

MULTIVARIATE ANALYSIS OF HEAVY METAL CONCENTRATION AND POLLUTION INDEX IN SOILS OF LAGOS AND ABEOKUTA, SOUTHWEST NIGERIA

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ABSTRACT

Heavy metals in soil have remained a persistent environmental problem that has not been completely addressed mostly in developing countries irrespective of the dangers it has on man and other biotic lives. Though, several studies have been carried out on the accumulation of metals in soils under different land use, little has been researched on newly and emerging cities. The study therefore employed multivariate statistical techniques to examine the pattern of heavy metal accumulation in soil of different land uses in Lagos being a well established city and Abeokuta being an emerging city in Southwestern Nigeria. Five surface (15cm) soil samples were randomly collected from each of the land uses and subjected to laboratory analysis using Atomic Absorption Spectrophotometer (AAS) technique. The results obtained revealed that the heavy metal contents were higher in Lagos metropolis than in Abeokuta metropolis. The study identified anthropogenic and lithogenic factors as the principal sources of heavy metal pollution in the two locations. In spite of the varying quantities of metals in the studied soils, the pollution load index showed the absence of metal pollution concern. In order to effectively control the rate and extent of metal pollution, the market based approach to environmental management should be put in place by government in the two locations.

Key Words: Environment, Heavy metals Land uses, Soil, Multivariate Analysis

1.0 Introduction

The changes in land-use directly modifies the functioning of ecosystems and these modifications have considerable impact on nutrient and metal concentrations in the soil, air and water which pose serious threat to human and biotic lives (Prajapati & Meravi, 2014). Urban related activities as well as urban renewal processes are some of the urban human activities have varying impacts on the environment. Such activities like vehicle repairs operation (mechanic workshop) and recreational centres among others usually lead to the contamination of soil with heavy metals. In Lagos and Abeokuta metropolis

which have witnessed rapid reforms in urban infrastructure in the past eight years, there have been tremendous buildups in heavy metals as a result of the nature of materials used in these developmental reforms directly or indirectly. The tremendous changes in land use have subjected the land to all forms of environmental degradation. This has further resulted in the buildup of heavy metals which are injurious to ecosystem.

There is consensus among scientists that the increasing rate of heavy metal contamination of soil ecosystem is due to anthropogenic activities such as industrial and

energy production, construction and fuel combustion (Nasralla, 1984; Li et al., 2007; Sharma et al., 2007). As a result of the environmental effects on heavy metal concentration, several studies have been carried out on the accumulation of metals in soils under different land uses. In Europe and Asia, different accumulation effects of heavy metal in the soil have been found under different land uses (Zheng et al., 2005; Gaw et al., 2006; Vince et al., 2014; Ghorbani et al., 2015). Also, in Nigeria, several studies have been carried out to examine the effect of land use change on heavy metal concentration in the soil (Ndiokwere and Ezehe, 1990; Usman and Ayodele, 2002; Uwah et al., 2009; Olukanni, and Adeoye, 2012; Abdullateef et al., 2014). However, most of these studies employed univariate statistical methods in explaining the pattern of heavy metal accumulation and contamination in the soil. Also, a handful of the available studies did not carry out a comparative analysis of heavy metals accumulation across different land uses in Lagos and Ogun States. Some of the few comparative studies only concentrated on the determination of heavy metals in dumpsite soils (Ademola et al., 2015). The present study therefore employed multivariate statistical techniques to examine the pattern of heavy metal accumulation in soil of different land uses in Lagos being a well established city and Abeokuta being an emerging city in Southwestern Nigeria. The research specifically examined the sources (natural or anthropogenic) of metal pollution in the identified land uses using principal components analysis and cluster analysis and also determined the ecological risk index (contamination factors and degrees of contamination/pollution) of metal pollution from the different land uses.

The result of potential ecological risk would help to identify metal inputs and their sources that need to be effectively managed in order to protect and manage the environment. The outcome of the study would

enable government and individual aware of the best land development technique to adopt in order to save our environment (soil) and the resources therein. The study would also crave the need for government and the people to understand the dynamism of land use change and the importance of practicing sustainable land development to protect the environment. It would also advocate the need for metal remediation after periods or years of land development mostly large-scale development by government and private individuals.

