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Heavy Metal Assessment in Sediments of Qua Iboe River Estuary, South-South, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Heavy metal assessment in Sediments from Qua Iboe River Estuary, South-South, Nigeria was steered between January, 2022 and December, 2022 with the goal of understanding the route sources of heavy metal concentration within the system. Sediment samples were collected monthly from five stations taking cognizance of areas with high, medium and low human activities along the estuary. The samples collected were analyzed using standard protocol as recommended by APHA. Sediments mean values for wet and dry seasons observe were: Cadmium (0.20±0.04 and 0.19±0.04 mg/kg), Chromium (0.35±0.07 and 0.28±0.05 mg/kg), Copper (0.97±0.15and 10.94±0.14 mg/kg), Iron (130.79±13.69 and 115.29±10.19 mg/kg), Lead (0.56±0.06 and 0.54±0.06 mg/kg), Zinc (19.36±2.24 and 18.71±2.78 mg/kg). Heavy metal concentrations in sediments were below the DPR target / intervention limits with exception of iron without a standard. Analysis of variance and paired

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sample t-test revealed significant ($p = 0.05$) spatial variation but no seasonal variations were observed respectively. Values of trace metal recorded in the sediment throughout the study duration when compared to DPR target / intervention limit were below the threshold level as recommended. This suggest minimal anthropogenic activities during the period of studies. Nevertheless, constant monitoring of water bodies at regular interval is strongly recommended.

Keywords: Spatial; temporal; variation; sediment; heavy metal; Nigeria.

1. INTRODUCTION

Crucial information on the impacts of pollution in aquatic ecosystem are assessed using sediments samples which are sensitive because the reflect the status of the environment [1]. Sediment plays a vital role in aquatic ecosystem as the providing habitat, feeding, spawning and rearing ground for many economic species [1]. Sediments aids in the remobilization of pollutants in marine ecosystem under certain environmental circumstances.

Enrichment of aquatic sediment with trace metals may adversely affect the health of aquatic organisms and in turn may results in species migration. Eighty (80) % of trace metal pollution in aquatic ecosystem in linked to anthropogenic activities such as industrialization, urbanization, agricultural activities, high human population and reworking of sediments by microorganisms [2].

Monitoring of Trace metal in aquatic system becomes pertinent because of the environmental risks associated with metal pollution. Sustainability of biodiversity is threatened due to metal pollution in aquatic ecosystem. This calls for concern as many important economic species may go on extinction if the trend of trace metal contamination continues unabated. Trace metals are needed by aquatic organisms in minute concentrations for their general wellbeing but when the concentrations are above the recommended threshold limit it may result in metabolic disorders [3]. Monitoring of trace metal pollution in aquatic ecosystem becomes pertinent in the face of environmental sustainability [4].

Sediments are sensitive indicators for monitoring and evaluation of contaminants in water bodies [1]. The bottom sediments are a reservoir for heavy metals and therefore earn distinct consideration in the planning and design of aquatic pollution research studies [5]. Several studies on the impacts of human activities on aquatic sediments have been reported – Udosen et. al. [6]; Chindah, et. al. [7]; Akpan and Thompson [8]; Uwah, et. al. [9]; Benson et. al. [10]; George and Efiom [1] and Efiom and George [4].

Thus, this study seeks to appraise the level of trace metal concentrations in the sediments of Qua Iboe River Estuary.

2. MATERIALS AND METHODS

2.1 Study Area

Qua Iboe River Estuary is a mesotidal palustrine ecotone of the parent river, Qua Iboe river. The estuary lies within latitude 04º 30´ 0 to 05º 30’ 0N and longitude 07º 30´ 0 to 08º 20’ 0E located within the Niger Delta region of Nigeria. The estuary is characterized by fine sandy beaches fringed with tidal mudflats and mangrove swamps [11].

2.2 Description of Study Sites

Station 1: Station 1 is Iwuokpom which lies between latitude 04^0 33´ 0’’N and longitude 07^{0}’56’0’’ E. Major human activities sited were fishing which include artisanal and commercial fishing with motorized boats with possible oil and fuel spills from the boat engine and direct open defecation into the Estuary.

Station 2: This station is located at Mkpanak between latitude 04^0 36´ 0’’ N and longitude 07^0 60’ 32’’ E. Off-loading of finished petroleum product from ship to pipelines is done in this station with high fishing activities.

