Impact of Spent Petroleum Products Discharge from Generating Plant on Soil Heavy Metal Concentrations within University of Calabar, Nigeria

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Abstract - **The impact of spent petroleum products (diesel and engine oil) discharge from generating plant on soil properties and heavy metal concentrations within the University of Calabar, Nigeria was investigated. Twelve composite soil samples (0-30 cm) were collected from four generating plants within the University. The soil texture irrespective of sampling point was sandy loam. The soil pH ranged from 6.5 to 7.3 in all the locations. The soil organic carbon and total nitrogen were more at point of discharge (POD) i.e. contaminated sites than the uncontaminated while phosphorus content was the reverse. The concentrations of Cd, Pb, Fe, Mn, Cu and Zn ranged from 3.08 - 4.60, 216.00 - 242.75, 322.20 - 517.02, 200.67 - 284.01, 49.99 - 58.27 and 103.67 - 150.67mgkg^{-1} at POD, respectively. The contamination/pollution index (MPI) classifies the soils at POD as being excessively polluted with Cd and Zn, severely polluted with Mn and Cu and moderately polluted with Pb and Fe. It is therefore recommended that the discharge of petroleum products from generating plant should be avoided in order to reduce the negative impact on the soil ecosystem and human health.**

Keywords: **Contamination/pollution index, diesel, engine oil, generating plant, heavy metals**

I. INTRODUCTION

The discharge of petroleum products consisting petrol, diesel or engine oil directly on the soil has both direct and indirect effect to soil properties especially the heavy metal concentrations of such soil. To avoid polluting the soil is to prevent or minimize the discharge of toxic substances into it up to the point that it is dangerous or harmful. Heavy metals occur naturally in the soil environment from the pedogenic processes of weathering of parent materials at levels that are regarded as trace (<1000 mgkg^{-1}) and rarely toxic [1] while some may come from anthropogenic sources [2]. Heavy metals in the soil from anthropogenic sources tend to be more mobile, hence bioavailable than pedogenic, or lithogenic ones [3].

Soil is a primary recipient of waste products resulting from anthropogenic activities of the modern society. Due to the disturbance and acceleration of nature’s slowly occurring geochemical cycle of metals by man, most soils of rural and urban environments may accumulate heavy metals to values high enough to cause risks to human health, plants, animals, ecosystems, or other media [4]. This simply means that it is the anthropogenic sources that increase the level of heavy metals in the soil environment to the point that it is harmful to the health of the soil, plants, animals and that of humans. Soils heavy metal contents are very significance because they are non-degradable also, they can accumulate for a long time [5] and when they are overloaded in the soil, they poses worrisome risk not only to the quality/health of soils, plants and natural water but also to human health [6].

The sources of petroleum products as contaminants are wide spread. According to [7], they are produced by refining crude oils and are used widely as transportation fuels as well as in stationary engines and in boilers, reciprocating engines, gas turbines, pipeline pumps, gas compressors, steam processing units in electric power plants and water heating facility. Significant changes occur in the properties of the soils that have been polluted with petroleum hydrocarbons affecting the physical, chemical and microbiological properties of soils [8, 9]. Within the University of Calabar, so many generating plants are being used regularly if not on daily basis because of lack/shortage of power supply by the government. This has subsequently given rise to the heavy use of petroleum products. Therefore, this study investigates the effects of petroleum products discharge from generating plants on soil properties and heavy metal concentrations of contaminated soils within the University of Calabar.

II. MATERIALS AND METHODS

A. *Description of the study location*

The study area covered four generating plants sites contaminated with petroleum products oil within the University of Calabar Campus, Calabar, Nigeria. Calabar lies between latitude 5° 32’ and 4° 27’ N and longitude 7° 15’ and 9° 28’ E in the Southeastern humid tropical rainforest zone of Nigeria. It has annual rainfall ranging from 2,000 mm to 2,500 mm, mean temperature range of 23° C to 33° and mean relative humidity of 60% to 90%.

