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Research Article

MULTIVARIATE STATISTICAL ASSESSMENT OF TRACE METALS OF FOREST SOILS OF ITU LOCAL GOVERNMENT AREA, AKWA IBOM STATE, NIGERIA

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ABSTRACT

The study evaluated six trace metals concentration and pollution of the forest soil of Itu Local Area of Akwa Ibom State, Nigeria. Multivariate statistical approaches were used to determine the anthropogenic and natural sources of the trace metal concentration in the forest soil sample area**.**Results obtained indicated three main components with Eigen value greater than one and significant total variance of 77.8%.The first factor explained total variance of 35.66 % with positive loading for Iron, Lead and Cadmium. This therefore showed that cadmium, lead and Iron are associated with and controlled by anthropogenic activities. The second factor however explained total variance of 23.30% with positive loading for Zinc. Therefore, zinc in the forest soil may be associated with the forest soil physical and geological formation. Hence there is need to check and control anthropogenic activities associated with human activities within the buffer zone of the forest area of Itu Local Government area to prevent bioaccumulation of Iron, Lead and Cadmium in the forest soil. Buffer zonein most forest reserved area in the state sometimes are being abused by the rural farmers that live and cultivate around the area. The application of pesticides and fertilizers as well as fossil fuel used within the buffer zone contributed significantly to the trace metal load in the forestsoil. Hence agricultural activities within forest are buffer zone should be prevented so as to prevent anthropogenic introduction of trace metal load in the forest soil area.

INTRODUCTION

Yang *et al.(*2014) revealed that Soil is an important ecosystem which interfaces with air, water and other abiotic components such as rock. Over the years soil pollution has become a problem in Akwa Ibom State, Nigeria in view of rapid economic growth and development in the rural areas of the state. Tracemetal loads are not only serious environmental issues, but has also become potential agricultural activities. It has hindered plant growth thereby preventing agricultural output. Akpan and William (2014) reported that at certain concentration it is harmful to plants, but however becomes toxic when concentration becomes elevated and higher than the permissible limits. In view of bioaccumulation and translocation factors of some plants species, these toxic trace metals can enter the food chain and become harmful to plant and animals (Hamzah *et al*.2011).For the forest soil the main pollution sources of trace metals are due to human activities such as application of pesticides, fertilizers and industrial wastes and atmospheric pollution from fossil fuels. Trace metals in forest soils have become higher than the background levels in most cases due to increase anthropogenic (Bukar *et al*.2016)). This has directly and indirectly contributed to increase trace metal load in the soil matrix inrural and urban areas.

Therefore, multivariate statistical analysis was used to evaluate the source of pollution of trace metal in forest soil (Sekabira *et al*.2010). The multivariate approaches which involve the application of principal component and cluster analysis are modern tools used to evaluate pollution (Saha and Hossain, 2012). It is significantly used to identify soil pollution sources and distinguish between the internal versus anthropogenic contribution (Yisa *et al*. 2011).

Hence the study with the focus on trace metals load in forest soil of Itu was undertaken in view of increase agricultural activities within the buffer zone of the forest area. There is that tendency of trace metal mobilization and transportation from the buffer zone to the forest soil in view of increase agricultural activities around this area. This could enhance the trace metal load in the soil within the area. Therefore, the study was

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focused on trace metal concentration with the view of evaluating the possible sources of trace metal pollution using multivariate approaches.

Study Area

The study area is Itu forest soil. Itu is one of the Local Government Areas in Akwa Ibom State Nigeria. The area is rich with abundance natural resources such as forest reserve. The forest reserve in Itu is unique in view of different biodiversity found in the area. The main occupation of the people of this area is farming. It is regarded as the food basket of Akwa Ibom State, Nigeria.

