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Research Article

MULTIVARIATE STATISTICAL ASSESSMENT OF TRACE METAL POLLUTION IN THE SOIL AT THE GAS FLARING SITE IN INUA -EYEN IKOT IBENO LOCAL GOVERNMENT AREA, AKWA IBOM STATE NIGERIA

Anthony Okon Etim*

Department of Environmental Management and Toxicology Michael Okpara University of Agriculture, UmudikeAbiaState, Nigeria

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ABSTRACT

The study evaluated trace nine metals concentration and pollution of the soil in crude oil producing gas flaring sites Inua -Eyen Ikot in Ibeno Local Government Area in Akwa Ibom State, Nigeria. Multivariate statistical approaches were used to evaluate sources of the trace metal concentration in soil samples assessed. Results obtained indicated three components as a major sources of trace metal load in the soil from gas flaring sites tested with Eigen value greater than one and significant total variance of 77.32%. The first factor explained total variance of 32.13 % with positive loading for Vanadium and Copper. While the second factor and third factor explained total variances of 23.38% and 16.82 % respectively. The second factor however showed positive loading for Manganese and Zinc. While the third factor showed positive loading for Nickel and Vanadium. The study revealed that anthropogenic activities due to gas flaring and other associated factors in view of crude oil production contributed to trace metal load in the soil samples tested from the study location. The level of trace metal such as lead, cadmium, Vanadium and Iron exhibited insignificant and negative correlations with other trace metals tested in the study location. Based on the principal component analysis Copper, Vanadium, Manganese, Zinc, Nickel as well as Chromium exhibited positive and significant relationship in the soil of the study location. This showed that the soil of the studied site in Inua-Eyen Ikot is affected by the activities of crude oil production. As such the site is not totally free from pollution. It is therefore not quite safe and suitable for agricultural activities in view of the effect caused by the metals on the crop yield and soil nutrient due to crude oil production activities on the soil of the study location.

INTRODUCTION

Adedosu *et al*. (2014) mentioned that soil is important component of the environment where food and other agricultural activities are undertaken. Ali *et al*. (2014) revealed that where the component of the soil become altered as results of pollution, plant growth and development are equally affected. Bam *et al*. (2014) further mentioned that the soil act as buffer zone to obnoxious substances generated and introduced into the environment. Chinenyeze *et al.* (2015) indicated that the soil properties become altered when the concentration of these contaminates are higher than the background concentration. Asmentioned by Chibuka*et al*. (2014) most of these contaminates may be easily transported from the soil to the plants. When this occur these substances such as trace metals are translocated and bioaccumulated in the different plant parts. The accumulation and translocation of these substances in plant exposes the human to trace metal toxicity. Metaltoxicityoccur when humansand plants are gradually exposed to the concentration higher than the acceptable permissible values.

Okunola *et al. (*2007) in the study on the soil samples collected at the crude oil polluted site due to gas flaring revealed the accumulation of Fe and Pb at the gas flaring site. Roozhaham *et al*. (2015) also mentioned that most of the gas flared at the crude oil production site contributed to remarkable increase in the concentration of trace metal in the soil and plants at the production site. Saha *et al*. (2012) further revealed that trace metals are obvious at the gas flaring site in view of the composition and the geological formation of the crude oil samples. According to Tijjani *et al*. (2013) the effect of the contaminants released at the gas flaring site is very dangerous especially when the contaminants trapped in the gas residue are