B. *Soil sampling and processing*

Soil samples were collected from four sites contaminated with petroleum products oil as a result of its discharge from generating plant within the University of Calabar Campus, Calabar. The locations were the Faculty of Science generating plant (L1), Faculty of Agriculture generating plant (L2), Bursary Department generating plant (L3) and University of Calabar Printing Press generating plant (L4). Three sampling points were mapped out at each location. The reference point (1) was at the point where the generating plant was placed with spillage of petroleum products and therefore referred to as point of discharge (POD) of the petroleum products from the generating plant into the soil. Point 2 was at a distance of 20 m from the reference point (1) and still within the discharge site (surrounding soil). Point 3 was 100 m from the reference point and served as the control.

Composite samples were collected at each sampling point at a depth of 0-30 cm using soil auger. Twelve composite samples were collected in all, three per location. All the soil samples were air-dried, sieved with 2 mm sieve and stored for onward laboratory analysis.

C. *Laboratory analysis*

The prepared soil samples were analyzed using standard procedures as outlined by [10]. For heavy metals determination, the soil samples were digested with perchloric and nitric acid and cadmium (Cd), lead (Pb), copper (Cu), manganese (Mn), iron (Fe) and zinc (Zn) were read using a buck 205 model Atomic Absorption Spectrophotometer (AAS).

D. *Quantification of soil heavy metal contamination/pollution index (MPI)*

The determination of contamination/pollution index (MPI) of heavy metals in soil was calculated as defined by [11] as in Equation 1 and the values obtained were interpreted following the guidelines given in Table 1.

$$MPI = \frac{\text{Concentration of metals in soil}}{\text{Reference soil (control)}} \quad \text{........Equation 1}$$

TABLE 1
Interval of Contamination/Pollution Index of Heavy Metals in Soil and its Significance

MPI	Significance	Remarks
< 0.1	Very slight contamination	No negative effect on soil, plant and environment
0.10 – 0.25	Slight contamination	“
0.26 – 0.5	Moderate contamination	“
0.51 – 0.75	Severe contamination	“
0.76 – 1.00	Very severe contamination	“
1.1 – 2.0	Slight pollution	Will pose negative effect on soil, plant and environment
2.1 – 4.0	Moderate pollution	“
4.1 – 8.0	Severe pollution	“
8.1 – 16.0	Very severe pollution	“
> 16.0	Excessive pollution	“

Adapted from [11]

III. RESULTS AND DISCUSSION

A. *Impact of Spent Petroleum Products Discharge from Generating Plant on Soil Properties*

Table 2 shows the impact of petroleum products discharge from generating plant on soil physico-chemical properties. The particle size distribution of the soil indicated that the soil texture is sandy loam irrespective of the location and sampling points (Table 2). This shows that the soils are coarse textured with a high content of sand indicating that the petroleum products discharge had no effect on the textural class. Similar result was obtained by [8] who observed no change in texture in spent engine contaminated soil when compared with the uncontaminated soil.

The pH of the soil ranged from 6.5 (slightly acid) to 7.3 (neutral) in all the locations indicating that all the sampling location were alkaline i.e., pH above 6.50. The mean values obtained at point of discharge, surrounding soil and control were similar. This finding agrees with [12] who reported that there was no significant difference ($p > 0.05$) in the soil pH between the control and the soil sample contaminated with spent engine oil.

The values for organic carbon ranged from 1.0 to 4.0 % with the highest mean value of 2.38 % obtained from the point of discharge (POD) of petroleum products oil, followed by the surrounding soil which had mean pH value of 1.3 % and the least mean value of 1.03 % was from the control. Similarly, soil total nitrogen was highest at POD and least in control with values ranging from 0.08 to 0.21%. This is in agreement with previous findings by several researchers [8, 9, 13, 14] that the contamination of soils by petroleum products results to increase in organic carbon and total nitrogen contents of the affected soils and attributed this to microbial mineralization of crude oil in the soil. As pointed out by [15], when soil is polluted by petroleum products oil, it leads to build up of essential elements like organic carbon. However, this contradicts the findings of [16] who reported that polluted soils were observed to be low in organic carbon.

