
Heavy Metal Pollution of Wetland Sediments in Some Cities of South-Western Nigeria

By

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ABSTRACT

Accumulation of metal contaminant in wetland sediment can pose serious environmental problem to public health, hence the evaluation of the geochemical impact of metals present in wetlands of Ibafo and Alapere environment. A total of thirty sediment samples were collected from fifteen sampling points at depths of (4cm-6cm) and (6cm-8cm) in the study area. Heavy metals concentrations were determined with the use of the Inductively Coupled Plasma Mass Spectrometry (ICP-MS) technique. Microsoft Excel, statistical package for social sciences (SPSS) was employed for the data interpretation and Corel draw to generate geochemical maps. Geochemical results revealed Alapere to be highly contaminated than Ibafo which was due mainly to high anthropogenic activities found in the area. A strong and positive correlation was observed between the metals at both depths in Ibafo and Alapere which indicates that the metals have same relationships regardless of the depth and are governed by the same geochemical processes which is anthropogenic. Metal ratio revealed a high depletion of metals into the environment of Alapere as compared with that of Ibafo indicating high environmental pollution in Alapere. Geo-accumulation Index (Igeo) values of Alapere at both depths are very strongly contaminated as compared with the metals in Ibafo this is due to the industrial discharge, indiscriminate sewage disposal, metal smelting, and indiscriminate burning of tyres, indiscriminate disposal of electronic components found in the study area. In conclusion Alapere wetland soils are observed to be more contaminated than Ibafo, due to divers' human activities found in the area. It has thus become imperative to establish timely monitoring and remediation strategies to alleviate the cumulative concentration of trace metals in the study area, to avoid any possible break-out of disease that could affect the public.

Keywords: Contaminant; Environmental problem; Remediation; Wetland; Monitoring

INTRODUCTION

Intense urbanization leads to emergence of increased industrialization has consequently led to extensive environmental pollution [1] from various heavy metals such

as arsenic (As), lead (Pb), copper (Cu), zinc (Zn), and nickel (Ni). Contamination of these metals has become a major concern globally, regionally and locally [2]. Heavy metal contamination inevitably affects all sector of

the environment, the sectors are soil, waters (ground and surface), stream sediments, particulates and even wetlands (coastal, tidal, non-tidal, inland, lacustrine, palustrine and riverine) [3]. Wetland generally fills 2.8×10^6 km² or 2.2% of the earth surface [4, 5]; in Africa, it covers 5.6 million km² (16% of the continent). Nigeria, has 24,009 km of Wetlands, some important once are Kanji Lake, Adiami-Nguru floodplains, Matgadru-Kabok floodplains, Niger-delta flood plains, Coaster lagoons, Delta of Cross river with many others [6, 7]. Wetlands in Nigeria are divided into two major groups these are saline (Niger River, Cross river estuary, Imo River and Qua Iboec River Estuary) and fresh wetlands (Niger delta, Niger River, Benue River, Cross River, Imo River, Ogun-Osun River, and Lake Chad) occupying 307,395.0 and 283,188.28 hectares respectively [8]. Impact of man (anthropogenic) and natural hazards has a way of affecting the ecosystem of wetlands thus leading to environmental degradation that influences the behavioral pattern of the ecosystem [9, 10]. Pollution of wetlands by heavy metal not only affects water quality but also the plants and animals found in the environment. A little amount of heavy metal is always present in fresh waters from terrigenous sources (weathering of rocks that result in geo-chemical recycling of heavy metal elements) [11, 12]. When trace elements get into the stream sediments and are entrapped, this form of entrapment helps the trace metals to be involved in absorption, co-precipitation, and complex formation which occurs in the stream sediment. Several workers observed that the rate at which heavy metals gets deposited in Wetlands are very high while the soils are found to be sensitive indicators for aquatic environment contaminant monitoring; and it can

effectively sequester hydrophobic chemical pollutants entering water bodies such as lakes, and also provide a useful archive of information on changing lacustrine and watershed ecology, [13, 14, 15, 16, 17, 18, 19, 20, 21]. Due to the influence of increase in industry and urbanization which leads to heavy metal contamination of wetland sediments geochemical impact of wetland sediments of Ibafo and Alapere SW Nigeria was assessed, while identifying any possible impact on public health. Several workers have established metal pollution of wetlands by heavy metals

Location and Geology

The study areas are Ibafo and Alapere South West and are located within Latitude $6^{\circ} 43' 53.4''$ - $6^{\circ} 43' 44.6''$ and $6^{\circ} 34' 49.5''$ - $6^{\circ} 34' 44.3''$ N, and Longitude $3^{\circ} 24' 58''$ - $3^{\circ} 25' 02.1''$ and $3^{\circ} 23' 30.1''$ - $3^{\circ} 23' 31.4''$ E respectively (Fig 1.0a&b). The areas are easily accessible and falls within the Dahomey Basin. The Basin is a marginal pull-apart basin initiated during the Early Cretaceous separation of South American and Africa plates there by constituting part of a system of West Africa pre-cratonic basins developed during the commencement of rifting, associated with the opening of the Gulf of Guinea in the Late Jurassic to Early Cretaceous [22].