Corresponding author:* **Anthony Okon Etim
Department of Environmental Management and Toxicology Michael Okpara University of Agriculture, UmudikeAbiaState, Nigeria

easily transported from the air to the immediate environment during flaring Chibuke *et al*. (2014) in their study on the soil impacted by the crude oil pollution indicated the present of Pb, Vi, Ni and Cu in the soil that exceeded the permissible exposure limits. As further reported by Essiett *et al*. (2010) Pb and Cd potentially have no nutritional value in plants and animals. As such lead is regarded as pollutants which may cause irreversible health condition in plants and animals. Metal toxicity according to Adedosu *et al*. (2014) could be chronic, acute depending on the level of exposure. Chronic and acute metal toxicity depends on time and duration of exposure. Acute metal toxicity occurs when the level of exposureoccurs repeated over short period of time with or without any significant changes being recorded. Chronic metal toxicity occurs when the level of exposure is higher and causes changes within long period of time. Chronic and acute metal toxicity are dangerous to both plants and animals. The accumulation of these substances in the body over time often lead to the destruction of vital organs such as liver and kidney in humans. In pants according Essiett *et a*l. (2010) metal accumulation may block the stomata of the plants thereby preventing the process of photosynthesis to occur.

Ukomma *et al*. (2016) stated that trace metalsas potentially pollutants are non-biodegradable and cannot be destroyed over time. In this case they can remain stable and often form ligands with other substances in the environment. The secondary substances form through the combinations and reaction of such metal may become injurious to the environment. Such substances often remain stable and cannot be easily disposed or degraded in the environment. Therefore, the study was undertaken to ascertain the effect of gas flaring activities on the soil of crude production site at Inua-Eyen Ikot in Ibeno Local Government Area of Akwa Ibom State, Nigeria. This was done in order to ascertain the effect of gas flaring activity on the soil of the study site.

Study Area

The study was conducted in Inua -Eyen Ikot gas flaring site oil producing area. Inua- Eyen Ikot is one of the villages in Ibeno Local Government Areas in Akwa Ibom State Nigeria where crude is abundantly processed and transported. Currently crude oil production is done both onshore within the specific locations of Inua -Eyen Ikot of Ibeno Local Government Areas of Akwa Ibom State, Nigeria. The area also had gas flaring site being located where edible plants species are cultivated.Some of these vegetables are widely consumed over the years by the people living within the study location

Experimental Design

A single factor in randomized block sampling design was utilized for this study. In this case sixlocations affected by gas flaring activities inInua -Eyen Ikot were randomly selected. Three areas with higher magnitude of flared gas were selected randomly for the purpose of these study. Soil samples were collected randomly and in triplicated from the area selected for the study.

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 (Osayande and Opoke (2018). the samples were subjected to wet acid digestion reacted with 2cm3 of 60% perchloric acid ($HClO_4$), 10cm3concentrated nitric acid (HNO_3) and 1.0 cm3 concentrated sulphuric acid (H_2SO4)(AOAC, 1990). 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 (Osayande and Opoke ,2018). 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

Descriptive and multivariate agglomerate hierarchal cluster analysis were employed to analyse the trace metal properties of the soil samples collected from designated study sites. The similarities between trace metals in the soil samples measured through the application of cluster analysis. The sources of trace metals determined using the principal components analysis. The level of correlation coefficient between trace metals in soil measured at $p<0,05$, $p<0.01$ to determine the relationship between the trace metals in the soils at the studied sites according to Kellow (2006).

RESULTSAND DISCUSSION

Descriptive Statistics of Trace Metal Concentration in Study Location

Table 1 show the minimum and maximum as well as the mean values and standard deviation of the trace metals in the study site. The Fe content of the studied site was higher when compared with other trace metal content at the study site. The result showed that the Fe content of the studied soil samples varied from 33.08mg/l to 38.47 mg/l with mean of 35.84mg/l ±1.83 mg/l. The high range of Fe in the studied soil samples may be attributed to the gas flaring and other related activities at the study site. However, the mean value of Fe at the studied site was higher than 15.00mg/l obtained by Efe (2010) in the contaminated soil obtained from gas flaring site in crude oil producing community in Nigeria. The results also showed that the Zn content varied from 10.06 mg/l to 16.84 mg/l with the mean of 12.84±1.8mg/l comparatively the mean value of Zn was lower than that reported by Edmund *et al.* (2017) in their study on the effect of gas flaring on the soil collected from the flaring site at the crude oil-bearing community of River State, Nigeria. The Pb content obtained from the study site also varied between 9.86mg/l to 21.63 mg/l with mean value of 16.53±0.98mg/l. Hence the high content of lead in the studied soil sample may be attributed to gas flared as results of crude oil production in the study site. Also, the mean value of Pb obtained at the study location was higher than 6.7mg/l obtained by Nta *et al.* (2017) in their study on the soil sample effected by crude oil pollution in crude oil producing community of Edo in Esit -Eket. Akwa Ibom State, Nigeria.

