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Geochemical Assessment of Industrial Activities on the Quality of Sediments and Soils Within the Lsdpc Industrial Estate, Odogunyan, Lagos, Nigeria

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Abstract: This study examined the impact of industrial activities within the LSDPC Industrial estate in Odogunyan, on the quality of the sediments and soils within the area. Twenty samples comprising drainage sediments and soils were obtained from within the drains and surrounding areas of the industrial estate. These samples were dried and disaggregated and sieved to appropriate sizes for geochemical analysis. The samples were subsequently digested and analyzed using ICP-OES at the Activation Laboratories, Ontario Canada. The results of the geochemical analysis showed the following range of concentration for some selected metals Cd (0.20-2.10ppm), Cu (28.00-153.00ppm), Pb (20.00-148.00ppm), Zn (61.00-1133.00ppm), Mn (189.00-2024.00ppm), Mo (bdl-6.00ppm) and W (bdl-6.00ppm). Geochemical evaluation of the results obtained from the analysis to ascertain their environmental implications indicated that these selected metals are the principal pollutants found in the study area and that the level of these metals in the soils and sediments around these industrial estate can be linked to the industrial practices of the manufacturing outfits located in the area who dump their untreated wastes into the environment without any treatment.

Key words: Odogunyan · Industrial estate · Drainage sediments · Geochemical evaluation

INTRODUCTION

The presence of heavy metals in environmental media has been a subject of great concern due to their non-biodegradable nature and the long biological half-lives for their elimination from living tissues. Although heavy metals occur in the sediments as a result of weathering and erosion, contamination comes from localized sources mostly from industries, agriculture, sewage sludges, landfill site, combustion of fossil fuels and road traffic. Several workers had highlighted the effects of industrialization on the quality of environmental media and human [1-8].

There has been tremendous growth of human and industrial population in the Lagos area in the past two decades with most industries striving for space with which to erect factories. The associated anthropogenic activities often result in environmental pollution. Heavy metals such as Zn, Cu, Pb, Cd, Mn, etc. are prominent components of industrial effluents, which are discharged into the environment and consequently pollute the aquatic ecosystem. It is therefore important to continuously carry out environmental impact assessment and audit in order to evaluate the effects of these metals on the environment.

Study Area: The Lagos State Property Development Corporation (LSDPC) Industrial Estate in Odogunyan, Ikorodu Local Government is one of the several industrial Estates set up by the State Government to cater for the need of investors who are interested in establishing manufacturing outfits in the State. It is located within Longitudes 3°15' and 3°25'E and on Latitudes 6°35'N and 6°40'N (Fig 1).

The industries in the area include those of textile, chemical, steel and footwear. These factories utilize huge volume of chemicals most of which have heavy metal as additives.

The wastewaters of these factories are discharged indiscriminately into the environment without any form of treatment. The drains are connected together to a large canal that conveys the wastewater away from the estate. The inhabitants of the area also engage in agricultural activities within the industrial estate using the water as irrigation water for their crops, especially the vegetable grown along the drains. With the continuous discharge of untreated wastewater by the factories into the drains and the continuous use of this wastewater as irrigation water for vegetables and other crops in the area, the possibility of contamination and eventual health hazard to the inhabitants of the area cannot be overruled. It therefore