The values of the soil available phosphorus (P) ranged from 3.75 - 45.62 $mgkg^{-1}$ with the highest mean value of 28.84 $mgkg^{-1}$ recorded in the control soil, followed by the surrounding soil (11.28 $mgkg^{-1}$) while the least mean value of available P (6.25 $mgkg^{-1}$) was recorded in the POD soil. This result agrees with the findings of [9, 14,16] who observed reduction in soil available phosphorus (P) as a result of crude oil contamination of the soil. This contradicts the findings of [8] who reported higher P values in contaminated site than in uncontaminated site.

The values of Ca ranged from 4.6 to 10.6 $cmolkg^{-1}$ with the highest mean value recorded in POD soil. Exchangeable Mg (0.4 to 5.4 $cmolkg^{-1}$), K (0.09 to 0.12 $cmolkg^{-1}$), Na (0.07 to 0.10 $cmolkg^{-1}$) and exchangeable acidity varied across the sampling locations. All the sites sampled were highly saturated with bases irrespective of the sampling points. The cation exchange capacity (CEC) which is an indication of the relative ability of K, Na, Ca and Mg to displace other cation was observed to be high. This could be attributed to the high pH values obtained in the study sites as CEC of most soil increases with pH.

B. Impact of Petroleum Products Discharge from Generating Plant on Soil Heavy Metal Concentrations

Table 3 shows the impact of petroleum products discharge from generating plant on soil heavy metal concentrations. According to [6], when heavy metals are above certain limits they exhibit adverse ecological effects and are toxic to plants, animals and humans at large. Cadmium (Cd) contents obtained in the soil at point of discharge (POD) ranged from 3.08 – 4.60 $mgkg^{-1}$ with a mean value of 3.67 $mgkg^{-1}$ exceeding the permissible limits given by [17, 18], WHO, Europe (EU) and United Kingdom (UK) standards (Table 3). The surrounding soil (20 m away) had a range of 0.23 – 0.35 $mgkg^{-1}$ while the control (100 m away) site had a range of 0.10 – 0.13 $mgkg^{-1}$ of Cd and were within/below the permissible limits given by the regulatory bodies earlier mentioned. The values obtained for Cd in the different sampling points differed from each other with a standard deviation (SD) of ± 1.74 and a coefficient of variability (CV) of 127% suggesting a marked difference of the contaminated sites with the control sites. The contamination/pollution index (MPI) as calculated using [11] equation classifies the soils at point of discharge of petroleum products from generating plant in the University of Calabar as being excessively polluted with cadmium (Table 4) and moderately polluted for the surrounding soil (Table 5). Although, it is not essential to plant growth, but under certain conditions, it can accumulate in some plants to level that are hazardous to animals and humans [19].

For lead (Pb), none of the contaminated sites had values that exceeded the permissible limits of 250 $mgkg^{-1}$ given by [18] and 300 $mgkg^{-1}$ given by EU Standard. Lead contents obtained in the soil at point of discharge (POD) ranged from 216.00 – 242.75 $mgkg^{-1}$ with a mean value of 229.25 $mgkg^{-1}$. The surrounding soil (20 m away) had a range of 118.00 – 129.00 $mgkg^{-1}$ with a mean value of 122.00 $mgkg^{-1}$ while the control (100 m away) site had a range of 100.00– 109.00 $mgkg^{-1}$ with a mean value 103.25 $mgkg^{-1}$of Pb. The values were, however, above the permissible limits given by WHO (0.3-10 $mgkg^{-1}$) and UK Standard (70 $mgkg^{-1}$) as presented in Table 3. Petroleum products has a higher concentration of lead (Pb) thus suggesting more level of lead pollution [20]. This notwithstanding, most of the values recorded for Pb from the study sites were within the recommended soil range of 2-200 $mgkg^{-1}$ given by [17]. The values obtained for Pb in the different sampling points differed from each other with a standard deviation (SD) of ± 58.42 and a coefficient of variability (CV) of 38.56% suggesting a marked difference of the contaminated sites with the control sites. The contamination/pollution index (MPI) classifies the soils at point of discharge of petroleum products in all the sampling points as being moderately polluted with lead (Table 4) and slightly polluted for the surrounding soil (Table 5)