The result also showed the Cu content of the studied soil sample varied between 0.32 mg/l to 0.62 mg/l with a mean value of 0.41±0.10mg/l. Hence the mean value of Cu obtained on the study soil sample was lower than the value 0.1 mg/l obtained by Efe (2.65 mg/l on their study on crude oil impacted soil. The V also varied between 0.16mg/l to 0.32mg/l with mean value of 0.255±.056mg/l. The mean value of V obtained at the soil are affected by the gas flaring activities in the studied area was however lower than that obtained by Essiett *et al*. (2010) on their study on crude oil affected soil of Akwa Ibom crude oil producing community. The Ni content of the studied soil sample varied between 0.16 mg/l and 0.24mg/l with mean value of 0.20±0.02mg/l. The result showed that the lower value in the standard deviation of V and Ni in the studied soil is due to the low concentration of V and Ni associated with crude oil gas flaring activities in the studied area. Manganese concentration in the studied soil sample also ranged between 0.14 mg/l to .42mg/l with mean value of 0.28±0.09mg/l. The result of the mean value of the Mn obtained in the study soil sample was however lower than that reported by Braide *et al. (*2016) on their study on crude oil impacted soil environment of Egbema crude oil producing community of ImoState, Nigeria. Table 1 also showed the Cd content of the studied soil sample with the range between 0.11mg/l to 0.33mg/l with mean value of 0.197±0.09mg/l. The results obtained was however lower than obtained by Edmund *et al*. (2017) on their study on soil impacted with crude heavy metal at the crude oil spillage site in River State, Nigeria.Cr ranged between 0.11 mg/l and 0.19mg/l with mean value of 0.13±0.03 mg/l. This value was also lower than 0.08mg/l obtained by Nta *et al*. (2017) on their study on crude oil impacted soil of Crude oil producing area of Akwa Ibom State, Nigeria.

Table 1 Descriptive Statistics of metal at the Study Site

Descriptive Statistics				
Trace Metal (mg/g)	**Minimum**	**Maximum**	**Mean**	**. Deviation**
Fe	33.08	38.47	35.8482	1.83823
Zn	10.06	16.84	12.8418	1.79694
Pb	9.86	21.63	16.5373	0.97509
Cu	.32	.62	.4709	.10387
V	.16	.32	.2455	.05733
Ni	.16	.24	.2045	.02423
Mn	.14	.42	.2873	.09078
Cd	.11	.33	.1927	.09645
Cr	.11	.19	.1318	.02601

Correlation Coefficient

The result of the correlation coefficient of the trace metals in the soil samples are as shown in Table 2. The results showed positive and negative correlation existed between the trace metals assessed in the soil sample of the studied location. The table showed that the correlation between Fe and other trace metals in the study location was positive and negative but insignificant, this showed that increase in Fe content in soil of the studied soil sample may not lead to corresponding increase in other metals in the study soil. Zn also correlated positively but significantly with Mn with r value 0.670 at P value equal 0.05. This showed that an increase in the concentration of Zn in the studied soil sample may lead to corresponding increase in the concentration of Mn in the soil of the study locations. Zn also correlated negatively but insignificantly with V and Cd with r value -.411 and -.395respectively, This showed that an increase in Zn concentration in the studied soil samples around the flare site may not lead to corresponding increase in V ad Cd in the study soil sample. Pb also correlated positively and significantly with Cu at r value of -0,758 and at$P \leq 0.01$.Also Cu correlated positively and significantly with V with r value .664 , but at $P \leq 0.05$.Cu also correlated negatively but insignificantly with Cd and Cr with r values of -535 and -565 respectively. Hence an increase in Cu contentment in the soil at the gas flaring site may not lead to the relative increase in the concentration of Cu and Cd at the study site.