The study makes use of the multiple-nuclei model to provide explanation on the changing land use pattern of Lagos and Abeokuta States as a result of the changes in population and socioeconomic activities over time. This model sees a city as growing and assumes that urban growth takes place around several distinct nuclei. These nuclei could include a market, recreational centre, a nearby village, a factory, a mine or a railway terminal among others. In the end, all the nuclei combines into one urban area largely agglomerated by residential, commercial, transport network and other land uses (Gidado, 2014). The nuclei based on their intensity and activities have implications on the environment; this is because the activities of some of these nuclei like market, recreational centre and industrial areas among others can lead to metal pollution and accumulation in the soil.

2.0 Materials and Methods

2.1 Study Area

The locations for this study are the metropolitan areas of Lagos and Abeokuta in Lagos and Ogun states which are the major existing and emerging urbanized cities in southwest Nigeria. Lagos and Abeokuta are located in the extreme south-west of Nigeria, precisely within 6° 27' 55.5192" N and 3° 24' 23.2128" E as well as are 7° 9' 0" North, 3° 21' 0" East respectively.

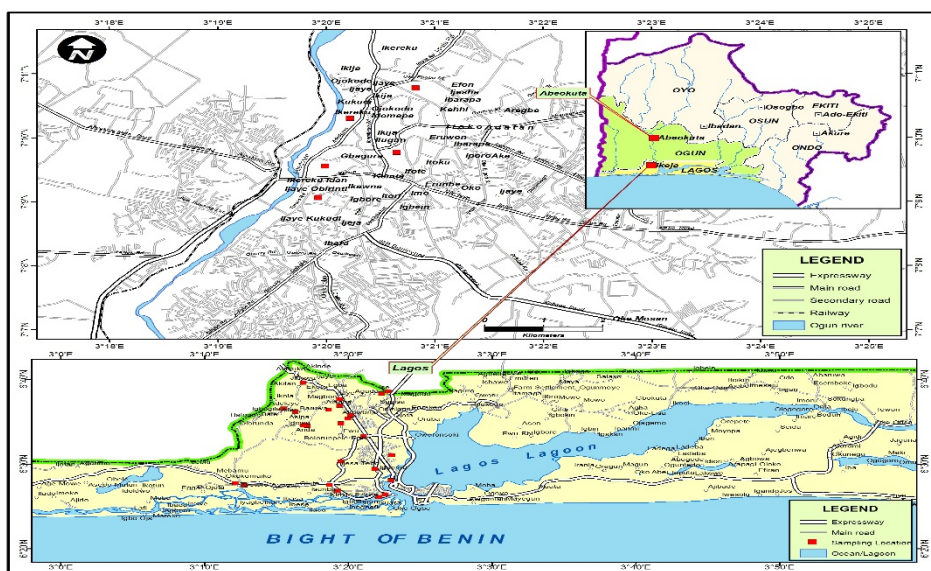


Fig. 1 Study Area
Source: LASU GIS Lab.

3.0 Methods

In each of the state, using simple random sampling technique, five surface (15cm) soil samples were collected from each of recreational centre, car wash, petrol station, abattoir, roadside, football field, hospital, mechanic workshop, motor park and tipper park with the aid of soil auger and cellophane paper. These samples were later subjected to laboratory analysis using Atomic Absorption Spectrophotometer (AAS) technique to examine the contents of Zinc (Zn), Iron (Fe), Colbalt (Co), Lead (Pb), Copper (Cu), Chromium (Cr) and Nickel (Ni). Data obtained from the laboratory on the concentrations of Zn, Fe, Co, Pb, Cu, Cr and Ni in soils of the different land uses were analysed using Principal Components Analysis (PCA), cluster analysis, Pollution load index (PLI), contamination index analysis and discriminant analysis to identify and group the various sources of metal pollution in the soil. PCA and discriminant analysis helps to reduce the number of metals as well as identify those that have been significantly affected while cluster analysis helps to group the metals into homogenous groups of similar pollutant sources.

Cluster analysis was applied to reorganize the metals into homogenous groups. In order to discriminate distinct groups of studied elements as tracers of natural or anthropogenic source, a hierarchical cluster analysis was performed on the 7 elements. The distance cluster represents the degree of association between elements. The lower value on the distance cluster is showing more significant for the association (Moghaddas et al., 2013). Hierarchical cluster analysis was also used in this study to identify the relatively homogeneous groups of heavy metals (Hu et al., 2013). Clusters were produced using Euclidian distance and the Ward method. The method of Ward is the best performing hierarchical clustering method, and even performs well for observation clustering (Templ et al., 2008; Moghaddas et al., 2013). The analyses were performed separately for metropolis in Lagos State and Abeokuta in Ogun State in order to know the sources (natural or anthropogenic) of metal introduction into the soil. Data collected was analysed using Statistical Package for Social Sciences (SPSS) Version (22.0) for Windows as well as excel spreadsheet.