Station 3: This station is characterized by a major market which serves as a distribution point for fisherfolks. It receives inputs from the markets and domestic waste from inhabitants of the area. The station is located at Iwuochang between latitude 04^0 38´ 12’’N and longitude 07^0 65’25’’E.

Station 4: This station is located at Eketai between latitude 4^0 39’ 15’’ N and longitude 07^0 68’12’’ E. It is surrounded by agricultural farmlands, wood industry, minimal fishing activities. A compact dredger was sited in this station during the study period.

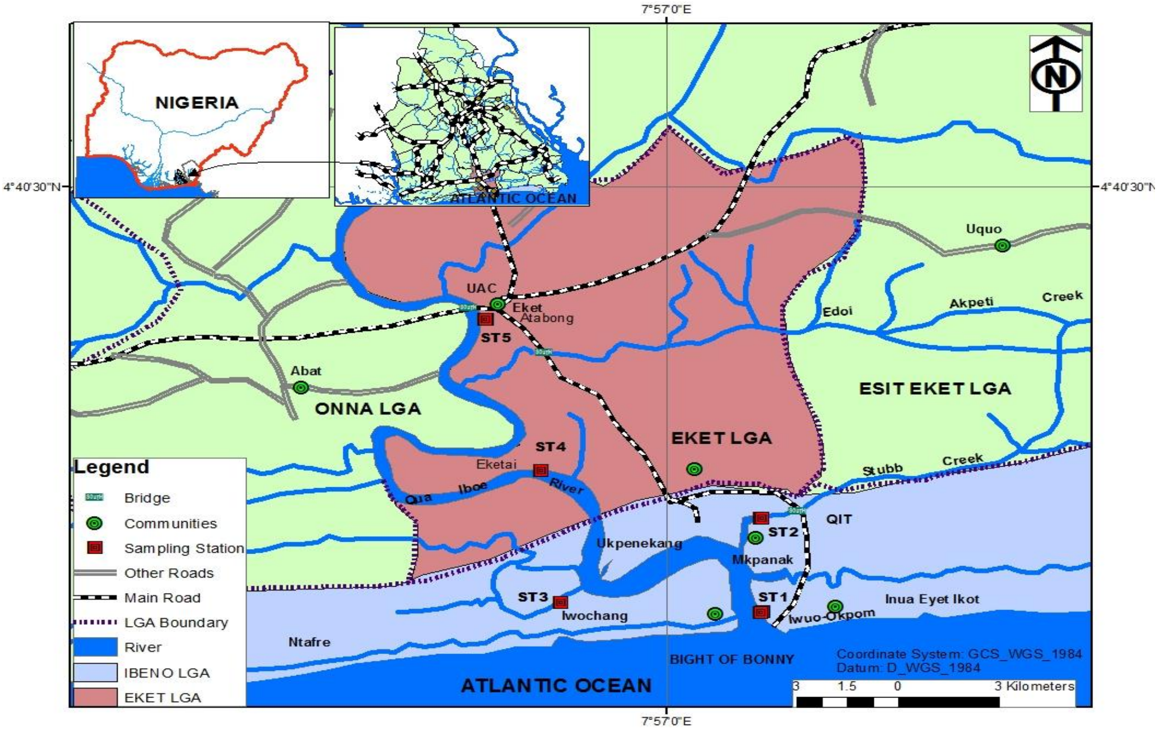

Fig. 1. Plot presentation of sampling sites in the estuary

Station 5: This station receives wastes from urban run-off because of its proximity to the road. Also, waste from abattoir sited near the study location eventually get into the station via surface run off. It is located at Atabong between latitude 04^0 32'0'' N and longitude 07^0 45' 0''E.

2.3 Collection of Sediment Sample

Sediments samples were collected monthly between January and December, 2022; covering the dry and wet seasons. At each sampling station the grab sampler was sent down to hit the sediment bottom for collection of sediment sample. Three (3) grab samples were collected at each station and was made to form a composite. Composite samples collected were dried, ground and sieved.

2.4 Determination of Trace Metals in Sediment

5g of the sediment sample was weighed and taken into a conical flask of 150ml. 50 mL of 0.1 HCL acid was added and the flash was agitated on an orbital shaker for 30 minutes at 200rev/min. The content was filtered into 50ml standard flask and made up to mark with 0.1 M HCL. Heavy metals were determined using Atomic Absorption Spectrophotometer (model GBC scientific AASGF 3000) according to APHA, [12] (2008).

