The International Journal Of Engineering And Science (IJES)
||Volume||2 ||Issue|| 11||Pages|| 19-26||2013||
ISSN(e): 2319 – 1813 ISSN(p): 2319 – 1805

Investigating The Effects Of Selected Heavy Metals On Topsoil At The Vicinities Of Two Automobile Mechanic Villages, Owerri Municipal,Nigeria

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ABSTRACT

The increased persistence of farming activities within mechanic villages poses health risk to the consumers of these agricultural produce. Studies on heavy metal contamination of top soils at the vicinities of two auto-mechanic villages was aimed at determining the concentrations of heavy metals, at the top soils of Nekede and Orji automobile mechanic villages located at Owerri municipal, Nigeria. The Soil samples were analyzed for selected heavy metals contamination namely: Cd, Cu, Pb and Cr. Soil samples were obtained in triplicates at the top soil 0-20, 20-40 and 40-60cm depths. The Overall, values of Cd, Cu, Pb and Cr in the workshop soil samples ranged from 8.83 to 18.67; 191.00 to 590.00; 693.33 to 2917.30 and 5.42 to 26.82 mg.kg^{-1}respectively; they decreased with an increase in depth in the two auto-mechanic villages when compared to the established intervention, target and allowable limits set for soils in Nigeria and some countries, the contamination of top soils at the two automobile mechanic villages were clearly higher in most cases. The soil pH was slightly acidic and alkaline ranging from 5.24 to 7.27. For soil particle size, the distribution of sand fraction was highest followed by clay and then silt. The recommendations of the study included enacting laws prohibiting indiscriminate dumping of refuse at the workshops; execution of some form of phyto-remediation measures at the village and enforcement of other environmental protection regulations as it affects farming within mechanic villages to arrest the ongoing buildup of these metals at the top soils in those locations.

KEY WORDS: *Soil, Contamination, Heavy Metal, Automobile mechanic, Nigeria.*

Date of Submission: 29 October 2013 Date of Acceptance: 05 December 2013

I. INTRODUCTION

Imo State has a total of three mechanic villages located at Nekede with an area of 550,362m^2, Orji 408,725m^2 and Okigwe 299,462m^2 of land (Nwachukwu et al., 2011). Nekede and Orji mechanic villages started with few workshops which have grown into many more shops. Activities conducted at the mechanic villages are typical of auto-mechanic repairs and invariably involves working with and spilling of oils, grease, petrol, battery electrolyte, paints and other materials which contain heavy metals unto bare soil. Heavy metals are chemical elements mostly with density greater than 4g/cm^3 found in all kinds of soil, rock and water in terrestrial and fresh water ecosystem. The very low general level of their content in soils and plants as well as the definite biological roles of most of them made them microelements (Lacatusu, 1998).

Heavy metal contamination of urban topsoil has been of major concern regarding their toxicity, persistence and non-degradability in the environment [Mellor and Bevon, (1999); Al-Chalabi and Hawker, (2000); Onianwa,(2001)]. Adverse effects of elevated concentrations of heavy metals to soil functions, soil microbial community composition and microbial growth have long been recognized under both field and laboratory conditions (Tyler et al., 1989).Heavy metal contamination of urban topsoil usually derives from anthropogenic sources such as emissions from automobile exhaust, waste incineration, land disposal of wastes, use of agricultural inputs, emissions from industrial processes and wet or dry atmospheric deposits [Onianwa et al., (2001); Zhenli et al., (2005)].

There has been little attention given to vicinities of automobile-workshops, which are also liable to pollution arising from gasoline combustion exhausts, lubricating oil spills, and other chemical inputs to automobile operations. In Nigeria, pollution problems associated with incidents of oils spills around automobile-repair workshops, resulting in metal contamination of topsoil, have been the subject of many reports [Onianwa et al., (2001); Osibanjo et al.,(1983); Oyindo and Agboola (1983)].