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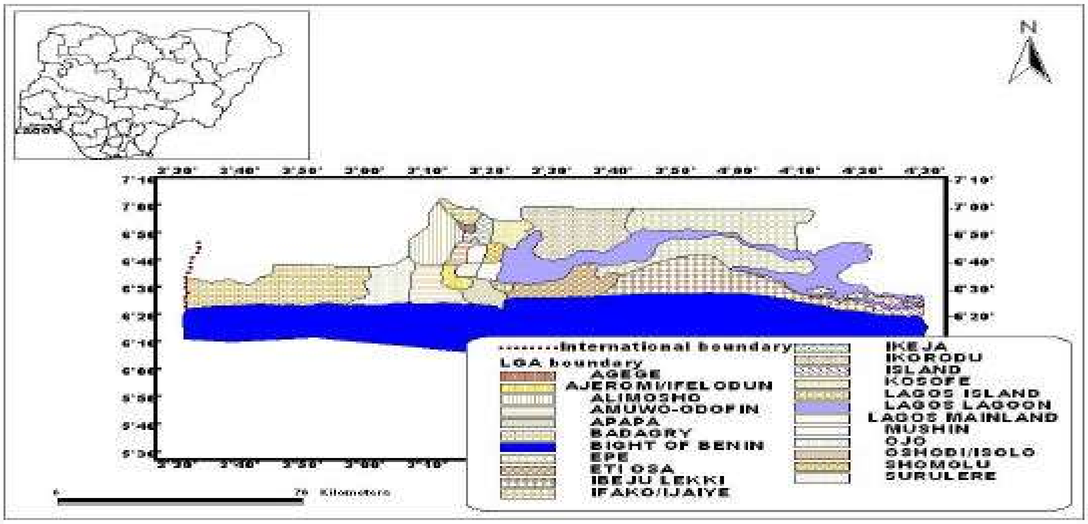

Fig. 1: Map of Lagos State Showing the Location of the Study Area (Inset Map of Nigeria)

becomes very desirable to ascertain the level of these potential hazardous heavy metals in the environment around the study area.

Geologically, the Tertiary to Recent Coastal Plain sands of southwestern Nigeria underlies the area. These are made up of a repeated succession of clay and sandy horizons. The clay ranges from reddish-brown to dirty white and the sands range from very fine to coarse and gravely in texture. Minor occurrences of peat and isolated ferruginous sandstones have been reported in the area.

MATERIALS AND METHODS

To ascertain the heavy metals contents of the sediments and soils of the industrial estate, twenty samples were collected from the drains and soils of the area. These were dried and sieved to sizes. 0.5g of the samples was subsequently digested using aqua regia at 95° C for two hours. These were then analysed using the Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) at the Activations Laboratories Limited, Ontario Canada. To guarantee reliability of the data, blanks and series of USGS geochemical standards were analysed at intervals of six samples.

The ICP-OES used allowed the determination of major and trace elements present in the samples analysed. However for the purpose of this work, emphasis is placed on seven selected heavy metals found to be of environmental significance. The Total Dissolved Solids (TDS) and Electrical Conductivity (EC) of the wastewater were also measured on the field using a digital conductivity meter (WTW LF 90 model).

RESULTS AND DISCUSSION

A summary of the results and geochemical evaluation of the selected heavy metal in the soils and sediments of the study area is presented in Table 1.

The concentration of the heavy metals showed that Cd ranges from 0.2-2.10 ppm, Cu 28.00-153.00 ppm; Mn 189.00-2024.00 ppm; Mo bdl-6.00 ppm; Pb 20.00-148.00 ppm; Zn 61.00-1133.00 ppm and W bdl-6.00ppm respectively. Most of the samples analysed showed that the selected metal contents are higher than the corresponding average shale concentration. This is an indication that the metals have been enriched in the sediments and soils of the industrial estates. The TDS and EC values also showed that most of the wastewater has been polluted with samples collected from the factories outlets recording values greater than 1000 for each parameter (Table 1).

To further ascertain the level of these metals in the environment, the metal ratio, geo-accumulation index, contamination factors and the degree of contamination were calculated. The background value that was used in this study is the global metal average of shale. This has been accepted as a worldwide geochemical standard as it represents an uncontaminated situation [6, 7, 9-12].

Metal Ratios: The metal ratios calculated for the analysed samples showed various degree of enrichment. Other than Mn, all the selected metals have metal ratios greater than 0.5. This showed that the metals have been enriched in the sediments and soils by

Table 1: Summary of the Heavy Metal Contents of the Soils and Sediments of the LSDPC Industrial Estate, Odogunyan