Other metals also showed variable correlation which was however negative and insignificant with each other at the study soil samples

Table 2 Correlation Coefficient of Metals at the Study Site

	Fe	**Zn**	**Pb**	**Cu**	**V**	**Ni**	**Mn**	**Cd**	**Cr**
Fe	1.000								
Zn	-.469	1.000	1.000						
Cu	.527	-.191	-.736**	1.000					
V	.494	-.411	-.577	.664*	1.000				
Ni	-.134	-.148	-.295	.286	.060	1.000			
Mn	-.237	.670*	.005	.082	-.205	-.363	1.000		
Cd	.051	-.395	-.009	-.535	-.207	-.103	-.405	1.000	
Cr	-.523	.012	.349	-.563	-.507	.000	.085	.139	1.000

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

Principal Component Analysis of Trace Metal at Study Location

The results of the principal component analysis of trace metals in the soil at the gas flaring site are shown on table 4. Results obtained indicated three main components with Eigen value greater than one and significant total variance of 77.32 % as shown on table 3. Factor one contributed total variance of 37.13 % with strong positive correlation with copper and vanadium but with negative loading for lead and Cadmium. This actually represented the impact of the trace metal in the soil was influenced by the gas flared near the study location. Factor two contributed total variance of 23.38 % with strong positive loading on Manganese and Zinc this represented the effect of other industrial effluent generated and disposed directly into the soil in the study locations. Factor three accounted for total variance of 16.82% and defined strong loading for Chromium and Nickel. This represented the impact of other industrial activities as well as effluent generated and disposed into the soil at the study locations

Cluster Analysis

The association among the trace metals in the 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 V,Ni,Cr, Cd, Mn and Cu. While cluster two shows linkage between Zn and Pb. Cluster 1 can be sub-divided into Cr,Cu and Mn as well as Ni, V, Cd. The linkages and interactions among these trace metals showed close similarities existed between them in the soil at the gas flaring site of Inua -Eyen Ikot. The relationship showed these metals as contaminants in the soil which originated from gas flared at the study site into the immediate environmental due to crude oil producing activities. However, Cr and Zn and Pb are also regarded as contaminant that originated from mixed anthropogenic and lithogenic sources in view of the similarities showed by these metals (Zn and Pb) with Iron. Cr in cluster 1 showed the same lithogenic relationship with Iron.

Table 3 Principal Component Analysis Matrix of Trace Metal

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	3.341	37.126	37.126	3.341	37.126	37.126	3.020	33.551	33.551
2	2.104	23.381	60.507	2.104	23.381	60.507	2.129	23.661	57.212
3	1.513	16.815	77.322	1.513	16.815	77.322	1.810	20.111	77.322
4	.877	9.750	87.072						
5	.509	5.656	92.728						
6	.303	3.363	96.090						
7	.218	2.424	98.514						
8	.105	1.168	99.682						
9	.029	.318	100.000						

Extraction Method: Principal Component Analysis.

As such may be regarded as contaminant originated from the same anthropogenicorigin. This is in line with the results obtained from the principal component analysis.

A plot of the major principal components of PCA resulted in three different plots (figure 3). The plot 1 showed very strong positive loading for Copper and Vanadium which is actually similar to factor 1(Figure 3). Plot two however showed strong positive loading for Zinc and Mn similar to factor two. Plot three of the cluster showed positive loading for Chromium and Nickel which is similar to factor three (Figure 3). 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 4 Total Component Extracted

Rotated Component Matrix[a]			
	Component		
	1	2	3
Cu	.951		-.183
Pb	-.808	.168	
Cd	-.754	-.510	
V	.715	-.257	-.303
Mn		.895	
Zn		.864	
Fe	.332	-.363	-.789
Ni	.345	-.300	.751
Cr	-.380		.704

Extraction Method: Principal Component Analysis.
a. Rotation converged in 4 iterations.

