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Distribution Of Heavy Metals And Other Physico-chemical Properties Of Soil At Automobile Mechanic villages, Imo State.

1,Okoro , A.C, 2,Chukwuma, G.O, 3,Chukwuma, E. C, 4,ugwu.I.E
1,2,3,4,Department of Agric and Bioresources Engineering, Nnamdi Azikiwe University, Awka

ABSTRACT: Studies to ascertain the distribution of heavy metals and changes in other physiochemical properties of soil was carried out at two automobile mechanic villages in Imo State. Soil samples were collected and analyzed in the laboratory for heavy metals and other physciochemical properties in triplicates at the 0-20, 20-40 and 40-60cm depths of the soil. The overall values of heavy metals Cd-Cadmium, Cu-Copper, Pb-Lead, Cr-Chromium and Fe-Iron ranged from 8.83 to 18.68; 191.00 to 590.00; 693.33 to 2917.30; 5.42 to 26.82 and 17,533 to 140,870mg.kg-1respectively. The analyzed result showed that the distribution of heavy metal in the soil decreased with increase in depth and were not significantly different with age. The soil physiochemical properties were also modified due to the presence of excess heavy metals. 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. This study showed that age did not affect heavy metals contamination of the soil.

Keywords: Age, automobile mechanic village, contamination, heavy metal, soil pH, soil porosity, textural composition.

I INTRODUCTION

Soil is a vital resource for sustaining basic human needs for a quality food supply and a livable environment [1]. It serves as a sink and recycling factory for both liquid and solid wastes. The possible hazards arising from pollution of the environment around automobile mechanic villages by heavy metals have surfaced more recently and the toxicity of some of these metals towards humans especially children when exposed to them from the atmosphere, water or food has been well documented.[2] observed that heavy metal concentrations in the soil are usually highest close to the source declining both in distance and depth.

Novak and Walk (2004)[3] found that metal hydroxide and water increases the sorption capacity of soil, which implies that spilling used acid on the ground in the mechanic village will increase soil acidity and the sorption capacity. Heavy metals are considered serious pollutants because of toxicity, persistence and their non-degradable conditions in the environment, thereby constituting threat to human beings and other forms of biological life [4],[5],[6],[7],[8]. There is increasing pressure on backyard farming within mechanic villages, hence the need to ascertain the distribution of heavy metals, compare them to the allowable limits and

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possible changes in the physico-chemical properties of the soil. The behaviour of heavy metals in the soil all depends not on one property, but on properties such as the soil pH, properties of metals, soil porosity, organic matter content, clay content, cation exchange capacities in the surrounding fluid. Oyedele *et.al.*,(2008)**[**9] studied Changes in soil properties and plant uptake of heavy metals on selected municipal solid waste dump sites in Ile-Ife, Nigeria and found that changes in physico-chemical characteristics at dump sites could be attributed to interactions of different soil properties rather a single factor. This paper therefore aims to determine the distribution of heavy metals and other physico-chemical properties of the soil

II. MATERIALS AND METHOD

3.1 Study Area Description

The study area is Imo State of Nigeria as shown in their respective maps(Figure 1). The mechanic villages were sited at Nekede and Orji, Owerri west and north local government areas of Imo State respectively with 550,362m^2 and 408,725m^2 of land provide a dramatic example of environmental impact due to their anthropogenic activities. These automobile mechanic villages were set up in 1983 and 1987 for Nekede and Orji respectively (table 1), with fewer shops then than the present status. Mostly the activities carried out there are basically repairing and maintaining automobile vehicles. The villages are sited around agricultural communities approximately one-kilometer distance from Owerri, the major state capital city of Imo State [10]. Nekede mechanic village fall under the geographical coordinates of longitude 7.04-7.06^{0}E and latitude 5.24-5.27^{0}N and lies on an area of flat agricultural land converted to mechanic workshops, shops and homes, where some of the mechanics and families live. At Nekede, the topography is relatively a level ground but towards the Otammiri River side that borders it to the west. Its landscape has been sculpted by erosion forming deep gullies with elevation ranging between 71.5 and 44.1 meters in the North-West and central sector and to about 65 meters on the east and south. Climate and vegetation falls under the rain-forest belt [10].The geology of the area consists of plain soil which is about 0.05-2.0mm in size. This type of soil has good drainage causing its fast drying [11].

