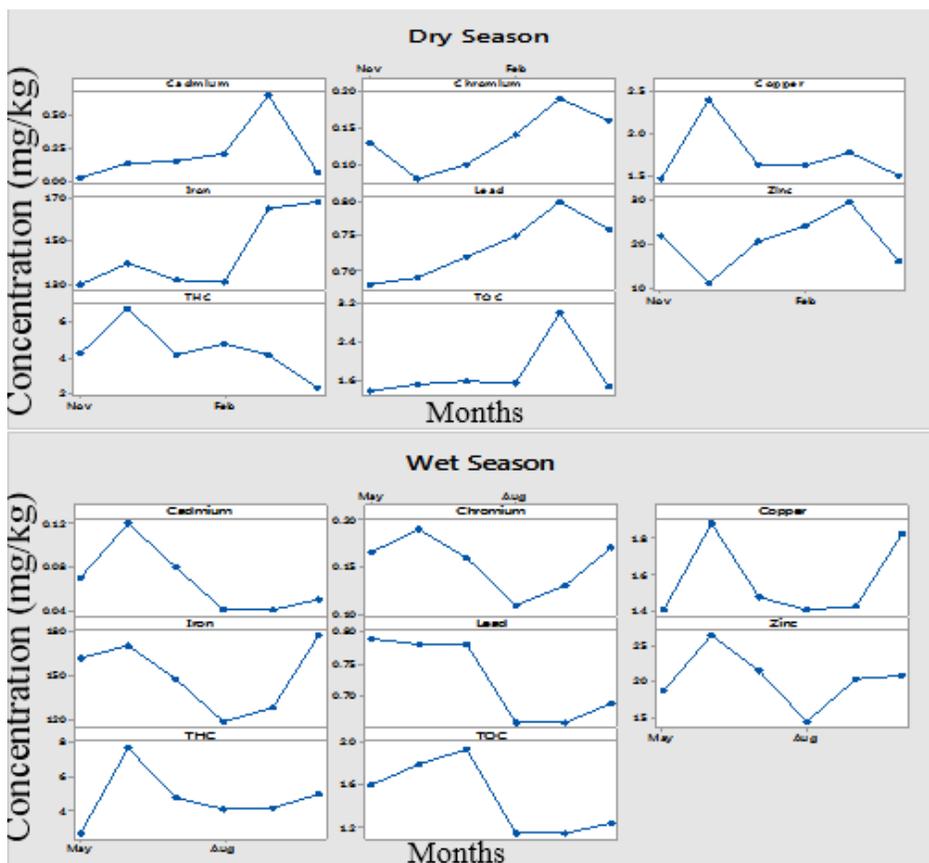


Fig 7: Contaminants concentration trend in the sediment of Qua Iboe River Estuary (Mkpanak)