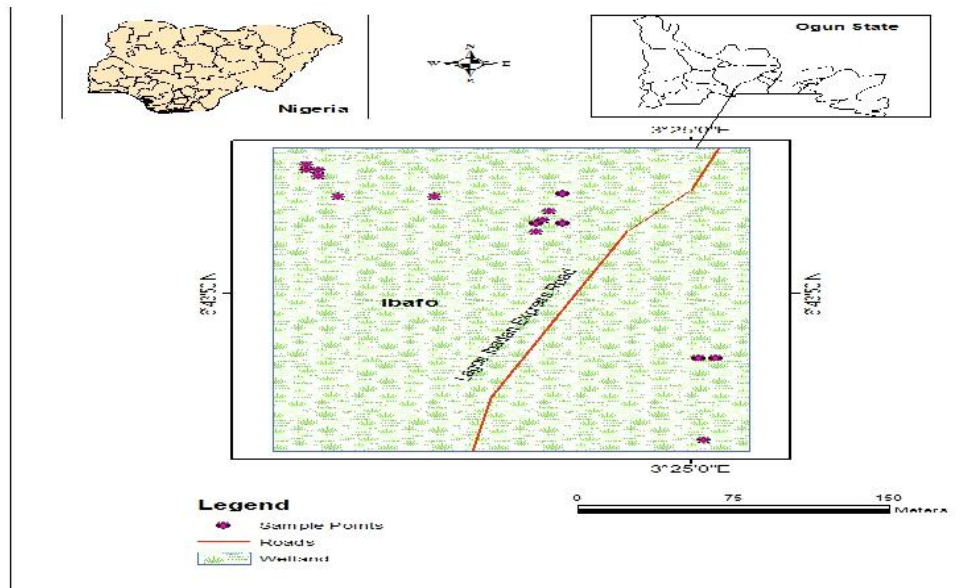


Figure 1.0a: Location and sample distribution map of Ibafo

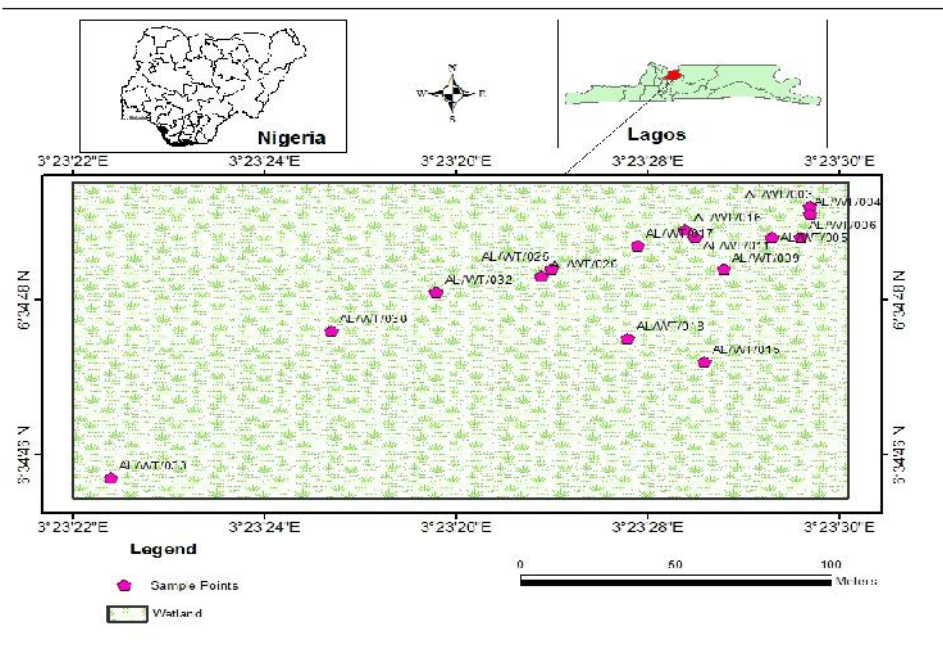


Fig 1.0b: Location and sample distribution map of Alapere

MATERIALS AND METHOD

Samples were collected randomly during the dry season with the use of core that is covered at the bottom by polythene bag in which the samples go to prevent contamination of the samples. Total

Dissolved Solids (TDS) and the Electrical Conductivity (EC) of the water in the sediment were also measured on the field with the use of a digital meter. samples were room dried to have a core shaped sediment, cut with a pair of knife into 2cm each, (0-2cm,

2-4cm, 4-6cm, 6-8cm) in which only the last two centimeters (4-6cm, 6-8cm) are analyzed here giving a total of 30 samples, and sieved with a $<63\mu\text{m}$ sieve after which

they were taken to Acme Laboratories in Canada for analysis using The Inductively Coupled Plasma Mass Spectrometry (ICP-MS) technique (Fig 2.0a&b).