TABLE 2

Impact of Spent Petroleum Products Discharge From Generating Plant on Physico-Chemical Properties of Soils within the University of Calabar

.Location	Sand (%)	Silt (%)	Clay (%)	Texture	pH	Org. C (%)	T.N (%)	Avail. P $mgkg^{-1}$	Exch. bases ($cmolkg^{-1}$)				Exch. Acidity	ECEC	BS (%)
									Ca	Mg	K	Na			
Point of Discharge (POD)															
L1	76	11.0	13.0	SL	6.6	2.0	0.16	3.75	10.6	0.4	0.12	0.09	0.20	11.41	98
L2	76	10.0	14.0	SL	6.8	1.8	0.10	5.00	9.0	0.6	0.12	0.10	0.20	10.02	96
L3	72	17.0	11.0	SL	6.5	1.7	0.10	7.87	7.6	1.2	0.10	0.09	0.32	9.31	97
L4	76	11.0	13.0	SL	7.2	4.0	0.21	8.37	6.2	5.4	0.10	0.08	0.36	12.14	98
Mean	75.0	12.25	12.75		6.76	2.38	0.14	6.25	8.35	1.9	0.11	0.09	0.27	10.72	97.25
Surrounding soil (20 m away)															
L1	77	12.0	11.0	SL	6.5	1.3	0.09	12.12	7.8	0.6	0.11	0.08	0.36	8.95	96
L2	73	15.0	12.0	SL	6.7	1.4	0.08	9.87	5.4	2.8	0.10	0.08	0.20	8.58	98
L3	73	14.0	13.0	SL	6.5	1.2	0.09	10.50	5.8	3.0	0.11	0.08	0.36	9.35	96
L4	77	12.0	11.0	SL	7.3	1.3	0.09	12.62	5.8	1.8	0.11	0.09	0.24	8.04	97
Mean	75.5	12.75	11.75		6.75	1.3	0.09	11.28	6.2	2.05	0.11	0.08	0.29	8.73	96.75
Control (100 m away)															
L1	76	14.0	10.0	SL	6.6	1.0	0.08	24.25	6.8	3.6	0.12	0.09	0.24	10.85	98
L2	75	14.0	11.0	SL	6.6	1.0	0.09	31.12	5.0	0.8	0.09	0.07	0.20	6.16	97
L3	77	12.0	11.0	SL	6.9	1.0	0.08	14.37	10.2	1.4	0.12	0.09	0.20	12.01	98
L4	77	12.0	11.0	SL	6.9	1.1	0.08	45.62	4.6	2.0	0.10	0.08	0.36	7.14	95
Mean	77	12.25	10.75		6.75	1.03	0.08	28.84	6.65	1.95	0.11	0.08	0.25	9.04	97

L1= Faculty of Science, L2= Faculty of Agriculture, L3= Bursary Department, and L4= University of Calabar Printing Press generating plant site

Iron (Fe) values ranged from 322.20 to 517.02 $mgkg^{-1}$ at point of discharge with a mean value of 416.98 $mgkg^{-1}$ while the surrounding soils had values that ranged from 160.04- 186.32 $mgkg^{-1}$ with a mean value of 170.12 $mgkg^{-1}$. The control (100 m away) site had a range of 157.00– 160.00 $mgkg^{-1}$ of Fe with a mean value of 158.28 $mgkg^{-1}$. The values obtained for iron in the study sites were very low compared to the recommended upper limit of 55,000 $mgkg^{-1}$ given by [17] meaning the soils were not contaminated with iron. The values obtained for Fe in the different sampling points differed from each other with a standard deviation (SD) of ± 150.50 and a coefficient of variability (CV) of 60.57%. Despite the low concentration of Fe observed in the study sites, the [11] contamination index classified the soils at point of discharge of petroleum products in all the sampling points as being moderately polluted with iron except at Location 4 (University of Calabar Printing Press) which was found to be slightly polluted (Table 4). The surrounding soil was classified as being slightly polluted across all sampling locations (Table 5).