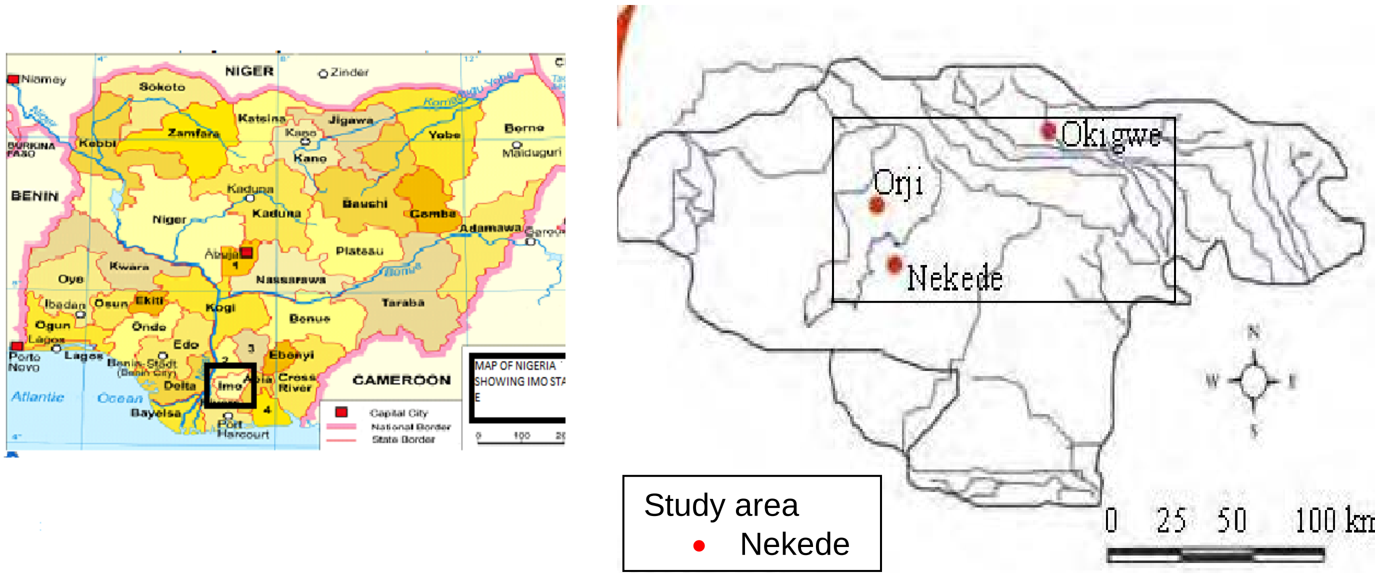

Figure 1: Map of Nigeria showing Imo state and the study area (Nwachukwu et al., 2010)

Table 1: General Information on the mechanic villages studied

S/n	Site	Area	Location (L.G.A)	Year Established	Age of site
1	A	NEKEDE	OWERRI WEST	1983	30
2	B	ORJI	OWERRI NORTH	1987	16

L.G.A:Local Government Area.

3.2 Soil Sampling

Three samples were collected randomly at different locations and depths at the study area and a control site at Ministry of Agriculture, Imo State, at three different depths (0-20, 20-40 and 40-60cm). 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 instantly.

3.3 Heavy Metal Analysis

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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 /perchloric acid 2:1 was added to the samples. These samples were allowed to digest. 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 using an Atomic Adsorption Spectrophotometer (AAS Model 210 VGP) after calibrating the equipment with different standard concentrations.

3.4 Statistical Analysis

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 ($P < 0.05$).

III. RESULTS AND DISCUSSION

4.1 Results

Heavy metals and soil pH showed significant differences ($p<0.05$) with respect to age at 0-20cm depth as shown in Table 2. The two mechanic sites, A(30 yrs) and B(16 yrs) similarly recorded higher concentrations of heavy metals than the control site (0 yr). This observation showed a discontinuous increase in heavy metal concentration with respect to age at the 0-20 cm depth (Figure 2). The control site recorded higher values for soil pH than the two mechanic sites; however, the soil pH neither increased nor decreased continuously with age. Percent porosity and soil texture did not vary ($p<0.05$) with age at the 0-20 cm depth.