4.0 Results and Discussion

4.1 PCA result of metal concentration in Lagos metropolis, Lagos State

PCA result using varimax normalized rotation produced two components that explained 64.8% of the variation in the original data set (Table 1). Based on the Kaiser criterion of extracting variables with eigenvalues >1 (Hu et al., 2013), two principal components were extracted from the 7 sets of heavy metal variables. Hu et al., (2013) noted that in the interpretation of PCA patterns, components greater than 0.71 coefficients are typically considered excellent, while those less than 0.32 are regarded as very poor. In the present study, loadings (correlation coefficients) of $\pm \geq 0.8$ were identified and selected as significant variables for understanding the type and source of metal pollution. The result of communalities in Table 1 show that the two extracted components vary from 41.9% for Zn to 93.2% for Co which indicate that all the heavy metals were well represented by the two principal components.

On the criterion of selecting only loading with $\pm \geq 0.8$, PC₁ has strong and positive loading on two variables; the variables are Co (0.963) and Ni (0.920). PC₁ are responsible for 40.0% of total variance in the overall data set and

symbolize anthropogenic pollution. The positive loadings indicate increase in the contents of Co and Ni with the increase in anthropogenic activities that generate these metals. PC₂ is responsible for 24.8% of the total variance and has only one variable that loaded positively on it. The variable is Cu (0.834) which also represented anthropogenic pollution rather than lithogenic origin. The positive loading implies increase in Cu content in the soil of the various land uses with increase in Cu generating activities. The two extracted components identify anthropogenic activities such as car wash, petrol station, abattoir, football field and hospital as the main sources of pollution of Co, Ni and Cu in Lagos State soil. The PCA result also implies that Co, Ni and Cu are the main metals with considerable levels of pollution in the soil. The accumulation of these metals in the soil has significant influence on soil quality. These metals are released into the soil from anthropogenic activities carried out across the various land uses such as vehicular emission, burning of fossil fuel, soldering of copper, disposal of copper and wastes among other activities that generate different quantities of these metals into the soil (Wuana and Okieimen, 2011).

Table 1: PCA rotated component matrix of heavy metal contents in Lagos metropolis, Lagos State

Metals	Principal component		Communalities
	PC ₁	PC ₂	
Co	<u>.963</u>	-.062	.932
Ni	<u>.920</u>	.164	.874
Fe	.793	.271	.702
Cr	.506	-.452	.460
Cu	.226	<u>.834</u>	.589
Pb	-.188	.724	.560
Zn	-.230	-.605	.419
Eigenvalues	2.798	1.738	
% variance	39.978	24.824	
Cumulative exp.	39.978	64.802	

The underlined coefficients of $\pm \geq 0.8$ are considered significant

4.2 PCA result of metal concentration in Abeokuta, Ogun State

PCA result using varimax rotation extracted three principal components that explained 80.1% in the original data set (Table 2). PC₁ had strong positive loading on two heavy metal parameters; the parameters were Pb (0.880) and Zn (0.814). PC₁ was responsible for 35.2% of total variance in the overall data set and symbolized anthropogenic pollution. PC₂ had strong positive loading on one variable; the variable was Cr (0.838); PC₂ was responsible for 23.3% of the total variance and signified anthropogenic pollution. PC₃ was

responsible for 21.7% of the total variance and had only one variable that loaded positively on it. The variable was Fe (0.931) which signified lithogenic origin rather than the result of human activities. The three extracted components recognise anthropogenic factors such as Car wash, Petrol station, Abattoir, Football field, Hospital etc as the main sources of pollution of Pb, Zn, Cr and Fe in Abeokuta soil. This further means that Pb, Zn, Cr and Fe are metals with significant levels of pollution in the soil.