Since the activity of auto-mechanics is one of the major routes for entry of heavy metals into the environment to cause heavy metal contamination of soil and drinking wells and crops, monitoring heavy metal contamination of soils is therefore necessary. This paper is aimed at determining top soil contamination by heavy metals at the vicinities of automobile mechanic villages at Orji and Nekede, Owerri Municipal, Imo State**.**

II. MATERIALS AND METHODS

1.2.1 Study Area

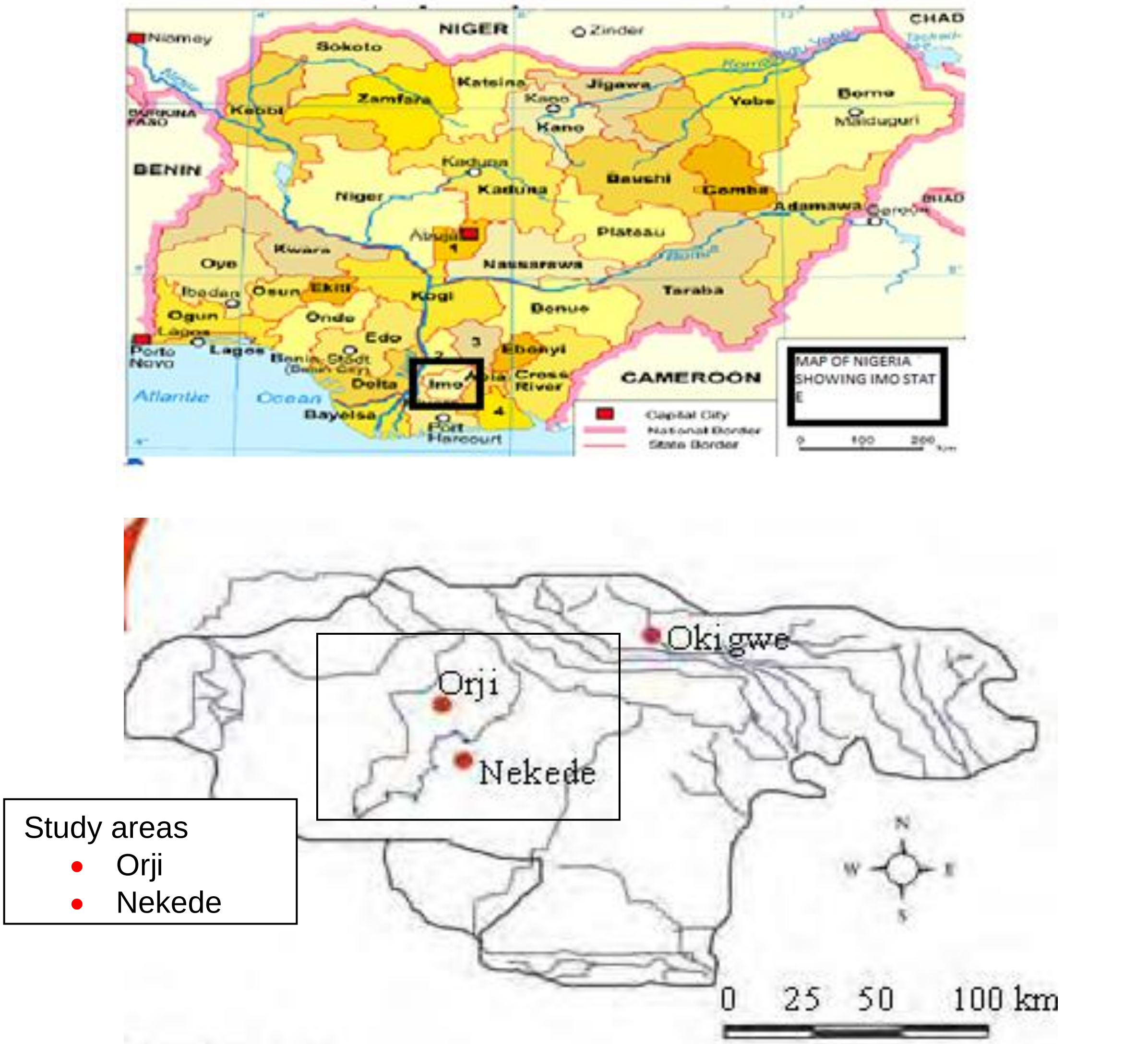

Figure 1: Map of Nigeria showing Imo state and the study area (Nwachukwu et al., 2010)

Table 1: General Information on the mechanic villages studied

S/n	Site	Area	Location (L.G.A)	Year Established
1	A	NEKEDE	OWERRI WEST	1983
2	B	ORJI	OWERRI NORTH	1987

L.G.A: LOCAL GOVERNMENT AREA.

