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Heavy Metals Contamination Profile in Soil from Automobile Workshops in Sapele, Nigeria

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Abstract Soils samples taken at depths, 0 – 15, 15 – 30, 30 – 45, and 45 – 60cm from five automobile workshops in Sapele metropolis were analysed for heavy metals. The total heavy metal pollution status, within the depths and between the locations was determined by method adopted by Lacatusu. At all locations considered, the heavy metals (Pb, Cu, Cr, and Cd) found were much higher than that from the control sample. The concentrations of Cu and Cd at most locations and depths were also higher than the recommended critical limits for several countries. Cadmium was not detected in control soil but values ranging from 1.35 to 9.97mg/kg were recorded for the automobile workshops soils. The degree of metal pollution was in order: Okerigwre > Gana New Rd. > Shell Rd. > Ajogodo > Akintola.

Keywords: *heavy metals, contamination, soils profile, automobile workshops, pollution status*

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1. Introduction

The increase inflow of used (tokunbo) automobiles into the Nigerian markets has also resulted increase in automobile repairs and workshops activities in most Nigerian cities. The automobile used (waste) oil contain oxidation products, sediments water and metallic particles resulting from machinery wears, organic and inorganic chemicals used in oil additives and metals that are present in fuel and transferred to the crankcase during combustion [1]. These workshops lack waste management practice: waste are indiscriminately discarded on the vicinity. The soil eventually becomes a repository of metals released from automobile workshops activities. Heavy metal pollution may occurs where the contents of these elements in the soil becomes higher than the maximum concentration, which has potential harmful effects on the environment. The objective of this study is to investigate the profile of heavy metals in soils within mechanic workshops in Sapele metropolis, and to ascertain the extent of metal pollution in these soils.

2. Materials and Methods

2.1. Study Area and Site Locations

The study was conducted on soils samples taken at depths, 0 – 15, 15 – 30, 30 – 45, and 45 – 60cm from five mechanic workshops locations in Sapele, Delta State, Nigeria. Viz: -Akintola (N05^{o}53.421' E005^{o}41.184'), Ajogodo (N05^{o}53.952' E005^{o}41.779'), Gana-New Road (N05^{o}54.701' E005^{o}45.025'), Shell Road (N05^{o}52.102' E005^{o}41.632), and Okirigwre (N05^{o}52.102' E005^{o}42.528').

2.2. Sample Collection

Mechanic workshops in the metropolis were chosen with ages of establishment over seven years, obtained by personal communication with artisans working on these sites. No waste management practice is done on these workshops. Composite soil samples were collected from five (5) different mechanic workshops at different depths using standard soil (hand) auger. Sample of uncontaminated soil were obtained in similar manner from nearby virgin land in Ubeyiyi (N05^{o}52.847'E005^{o}42.528') in the metropolis to serve as control. The collected samples were transferred into a black polythene bag, properly labelled and transported to the laboratory [2].

2.3. Preparation and Analysis of Samples

The samples were air-dried for a period of two weeks in a well ventilated space [3]. A representative sample was obtained using quartering method. The dried representative soil samples were crushed in porcelain mortal and sieved through 2mm (10 mesh) stainless sieve prior to analysis. The total heavy metals in soils were determined with Atomic adsorption spectrophotometer (Model 210 VGP) after digestion with a (5:1) mixture of nitric and perchloric acids [4].

3. Results and Discussion

Table 1 shows the mean concentrations of metals at each depth. The average metals concentrations at each depth as well as the critical limits of heavy metals in soil

for several countries for protection of all land uses are shown in Table 2 and Table 3 respectively.