Table 2: PCA rotated component matrix of heavy metal contents in Abeokuta, Ogun state

Metals	Principal component			Communalities
	PC ₁	PC ₂	PC ₃	
Pb	<u>.850</u>	.021	.014	.723
Zn	<u>.814</u>	.155	.497	.934
Ni	-.696	.291	.397	.726
Cr	-.302	<u>.838</u>	-.034	.795
Cu	.388	.740	-.168	.726
Fe	.021	-.191	<u>.931</u>	.903
Eigenvalues	2.111	1.396	1.300	
% variance	35.190	23.261	21.661	
Cumulative exp.	35.190	58.451	80.112	

The underlined coefficients of $\pm \geq 0.8$ are considered significant

4.3 Cluster analysis for Lagos metropolis, Lagos State

Cluster analysis yielded a dendrogram (Figure 2) that grouped all 7 heavy metal parameters into one statistically significant cluster. The only cluster produce consist of Co, Ni, Pb, Cu, and Cr. This cluster has high number of metals. The parameters on the only produced cluster demonstrate similarities in sources of pollution, which are basically controlled by anthropogenic activities. These metals are significantly correlated with each other and form a cluster. The grouping of these metals in

the same cluster is indicative of similar distribution patterns. The result in Figure 2 substantiates result of PCA which identifies anthropogenic factors as the main sources of metal pollution in the soils of the respective land uses in Lagos metropolis. Nevertheless, the increasing contents of these metals in the soil are caused by the diverse human activities carried out in the different land uses considered in the present study.

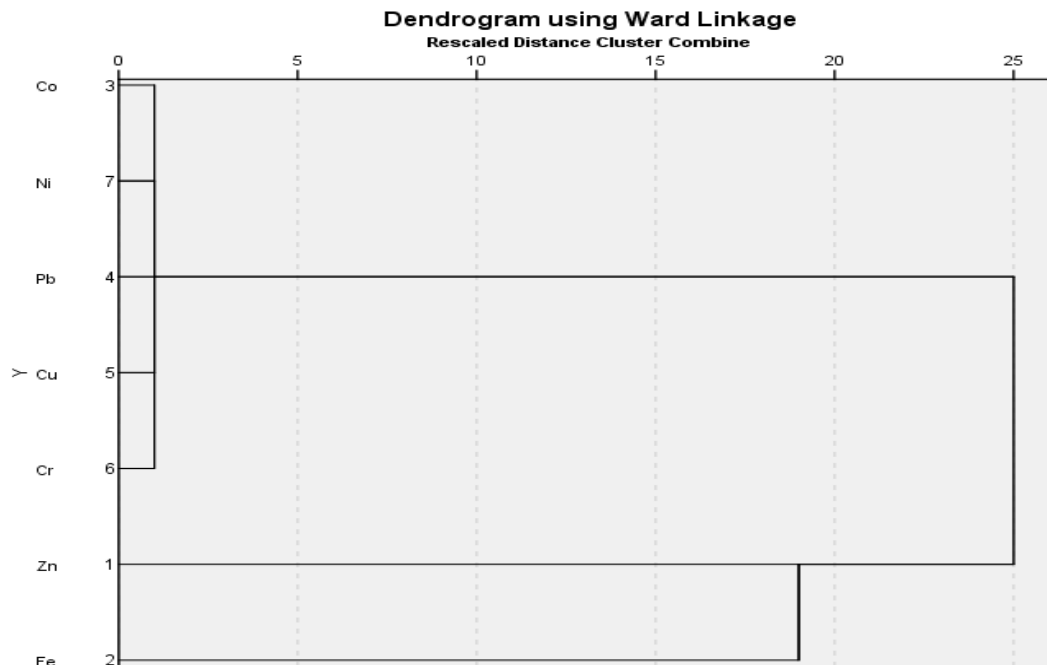


Figure 2: Cluster tree of metal pollution in Lagos Metropolis

4.4 Cluster analysis for Abeokuta, Ogun State

Cluster analysis of heavy metal parameters produced two statistically significant clusters (Figure 3). Cluster I consist of Co, Ni, Zn and Pb. This group (cluster) has the high number of metals. These parameters showed similarities in sources of pollution, which are basically controlled by both anthropogenic activities and lithogenic. Cluster II consisted of Cr and Cu. These are controlled by

anthropogenic activities. It also shows that Zn and Pb are significantly correlated with each other and formed a cluster. Positive association was also observed between Cu and Cr. Similar pattern of association was reported by Hu et al., (2013). The strong associations are indicative of similar distribution patterns.