1.2.2Soil Sampling

Random samples of the mechanic village were taken. Three samples were collected each at Nekede and Orji at the depth of 0-20, 20-40 and 40-60cm.The topsoil was denoted by T(0-20cm) while the deep soils were denoted by D1(20-40cm) and D2(40-60cm).

A green uncontaminated site at the Ministry of Agriculture was used as a control. These samples were collected using a soil auger. Each sample was immediately placed in a fresh plastic bag and tightly sealed. All samples were transported to the laboratory where analytical procedure commenced immediately. The samples were collected by October 2012.

1.2.3 Heavy Metal Analysis. The soil was spread on a clean plastic sheet placed on a flat surface and air dried in open air in the laboratory under room conditions for 24 hours. Afterwards the soil was sieved on a 2mm sieve and 5gram of sample was taken from the sieved soil and put in a beaker 10ml of nitric acid 2:1 was added to the samples for digestion. Next HCl and distilled water ratio 1:1 were added to the digested sample and the mixture transferred to the digester again for 30minutes.

The digestate were then removed from the digester and allowed to cool to room temperature. The cool digestate was washed into a standard volumetric flask and was made up to the mark with distilled water. Determination of heavy metal concentration was done in an atomic adsorption spectrophotometer (AAS Model 210 VGP) after calibrating the equipment with different standard concentrations. The pH was determined by an electronic Jenway glass electrode pH meter (Model 3510). Particle size will be determined by the hydrometer method using sodium hexametaphosphate as the dispersant (Bouyoucous, 1962).The results were analyzed using the GenStat statistical package. ANOVA was used to determine differences between treatment means and were separated using the Duncans new multiple range test (DNMRT) at 5% level of significance.

1.2.4 **Contamination Factor and Pollution Load Index**

To assess the extent of contamination of heavy metals in soils and to provide a measure of the degree of overall contamination in a particular soil, contamination factor and pollution load index has been applied (Hakanson,1980). The contamination Factor (CF) parameter is expressed as:

$CF = C_{metal} / C_{background}$ ……………………………………...equation (i)

Where; CF = contamination factor,

C_{metal} = concentration of pollutant in sediment

$C_{background}$ = background value for the metal.

The CF reflects the metal enrichment in the sediment. The geochemical background values in continental crust averages of the trace metals under consideration reported by Taylor and McLennan (1985) was used as background values for the metal. The CF was classified into four groups (Mmolawa et al., 2011). Where the contamination factor $CF < 1$ refers to low contamination; $1 \leq CF \leq 3$ means moderate contamination; $3 \leq CF \leq 6$ indicates considerable contamination and $CF > 6$ indicates very high contamination.

The pollution load index at the study area also was evaluated for the extent of metal pollution by employing the method based on the pollution load index (PLI) developed by Thomilson et al., (1980) as follows:

$PLI = \sqrt[n]{(CF1 \times CF2 \times CF3 \times \ldots\ldots CFn)}$ ………………………….equation (ii)

Where; n = number of metals studied (five in this study) and

CF = contamination factor calculated as described in an earlier equation.

The PLI provides simple but comparative means for assessing a site pollution quality, where a value of $PLI < 1$ denote perfection; $PLI = 1$ represent that only baseline levels of pollutants are present and $PLI > 1$ would indicate deterioration of site quality (Thomilson et al., 1980).

III. RESULTS AND DISCUSSION.

The results as presented in table 2, showed the concentration of Copper, Lead, Cadmium and Chromium at locations A, B and control. Lead(Pb) was highest in topsoil contamination with Cadmium(Cd) least in the two auto-mechanic villages in Owerri. Their order of abundance were Pb>Cu>Cr>Cd. There was a significant difference for the elements at $p < 0.05$ at locations A and B except the control.