Metal	Range of Concentration (ppm)	ASC	Metal Ratios	I geo	C_f	C_{deg}
Cd	0.20-2.10	0.30	0.67-7.00	0-2	0.7-7.0	22.4
Cu	28.00-153.00	50.00	0.70-2.70	0-1	0.7-2.7	9.7
Mn	189.00-2024.00	850.00	0.22-2.38	0-1	0.2-2.4	6.6
Mo	Bdl-6.00	2.00	1.00-3.00	0-1	1.0-3.0	6.2
Pb	20.00-148.00	20.00	1.00-7.40	0-2	1.0-7.4	22.9
Zn	61.00-1133.00	90.00	0.68-12.59	0-3	0.7-12.6	25.4
W	Bdl-6.00	1.80	0.56-3.33	0-1	0.6-3.3	6.8
TDS (mg/l)	558-1790	-	-	-	-	-
EC (øS/cm)	631-2040	-	-	-	-	-

ASC = Average Shale Concentration I geo =Geo-accumulation index C_f = Contamination Factor C_{deg} = Contamination Degree

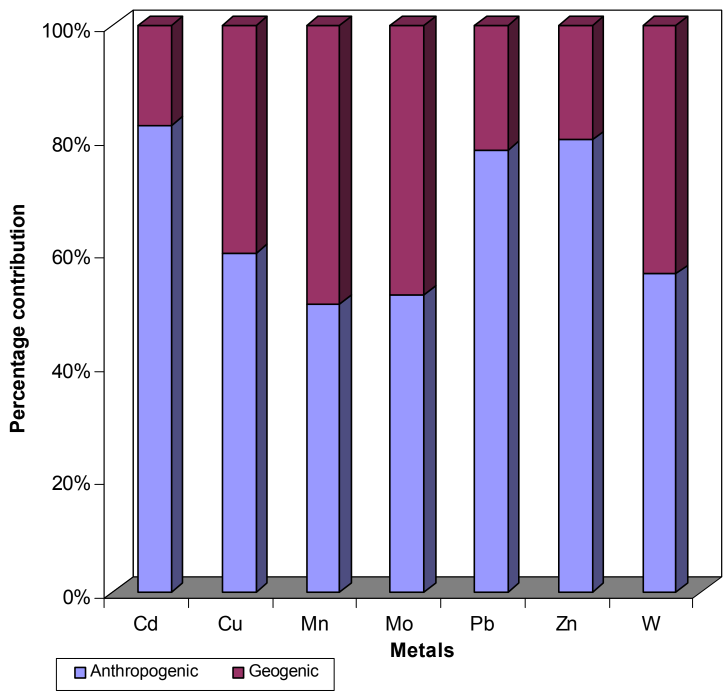

Fig. 2: Sources of metals in the study area

at least a factor of 0.5 with the highest elevation noticed for Zn, which is elevated with a factor as high as 12.59 in one of the sample.

To ascertain the source of the metal elevation in the samples, which is to determine whether they have been geogenically or anthropogenically derived the average shale content, was taken as the geogenically derived portion. This was deducted from the measured concentration and the resulting values converted into the percentage of the geogenically-induced portion. This revealed that for the selected metals, Cd, Pb, Zn and W have over 60% of their content contributed by anthropogenic sources while Cu, Mn and Mo have over 60% of their content contributed by geogenic means (Fig.2). The implication of this is that wastewater discharged by the industries is metal laden with Cd, Pb, Zn and W as well as for some percentage of Cu, Mn and Mo.

The Geo-accumulation Index: The geo-accumulation index [10] is often used for the quantification of metal accumulation in sediments and to classify sediments as either polluted or unpolluted with such metals. The geo-accumulation index has six classes ranging from unpolluted to very highly polluted. The range of the calculated geo-accumulation index for the selected metals in the samples is presented in Table 1. The geo-accumulation index is calculated using the formula:

Table 2: Correlation Co-efficient matrix of selected Metals In the Study Area

	Cd	Cu	Mn	Mo	Pb	Zn	W
Cd	1.00						
Cu	0.58	1.00					
Mn	-0.32	-0.39	1.00				
Mo	0.16	0.56	-0.05	1.00			
Pb	0.44	0.86	-0.33	0.64	1.00		
Zn	0.56	0.89	-0.36	0.57	0.93	1.00	
W	0.37	0.57	-0.21	0.51	0.62	0.61	1.00