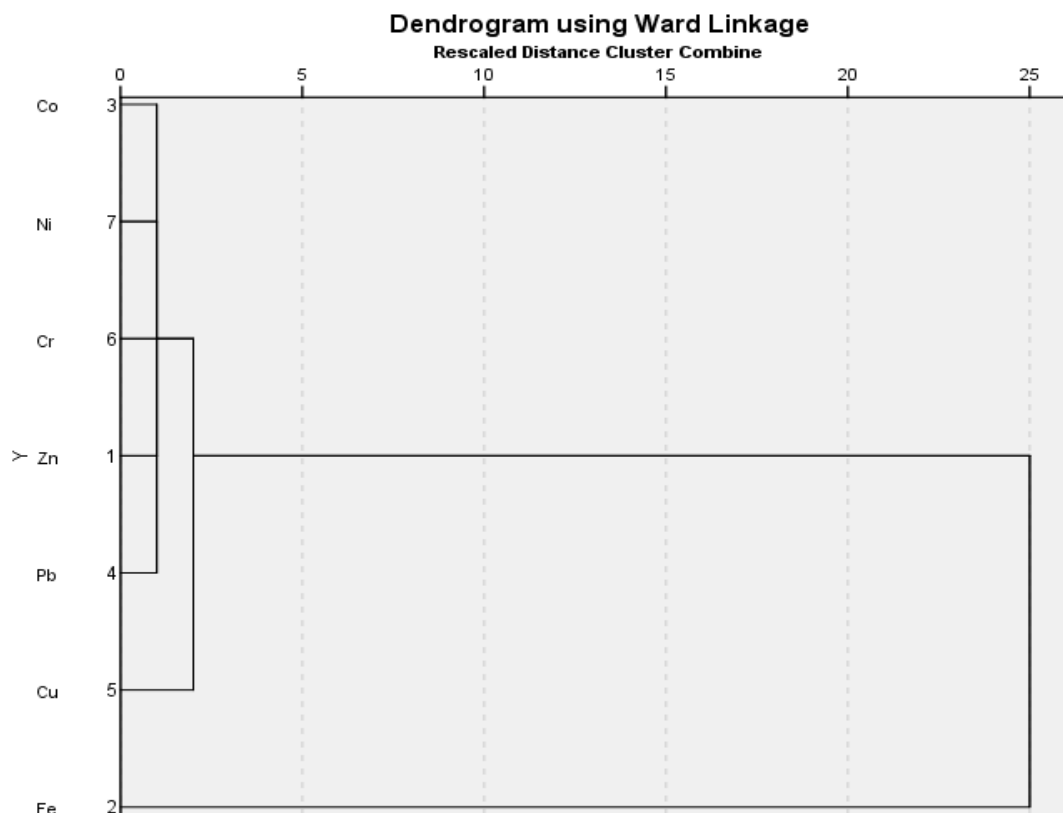


Figure 3: Cluster tree of metal pollution in Abeokuta, Ogun State

4.5 Assessment of heavy metal contamination in the soil

The indices use to assess heavy metal contamination in the soils are contamination factor (C_f), degree of contamination (Cdeg) and pollution load index (PLI).

Contamination factor (C_f)

This technique was used to assess the contamination status of soil. The level of contamination of soils with heavy metals is expressed thus:

$$\text{Contamination factor } (C_f) = \frac{\text{Heavy metal concentration in soils}}{\text{Background rock value}}$$

Where: Heavy metal concentration in soils is the concentration of a given metal in the soil sample and Background rock value is the value of the metal equals to the world surface rock average given by Martin and Meybeck (1979) cited in Saikia et al., (2014). This approach was also employed by Abbaslou et al., (2013), Saikia et al., (2014) and Ololade (2014). The level of contamination is determined by Jafaru et al., (2015).

4.5.1 Contamination factor of metal in Lagos metropolis, Lagos State

The results in Table 3 indicate that the mean level of metal contamination ranged from 0.12 to 187.20. Based on Hakanson classification cited in Jafaru et al., (2015), the values for Fe, Co, Cu, Cr and Ni across the land uses fall under the category of low contamination factor. However, the values obtained for Pb across the land uses range from 0.00 to 1.61

which indicate low to moderate contamination in the area, while Zn show low to very high contamination. It therefore implies that activities around football field, motor-park and roadside are to be monitored. Very high contamination of Zn was found in football field. This land use has discarded substances with high Zn content resulting in the contamination of the soil with several implications. Wuana and Okieimen (2011) stated that Zn concentrations are rising unnaturally due to anthropogenic activities. Zn can interrupt the activity in soils, as it negatively influences the activity of

microorganisms and earthworms, thus retarding the breakdown of organic matter (Wuana and Okieimen, 2011). On zinc-rich soils, only a limited number of plants have a chance of survival. That is why there is not much plant diversity near zinc-disposing factories. In all, the contamination factor implies that the soils in Lagos and across the land uses have low contamination for Fe, Co, Cu, Cr and Ni; low to moderate contamination for Fe and low to very high contamination for Zn. It could therefore be said that the level of metal accumulation in the soil ranges from low to very high contamination.