Figure 2.0a: Sampling point ($E3^{\circ} 24' 57.6'' N6^{\circ} 43' 52.4''$)



Figure 2.0b: Division of the samples into intervals

RESULTS AND DISCUSSION

Heavy metal distribution

Geochemical results (Table 1) of the study area revealed that Alapere is highly contaminated when compared with metals of Ibafo which was due mainly to high anthropogenic activities found in the area as compared with Ibafo. Comparing the metal values with [23 a & b, 24] per depth, wetland soils in Ibafo are still found within the

guideline limits with the exception of Zn and Cu in [24] which was due to the influx of water-runoffs from markets and refuse dump found in the area. Alapere wetland soils was found to be heavily polluted for all the metals with the exception of Ni [23a] this was due to the high urbanization and industrialization found in the community which has led to indiscriminate dumping of refuse, and uncontrolled effluents in the area, metals also

get into the soils from the construction of roads and mechanic workshops found in the area. With depth it was observed that the soil decreases with depth with the exception of Zn in the two locations mainly due to the indiscriminate dumping of refuse in both locations (Fig 3.0).

A strong and positive correlation (Table 2) was observed between the metals at both depths in Ibafo (I) and Alapere (A) which indicates that the metals have same relationships regardless of the depth and are governed by the same geochemical processes which is anthropogenic. factor analysis (Table 3) that accounted for 86.463% of the variability in the original data at a depth of 4-6cm. Factor 1 accounted for 52.450% of the variation in the original data (caused by Pb, Zn, Cu, and Ni). Factor 2 accounted for 21.683% of the variation in the original data (caused by Cu, Pb and Ni) (Fig 4.0a-c). This confirms the positive correlations between the factors and the elements and could probably indicate a similar source for the elements. In Alapere the first component accounts for 65% and showed a strong and positive loading for the elements while the second components account for over 20% of the total variance has contributed elements in the environment. Ibafo at depths 6-8cm, 75.324% of the variation in the original data at this depth. Factor 1 accounted for 47.874%, while Factor 2 accounts for 27.450% of the total variation in the original data; while Alapere, has 91% variance. The first component account for 64.71% of the variance showing a very strong positive loading for the elements. The second component account for 18.09% of the variance which shows strong positive while the third components accounts for 8.67% of the variance shows low positive loading. strong and positive loading of the

metals observed in Ibafo and Alapere confirms their correlation and it indicates that all the metals were contributed by the same anthropogenic source which could be industrial discharge, indiscriminate sewage disposal, metal smelting, and indiscriminate burning of tyres, indiscriminate disposal of electronic components, combustion of exhaust pipes of vehicles, industrial activities like sewage sludge, metal smelting that were seen in the study area.

Statistical evaluation

Metal ratio: degree of pollution can be quantified from the metal ratio.

$$\text{Metal Ratio} = C_n/B_n$$

Where;

C_n = Obtained concentration of metals (ppm)

B_n = calculated background value for metals (ppm)

If $C_n = B_n$, then there is no enrichment, if $C_n < B_n$, that means there is a depletion. But if $C_n > B_n$, then there is an enrichment.

The red colors (Tables 4a&b) indicate locations where $C_n = B_n$. This means there is no enrichment in the concerned metals respectively; blue indicates locations where $C_n < B_n$, indicating that there is a depletion in the affected metals; bold black indicates positions where $C_n > B_n$. This means that there is enrichment in the metals concerned respectively. The result revealed a high depletion of metals into the environment of Alapere as compared with that of Ibafo indicating high environmental pollution in Alapere.

Geoaccumulation index (I_{geo}): has been used to evaluate the degree of metal contamination or continued pollution in terrestrial, aquatic and marine environment

[27]. The *Igeo* of a metal in a sediment can be calculated from the formula [28].