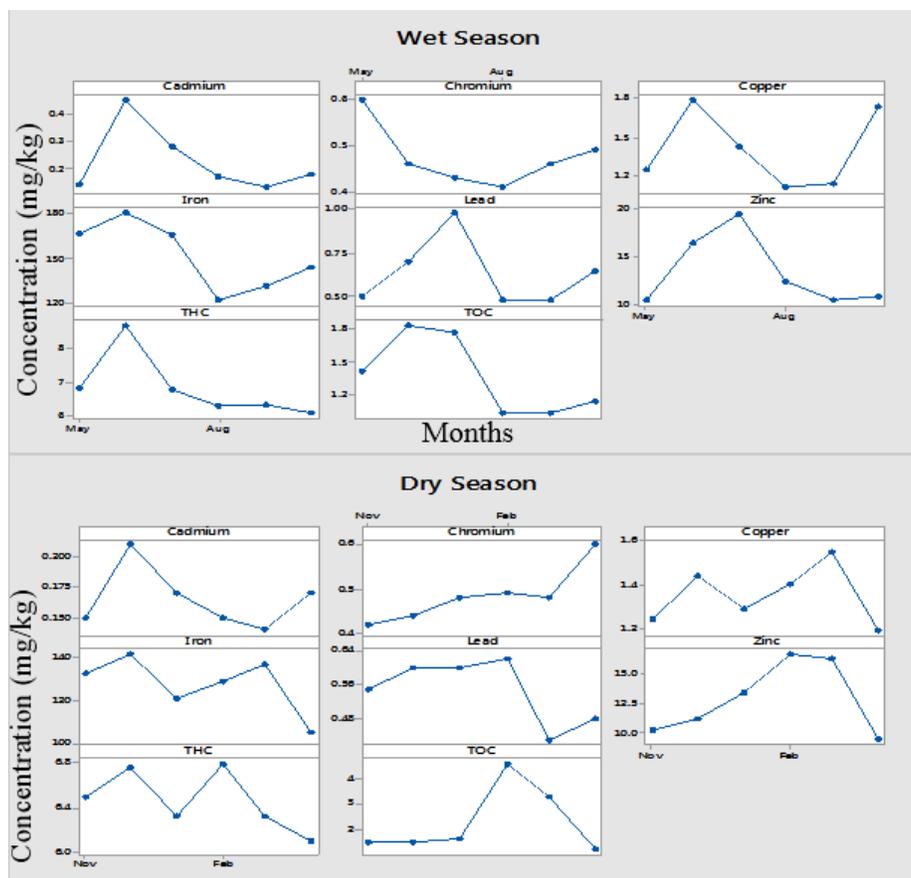


Fig 8: Contaminants concentration trend in the sediment of Qua Iboe River Estuary (Iwuochang)

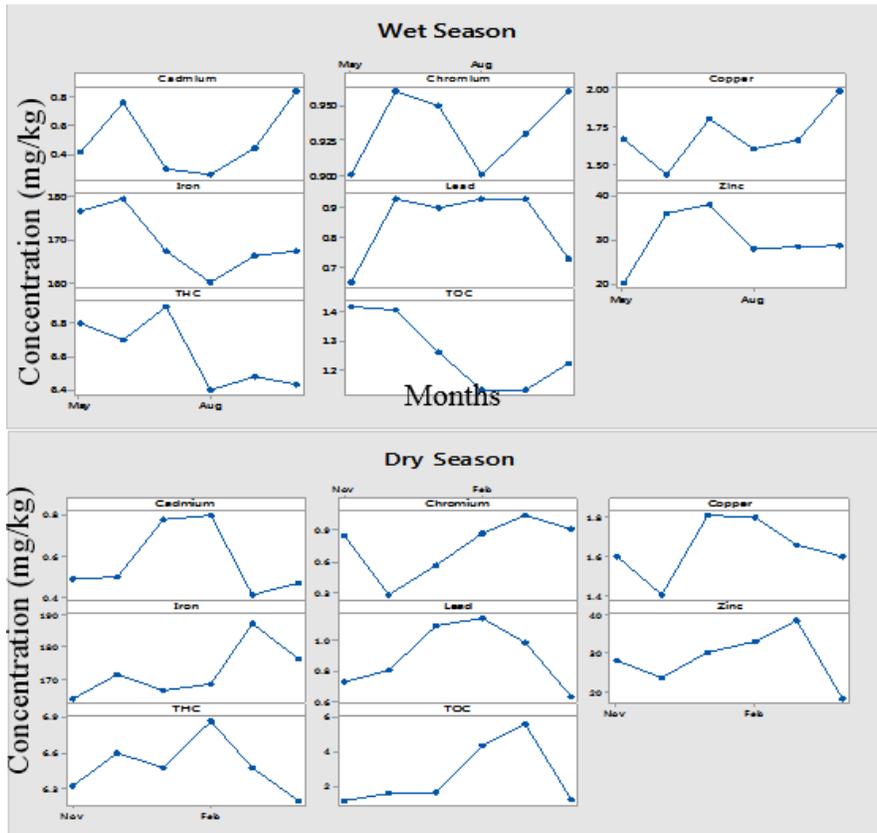


Fig 9: Contaminants concentration trend in the sediment of Qua Iboe River Estuary (Eketai)