Table 3: Contamination factor of metal in Lagos metropolis. Lagos State

Land uses	Mean contamination factor						
	Zn	Fe	Co	Pb	Cu	Cr	Ni
Recreational centre	0.44	0.36	0.38	0.67	0.30	0.14	0.26
Car wash	1.15	0.00	0.00	1.15	0.67	0.26	0.15
Petrol station	1.20	0.00	0.00	1.61	0.35	0.20	0.04
Abattoir	0.46	0.00	0.00	0.00	0.19	0.13	0.00
Roadside	6.15	0.24	0.74	0.28	0.30	0.47	0.35
Football field	187.20	0.00	0.00	0.29	0.13	0.24	0.12
Hospital	0.46	0.00	0.00	0.42	0.15	0.12	0.00
Mechanic workshop	1.81	0.34	0.34	0.79	0.36	0.12	0.39
Motor Park	6.87	0.24	0.48	0.52	0.86	0.25	0.32
Tipper Park	1.33	0.35	0.24	0.63	0.38	0.24	0.23

4.5.2 Contamination factor (Cf) of metal in Abeokuta, Ogun State

The results in Table 4 indicate different levels of metal contamination in the soil of Abeokuta, Ogun State. The results reveal that mean level of metal contamination range from 0 to 0.19. The contamination factor for all the land uses fall under low contamination factor. This result further mean that across the land uses in Abeokuta, Ogun State have low

contamination factors. However, land use with a sign of concern is the petrol station, car wash and abattoir whose contamination factors are gradually increasing. This means that the activities carried out in these land uses need to be put under control to keep the level of Pb and Cu low.

Table 4. Contamination factor of metal in Abeokuta, Ogun State

Land uses	Mean contamination factor						
	Zn	Fe	Co	Pb	Cu	Cr	Ni
Recreational centre	0.003	0.0003	0	0.0125	0.0016	0.0002	0
Car wash	0.004	0.0001	0	0.0106	0.0042	0	0
Petrol station	0.006	0.0013	0	0.0202	0.1875	0.0003	0
Abattoir	0.008	0.0008	0	0.0292	0.0035	0.0002	0
Roadside	0.009	0.0014	0	0.0200	0.0009	0	0

Football field	0.004	0.0003	0	0.0131	0.0041	0.0002	0
Hospital	0.003	0.0009	0	0.0019	0.0017	0.0003	0.0002
Mechanic workshop	0.005	0.0011	0	0.0146	0.0042	0	0
Motor Park	0.006	0.0003	0	0.0606	0.0050	0	0
Tipper Park	0.012	0.0008	0	0.0587	0.0822	0.0002	0

4.6 Degree of contamination of metal (Cd)

Degree of contamination (Cd) is the sum of all contamination factors (Cf) for a given set of pollutants (Yekeen and Onifade, 2012). The categories of degree of contamination are given below thus:

- ✓ Cd values of <5 implies low contamination;
- ✓ $5 < Cd < 10$ means moderate contamination;
- ✓ $10 < Cd < 20$ shows considerable contamination and
- ✓ $20 < Cd$ implies very high contamination.

4.6.1 Degree of contamination of metal (Cd) in Lagos metropolis, Lagos State

The results in Table 5 shows that the degree of contamination ranged from 0.78 to 187.98 indicating low to very high degree of metal contamination across the different land uses. Looking at the values for respective land uses, it shows that football field has a very high degree contamination, while motor-park and roadside are of moderate degree of metal contamination; other land uses show low degree of metal contamination. The

percentage of contamination across the land uses shows that 70% of the land uses demonstrate low degree of contamination (LDC), 20% fall in the category of moderate degree of contamination (MDC), while only 10% (football field) shows very high degree of contamination (VHDC). The results further reveal that soil across the land uses show different degrees of contamination. It however, identifies football field, motor-park and roadside as areas of concern due to the considerable level of metal contamination in the soil. This means that the activities carried out on these land uses mostly on football field need to be put under control to reduce the level of metal contamination. Others land uses with signs of concern as a result of the gradual increase in the degree of metal contamination in the soil include mechanic workshop and tipper-park. The activities carried out on these two land uses are gradually resulting in metal contamination in the soil. However, the result identify abattoir as land use with the lowest degree of contamination, followed by hospital.