Soil Sampling and Laboratory Analysis

One gram of the oven dried ground soils previously washed with nitric acid and distilled water was placed in 100cm3 kjedahl digestion flask (Tijjani *et al*.2013). The samples were subjected to wet acid digestion reacted with 2cm3 of 60% perchloric acid (HClO4), 10cm3 concentrated nitric acid (HNO3) and 1.0 cm3 concentrated sulphuric acid (H2SO4) (Tijjani *et al*.2013) .The mixture was swirled gently and slowly at moderate heat on the digester, under a fume hood. The heating continuous until dense white fumes appeared which was then digested for 15 min, set aside to cool and diluted with distilled water. The mixture was filtered through the Whatman filter paper into a 100cm3 volumetric flask, diluted to mark (Akpan and Willain, 2014). The blank and the samples were digested in the same way. The concentration of the metals present in each soil was obtained using HACH3900 model Spectrophotometer using ten 10mls of digested soil solution with the relative powder pillows. Dilution factors applied when the concentration was noticed high.

Statistical Analysis

Regression coefficient, principal component analysis and multivariate agglomerate hierarchal cluster analysis were employed to analyse the trace metal properties of the soil samples at the waste dumpsite. The similarities between trace metals in the soil dumpsite was measured by cluster analysis. The sources of trace metals determined using the principal components analysis in the soil at the dumpsites. The level of correlation coefficient between trace metals in soil measured at $p<0,05$, $p<0.01$ in order to determine the relationship between the trace metals in the soil at the waste dumpsites studied according to Kellow (2006).

RESULTS AND DISCUSSION

Correlation Coefficient Matrix

Correlation matrix in table 1 shows that, most of the trace metals correlated with one another either positively or negatively, but also insignificant at $P< 0.05$ as indicated by their r values in table 1. However strong positive correlation existed between Pb and Cd at $P<0.05$ wit r value of 0.597. Consequently, the present of lead in the forest soil may have lead to the increase in the concentration of cadmium at the soil. Nevertheless, the availability of other trace metals in the studied soil may have influenced the availability of the other negatively but insignificantly and therefore their concentration may be affected by variable factors (Tijjani *et al*.2013).

Table 1 Correlation Matrix of trace Metal in Forest Soil

Correlations						
	Fe	Zn	Pb	Cd	Cr	Cu
Fe	1.000					
Zn	-.105	1.000				
Pb	.322	.406	1.000			
Cd	.258	.442	.597*	1.000		
Cr	.399	-.133	.000	.416	1.000	
Cu	-.168	-.326	-.396	-.435	-.034	1.000

*. Correlation is significant at the 0.05 level (2-tailed).

Principal Component Analysis

The results of the principal component analysis of trace metals in the forest soil of Itu Local government Area are shown on table 3. Results obtained indicatedthree main components with Eigen value greater than one and significant total variance of 77.8%. Factor one contributed total variance of 36.66% with strong positive correlation with Iron, Lead and Cadmium but with negative loading for Zinc. This represented the impact of the trace metal in the soil was influenced by anthropogenic activities caused by human factors within the area. Factor two contributed total variance of 23.30 % with strong positive loading on Zinc this represented the impact of agricultural effluent and natural process in the soil of the forest soil of the Itu Local Government Area. Factor three accounted for total variance of 18.89 % and defined strong loading for Chromium and copper. This represented the impact of other industrial effluent and natural process within the studied soil sample.