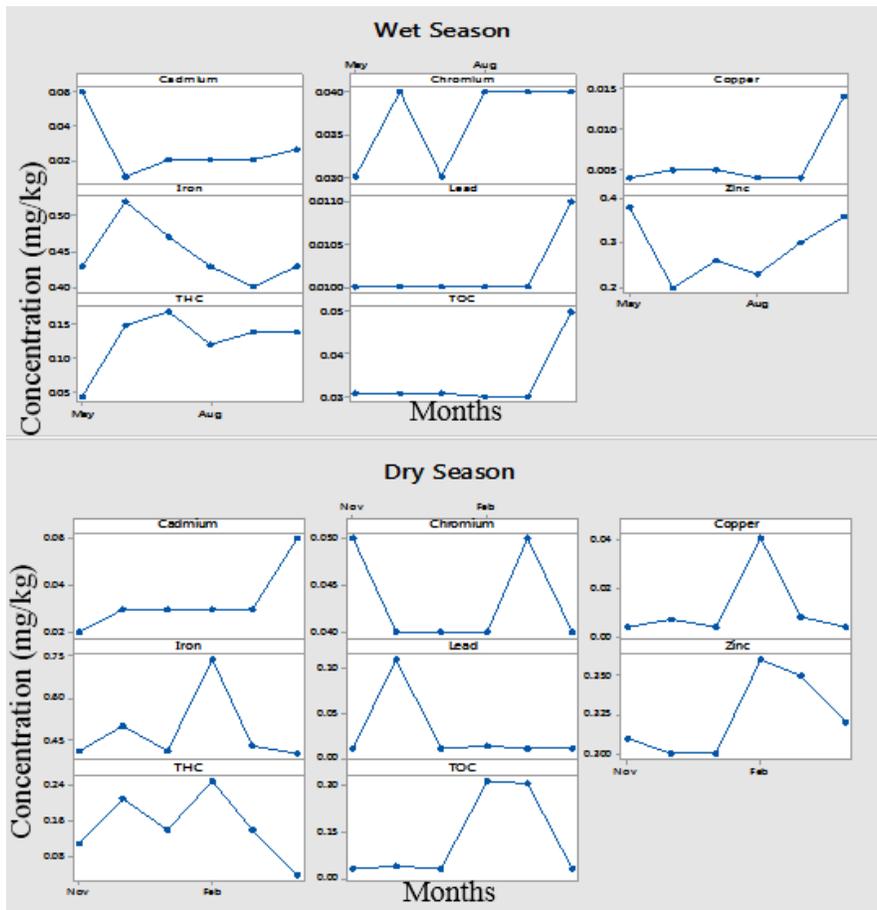


Fig 10: Contaminants concentration trend in the sediment of Qua Iboe River Estuary (Atabong)

4. Discussion

4.1 Seasonal and Spatial Variation in Trace Metal Concentration in Sediments

In this study, higher dry season mean values of trace metal concentration than wet season values were observed. This trend may be due to adsorption to sediment particles because of reduced water volume usually associated with increase evaporation rate in the dry season (Obasahan, 2008) [22] or metal dissolution as a result of low water pH (Tomilson *et. al.* 1980) [30]. Higher levels of trace metals in the studied sites compared to the control sites confirms the fact that the control site has a lower pollution status compared to other locations. This observation clearly shows that there is a link between coastal activities and the observed status of sediment of Qua Iboe River Estuary.

All the metals investigated in both seasons were below the Department of Petroleum Resources (DPR) target / intervention limits for sediment quality guideline except iron which was above the DPR target limit (DPR, 2002) [11]. The results from this studies is consistent with related study conducted by (Olatunji and Osibanjo, 2012, Ideriah, *et. al.* 2013; Chinda *et. al.* 2009; Ikpee, *et. al.* 2009) [23, 17, 9, 18]. High level of iron in sediment of this study area and other parts of Nigeria has been reported by other authors (Udosen, *et. al.* 2007; Issa, *et. al.* 2011; Opaluwa, *et. al.* 2012) [31, 19, 25]. Most of the pipelines used in conveying oil from the platform to the treatment sites are made up of iron, ferro-chromium materials and alloys of zinc and iron which when corroded can result in the release of these metals into the aquatic ecosystem. Moreover, the concentration of Fe in sediment may be due to the nature of the soil along the aquatic ecosystem and high levels of iron in Nigerian soils have been reported by (Oluwu, *et.al.* 2010) [24].