The concentration of manganese across all sampling locations was found to be lower than the permissible limit in soil, which is 100 – 4000 $mgkg^{-1}$ as given by [17]. However, higher values were observed at contaminated sites when compared with the uncontaminated (control) sites. The values ranged from 200.67 to 284.01 $mgkg^{-1}$ at point of discharge with a mean value of 239.35 $mgkg^{-1}$ while the surrounding and the control soil had values ranging from 60.30 to 66.11 and 45.00 to 50.10 with respective means of 63.61 and 48.28 $mgkg^{-1}$. The values obtained for Mn differed from each other with SD of 92.31 and CV of 78.84. Based on the [11] contamination index, the soils at POD across all sampling locations were classified as being severely polluted with Mn (Table 4) while the surrounding soils across all sampling locations were classified as being slightly polluted (Table 5).

For copper (Cu), the values ranged from 49.99 to 58.27 $mgkg^{-1}$ with a mean of 52.73 $mgkg^{-1}$ at point of discharge while the surrounding and the control soil had values ranging from 14.19 to 17.00 and 9.78 to 11.04 with respective means of 15.81 and 10.24 $mgkg^{-1}$. The values recorded for Cu from the study sites were within the recommended soil range given by all the regulatory bodies cited in Table 3. This means that the Cu levels in the study sites do not reach a level that is capable of negatively affecting the soil. However, the [11] pollution index classified the soils at point of discharge across all sampling locations as being severely polluted (Table 4) while the surrounding soils are classified as being slightly polluted (Table 5). The values obtained for Cu differed from each other with SD of 19.80 and CV of 75.39.

Zinc concentration at the point of discharge of petroleum products oil from the generating plant ranged from 103.67 to 150.67 $mgkg^{-1}$ with a mean of 132.77 $mgkg^{-1}$. The surrounding soil (20 m away) had a range of 9.78 to 10.32 $mgkg^{-1}$ with a mean value of 10.06 $mgkg^{-1}$ while the control (100 m away) site had a range of 7.68 to8.76 $mgkg^{-1}$ with a mean value 8.41 $mgkg^{-1}$of Zn. The concentrations of Zn at all sampling points fall within the permissible limits given by all the regulatory bodies cited in Table 3 except the limit given by WHO [19] which showed that soils at POD across all sampling locations far exceeded the permissible limits of 12 to 60 $mgkg^{-1}$. Based on the [11] contamination index, the soils at POD across all sampling locations were classified as being very severely polluted (L1 and L2) to being excessively polluted (L3 and L4) with Zn (Table 4) while the surrounding soils across all sampling locations were classified as being slightly polluted (Table 5). The values obtained for Zn differed from each other with SD of 61.92 and CV of 122.83.

The high concentration of heavy metals obtained at point of discharge in this study is in agreement with the reports given by [8, 13] that oil contaminated soils contained more heavy metals when compared with the uncontaminated soils.

IV. CONCLUSION

The results obtained in this study indicated that the release of hydrocarbons into the soil ecosystem have negative impact on the soil environment as it increased the concentration of soil heavy metals thereby polluting natural underground water aquifers as well as constituting health hazards to both fishes, animals and human beings. Based on the findings of this research work, it is recommended that the discharge of hydrocarbon fuel particularly petroleum products, should be avoided in order to reduce the negative impact on the soil ecosystem, underground water aquifer as well as human health in general.