$$I_{geo} = \log_2 [(C_n / 1.5B_n)]$$

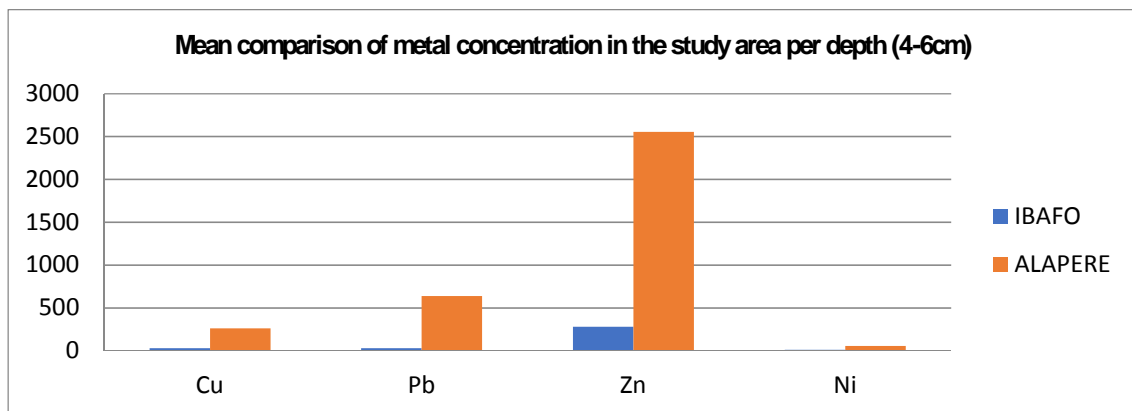
The degree of metal pollution is assessed in term of seven contamination classes based on the increasing numerical value of the index as follows: $I_{geo} < 0$ means uncontaminated; $0 \leq I_{geo} < 1$ means uncontaminated to moderately contaminated; $1 \leq I_{geo} < 2$ means moderately contaminated; $2 \leq I_{geo} < 3$ means moderately to

strongly contaminated; $3 \leq I_{geo} < 4$ means strongly contaminated; $4 \leq I_{geo} < 5$ means strongly to very strongly contaminated; $I_{geo} \geq 5$ means very strongly contaminated. *Igeo* values of Alapere at both depth is very strongly contaminated as compared with the metals in Ibafo this is due to the industrial discharge, indiscriminate sewage disposal, metal smelting, and indiscriminate burning of tyres, indiscriminate disposal of electronic components found in the study area

Table 1: Mean Statistical Values of The Study Area with Depth (Cm)

LOCATIONS	DEPTH	Cu	Pb	Zn	Ni
IBAFO	4-6	28.6	27.3	278.3	10.0
ALAPERERE	4-6	258.3	636.9	2553.7	52.9
IBAFO	6-8	26.8	27.3	253.3	10.7
ALAPERERE	6-8	236.8	621.9	2741.4	53.9
Ewers 1991a		-	100	100	100
*ICRCL 1997		10	50	25	20
Ewers 1991b		50	50	200	50

- a. Recommended guideline value for maximum limit of heavy metal levels in irrigation soil
- *Mean of heavy metal limit in soil for agriculture and recreation and recreation recommended by Interdepartmental Committee for Redevelopment of Contaminated Land (ICRCL)
- b. Guidelines line values for tolerable total metal concentrations in agricultural soil recommended by Swiss Ordinance