2.5 Data Presentation

Data obtained from the study were subjected to one-way analysis of variance (ANOVA) and Least Significant Difference (LSD) test was employed to separate significant differences in mean values computed for stations while paired sample t-test was used to compare the seasons. The probability level was set at P = 0.05

3. RESULTS

3.1 Mean Concentration of Heavy Metal in Sediments

The mean range of cadmium values recorded in the stations were 0.03±0.0 mg/kg (Atabong) – 0.52±0.06 mg/kg (Eketai) (Table 1). The spatial variation of cadmium showed significant difference ($p<0.05$). Eketai was significantly higher than the other stations while Iwuochange was significantly higher than the control (Ataobong). Variation between the dry and wet season showed no substantial difference (P = .05) (Table 2). Fig. 2 showed the spatial and temporal variations of cadmium concentration.

Table 1. Mean spatial variations in heavy metals in Qua Iboe river estuary

Heavy metal	Iwuokpom	QIT	Iwuochang	Eketai	Ataobong	DPR limits
Cd.	0.12±0.02^{bc}	0.14±0.05^{bc}	0.19±0.03^{b}	0.52±0.06^{a}	0.03±0^{c}	0.80
Cr.	0.08±0.04^{c}	0.13±0.01^{c}	0.47±0.01^{b}	0.83±0.06^{a}	0.03±0^{c}	100
Cu.	1.64±0.11^{a}	0±0^{c}	1.37±0.06^{b}	1.64±0.05^{a}	0.01±0^{c}	36
Fe	150.22±4.18^{b}	147.79±5.85^{b}	139.59±6.28^{b}	170.67±2.25^{a}	0.46±0.03^{c}	-
Pb	0.55±0.06^{c}	0.72±0.01^{b}	0.57±0.04^{c}	0.84±0.05^{a}	0.002±0^{d}	85
Zn	24.95±4.49^{a}	24.58±4.42^{a}	13.08±0.97^{b}	27.85±2.05^{a}	0.29±0.02^{c}	140

Means with different superscripts along the same row are significantly different (Duncan's test) p<0.05

Table 2. Seasonal variations in heavy metals in Qua Iboe river estuary

	Dry	Wet
Cadmium	0.20±0.04^{a}	0.19±0.04^{a}
Chromium	0.35±0.07^{a}	0.28±0.05^{a}
Copper	0.97±0.15^{a}	0.94±0.14^{a}
Iron	130.79±13.69^{a}	115.29±10.19^{a}
Lead	0.56±0.06^{a}	0.54±0.06^{a}
Zinc	19.36±2.24^{a}	18.71±2.78^{a}

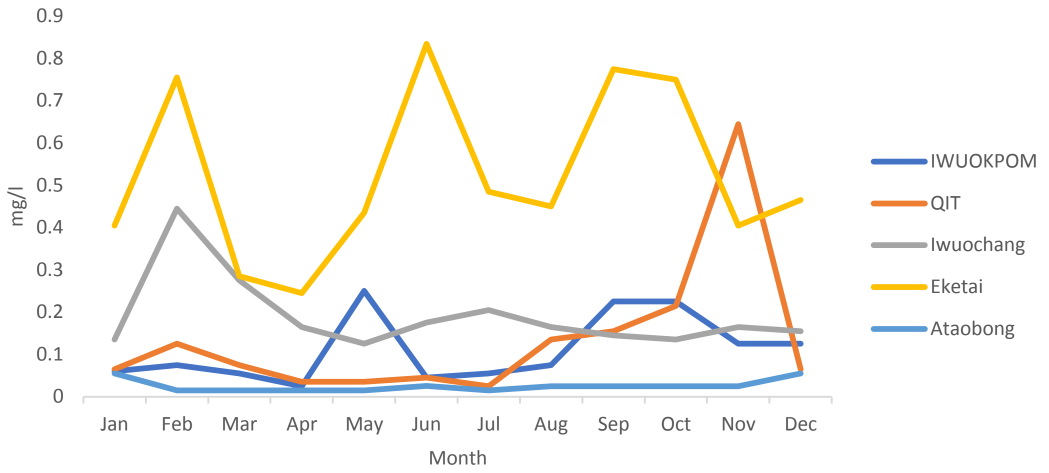

Fig. 2. Spatio-temporal variations of cadmium in Qua Iboe river estuary

The mean values recorded for chromium were from 0.03±0.00 mg/kg (Atabong) - 0.83±0.06 mg/kg (Eketai). Significant spatial variation ($p < 0.05$) was observed for chromium. Eketai and Iwuochange were significantly higher than the other stations. However, there was no significant seasonal variation (Table 2). Fig. 3 showed the spatio-temporal variations of chromium.