TABLE 3

Impact of Petroleum Products Discharge from Generating Plant on Soil Heavy Metal Concentrations within the University of Calabar

Location	Heavy metals ($mgkg^{-1}$)					
	Cd	Pb	Fe	Mn	Cu	Zn
Point of Discharge (POD)						
L1	3.67	242.75	410.23	239.40	51.98	127.52
L2	3.08	216.00	517.02	233.33	58.27	103.67
L3	3.33	235.50	418.46	284.01	49.99	150.67
L4	4.60	222.75	322.20	200.67	50.67	149.23
Mean	3.67	229.25	416.98	239.35	52.73	132.77

Surrounding soil (20 m away)						
L1	0.35	129.00	160.09	60.30	14.19	10.05
L2	0.23	118.00	186.32	66.11	16.01	9.78
L3	0.26	118.00	160.04	63.12	17.00	10.09
L4	0.33	123.00	174.02	64.89	16.03	10.32
Mean	0.29	122.00	170.12	63.61	15.81	10.06
Control (100 m away)						
L1	0.10	101.00	158.10	50.01	10.25	8.60
L2	0.11	100.00	158.00	48.02	9.89	7.68
L3	0.10	109.00	160.00	50.10	9.78	8.59
L4	0.13	103.00	157.00	45.00	11.04	8.76
Mean	0.11	103.25	158.28	48.28	10.24	8.41
SD	**1.74**	**58.42**	**150.50**	**92.31**	**19.80**	**61.92**
Variance	**3.04**	**3413.03**	**22651.24**	**8521.46**	**392.16**	**3833.66**
CV	**127**	**38.56**	**60.57**	**78.84**	**75.39**	**122.83**
Permissible limits						
Nangia (1991)	0.01-0.7	2-200	7000-55,000	100-4000	2-100	10-300
Rowell (1994)	3	250	-	-	135	300
WHO (Asemave & Anhwange, 2012)	0.02-0.5	0.3-10	-	-	1-12	12-60
EU STD	3	300	-	-	140	300
UK STD	1.4	70	-	-	63	200

L1= Faculty of Science, L2= Faculty of Agriculture, L3= Bursary Department and L4= University of Calabar Printing Press generating plant site, STD= standard

TABLE 4
Metal Contamination/Pollution Index (MPI) of Heavy Metals in Soils at the Point of Discharge of Petroleum Products from Generating Plant in University of Calabar

Heavy metals ($mgkg^{-1}$)	Concentration at POD ($mgkg^{-1}$)	Control site concentration ($mgkg^{-1}$)	MPI	Class interval Lacatusu (2000)	Significance	Remarks
L1= Faculty of Science						
Cadmium	3.67	0.10	36.7	>16.0	Excessive pollution	Will pose negative effect on soil, plant and environment
Lead	242.75	101	2.40	2.1 – 4.0	Moderate pollution	″
Iron	410.23	158.10	2.59	2.1 – 4.0	Moderate pollution	″
Manganese	239.40	50.01	4.79	4.1 – 8.0	Severe pollution	″
Copper	51.98	10.25	5.07	4.1 – 8.0	Severe pollution	″
Zinc	127.52	8.60	14.83	8.1 – 16.0	Very severe pollution	″
L2= Faculty of Agriculture						
Cadmium	3.08	0.11	28.0	>16.0	Excessive pollution	Will pose negative effect on soil, plant and environment
Lead	216.00	100	2.16	2.1 – 4.0	Moderate pollution	″
Iron	517.02	158.00	3.27	2.1 – 4.0	Moderate pollution	″
Manganese	233.33	48.02	4.86	4.1 – 8.0	Severe pollution	″
Copper	58.27	9.89	5.89	4.1 – 8.0	Severe pollution	″
Zinc	103.67	7.68	13.50	8.1 – 16.0	Very severe pollution	″
L3= Bursary Department						
Cadmium	3.33	0.10	33.3	>16.0	Excessive pollution	Will pose negative effect on soil, plant and environment
Lead	235.50	109	2.16	2.1 – 4.0	Moderate pollution	″
Iron	418.46	160.00	2.05	2.1 – 4.0	Moderate pollution	″
Manganese	284.01	50.10	5.67	4.1 – 8.0	Severe pollution	″
Copper	49..99	9.78	5.11	4.1 – 8.0	Severe pollution	″
Zinc	150.67	8.59	17.54	>16.0	Excessive pollution	″
L4= University of Calabar Printing Press						
Cadmium	4.60	0.13	35.4	>16.0	Excessive pollution	Will pose negative effect on soil, plant and environment
Lead	222.75	103	2.16	2.1 – 4.0	Moderate pollution	″
Iron	322.20	157.00	1.41	1.1 – 2.0	Slight pollution	″
Manganese	200.67	45.00	4.46	4.1 – 8.0	Severe pollution	″
Copper	50.67	11.04	4.59	4.1 – 8.0	Severe pollution	″
Zinc	149.23	8.76	17.04	>16.0	Excessive pollution	″

