

RESPONSE OF HEAVY METALS CONTAMINATED ULTISOL TO ORGANIC AMENDMENTS IN NSUKKA SOUTH-EAST NIGERIA



*AHAMEFULE, H. E.¹, NWOKOCHA, C. C.², IHEM, E.³, AND AMANA, S. M.⁴

¹Department of Agronomy, University of Ilorin, P.M.B.1515, Ilorin, Kwara state, Nigeria ²National Root Crops Research Institute, Umudike, Abia State, Nigeria ³Department of Soil Science and Technology, Federal University of Technology Owerri, Imo State. ⁴Department of Agronomy, Nasarawa State University Keffi, Nigeria. *Corresponding author: ahamefule.he@unilorin.edu.ng, flamepearls@yahoo.com

ABSTRACT

An experiment was conducted in the University of Nigeria Nsukka Teaching and Research Farm to determine the response of heavy metals contaminated Ultisol to organic amendments. The treatments were arranged in a split-plot in Randomized Complete Block Design (RCBD), replicated thrice. Main plot treatments were 0 % (control), 1 %, 2 %, and 3 % waste crank-case oil (source of Zn, Pb, Cr and Fe) applied in a single dose at 0, 10,000, 20,000 and 30,000 mg kg⁻¹ soil, respectively. The sub-plot treatments were control (no amendment = NA), palm oil mill effluent (PE), oil palm bunch refuse (PR) and cassava peels (CS) applied at 12 Mg/ha each, per year. Top soil samples were collected at 0, 3, 6, 12, 18, 24, 30 and 36 months and analyzed for the concentrations of heavy metals (Zn, Pb, Cr and Fe). Results obtained indicated that though the waste crank-case oil led to increased heavy metal concentrations in the treated soils, the observed increments, however, fell within tolerable levels for soil. Among the organic amendments tested for their efficacy to decontaminate heavy metals from soil, PE exhibited the highest efficacy. Keywords: Heavy metals, waste crank-case oil, contamination, organic amendment, Ultisol

INTRODUCTION

Environmental (air, water or land) pollution has been studied to cause severe illness and sudden death in human beings for many centuries and can result from mining, automobile exhaust, agricultural and industrial activities among others. Heavy metals which are chemical elements with a specific gravity that is at least 5 times the specific gravity of water were since classified among major causes of environmentally related health risks (Adedokun et al., 1989; Galadima et al., 2011). Some well-known toxic metallic elements with a specific gravity that is 5 or more times that of water are arsenic, 5.7; cadmium, 8.65; iron, 7.9; lead, 11.34; and mercury, 13.54 (Galadima et al., 2011). Heavy metals occur as natural constituents of the earth crust, and are persistent environmental contaminants since they cannot be degraded or destroyed. Although these elements are lacking in abundance they are not lacking in significance (Chen and Chen, 2001). Mercury and lead for example are widely used in technology but are so toxic that minute quantities can destroy life.

In Nigeria today numerous studies indicated that industrial activities release heavy metals either as solid, gas and most especially liquids in the form of waste water or effluents allowed to drain into water ways or bodies (Ladigbolu and Balogun, 2011). Small scale road side activities of automobile technicians for instance, are also significantly contributing to the transmission of these toxic species (Bryee-Smith, 1971; Garba et al., 2010; Galadima et al., 2010; Ahamefule et al., 2014). Heavy metals can generally be introduced into the environment and consequently living organisms through air, water, food or soil (Ayodele and Abubakar, 2001; Ibeto and Okoye, 2010). However, the concentration and re-concentration depend on the type of heavy metals and the activities taking place in a particular area. In Nigeria today several ways were identified through which specific heavy metal can be transmitted to living species. Continuous use of leaded gasoline contributed greatly to the number of cases of childhood lead poisoning. Leaded gasolines contain lead in the concentration range of 0.65 to 0.74 g/L (Thomas and Kwong, 2001) in Nigeria. Lead pollution from automobile emissions in Nigeria had