Table 3: Comparison of Metal contents in the Study Area with other parts of the World

Locations	Cd	Cu	Mn	Pb	Zn
Lucknow[4]	1.30	70.00	600.00	41.00	181.00
Kanpur[4]	1.19	67.00	760.00	68.00	189.00
Germany[2]	1.81	108.00	469.00	74.00	370.00
Delhi[5]	4.50	275.00	695.00	76.00	561.00
Agra[5]	32.50	339.00	718.00	168.00	554.00
Ibadan[8]	0.38	82.36	-	72.05	490.82
Odogunyan	0.20-2.10	28.00-153.00	189.00-2024.00	20.00-148.00	61.00-1133.00
ASC[1]	0.30	50.00	850.00	20.00	90.00

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

Where I_{geo} is the geo-accumulation index, C_n the measured metal concentration in soils/sediments and B_n the background values for the particular metal (the average shale value).

The geo-accumulation index for Cu, Mn and W range from 0-1 and this means that the quality of the samples ranges from uncontaminated to moderately contaminated with these metals. Pb and Zn have their geo-accumulation index ranging from 0-2 and 0-3 respectively. These indicate that the samples are uncontaminated to moderately contaminated with Pb and uncontaminated to moderately to heavily contaminated with Zn. The evaluation of the geo-accumulation index for these selected metals revealed that they have accumulated in the samples in quantities that impair the quality of the sediments and soils of the industrial estates.

Contamination Factor and Contamination Degree: The level of the pollution of the sediments and soils from the industrial estate was further investigated by calculating the contamination factor and contamination Degree for each metal in the samples [13, 14].

The contamination factor is calculated using the formula:

$$C_f = C^{I}_{0}{}^{-1} C_n^{1}$$

Where $C^{I}_{0}{}^{-1}$ is the mean content of metals from at least five sampling points, C_n is the average content of each metal.

The contamination factor represents the individual impact of each metal on the sediments while the degree of contamination index is calculated as the percentage contribution of all the metals to the contamination suffered by the soil or sediment samples. If the total contamination suffered by the sediment is resolved to 100% the individual contribution to the overall contamination by the selected metals are Cd 22.4%, Cu 9.7%, Mn 6.6%, Mo 6.2%, Pb 22.9%, Zn 25.4% and W 6.8% respectively. This showed vividly that Cd, Pb and Zn are more significant as contaminants of the soils and sediments of the drains within the industrial estates and that they constitute the greater portion of the metals in the wastewater released from the industries.

Statistical Analyses: To further understand the relationship between the heavy metals analysed, the results were subjected to correlations and R-mode Factor statistical analyses. The correlation analysis carried out revealed that there are very strong positive correlations between Pb and Zn with a correlation coefficient matrix of 0.93; Zn and Cu (0.89) and Cu and Pb (0.86) (Table 2).