Table 2: Effects of Age on Heavy Metal Concentration and other physiochemical Properties of Soils at the 0-20cm depth at the automobile Villages

Mechanic Site	Age of site (yrs)	Soil Texture (%)			Soil pH	Porosity %	Heavy metals concentration				
		Sand	Silt	Clay			Cu	Pb	Cd	Cr	Fe
A	30	82.00	5.00	13.00	7.27^{ab}	41.60	498.00^{a}	2917.30^{a}	18.68^{a}	25.82^{a}	131,570^{a}
B	16	74.67	6.33	19.00	6.20^{b}	25.20	590.00^{a}	2332.70^{a}	18.35^{a}	23.43^{a}	140,870^{a}
C	0	81.33	5.67	13.00	8.27^{a}	33.60	40.00^{b}	0.24^{b}	0.08^{b}	0.03^{b}	5000^{b}
	SEM	2.08	0.47	2.17	0.38	3.73	91.17	479.35	311.86	4.32	224.49

a, b – means at the same row with different superscripts are significantly different at $p<0.05$;
A- Nekede; B- Orji; C-Control, Cu- Copper; Pb- Lead; Cd- Cadmium; Cr- Chromium; Fe- Iron; SE- Standard error.

Table 3: Effects of Age on Heavy Metal Concentration and other physiochemical Properties of Soils at the 20-40cm depth at the automobile Villages

Mech	Age of	Soil Texture (%)	Soil	Porosity	Heavy metals concentration

anic Site	site (yrs)	Sand	Silt	Clay	pH	%	Cu	Pb	Cd	Cr	Fe
A	30	78.00[a]	5.00	17.00[b]	5.14[c]	34.70[b]	378.33[a]	1719.30[a]	11.62[a]	12.83[a]	47,900[a]
B	16	68.67[b]	5.00	26.00[a]	6.50[b]	77.30[a]	405.00[a]	1340.70[a]	11.14[a]	10.05[a]	58,600[a]
C	0	77.33[a]	7.33	15.33[b]	8.70[a]	42.40[b]	15.00[b]	8.18[b]	0.30[b]	4.03[b]	3533[b]
	SEM	1.62	0.62	1.90	0.55	7.16	66.77	303.49	192.11	2.02	88.71

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

Table 4: Effects of Age on Heavy Metal Concentration and other physiochemical Properties of Soils at the 40-60cm depth at the automobile Villages

Mech anic Site	Age of site (yrs)	Soil Texture (%) Sand	Silt	Clay	Soil pH	Porosity %	Heavy metals concentration Cu	Pb	Cd	Cr	Fe
A	30	62.33[b]	20.67[a]	17.67	5.31[b]	41.60[a]	285.00[a]	1134.00[a]	8.85[a]	7.80[a]	19,333[a]
B	16	63.33[b]	9.33[b]	26.33	6.42[a]	38.40[a]	191.00[ab]	693.33[a]	8.83[a]	5.42[b]	17,533[a]
C	0	75.67[a]	7.00[b]	17.33	7.27[a]	3.00[b]	13.00[b]	8.05[b]	0.16[b]	3.05[c]	2833[b]
	SEM	2.61	2.22	2.14	0.32	6.62	48.38	181.54	151.31	1.19	27.66

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

Significant differences ($p<0.05$) were observed in the heavy metals, percent porosity, soil pH, sand and clay textural components, at the 20-40 cm depth, with respect to age, as shown in Table 3. The two mechanic sites with higher years of contamination similarly showed higher values for the heavy metals than the control site at the 20-40 cm depth. This observation again, showed a discontinuous increase in heavy metal concentration with respect to age at the 20-40 cm depth(Figure3). The two mechanic villages therefore did not vary in their heavy metal concentration. Age affected the sand and silt percent, soil pH and porosity percentage of the two mechanic villages. Location B(16yrs) showed higher values for percent clay and percent porosity but lower values for percent sand compared to A (30 yrs) and the control site (0 yr). Percent sand was significantly high in the control site which compared favorably with A (30yrs) (which has higher years of heavy metal contamination) but lower in B (16yrs) with lower age of contamination. The control site with zero year of contamination showed less similarities with B(16yrs) but more similarities with A(30yrs) which has highest years of heavy metal concentration, in terms of sand, clay and percent porosity. Apparently, no clear pattern or trend was observed for the effect of age on these parameters. The control site however, showed higher values of soil pH in relation to the two mechanic sites. The soil

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pH was highest in the control site but decreased with an increase in age of contamination of soil by heavy metals, with B (16yrs) showing higher values than A (30yrs). This may be because at higher pH heavy metals tend to accumulate in the soil. No significant difference was observed in percent silt at the 20-40 cm depth.