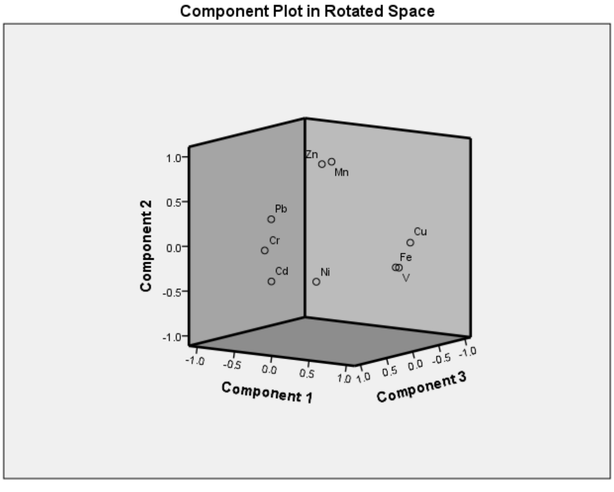

Figure 1 Plot of the Principal Component Extracted

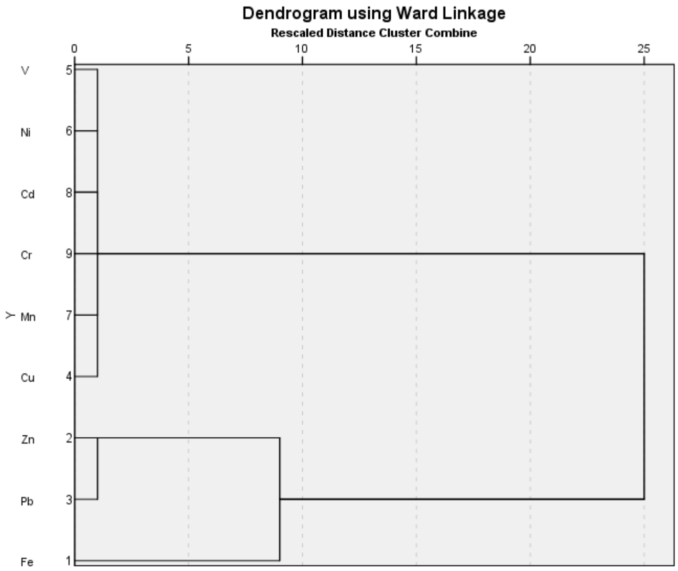

Figure 2 Hierarchical Cluster Analysis of the Trace Metal at the study Site

CONCLUSION

The study revealed that the gas flaring site at the Inua Eyen Ikot in Ibeno local Government area negatively affected the soil properties at the study sites. The introduction of trace metal into the soil as revealed by the multivariate analysis has revealed that the gas flared has the tendency of releasing trace metals into the soil matrix. Though gas flaring is often done to ease operational activities this have the tendency of causing environmental problem within the crude oil producing areas. Hence agricultural activities could be prevented in such area in view of the associated effect of such activities on the soil fertility due to contaminants released into the immediate environment. Therefore, since the associated gas flared released obnoxious substances into the soil environment potentially hindered the soil fertility and plant growth. multinational organization involved in crude oil production, processing and transportation should compress the gas and alternatively use such to produce electricity to host community. In essence by doing so much of the trace metals and other hydrocarbons substances produced and released into the immediate environment could be reduced. Regulatory agencies both local and national should enforced zero gas flaring policies so as to reduced the number of gas flaring sites experienced in crude oil bearing communities of both onshore and offshore locations of Niger- Delta coastal communities of the southern part of Nigeria

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