been extensively studied and documented in various Nigerian and international publications (Onianwa, 2001; Umoren and Onianwa, 2005). Nriagu et al. (1997) investigated blood lead levels in 87 children aged 1-6 years from Kaduna state. An average of 10.6 µg/dl was found, with some children having up to 30 µg/dl. The values exceeded the maximum allowed limit of 10 µg/dl recommended by Centre for Disease Control (CDC) and correlated linearly with the distance of house from highly trafficking roads, as well as, whether a family owns a car or not. At the beginning of the 21st century Federal Environmental Protection Agency (FEPA) of Nigeria examined the lead concentrations in soils from roads, markets and motor parks of Lagos, Aba, Abuja, Ibadan, Kaduna and Port Harcourt. The results revealed elevated and health threatening concentrations (Ukemenam, 2014). Overload of metal ions in soil environment clearly poses a significant risk to the quality of soils, plants, natural waters and human health (Adraino, 2001). The presence of heavy metals in soil could be a double edged sword ranging from the role in normal growth of plants and living organisms to toxicity associated with presence of certain metals (Pb, Cd and Hg etc). Concentrations of about 100 to 1000 ppm have been recorded depending on the nature of the activities, carried out in a particular area (Galadima et al., 2010; Garba et al., 2010). The bioavailability of metal ions in soils is influenced by the pH, temperature, redox potential, cation exchange capacity, organic matter, competition with other metal ions, composition and quality of soil (Skorda and Kelepertsis, 2005; Machender et al., 2010). Other anthropogenic sources include mining and metallurgic industries, manufacture of batteries, ammunition, pipe, cable sheeting, solder, paint, trash incineration and waste crankcase oil (Edebiri and Nwanokwale, 1981). The principal route of exposure for people in the general population is food and lead in contaminated drinking water, working and hand to mouth activities of young children living in polluted environments and the lead dust brought home by industrial workers on their clothes and shoes (Galadima et al., 2012). Chromium is one of those heavy metals whose concentration steadily increases due to industrial growth, especially the development of chemical and tanning industries. Cement

producing plants are potential sources of atmospheric chromium particulate that are deposited on land and water; and are eventually carried out to river by runoff water (Dan-Azumi and Bichi, 2010). Other Industrial sources of chromium include wastewater from chrome plating, metal finishing industries and textile industries. Other sources of chromium permeating the environment are air, water erosion of rocks, power plants on liquid fuels, brown and hard coal, industrial and municipal waste (Fatoki, 2003).

According to Garbisu and Alkorta (2001) heavy metals cannot be destroyed biologically (non-degradable) but are only transformed from one oxidation state or organic complex to another. The authors observed that as a consequence of the alteration of its oxidation state, metal may become either: (i) more water soluble and are removed by leaching, (ii) inherently less toxic (iii) less water soluble, so that they precipitate and then become less bio-available or removed from the polluted area. One way of doing this is by the addition of nutrients to the soil system to boost the population and hence the activities (bioremediation) of indigenous micro-organisms. Organic materials have been reported to chelate heavy metals thereby rendering them unavailable (Shazia et al., 2015). Therefore, this study was aimed at assessing the efficacy of some cheap and more readily available organic materials as soil amendments in a soil contaminated with heavy metals laden waste crank-case oil. The objectives of this study therefore are two folds; to determine the soil concentration levels of some heavy metals introduced through the disposal of waste crank-case oil, and to assess the efficacy of some organic amendments in reducing the bioavailability of selected heavy metals.

MATERIALS AND METHODS

Site description

This study was conducted from 2006 to 2008 in the Teaching and Research Farm of the University of Nigeria, Nsukka, located by latitude $06^{0}52$ 'N and longitude $07^{0}24$ 'E and at an elevation of 400m above sea level. Mean annual temperature of this location ranges between 26 and 31^oC. The average annual precipitation is about 1700mm (FORMECU, 1998) but the area experiences distinct wet (April to October) and dry (November to March) seasons. Rainfall during the wet season is bi-modally distributed, with peaks in July and September and a short dry spell around mid- August.