Mean range value for Cu recorded in the stations were 0.00±0.00 at (Atabong) – 1.64±0.05 mg/kg at (Eketai) and (Iwuokpom) respectively (Table 1). The spatial variation of copper showed significant difference ($p<0.05$). Iwuokpom and Eketai were significantly higher with the lowest value recorded at Mkpanak. Seasonal variation between the dry and wet season showed no significant difference ($p > 0.05$) (Table 2). Fig. 4 showed the spatial and temporal variations of cadmium concentration during the study duration.

The mean range values for Fe recorded across the stations were 0.46±0.03 at (Atabong) – 170.67±2.25 mg/kg at Eketai (Table 1). Spatially, significant variation ($p<0.05$) was recorded for iron during the study. Eketai recorded higher Fe values with the lowest value recorded at Atabong. There was no significant difference between wet and dry season ($p > 0.05$) (Table 2). Fig. 5 showed the spatial and temporal variations of iron concentration during the study duration.

Spatially, the mean values of Pb computed during the study range between 0.002±0.00 at (Atabong) - 0.84±0.05 at (Eketai) (Table 1). There was a spatial significant variation at p = 0.05 for Pb but no significant difference was recorded temporally during the period of study (Tables 1 and 2). Fig. 6 shows the temporal and spatial variation in Pb throughout the study duration.

Mean values of Zn computed spatially throughout the study range between 0.29±0.02 at (Atabong) - 27.85±2.05 at (Eketai) (Table 1). Significant variation at p = 0.05 was observe for Zn across the stations but there was no significant difference recorded between seasons (dry and wet) throughout the period of study (Tables 1 and 2) respectively. Fig. 7 shows the temporal and spatial variation in Zn throughout the study duration.