Table 2: Heavy metal content of two auto-mechanic villages in Owerri. Imo State.

Depth(cm)	Parameter(Mg.kg^{-1})	Control	A	B	SE
T(0-20)	**Cu**	**40.00^{b}**	**498.00^{a}**	**590.00^{a}**	**91.17**
	Pb	**0.24^{b}**	**2917.30^{a}**	**2332.70^{a}**	**479.35**
	Cd	**0.08^{b}**	**18.67^{a}**	**18.34^{a}**	**311.86**
	Cr	**0.03^{b}**	**26.82^{a}**	**23.43^{a}**	**4.32**
D1(20-40)	**Cu**	**16.00^{b}**	**378.33^{a}**	**405.00^{a}**	**66.77**
	Pb	**0.18^{b}**	**1719.30^{a}**	**1340.70^{a}**	**303.49**
	Cd	**0.30^{b}**	**11.62^{a}**	**11.14^{a}**	**192.11**
	Cr	**0.03^{b}**	**12.83^{a}**	**10.05^{a}**	**2.02**
D2(40-60)	**Cu**	**13.00^{b}**	**285.00^{a}**	**191.00^{ab}**	**48.38**
	Pb	**0.05^{b}**	**1134.00^{a}**	**693.33^{a}**	**181.54**
	Cd	**0.16^{b}**	**8.85^{a}**	**8.83^{a}**	**151.31**
	Cr	**0.05^{c}**	**7.80^{a}**	**5.42^{b}**	**1.19**

Values are means of three measurements. a, b – means at the same row with different superscripts are significantly different at p<0.05; A- Nekede; B- Orji; SE- Standard error; Cu- Copper; Pb- Lead; Cd- Cadmium; Cr- Chromium.

Table 3: Soil PH in two auto-mechanic villages in Owerri, Imo State.

Depth(cm)	A	B	Control	SE
T(0-20)	7.27^{ab}	6.20^{b}	8.27^{a}	0.38
D1(20-40)	5.14^{c}	6.50^{b}	8.70^{a}	0.55
D2(40-60)	5.31^{b}	6.42^{a}	7.27^{a}	0.32

Table 4:Textural composition of two auto-mechanic villages in Owerri, Imo State

Depth(cm)	Parameter(%)	Control	A	B	SE
T(0-20)	Sand	82.00	74.67	81.33	2.08
	Silt	5.67	5.00	6.33	0.47
	Clay	13.00	13.00	19.00	2.17
D1(20-40)	Sand	78.00^{a}	68.67^{b}	77.33^{a}	1.62
	Silt	7.33	5.00	5.00	0.62
	Clay	15.33^{b}	17.00^{a}	26.00^{b}	1.90
D2(40-60)	Sand	62.33^{b}	63.33^{b}	75.67^{a}	2.61
	Silt	7.00^{b}	20.67^{a}	9.33^{b}	2.22
	Clay	17.33	17.67	26.33	2.14

Values are means of three measurements. a, b – means at the same row with different superscripts are significantly different at p<0.05; A- Nekede; B- Orji; SE- Standard error

Table 5: Target and intervention values for some metals for a standard soil.

Metal	Target value (mg.kg^{-1})	Intervention value(mg.kg^{-1})
Ni	**140.00**	**720.00**
Cu	**0.30**	**10.00**
Cd	**100.00**	**380.00**
Pb	**35.00**	**210.00**
As	**200.00**	**625.00**
Hg	**85.00**	**530.00**

(DPR-EGASPIN, 2002)

Soil pH was significance at $P < 0.05$ for locations A and control sites, whereas B had no significance (table 3). Soil pH at A was highest at the top soil T(0-20cm) and decreased with an increasing depth at the deep soils D1(20-40cm) and D2(40-60cm), while at B it was least at the top soilT(0-20cm). It increased and later decreased with depth. From table 3, 82.00% and 74.67% were recorded as the highest values of sand at the top soil T(0-20cm) for A and B respectively. Silt was least at the top soil T(0-20cm) for locations A and B with the values 5.00% and 6.33%. Clay known to affect the concentration of heavy metal in the soil had their least values at the top soil T(0-20cm) 13.00% and 19.00% for locations A and B respectively. Sand decreased with an increase with depth while silt and clay generally increased with an increase with depth.