Table 5: Degree of metal contamination in Lagos metropolis, Lagos State

Land uses	Cdeg
Recreational centre	2.55
Car wash	3.38
Petrol station	3.40
Abattoir	0.78
Roadside	8.53
Football field	187.98
Hospital	1.15
Mechanic workshop	4.15
Motor Park	9.54
Tipper Park	3.40

4.6.2 Degree of contamination of metal (Cd) in Abeokuta metropolis, Ogun State

The degree of contamination of heavy metal in soils of Abeokuta city, Ogun State is shown in Table 6 and the degree of contamination ranged from 0.01 to 0.22 indicating low degree of metal contamination across different land uses. A cursory look at the values for respective land uses shows that all the land uses give an indication of low degree of contamination; this implies that the study land uses in Abeokuta do not result in much

soil contamination. The percentage of contamination across the land uses shows that 100% of all the land uses demonstrates low degree of contamination (LDC). The result obtained therefore indicates that soil across the land uses portrays low degrees of contamination. This may be as a result of the ages of these land uses since the city is an emerging city in terms of activities.

Table 6: Degree of metal contamination in Abeokuta metropolis, Ogun State

Land uses	Cdeg
Recreational centre	0.02
Car wash	0.02
Petrol station	0.22
Abattoir	0.04
Roadside	0.03
Football field	0.02
Hospital	0.01
Mechanic workshop	0.02
Motor Park	0.07
Tipper Park	0.15

4.7 Pollution load index (PLI)

This measure shows the level of accumulation of metals or pollution in a given soil sample. The PLI was also assessed to know the transportation facility that was most polluted (Mmolawa et al., 2011). It gives the status of metal pollution in the soil which enables necessary remediation action to be put in

place. In determining the level of metal loads in the soil, the categorization given by Harikumar et al., (2009) is used as follows;

- ✓ A *PLI* value above 1 (>1) indicates soil pollution.
- ✓ A *PLI* value less than 1 (<1) indicate no pollution.

4.7.1 Pollution load index (PLI) in Lagos metropolis, Lagos State

The results in Table 7 show that the PLI values ranged from 0.00 to 0.60 which were far lower than unity i.e. <1. The results obtain imply absence of metal pollution. The values of the pollution load index result do not show much fluctuation. Lower values of PLI imply no considerable input from anthropogenic sources. There is, in general, a decrease in PLI

values in the area of study indicating dilution and dispersion of metal content (Sarala and Uma, 2013). Thus, the PLI of soils in Lagos metropolis indicate absence of pollution irrespective of the numerous human activities in the area. In all, the PLI of soils in Lagos State indicates the absence of pollution concern.

Table 7: Pollution load index (PLI) in Lagos metropolis, Lagos State

Land uses	PLI (mean values)
Recreational centre	0.33
Car wash	0.00
Petrol station	0.00
Abattoir	0.00
Roadside	0.55
Football field	0.00
Hospital	0.00
Mechanic workshop	0.43
Motor Park	0.60
Tipper Park	0.39

4.7.2 Pollution load index (PLI) in Abeokuta metropolis, Ogun State

Likewise, the result in Table 8 showed that the PLI values ranged from 0.00 to 0.002 which were far lower than unity i.e. <1. The result obtain also imply absence of metal pollution

and further indicates adequate dilution and dispersion of metal content. PLI of soils in Abeokuta indicate absence of pollution concern.

Table 8: Pollution load index (PLI) in Abeokuta metropolis, Ogun State

Sample sites	PLI (mean values)
Recreational centre	0.000
Car wash	0.000
Petrol station	0.000
Abattoir	0.000
Roadside	0.000
Football field	0.000
Hospital	0.002
Mechanic workshop	0.000
Motor Park	0.000
Tipper Park	0.000