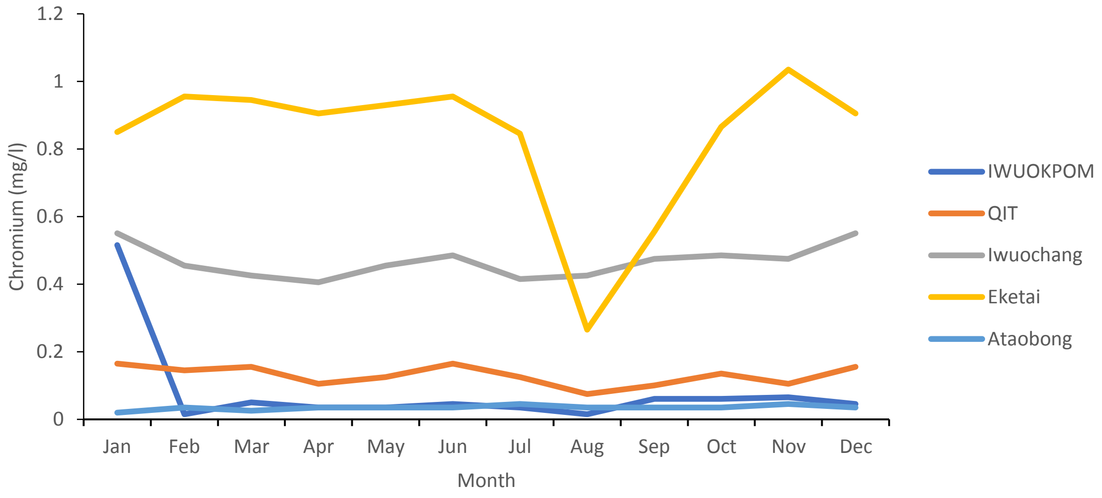

Fig. 3. Spatio-temporal variations of chromium in Qua Iboe river estuary

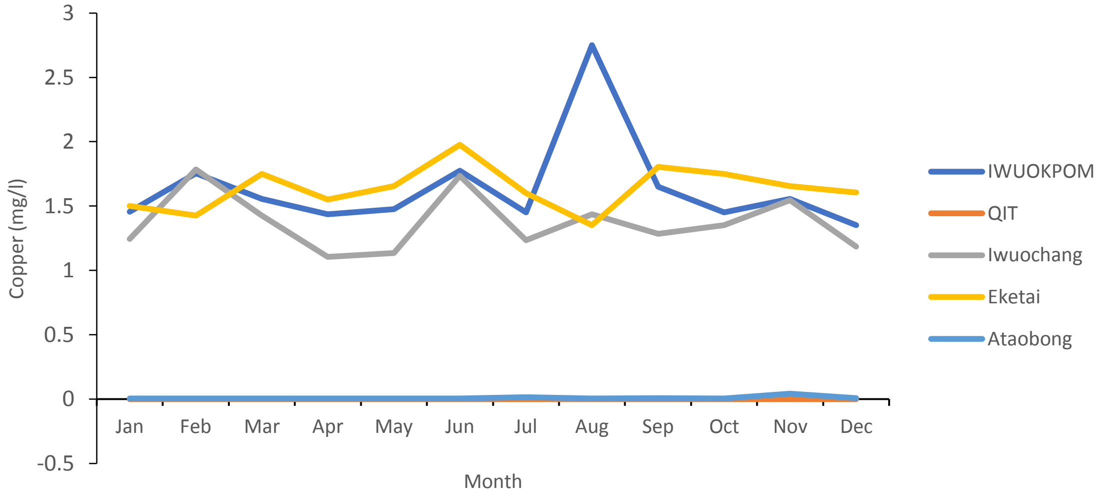

Fig. 4. Spatio-temporal variatioins in copper in Qua Iboe river estuary for wet and dry season (January, 2022 -December, 2022)

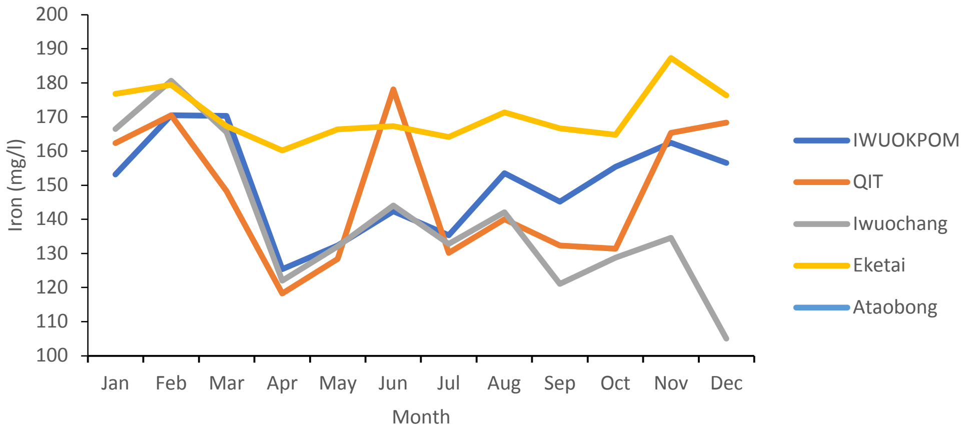

Fig. 5. Spatio-temporal variatioins in iron in Qua Iboe river estuary for wet and dry season (January, 2022 -December, 2022)

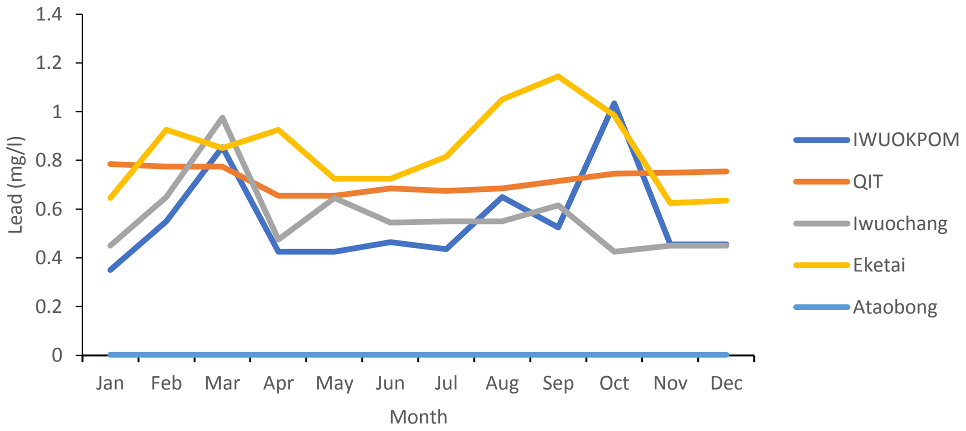

FIG. 6. Spatio-temporal variatioins in lead in Qua Iboe river estuary for wet and dry season (January, 2022 -December, 2022)