The highest values of Cu measured at locations A and B (table 2) were within the top soil T(0-20cm) when compared to the deep soils at D1(20-40cm) and D2(40-60cm). These values were several times higher than the target and intervention values in a standard soil (Table 5) and the toxic limit of 250mg.kg^{-1} set by USEPA (1986) for agricultural soils. It was also high when compared to the control values at the top and deep soils (table 2). Concentrations of Cu were high in the mechanic workshops under low clay composition in the soils of A and B. It had also been demonstrated that clay is an important parameter for predicting the exchange capacity of soil (Kadeba,1978), the higher the clay content the more the exchange capacity of the soil. Elevated levels of copper on the top soil of the auto-mechanic locations may also be traceable to high use of copper conductors and wires, tubes, solders and myriads of other maintenance items made from copper. According to Alloway (1990) and Lenntech (2009) when copper ends up in soils, it strongly attaches to organic matter and minerals. As a result, it does not travel very far after release. Perhaps this explains why in this study, the highest values of copper recorded in most of the locations were at the top soil T(0 to 20cm) depth (figure 2). As a result of this limited mobility, applied copper tends to accumulate

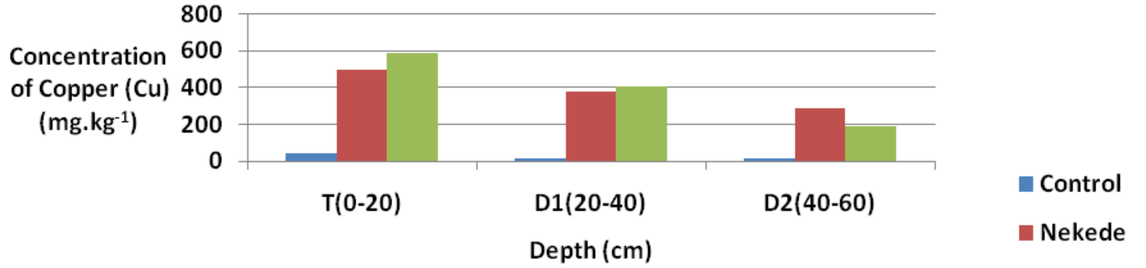

Figure 2:Concentration of Copper (Cu) in two Mechanic Villages in Imo State

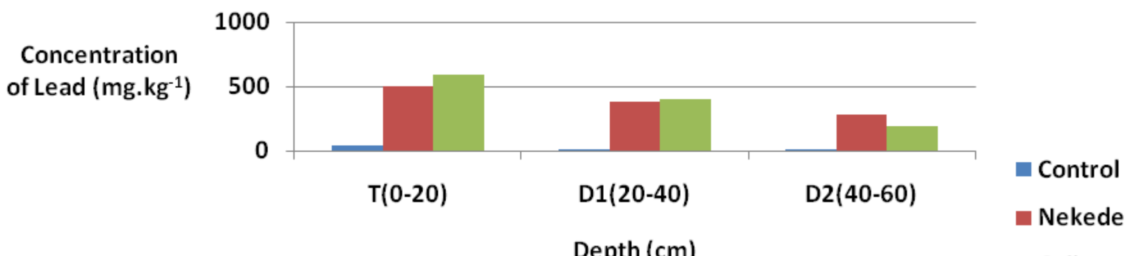

Figure 3:Concentration of Lead (Pb) in two Mechanic Villages in Imo State

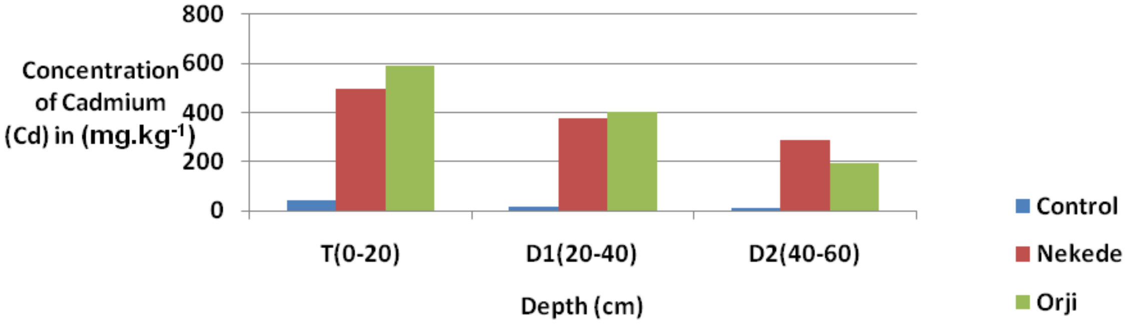

Figure 4:Concentration of Cadmium (Cd) in two Mechanic Villages in Imo State

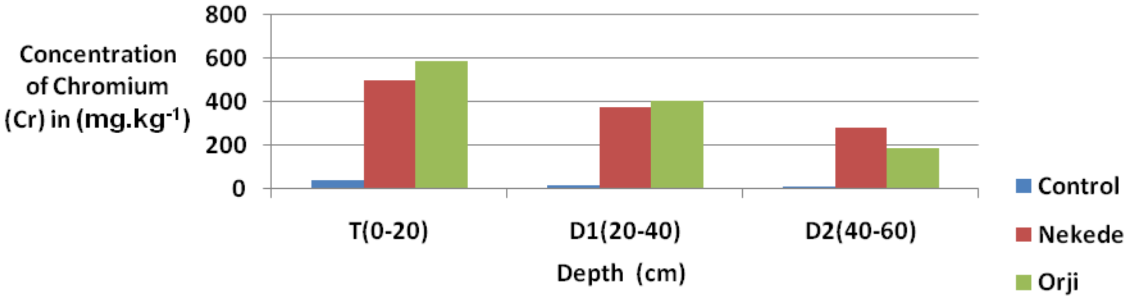

Figure 5: Concentration of Chromium (Cr) in two Mechanic Villages in Imo State