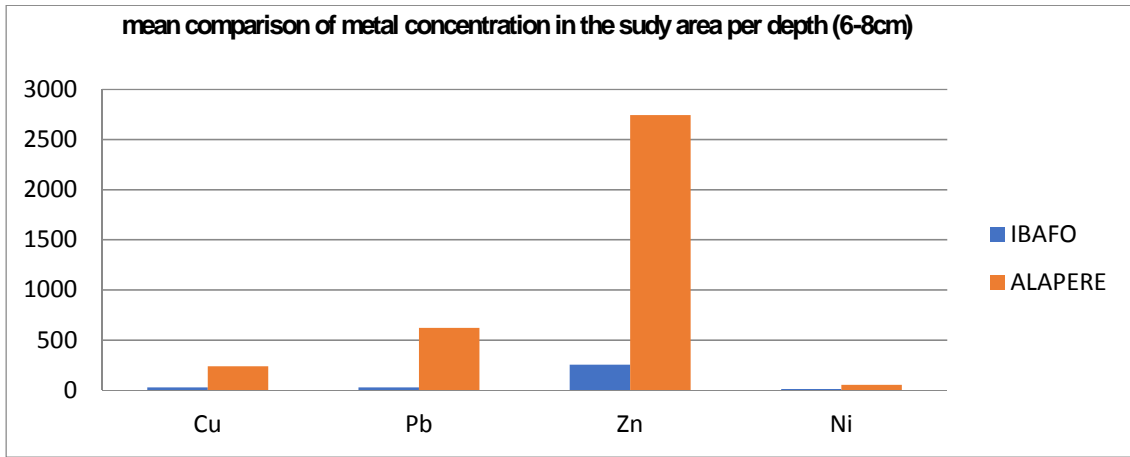


Fig 3.0: Mean comparison of metal concentration

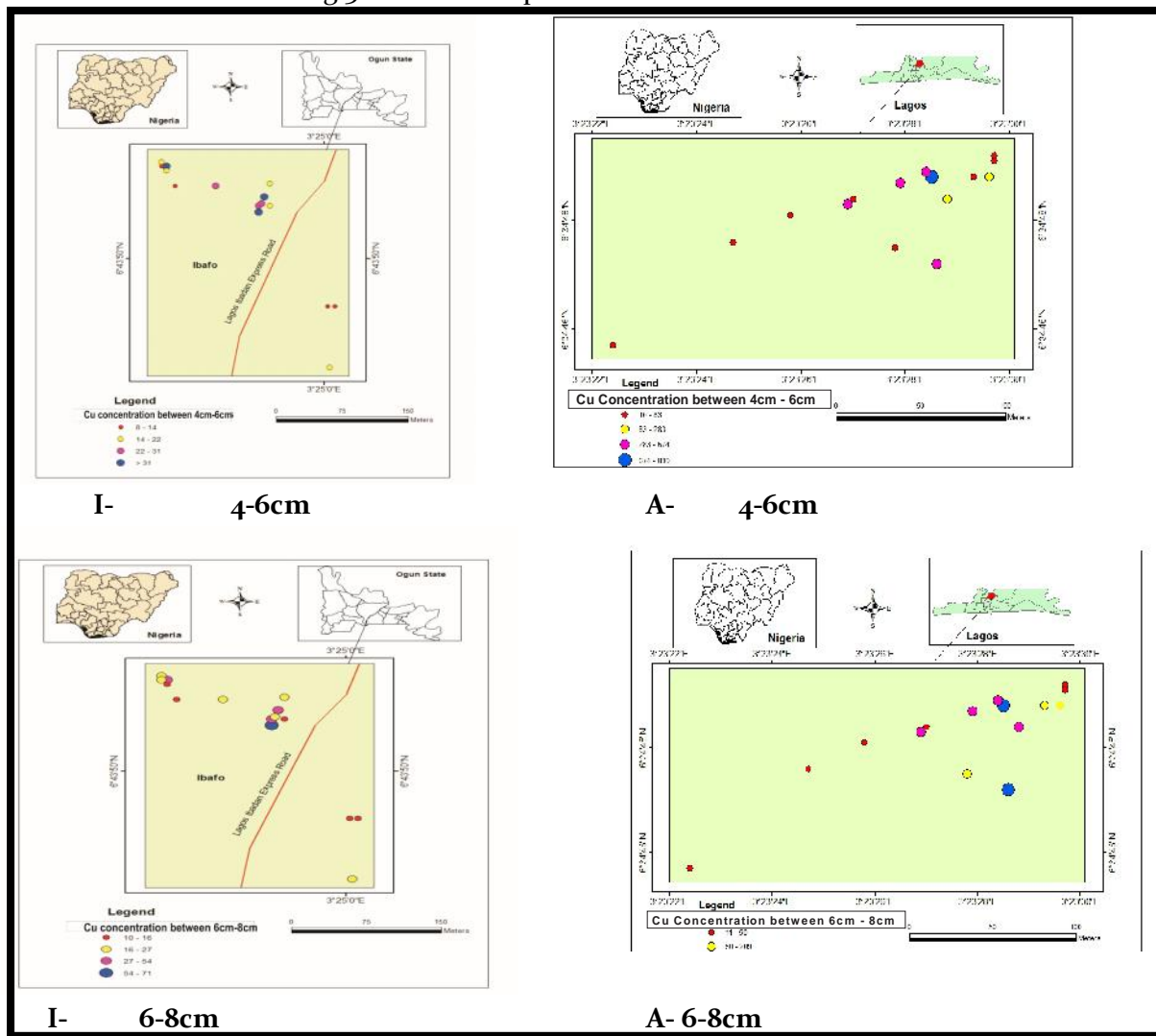


Fig 4.0a : Concentration of Cu for Ibafo (I) and Alapere (A) at (4cm-6cm) and (6cm-8cm) depth respectively