Table 1. Mean concentration of metals (mg/kg) in soil

Samples	Depths (cm)	Pb	Cu	Cr	Cd
AK	0-15	39.32±1.23	99.54±1.26	20.20±2.00	8.18±0.25
	15-30	39.80±2.00	84.68±1.00	36.90±1.84	5.45±1.50
	30-45	27.86±1.50	54.59±1.47	13.69±2.20	3.49±0.50
	45-60	16.36±2.00	46.88±1.30	9.90±1.10	1.95±0.50
AJ	0-15	35.34±1.30	88.10±0.00	62.70±1.70	8.80±1.00
	15-30	24.40±1.00	77.55±0.00	51.55±0.99	6.08±1.50
	30-45	15.24±2.50	55.35±1.00	31.70±1.56	3.81±0.55
	45-60	7.20±1.70	47.99±0.40	20.16±1.40	1.35±0.00
GN	0-15	30.78±1.00	76.94±1.67	38.95±1.80	9.97±0.55
	15-30	25.99±3.00	64.94±1.39	29.94±2.80	6.22±1.55
	30-45	19.87±0.00	54.69±1.14	18.55±2.00	4.76±1.05
	45-60	9.89±0.00	46.97±2.20	9.21±1.40	2.11±0.50
SR	0-15	37.76±0.90	94.41±3.00	34.17±1.20	9.41±1.00
	15-30	27.56±1.00	89.17±3.70	21.88±1.00	6.69±0.75
	30-45	18.20±2.10	71.41±1.16	12.34±2.00	4.14±0.60
	45-60	12.40±2.00	44.19±1.58	8.12±1.10	1.55±0.50
OK	0-15	39.85±1.90	99.58±0.00	23.90±1.90	9.58±0.50
	15-30	32.80±2.80	95.23±2.00	19.46±3.40	7.30±0.55
	30-45	19.60±3.10	58.52±1.10	11.60±3.00	4.70±1.00
	45-60	10.95±2.00	23.99±3.30	8.40±2.10	2.13±0.50
CT	0-15	1.45±0.00	15.58±3.00	0.20±0.00	0.02±0.00
	15-30	0.75±0.10	7.55±0.00	0.14±0.00	<0.01
	30-45	0.44±0.00	1.47±0.00	0.06±0.10	<0.01
	45-60	0.15±0.00	0.57±0.00	<0.04	<0.01

AK→ Akintola, AJ →Ajogodo, GN→ Gana-New Road, SR→ Shell Road, OK →Okirigwre, CT →Control.

Table 2. The average metals contents of soil at the different depths

Depths (cm)	Pb (mg/kg)	Cu (mg/kg)	Cr (mg/kg)	Cd (mg/kg)
0-15	36.61±3.70	91.71±9.51	35.98±16.74	9.19±0.70
15-30	30.11±6.27	82.31±11.66	31.95±12.94	6.35±0.69
30-45	20.15±4.68	58.91±7.17	17.68±8.27	4.18±0.55
45-60	11.36±3.38	42.00±10.17	11.16±5.08	1.82±0.35

Table 3. Critical limit of heavy metals in soil for several countries

Countries	Critical limit (mg/kg)				
	Zn	Pb	Cu	Cr	Cd
Canada	50	25	30	20	0.5
Denmark	100	40	30	50	0.3
Finland	90	38	32	80	0.3
Czech republic	150	70	70	130	0.4
Netherland	140	85	36	100	0.8
Switzerland	200	50	50	75	0.8
Ireland	150	50	50	100	1.0
Eastern Europe	100	32	55	90	0.2

(Eastern Europe include Russia, Ukraine, Moldova and Belarus)
Sources: De Vries and Bakker, 1998.

The concentrations of heavy metals obtained from this study generally decreased vertically with soil depth. This higher level of metals on the top or surface soil is expected since the top soil is the point of contact. The surface soils therefore, represent better indicators of metallic burdens since the metal levels decreased with depth in all the locations. Lead in the soils has an average top-soil value of 36.61mg/Kg. This value was higher than the critical soil Pb limit for Canada (25mg/Kg), and Eastern Europe (32mg/Kg); but lower than those of Finland (38mg/Kg), Denmark (40mg/Kg), Czech Republic (70mg/Kg), Netherland (85mg/Kg), and Switzerland and Ireland (50mg/Kg). The average top-soil value for Cu (91.71mg/kg) was higher than the critical limit of Cu for the several countries. Chromium average top-soil value was 35.98mg/Kg and was only higher than the critical limit of Cr for Canada (20mg/Kg). The average Cd content for the top-soils was 9.19mg/Kg. This value was higher than the critical limit of Cd for several countries (Table 3). This is an indication of pollution by cadmium in the soil. Shear off from metal plating, leachates from used oils and old tyres frequently burnt on these sites are likely source of cadmium.

Table 4.Heavy metal pollution profile, calculated from total metal C/P index.

SAMPLE	Depths(cm)				
	0-15	15-30	30-45	45-60	Total
AK	22.26	17.16	10.60	6.61	56.63
AJ	25.08	18.30	11.66	5.60	60.64
GN	25.68	17.14	13.09	6.64	62.55
SR	25.19	18.55	12.01	5.48	61.23
OK	25.27	20.06	12.71	5.92	63.96
CT	0.63	0.31	0.09	0.05	1.08

Table 5. Significance of intervals of contamination/pollution (C/P) index

C/P	Significance
<0.1	Very slight contamination
0.10-0.25	Slight contamination
0.26-0.50	Moderate contamination
0.51-0.75	Severe contamination
0.76-1.0	Very severe contamination
1.1-2.0	Slight pollution
2.1-4.0	Moderate pollution
4.1-8.0	Severe pollution
8.1-16.0	Very severe pollution
>16	Excessive pollution

Source: Lacatusu, 1998.