The general result of this study shows that the metals from the various land uses fall within World Health Organization (WHO) permissible limit for the concentration of heavy metals in soil. However, the contents of Zn mostly in football field, motor-park and roadside as well as Fe contents in tipper-park and recreational center exceed WHO permissible limit. Comparatively, the concentration of heavy metal was observed to be much higher in Lagos metropolis than in Abeokuta. The study observe that anthropogenic factors are the main sources of heavy metal inputs in soils of the two locations with the former contributing

more to the accretion of metals in the soil. Result of contamination factor reveals that soils in Lagos and across the land uses have low contamination for Fe, Co, Cu, Cr and Ni; low to moderate contamination for Fe and low to very high contamination for Zn. In Abeokuta, the land uses show low contamination factors. In addition, results of pollution load index indicate absence of metal pollution in the two locations. This result substantiates the result of metal concentration in the soil in comparison with WHO permissible limits. It therefore shows that heavy metals in the two locations are

within safe limits. However, the activities carried out on football field in Lagos State need to be put under control to reduce the level of metal contamination.

5.0 Summary of findings, Conclusion and Recommendations

5.1 Summary of findings

The study showed that in Lagos metropolis anthropogenic activities were identified as the main source of pollution of Co, Ni and Cu. The PCA results also implied that Co, Ni and Cu were main metals with considerable levels of pollution in the soil. In Abeokuta, anthropogenic and lithogenic factors were main sources of pollution of Pb, Zn, Cr and Fe. In addition, the result of cluster analysis in Lagos metropolis grouped the parameters into one statistically significant cluster and identified anthropogenic activities as the source of pollution. In Abeokuta metropolis, two statistically significant clusters with similarities in sources of pollution were produced and identified anthropogenic activities.

The contamination factor of metal in Lagos metropolis ranged from 0.12 to 187.20 with values of Fe, Co, Cu, Cr and Ni across the land uses within the category of low contamination factor. Pb across the land uses indicated low to moderate contamination, while Zn showed low to very high contamination. The level of metal contamination in Abeokuta ranged from 0 to 0.19 and all the land uses fell under low contamination factor. The degree of contamination of metal in Lagos metropolis revealed low to very high degree of metal contamination across the different land uses. Football field showed very high degree of contamination, while motor-Park and roadside indicated moderate degree of metal contamination; other land uses showed low degree of metal contamination. In addition, the degree of contamination of metal in Abeokuta indicated low degree of metal

contamination across different land uses. Generally, the results of metal contamination in the area portrayed low degrees of contamination. The pollution load index in Lagos and Abeokuta metropolis therefore showed the absence of metal pollution concern.

5.2 Conclusion

The study shows that the heavy metal contents are extremely high in Lagos metropolis than in Abeokuta and that human activities in the two cities generate different quantities of heavy metals. The study identifies anthropogenic factors as the principal sources of heavy metal pollution in the two locations.

5.3 Recommendations

The various activities carried out mostly in Lagos metropolis should be properly monitored by environmental officers while activities or operations observed to have implications on metal accumulation should be relocated and properly controlled. The city should be properly planned through urban renewal activities. This will enable industries with same line of operation to be situated in a particular area and their activities properly controlled. The metals in Lagos metropolis are attributed to the numerous activities in the area; as such government should help reduce the conglomeration of industries in one location. This will go a long way in reducing the intensity of metal pollution because proper monitoring can be carried out.

To effectively control the rate and extent of metal pollution, the market based approach to environmental management should be put in place by government in the two locations. The market-based instruments approach would involve imposing charges only for pollutants that exceeded emissions standards by the Nigerian Federal Environmental Protection Agency. The emission charges or taxes based on the quantity of pollutants discharged will go a long-way in reducing the

rate of metal contamination. It will make companies and individuals alike to be mindful of their activities.

5.4 Implications of the results for urban planning

In today's rapid urbanization and increasing human population, the two important elements that practitioners in the built environment especially Town Planners have to deal with are primarily land, soil, water and vegetation. The result obtained in this study has shown the need of urban planning in the distribution of human activities. In trying to effectively plan the cities of Lagos and Ogun States, urban planners need to take into cognizance the environmental implications of allocating a piece of land or an area for development. Such implications or

consideration should be on the effects of metal contamination and pollution on available water sources, vegetation and soil and the overall consideration of the human health. The introduction of heavy metal in the soil must therefore be given top priority in planning and the best possible way to reduce metal pollution and its extent needs to be properly looked into before an area is marked for development. The result also shows the need for the spatial distribution of homogenous activities in the study locations. This will help to enhance effective monitoring of pollution. This therefore means that effective land use planning and the application of appropriate practices mostly in Lagos State with reduce the level of metals accumulation in the soil.

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