Similarly, Table 4 equally showed significant differences ($p<0.05$) in the heavy metals, percent porosity, soil pH, sand and silt textural components at the 40-60 cm depth with respect to age. The heavy metals again showed higher values at the two auto-mechanic sites with more years of contamination, than the control, even at higher depths. This may due to high discharge of grease, condemned oil, battery electrolyte, etc poured carelessly to bare soil. The effect of age was largely observed on higher depths (40-60cm) as copper (Cu) and chromium (Cr) showed a trend in which concentrations increased with age of contamination; whereby, A (30 yrs) recorded the highest values for Cr and Cu followed by B (16yrs), and lastly the control site with zero year of heavy metal contamination (Figure 4). The effect of age on soil texture, soil pH and percent porosity became more pronounced at higher depth (40-60cm). The soil pH decreased continuously with age while percent silt increased continuously with age. A discontinuous increase was observed for percent sand and percent porosity when the three sites were compared; the two mechanic villages therefore, did not vary from each other due to age, in terms of percent sand and porosity. No significant difference ($p>0.05$) was observed in percent clay at the 40-60cmdepth.

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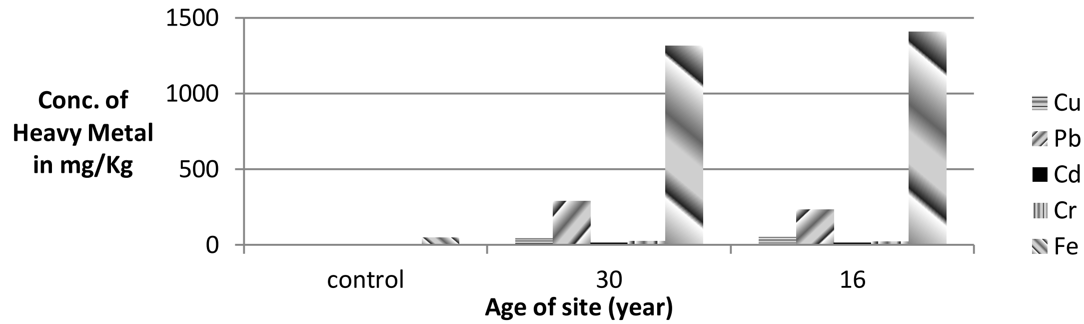

Figure 2: Effect of age on Heavy MetalConcentration at 0-20 cm depth. Values of Iron and Lead were scaled down to 1: 100

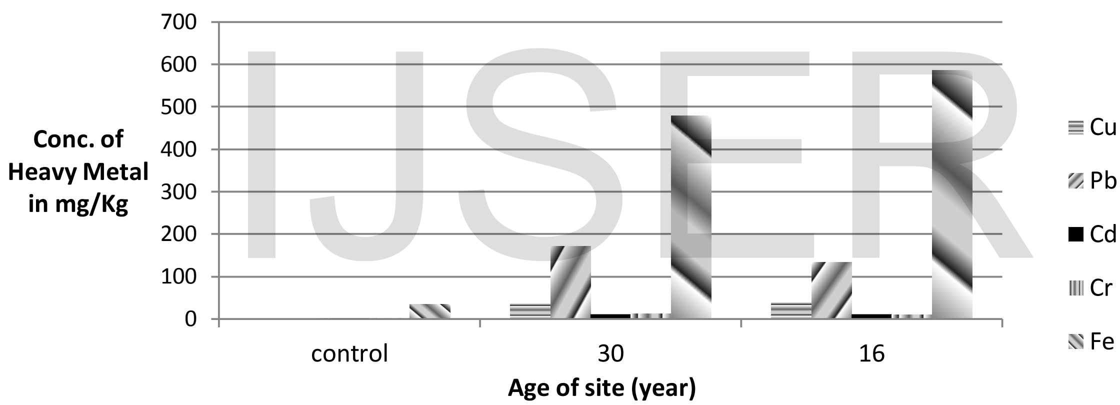

Figure 3: Effect of Age on Heavy Metal Concentration at 20-40 cm depth. Values of Iron and Lead were scaled down to 1: 100