To explain the heavy metal profile on the locations, an appraising method by calculating the contamination/

pollution (C/P) index values for each metal in each location was calculated using the Canadian critical limits for heavy metals in soil (Table 3). Most Regulatory limits are derived with the principle "**A**s **L**ow **A**s **R**easonably **A**cievable" (ALARA). Critical limits however, are based on the viewpoint of protection of human health [6]. The contamination/ pollution index represents the metal content effectively measured in soil by chemical analysis and the critical limits from a reference table [5]. Table 4 show the C/P indices distribution for different depths in all location. There is much difference between the concentrations of metals in soils (Table 1) and the potential treat pose by them expressed though their c/p index value (Table 4). Lacatusu [7] established that the c/p value index is directly proportional to their level of contamination and pollution of specific metal species in each case. Higher value > 1 indicate higher risk while lower values < 1 connote minimal risk to the environment (Table 5). To obtain a profile (Table 4), the total pollution ranges defined by multiple pollution found from contribution from each metal contamination/ pollution status were used. The observed trend for all samples shows that the top-soils are heavily loaded with heavy metals than the sub-soils. Okirigwre (OK) had the highest total pollution by heavy metals with value of 63.96. The values for the other locations are AK (56.63), AJ (60.64), GN (62.55), and SR (61.23). These values are much higher than the control (CT) value (1.08). The degree of metal pollution in the locations was in the order: Okerigwre > Gana New Rd. > Shell Rd. > Ajogodo > Akintola. Characterization based on the significance of intervals of contamination/pollution (C/P) index in Table 5, reveals that due to multiple pollutions, all the locations are moderately polluted with respect to the four metals.

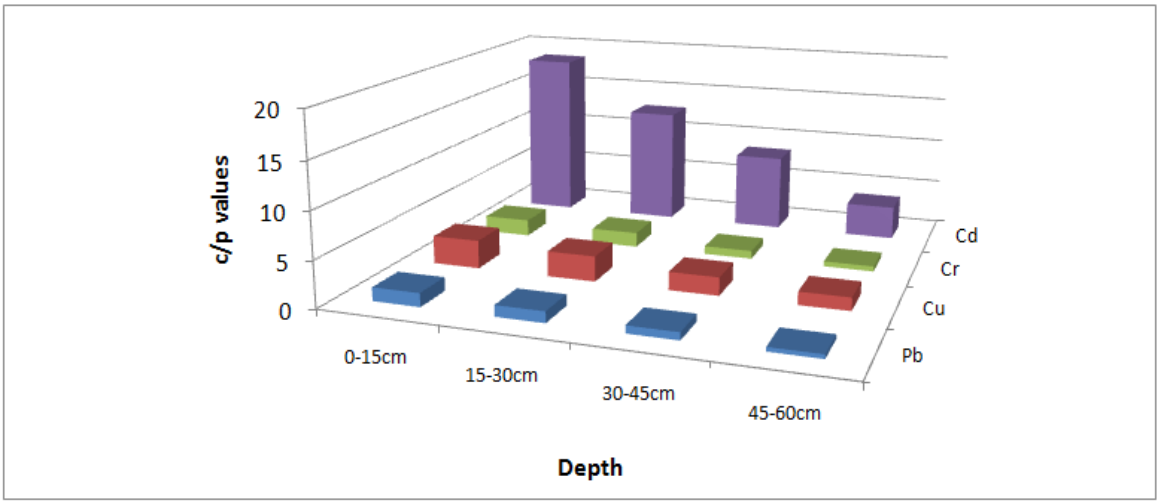

Figure 1. Plot of c/p versus depth for heavy metals in the soils

Figure 1 shows the graph of c/p index versus depth for each metal calculated from the average concentrations of the metals using the Canadian critical limits for heavy metals in soil. The soils were polluted at all depths with cadmium and copper; while only the top-soils (0-15cm & 15-30cm) were polluted with lead and chromium. Generally, the metals contents decreases with increase in depths. The relative high concentrations found for Cd metal even at depth 45 -60cm signifies that the metals in these locations are not restricted to top-soil (0 -15cm), and that there are possibilities of leaching of these metals to underground water and subsequent effects on public health.

4. Conclusion

Type of contaminant, concentration and vertical distribution in soil are required inputs for development of predictive models, effective remediation and risk assessment. The concentrations of Cu, and Cd at most locations and depths in this study were higher than the recommended critical limits for several countries. Lead and Chromium have their top-soil (0 – 30cm) values higher than most established critical limits but the sub-soil (30 – 60cm) were within the stipulated limits. The relative high concentrations found for cadmium even at depth 45 - 60cm, signifies that heavy metals in these sites are not restricted to top – soil (0 -15cm), and that there are possibilities of leaching of these heavy metals to underground water and subsequent effects on public health.

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