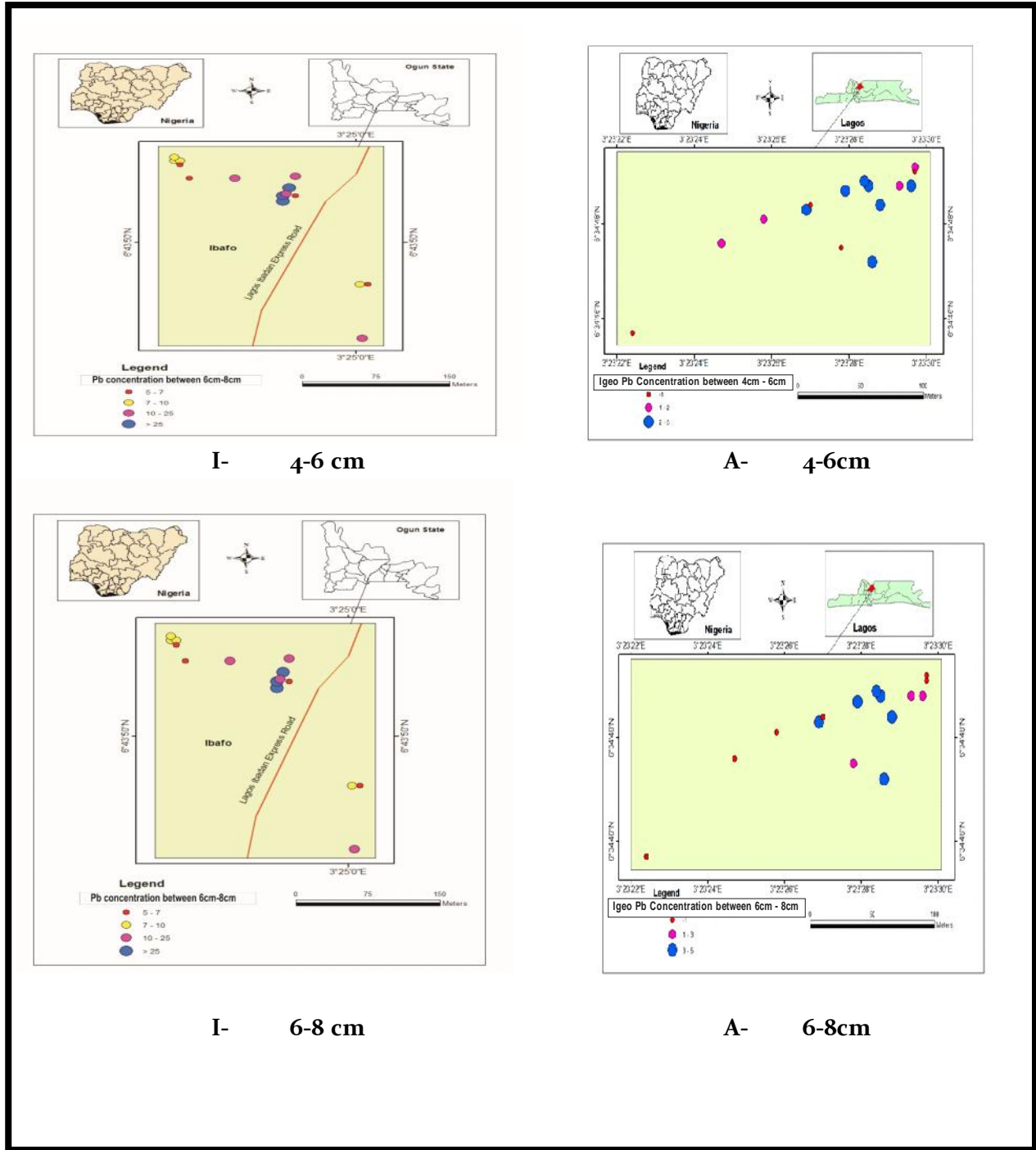


Fig 4.ob : Concentration of Pb for Ibafo (I) and Alapere (A)at (4cm-6cm) and (6cm-8cm) depth respectively