TABLE 5

Metal Contamination/Pollution Index (MPI) of Heavy Metals in the Surrounding Soils where Generating Plant within the University of Calabar are Kept

Heavy metals (mgkg^{-1})	Surrounding soil concentration (mgkg^{-1})	Control site concentration (mgkg^{-1})	MPI	Class interval Lacatusu (2000)	Significance	Remarks
L1= Faculty of Science						
Cadmium	0.35	0.10	3.5	2.1 – 4.0	Moderate pollution	Will pose negative effect on soil, plant and environment
Lead	129.00	101	1.28	1.1 – 2.0	Slight pollution	″
Iron	160.09	158.10	1.01	1.1 – 2.0	Slight pollution	″
Manganese	60.30	50.01	1.21	1.1 – 2.0	Slight pollution	″
Copper	14.19	10.25	1.45	1.1 – 2.0	Slight pollution	″
Zinc	10.05	8.60	1.17	1.1 – 2.0	Slight pollution	″
L2= Faculty of Agriculture						
Cadmium	0.23	0.11	2.09	2.1 – 4.0	Moderate pollution	Will pose negative effect on soil, plant and environment
Lead	118.00	100	1.18	1.1 – 2.0	Slight pollution	″
Iron	186.32	158.00	1.18	1.1 – 2.0	Slight pollution	″
Manganese	66.11	48.02	1.38	1.1 – 2.0	Slight pollution	″
Copper	16.01	9.89	1.62	1.1 – 2.0	Slight pollution	″
Zinc	9.78	7.68	1.27	1.1 – 2.0	Slight pollution	″
L3= Bursary Department						
Cadmium	0.26	0.10	2.6	2.1 – 4.0	Moderate pollution	Will pose negative effect on soil, plant and environment
Lead	118.00	109	1.08	1.1 – 2.0	Slight pollution	″
Iron	160.04	160.00	1.00	1.1 – 2.0	Slight pollution	″
Manganese	63.12	50.10	1.26	1.1 – 2.0	Slight pollution	″
Copper	17.00	9.78	1.74	1.1 – 2.0	Slight pollution	″
Zinc	10.09	8.59	1.27	1.1 – 2.0	Slight pollution	″
L4= University of Calabar Printing Press						
Cadmium	0.33	0.13	2.54	2.1 – 4.0	Moderate pollution	Will pose negative effect on soil, plant and environment
Lead	123.00	103	1.19	1.1 – 2.0	Slight pollution	″
Iron	174.02	157.00	1.11	1.1 – 2.0	Slight pollution	″
Manganese	64.89	45.00	1.44	1.1 – 2.0	Slight pollution	″
Copper	16.03	11.04	1.45	1.1 – 2.0	Slight pollution	″
Zinc	10.32	8.76	1.18	1.1 – 2.0	Slight pollution	″

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