in soil (Slooff et al., 1989). On copper rich soils, only a limited number of plants have a chance of survival. In surface water, copper can travel great distances, either suspended on dust particles or as free ions. Soil types have finite holding capacities for copper ions, and leaching can occur when the copper levels applied exceed this capacity (Adriano, 1986).When the values of lead (Pb) (table 2) at the top soils T(0-20cm) were compared to values for the target and intervention limits of heavy metals concentrations in a standard soil(table 5), it showed a clear increase in heavy metal contamination of top soils (figure 3). These values were also above the range (30-300mg.kg^{-1}) set by USEPA(1986) described as toxic to agricultural soils. The control values did not exceed the standard limits set by other countries (table 2), implying that high levels of lead(Pb) contamination of soil at A and B are basically from the activities at the auto-mechanic villages. Higher values of Pb was recorded at the topsoil T(0 to 20cm) for locations A and B than at the deep soils D1(20-40cm) and D2(40 to 60cm) which corroborates with the observed high retention of Pb in the top soil by Davies (1995) who stated that Pb is especially prone to accumulate in the surface horizons of soil because of its low water solubility resulting in very low mobility. Adelekan and Abegunde (2011) reported higher soil retention of lead (15,000Mg.kg^{-1}) at 30 to 45cm depth compared to that recorded at the top layer. Adie and Osibanjo (2009) found a range of 243 to 126,000 mg.kg^{-1}in soils from the premises of a battery manufacturing plant. Nwoko and Egunjobi (2002) found Pb concentrations which were described as being highly elevated in soil and vegetation in an abandoned battery factory site, which was as a result of local Gold miners, who mine and process Gold within the village thereby putting the villagers at risk.