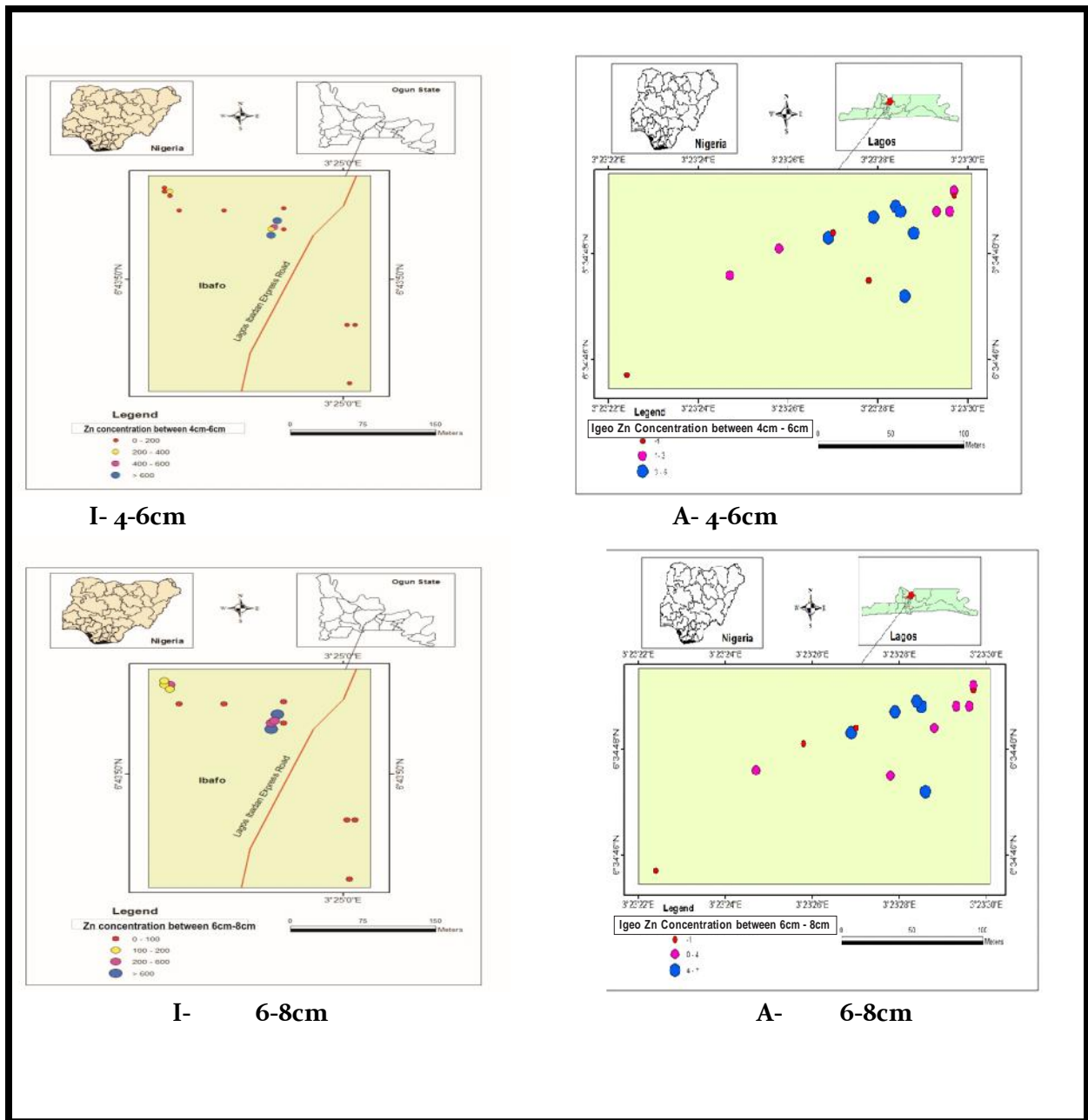


Fig 4.0c : Concentration of Zn for Ibafo (I) and Alapere (A) at (4cm-6cm) and (6cm-8cm) depth respectively

Table 2: Correlation Coefficient at depths 4cm-6cm versus 6cm-8cm for Ibafo and Alapere

I 4-6 cm	Cu	Pb	Zn	Ni	I 6-8 cm	Cu	Pb	Zn	Ni
Cu	1				Cu	1			
Pb	0.786	1			Pb	0.872	1		
Zn	0.636	0.653	1		Zn	0.733	0.746	1	
Ni	0.686	0.695	0.838	1	Ni	0.743	0.810	0.856	1
A 4-6 cm	Cu	Pb	Zn	Ni	A 6-8 cm	Cu	Pb	Zn	Ni
Cu	1				Cu	1			
Pb	0.889	1			Pb	0.985	1		
Zn	0.869	0.86	1		Zn	0.833	0.782	1	
Ni	0.962	0.88	0.778	1	Ni	0.946	0.915	0.757	1

Table 3: Factor Analysis at depths 4cm-6cm versus 6cm-8cm for Ibafo and Alapere

4-6 cm	1I	2I	1A	2A	6-8 cm	1I	2I	1	2	3
Cu	0.862	0.255	0.955	-0.19	Cu	0.862	0.255	0.956	-0.129	0.221
Pb	0.916	0.103	0.896	0.264	Pb	0.916	0.103	0.919	0.202	0.283
Zn	0.836	0.062	0.868	0.237	Zn	0.836	0.062	0.867	-0.061	0.232
Ni	0.929	0.142	0.948	0.169	Ni	0.929	0.142	0.958	0.083	0.183
Total	5.745	3.294	8.487	2.657	Total	5.745	3.294	8.412	2.351	1.127
% of Variance	47.87	27.45	65.28	20.43	% of Variance	47.87	27.45	64.70	18.08	8.671
Cumulative %	47.87	75.32	65.28	85.72	Cumulative %	47.87	75.32	64.70	82.79	91.46
	4	4	8	4		4	4	7	6	6