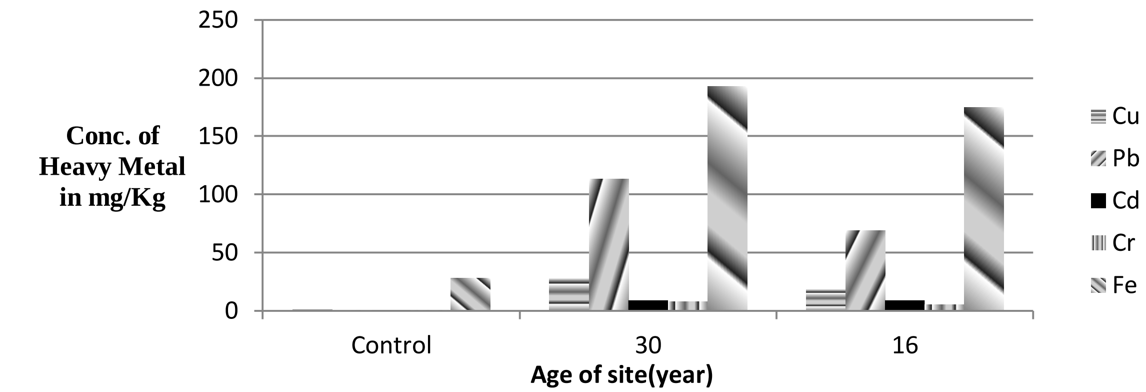

Figure 4: Effect of age on Heavy Metal Concentration at 40-60 cm depth. Values of Iron and Lead were scaled down to 1: 100

3.1 Discussion

The highest values of Cu, Pb and Fe measured at locations A and B(table 2, 3 and 4) are several times higher than the target and intervention values in a standard soil (Table 5), the allowable limits in all the countries (table 6) and the toxic limit of 250mg.kg^{-1} set by [12] for agricultural soils. Values of Cr in locations A and B were below the maximum value 750mg.kg^{-1} set by the [13] for agricultural soils. Almost all the values for location A and B were above the allowable limit (table 6) set by United Kingdom and Luxembourg with Cd limit of 3 mg.kg^{-1}. Soil Cd limit of 1 mg.kg^{-1} is set in Norway [14], Germany, Ireland, Spain and Portugal [15]. Switzerland set a value of 0.8 mg.kg^{-1} for Cd [16] while Sweden set 0.4 mg.kg^{-1} [15] and the values were below the range set by [17],[12] permissible for agricultural soils. Figures 2, 3 and 4 showed that the soil heavy metals content was significantly lower on the control site with no waste, while the oldest automobile site which was about 30 years old had the highest concentration of heavy metals(Pb, Cd and Cr), this is in line with the result obtained by [9]. Lead(Pb) reduced with increased depth which was in line with studies by [18], [19],[20],[21].

The behaviour of heavy metals in the soil all depends on the soil pH, properties of metals, redox conditions, clay content, cation exchange capacity

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and soluble ligands in the surrounding fluid. The pH of the soils under study generally hovers around the slightly acidic to neutral range. These values are expected as most soils in the tropics have their ranging from acidic to slightly neutral [19]. This may be responsible for the relative immobility of the heavy metals in the soils. Heavy metals are generally more mobile in the soil in the acidic pH range. For soil particle size, the distribution of sand fraction was highest followed by clay and then silt (tables 2,3 and 4). Similar observation of sand size fraction dominance had been reported [22],[11]. According to Kadeba,(1978)[23] clay which is an important parameter for predicting the exchange capacity of the subsoil, increased down the profile. The porosity obtained at the three sites was inconsistent (Table 2). It increased with an increasing depth and latter decreased for locations A and B except in the control were it decreased and latter increased with an increasing depth and corresponds with the result of [24].This implies that porosity was high at the top soil, which may be due to the length of time the soil was subjected to automobile waste and the sloppiness of the mechanic villages.

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

metal	Target value Mg/Kg	Intervention value (Mg/Kg)
Ni	140.00	720.00
Cu	0.30	10.00
Zn	-	-
Cd	100.00	380.00
Pb	35.00	210.00
As	200.00	625.00
Cr	20.00	240.00
Hg	85.00	530.00

[25]

Table 6: Allowable limits of heavy metal concentration in soils (Mg/Kg)

Heavy metal	Australia	Germany	France	Luxembourg	Netherland	Sweden	United Kingdom
Cd	1-2	1	2	1-3	0.5	0.4	3
Cr	100	60	150	100-200	300	60	400
Cu	60-100	40	100	50-100	40	40	135
Ni	50-70	50	50	30-75	15	30	75
Pb	100	100	100	50-300	40	40	300

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1.4 CONCLUSION AND RECOMMENDATIONS

Heavy metals concentration was high in soils around automobile mechanic villages. This poses health risks to inhabitants of these mechanic villages. 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. It was also observed that age did not affect the concentration of heavy metals at the study area. 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.

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