When the values of cadmium (Cd) (table 2) at the top soils T(0-20cm) were compared to values for the target and intervention limits of heavy metals concentrations in a standard soil(table 5), it showed a poor concentration of Cadmium at the two auto-mechanic sites. Almost all the values for locations A, B and control were below the range set by (MAFF,1992 and USEPA,1986) permissible for agricultural soils. Cadmium was relatively same at locations A and B, decreasing with an increasing depth (figure 4). Nwachukwu et al., (2010) reported a result in consonance with that obtained from this work. Higher levels of measured Cd at the topsoils of the auto-mobile mechanic villages may be because Cadmium is a “modern metal” been used increasingly in corrosion prevention (Alloway, 1990). Mostly, It is often used instead of zinc for galvanizing iron and steel (Tucker et al., 2003).This may suggest a high level of Cd deposits on the soil when these iron metals are weak. Also, low pH generally increases mobility of heavy metals and table 3 showed a high pH value across the study areas, implying low mobility for Cd.

Locations A and B have their values of Cr higher at the top soil T(0-20cm) than at the deep soil D1(20-40cm) and D2(40-60cm)(table2). The value of Chromium (Cr) at the top soilT(0-20cm) was within the target and intervention limit set for a standard soil(table 5) while those of the deep soil D1(20-40cm) and D2(40-60cm) were below these standards. The value of chromium decreased with an increase in depth (figure 5). However, the maximum value measured is below the limit of 750mg.kg^{-1} set by the CCME (2009) for agricultural soils. Top soil values for Cr in locations A and B were low. This implies that Cr do not contaminate top soils at the two automobile mechanic villages. Chromium is one of those heavy metals with high environmental concentration which is steadily increasing due to industrial growth, especially the development of metal, chemical and tanning industries.

Contamination factor (CF) and pollution load index (PLI) of heavy metals

The contamination Factor (CF) for each heavy metal at various depths and PLI values for each depth of the study site was calculated as in Table 5 below:

Table 6: Contamination Factor (CF) and Pollution Load Index (PLI) of heavy metals at Nekede Orji and mechanic villages.

	CF					PLI
depth	**Cu**	**Pb**	**Cd**	**Cr**	**Fe**	
0-20cm depth	**21.65**	**18233.13**	**103.72**	**670.50**	**34.73**	**248.80**
20-40cm depth	**16.45**	**10745.63**	**64.56**	**320.75**	**12.64**	**135.85**
40-60cm depth	**12.39**	**7087.50**	**49.17**	**195.00**	**5.10**	**84.45**

The CF values which suffered considerable enrichment for all the heavy metals assessed decreasing with an increase in depth. The order of contamination at the top soil T(0-20cm) depth was Pb>Cr>Cd>Cu while at the deep soil D1(20-40) and D2(40-60cm) it followed the trend Pb>Cr>Cd>Cu. The pollution load index values as calculated were all above '1' implying an urgent need for an intervention checking disposal culture and farming activities at the study areas. The values decreased with an increase in depth thereby endangering farming activities as the top soils known to contain lots of nutrient is contaminated around the mechanic village.

1.4 CONCLUSION AND RECOMMENDATIONS

The high level of heavy metals at the top soils in Orji and Nekede mechanic villages pose health risks to inhabitants of these mechanic villages that engages in backyard farming. This also raises significant environmental concern on the level of soil contamination which can be easily drained to nearby water sources used for portable uses at the study area. This may extend to nearby farmlands if measures to control the activities that increase the concentration of heavy metals at these sites are not implemented. It was also obvious that while lead(Pb) and Copper(Cu) were in excess, Cadmium(Cd) and Chromium (Cr) were either within or lower than permissible limits set for agricultural soils.

It is therefore pertinent to recommend as follows:

[1] Strict adherence to proper disposal of auto-mechanic wastes should be ensured.
[2] Strict compliance to regulatory limits in sludge to be released from these villages into the environment is recommended.
[3] The suggested phyto-remediation measures of soil should also as a matter of urgency started at these locations.
[4] Keeping the auto-mechanics abreast of the information on the level of soil contamination by heavy metals always is recommended.
[5] Seminars should be conducted for farmers living within these areas on the need to refrain from planting around mechanic villages as the top soils are highly contaminated by heavy metals.

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