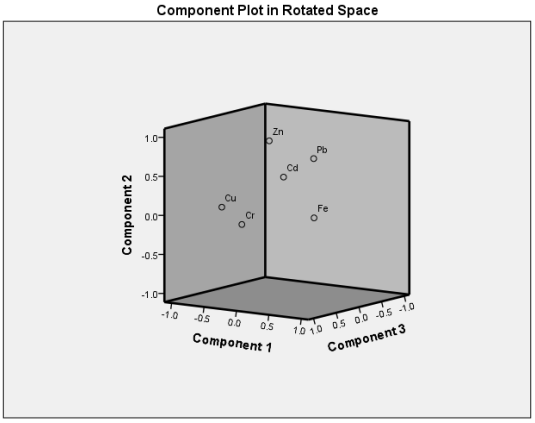

Figure 1 Component Plot in Rotated Matrix of Forest Soil

Cluster Analysis

The association among the trace metals in the forest soil is illustrated in figure 2. Figure 2 shows two main clusters. Clusters showed were based on Wards method of extraction. Cluster 1 showed linkage between Cd, Cr,Cu and Pb. While cluster two shows linkage between Fe and Zn. Cluster 1 can be sub-divided into Cd and Cr and Cu and Pb. The linkages and interactions among these trace metals showed close similarities existed between them in the soil of Itu forest area. The relationship showed these metals as contaminants in the soil originated anthropogenic and human related activities within the study area. However, Zn and Fe showed week relationship. Therefore, Zn and Fe could be regarded as contaminant that originated from mixed anthropogenic and lithogenic sources in view of the similarities showed by these metals Zn with Iron. Pb, Cr, Zn in cluster 1also showed the same lithogenic relationship with Iron.

Principal Component Analysis

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.140	35.663	35.663	2.140	35.663	35.663	1.747	29.123	29.123
2	1.398	23.301	58.964	1.398	23.301	58.964	1.573	26.224	55.347
3	1.130	18.838	77.802	1.130	18.838	77.802	1.347	22.455	77.802
4	.608	10.135	87.937						
5	.401	6.680	94.618						
6	.323	5.382	100.000						

As such may be regarded as contaminant originated from the same geological origin and formation. The relationship as shown in cluster confirms the findings obtained in the Principal component analysis

A plot of the major principal components of PCA resulted in three different plots (figure 1).

The plot 1 showed very strong positive loading for Fe, Zn and Pb which is actually similar to factor 1(Figure 1). Plot two however showed strong positive loading for Zinc similar to factor two. Plot three of the cluster showed positive loading for Chromium and copper which is similar to factor three (Figure 1). Others showed negative relationship with no factor loading for any other trace metals as showed in the plots. As such the relationship and similarities among other trace metals drafted towards zero as shown in figure 3.

Table 3 Component Extracted

Component Matrix[a]			
	Component		
	1	2	3
Fe	.756	-.367	.059
Zn	.128	.916	-.097
Pb	.730	.378	-.276
Cd	.706	.268	.205
Cr	.396	-.087	.854
Cu	-.603	.450	.520

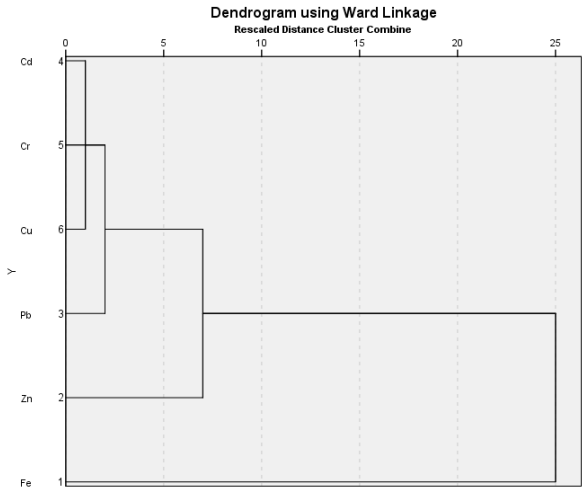

Figure 2 Hierarchical Cluster of Trace Metal in Forest Soil

CONCLUSION

The outcome of the multivariate analysis has shown that the pollution source of the forest soil is associated with anthropogenic and human related activities within the forest area buffer zone area.

The increase in positive loading for Iron, Lead and Cadmium in the forest soil area could be detrimental to the growth and development of other biodiversity within the forest area. Such accumulation could result in the bioaccumulation and translocation of these metals into the food chain through the edible vegetables and fruits.

Potentially such could become detrimental to humans and animals that feeds on these plants in the forest area. Over time the toxicity concentration of those metals could exceed the permissible exposure limits thereby causing severe heath consequences to humans. Hence since the concentration of Fe, Lead and Cadmium are associated with anthropogenic and human related activities there is urgent need to regulate activities within the forest areas so as to prevent abnormal increase in these trace metal load within the forest area of Itu Local Government Area of Akwa Ibom State, Nigeria. There is need to educate the rural farmers living around the buffer zone of the forest area on the important of good agricultural practice.

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