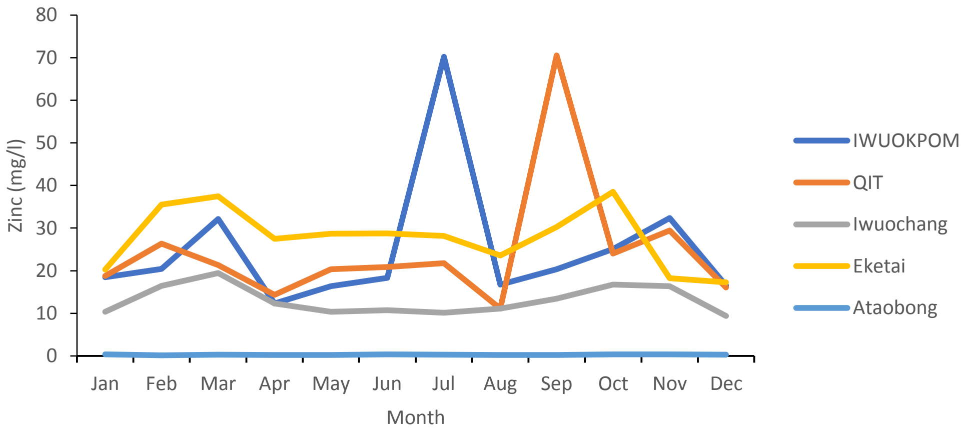

Fig. 7. Spatio-temporal variatioins in zinc in Qua Iboe river estuary for wet and dry season (January, 2022 -December, 2022)

4. DISCUSSION

The results showed an interesting pattern with higher values of heavy metal concentration recorded in the dry season when compared to the wet season. Results of this study agrees with earlier reports by George and Efiom [1]; Efiom and George [4]. This trend may be due to dilution of metal concentration during the rainy season by direct precipitation / run off from adjourning lands or reduction in human / industrial activities as a result of the rains. Levels of heavy metals concentrations in each of the stations were adjudge based on human activities in each of these stations. The high values of heavy metal concentration recorded at Eketai are a clear evidence of the levels of anthropogenic activities in the stations. These activities included, dredging, wood lumbering, boat transportation, agricultural activities, bathing, washing of clothes and cars and indiscriminate disposal of both domestic and industrial waste. Comparing the results obtained in the present study with DPR standard, it was observed that the values recorded were below the sediment quality guideline for all the studied metals exception of iron [13]. High values of iron in Nigerian soil and in related studies have been reported by several authors. This result confirms earlier assertion reported by George and Efiom [1]; Efiom and George [4] in a related study.

Iron is one of the most abundant heavy metals on the earth crust and even in the sea. However, the high concentration of iron in sediment of the study area is not uncommon as this is the case for Nigerian soils.

Elemental concentrations of heavy metal reach sediments via different routes such as atmospheric fallouts, improper disposal of solid and liquid wastes, miming activities, sewage and using of pesticides and fertilizers in agricultural practice. These activities are majorly due to human perturbations. Environmental pollution is linked to explosion in human population which are causing serious threats to ecosystem sustainability.

If the trend of human activities within the study area continues unabated, its likely that the levels of metal in the sediment of Qua Iboe River Estuary will significantly be increased with devastating impacts on benthic dwelling organisms.

5. CONCLUSION

The values of heavy metals recorded in the present study were all lower than DPR sediment quality guideline exception of iron. However, the values of heavy metal recorded in the sediment of the study area is an indication of human perturbations within or at close proximity to the study area. Environmentalist world over is concerned with the effects of pollution on the sustainability of aquatic resources. In order to ensure sustainability of these resources for future generation without compromising, there is an urgent call for all stakeholders to create the necessary awareness on the ways to drastically reduce, re-use and recycle wastes generated from homes, industries and agricultural practice. This study recommends that inorganic fertilizers and pesticides should be replace with organic products to help curtail some of the routes causes of heavy metals in our environment.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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