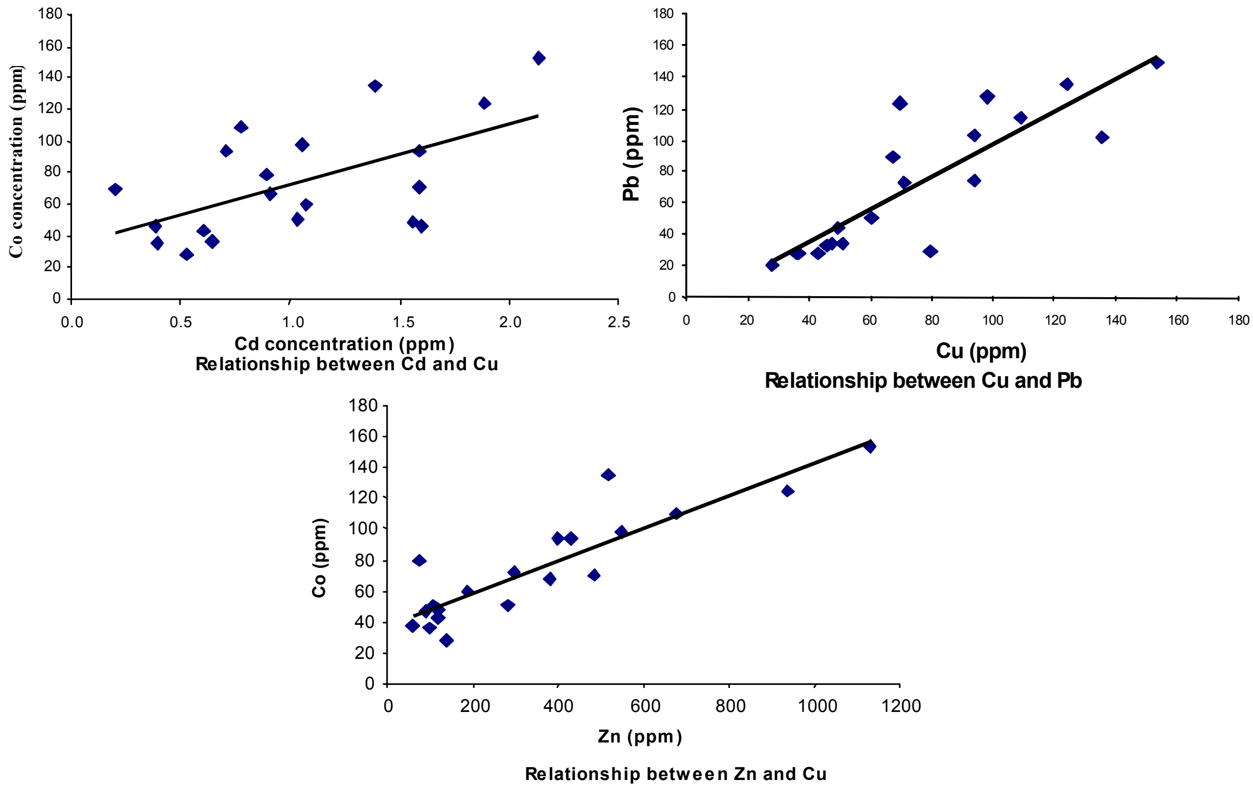

Fig. 3: Scatter Plots showing relationship between some of the Metals in the Study Area

Other metals also showed some positive correlations with each other (Table 2). These confirm the view that the metals have been contributed from the same source into the soils and sediments of the study area, which is the discharged wastewater. Mn, however showed negative correlation with all the other metals and confirming that most of the Mn found in the study area has been contributed by geogenic factors rather than anthropogenic and this is the reason why the metal ratio for Mn is less than 0.5 (Tables 1 and 2). The various correlation relationships are shown in Figure 3.

The R-mode factor analysis of the metal concentration also revealed that the metals could be grouped into two. The metals in the first component are Zn, Pb, Cu, Mo and Cd. This group of elements accounts for over 60% of the cumulative variance and indicate that they have been sourced from the same origin as well as being held in similar conditions in the soils and sediments of the study area. The second component is made up of only Mn, which account for about 15% of the total variance. The separation of Mn from the other group of metals is a further confirmation that the Mn in the samples analysed have been sourced from an origin different from that for others.

Comparing the metal contents of the industrial Estate with metals from other parts of the world especially India which has similar development pattern, it was revealed the level of the metals in the sediments of the study area is at par with those other industrial layouts and in certain instances surpassed it. The implication of this is that the sediment and soil quality of the LSDPC Industrial Estate in Odogunyan, Ikorodu has been greatly impacted by the industrial activities and that with continuous discharge of untreated wastewater into the drains and the subsequent usage for irrigation of crops especially vegetables grown along the drains poses a potential health hazard to the inhabitants of the area as well as aquatic biota found around the study area.

CONCLUSIONS

The quest for industrialization cannot be made in the absence of proper environmental safeguards. This will only lead to environmental destruction and subsequent health hazard to human, animals and plants. The groundwater system may also be impacted negatively if the heavy metals succeed in percolating into the groundwater system. The current level of heavy metals in the study area is unacceptable and efforts should put in place s to arrest the trend and ameliorate the precarious situation.

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