Generally, elemental concentrations of sediments depends not only on anthropogenic and lithogenic sources but also on the textural characteristics such as organic matter, mineralogical composition and depositional environment of the sediments (Pourang, *et.al.* 2005) [26]. Fine sediments (mud) dominate QIRE and trace metals are believed to be more associated with smaller grain size particles. This assertion was supported by (Saeed and Shaker, 2008) [27] who stated that the concentration of metals in sediment depends on the amount of organic compound and its particle size. Other factors that affect the abundance of metals in sediments include the trace metal content of the rock and parent material of soil formation (Yi, *et.al.* 2011) [34].

In this study, higher mean values of total organic carbon and total hydrocarbon was observed in the dry season than wet season. This trend may be due to adsorption to sediment particles because of reduced water volume usually associated with increase evaporation rate in the dry season (Obasahan, 2008) [22]. Higher levels of TOC and THC in the studied sites compared to the control sites confirm the impacts of coastal activities on environmental variables. The low values of TOC and THC recorded during the wet season may be attributed to dilution effects. In addition, various chemical, physical and biological processes that are known to degrade petroleum hydrocarbon in water may undoubtedly have contributed to the general decrease in the hydrocarbon levels observed during wet season (Corredor, *et.al.* 1990) [10]. The level of organic matter decomposition may be attributed to the variation in TOC content while input result from other sources like domestic wastes, discharge of sewage, drifts from polluted areas and other

activities is responsible for the variation observed in THC across the stations. The results of findings corroborates with previous studies reported by (Horsfall, *et. al.* 1994; Corredor, *et. al.* 1990; Chindah, *et. al.* 2004) [16, 10, 8].

4.2 Multivariate Analysis and Source Apportionment

The use of correlation analyses in establishing relationships within and between variables, locations and organisms is well established in literature (Benson *et. al.* 2016). Positive correlations between metal pairs (Cadmium, Chromium, Copper, Iron, Lead and Zinc) denote that an increase in one of these parameters leads to a corresponding increase in the other. Significant correlation coefficient between metal pairs interprets that they may have same accumulation potentials, unitary anthropogenic pollution or natural pollution source and chemical association between the trace metals within a particular area (Moses *et. al.* 2015) [20]. The agglomeration patterns observed in the cluster dendrogram representing contaminants concentration of the stations in both rainy and dry season assort the stations in line with salinity gradient and proximity to the ocean and the pattern of assortment of individual contaminants (heavy metals, TOC and THC) identify three pollution sources (anthropogenic, intermediate and lithogenic sources). Similar observations have been observed by earlier researchers (Benson and Essien, 2012) [5]. According to Southwood *et. al.* (2000) [28], time series can be used to gain insight into the range of dynamic behaviour shown by living populations or physicochemical dynamism. Time series may also be used for forecasting. This bear evidences in this result. This is true in all cases in that the sediment concentration of individual metals vary in space and time. This variability emanates and is sustained by the cycles and levels of coastal activities earlier alluded to in this research. In confirming this observation, Benson and Essien (2012) [5] noted that increase in coastal activities affect the quality of benthic ecosystems with respects to time.

5. Conclusion

This study was designed to assessed the linkages between coastal activities and the observed status of sediment quality from Qua Iboe River Estuary (QIRE), Nigeria and evaluate the impacts of these activities. Only iron was above the sediment quality guideline stipulated by Department of petroleum Resources while the results for other contaminants such as Cd, Cr, Cu, Pb, Zn, THC and TOC reveal level of bioaccumulation and if the trend continues without checkmating the level of coastal activities may cause potential ecological risk to sediment dwelling organism. This calls for the need to educate the rural dwellers on proper management and disposal of waste and also industries should adhere to proper treatment and minimization in the discharge of industrial waste which has been identified as one of the major sources of trace metals in sediment of QIRE.

6. References

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