Table 4a: Metal Ratio at 4-6 cm for Ibafo and Alapere

Sampling point at 4-6 cm	I Cu ppm	I Pb ppm	I Zn ppm	I Ni ppm	A Cu ppm	A Pb ppm	A Zn ppm	A Ni ppm
1	1.57	4.50	1.94	2.17	1	2	3	3
2	2.21	2.75	1.00	1.67	0	1	0	1
3	3.79	8.50	22.60	3.83	2	4	3	3
4	1.79	3.50	6.80	1.33	3	7	10	13
5	1.93	5.38	5.46	1.67	5	17	12	12
6	5.50	16.13	9.35	2.50	17	28	30	37
7	1.21	1.63	0.82	1.17	13	26	63	18
8	1.00	0.75	1.86	1.00	11	41	47	26
9	1.50	1.88	3.05	1.67	9	13	38	20
10	1.00	0.75	1.08	1.33	1	1	1	1.2
11	4.57	1.75	4.69	1.50	1	1	1	2
12	1.57	1.00	2.52	1.67	9	17	27	18
13	1.00	1.13	1.05	1.33	1	2	3	1
14	0.57	0.38	1.42	0.67	0	2	2	1
15	1.43	1.13	0.60	1.50	0	1	1	0.6

Table 4b: Metal Ratio at 6-8 cm for Ibafo and Alapere

Sampling point 6-8 cm	I Cu ppm	I Pb ppm	I Zn ppm	I Ni ppm	A Cu ppm	A Pb ppm	A Zn ppm	A Ni ppm
1	1.19	4.17	1.61	1.86	4	2	4	3
2	1.69	3.83	1.29	1.43	1	0	0	1
3	3.38	12.67	26.76	3.57	7	6	4	3
4	1.13	3.00	8.45	1.00	16	8	18	13
5	2.56	11.50	8.76	2.14	22	17	19	11
6	4.44	19.17	12.86	2.43	54	29	47	29
7	0.88	1.00	0.86	0.86	54	30	104	17
8	1.19	1.67	3.61	1.44	39	24	69	20
9	1.00	1.00	2.55	1.14	28	12	104	17
10	0.88	0.83	0.78	1.00	6	3	6	2
11	2.92	1.50	4.49	1.14	3	1	1	2
12	1.38	1.50	2.61	1.71	35	20	45	16
13	0.69	1.17	1.00	1.00	2	2	4	1
14	0.63	1.33	1.08	0.86	1	1	1	1
15	1.19	3.17	0.86	1.57	1	1	1	1

Table 5a: Geo-accumulation Index at 4-6 cm for Ibafo and Alapere

4-6 cm	Cu	Pb	Zn	Ni	Cu	Pb	Zn	Ni
Sampling point	I	I	I	I	A	A	A	A
1	0.65	2.17	0.96	1.12	0	1	2	2
2	1.15	1.46	0.00	0.74	-2	-1	-1	0
3	1.92	3.09	4.50	1.94	1	2	1	2
4	0.84	1.81	2.77	0.42	2	3	3	4
5	0.95	2.43	2.45	0.74	2	4	4	4
6	2.46	4.01	3.23	1.32	4	5	5	5
7	0.28	0.70	-0.29	0.22	4	5	6	4
8	0.00	-0.40	0.90	0.00	3	5	6	5
9	0.59	0.91	1.61	0.74	3	4	5	4
10	0.00	-0.42	0.11	0.42	-1	0	0	0
11	2.19	0.81	2.32	0.58	0	-1	0	1
12	0.65	0.00	1.34	0.74	3	4	5	4
13	0.00	0.17	0.07	0.42	0	1	2	0
14	-0.81	-1.42	0.50	-0.59	-2	1	1	0
15	0.51	0.17	-0.74	0.59	-2	0	-1	-1

Table 5b: Geo-accumulation Index at 4-6 cm for Ibafo and Alapere

6-8 cm	Cu	Pb	Zn	Ni	Cu	Pb	Zn	Ni
Sampling point	I	I	I	I	A	A	A	A
1	1.76	3.66	4.74	1.84	2	1	2	1
2	0.17	1.59	3.08	0.00	0	-1	-1	0
3	1.36	3.52	3.13	1.10	3	3	2	2
4	2.15	4.26	3.68	1.28	4	3	4	4
5	-0.19	0.00	-0.26	-0.22	4	4	4	3
6	0.25	0.74	1.85	0.19	6	5	6	5
7	0.00	0.00	1.35	0.19	6	5	7	4
8	-0.19	-0.26	-0.37	0.00	5	5	6	4
9	1.55	0.59	2.17	0.19	5	4	7	4
10	0.46	0.59	1.39	0.78	3	2	3	1
11	-0.54	0.22	0.00	0.00	1	-1	0	1
12	-0.68	0.42	0.11	-0.22	5	4	5	4
13	0.25	1.66	-0.22	0.65	1	1	2	0
14	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	-1

CONCLUSION

The study revealed that Alapere wetland soils are more contaminated than that of the Ibafo, due to the human activities like automobile repair and spillage of oil from petroleum tanker that pack along the area. it becomes imperative to establish timely monitoring and remediation strategies to alleviate the cumulative concentration of trace metals in the study area.

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