The soil was a reddish brown sandy loam Ultisol (Oxic Paleustult) belonging to the Nkpologu series and formed from false bedded sandstone parent materials (Nwadialo, 1989). The site was under natural vegetation fallow, predominantly *Pennisetum purpurem, Mimosa pudica* and *Cynodon dactylon* for about 14 years.

Field Methods

Experimental design and layout

The experiment was a split plot laid out in a Randomized complete Block Design (RCBD) with four (4) levels of waste crank-case oil contamination replicated three (3) times giving a total of 12 plots. Main plot treatments were 0 % (control), 1 %, 2 %, and 3 % waste crank-case oil (source of Zn, Pb, Cr and Fe) applied in a single dose at 0, 10,000, 20,000 and 30,000 mg kg⁻¹ soil, respectively. The sub-plot treatments were control (no amendment = NA), palm oil mill b = slight contamination (0, 1 - 0, 25)

0	- singin containination	(0.1	0.25)
с	= moderate contamination	(0.26	-0.50)

d = severe contamination (0.51 - 0.75)

effluent (PE), oil palm bunch refuse (PR) and cassava peels (CS) applied at 12 Mg/ha each, per year. A land area of 0.0256 ha was used for this study. The main plots measured 15.125 m² ($5.50 \times 2.75 \text{ m}$) while the sub-plots measured 2.75 m² ($2.75 \times 1.0 \text{ m}$).

Field preparations

Soil samples for routine laboratory analyses were collected in a grid of $2 \ge 1$ m, bulked and a composite sample taken for determination of initial physical and chemical properties of the site. Glyphosate, a post emergence herbicide (a.i ispropylamine) and butachlor, a pre-emergence herbicide (a.i.2-chloro-2, 6- diethyl – N (butoxy methyl) acetanilide) were used to control weeds. The plots were manually tilled and the waste crank-case oil applied two weeks before soil amendment to allow for adequate percolation.

Laboratory analysis

Routine laboratory analysis

Determination of soil textural class was achieved by the hydrometer method as described by Gee and Or (2002). Soil pH was measured in 1: 2.5 suspensions of soil in distilled water and 0.1 M KCl (Hendershot *et al.*, 1993). Organic carbon was determined using chromic wet oxidation method according to Nelson and Somers (1982). Total nitrogen was determine by micro-kjeldahl method (Bremner and Yeomans, 1988) while available Phosphorus was determined by Bray II method described by Olsen and Somers (1982).Effective cation exchange capacity (ECEC) was calculated as the sum of the exchangeable bases and exchangeable acidity.

Heavy metal analysis

Bio-available or soluble concentration of heavy metals was determined by Aqua Regia method. The procedure involved digestion of 3 g air dried, pre-sieved (<2 mm), soil samples with 10 ml HCl and 3.5 ml HN0₃. Every digest batch included two blanks and one International Atomic Energy Agency (IAEA) reference sample. The mixtures were left overnight in the digestion block without heating under the switch–on fume cupboard. The following day, they were heated for 2 hours to 140° C, gradually increasing the temperature to control foaming. Distilled water was added to cool the digestates and then filtered with Whattman No. 542 filter paper (pre-washed with 0.5 M HN0₃ and the wash solution discarded) and topped up to 100 ml with distilled water.

The filtrates were analyzed for Al, Cr, Fe, Pb and Zn using Atomic Absorption Spectrophotometer (AAS). The values were compared with the widely used normal and critical levels of total concentrations of heavy metals for soil by Environmental Agencies given by Kabata-pendias and Pendias (1984) as cited by Alloway (1990) (Table 1). The contaminant/pollution limit (C/P index) was calculated as the ratio between the heavy metal content in the soil and the toxicity criteria (the tolerable levels) of Kabata-pendias and Pendias (1984). The C/P index values < 1 indicate soil contamination (C) range values > 1 indicate pollution (P) range. The result was further classified according to Lacatusu (1998) as:

a = very slight contamination (C/P < 0.1)

- e = very severe contamination (0.76 1.00)
- f = slight pollution (1.1 2.0)
- g = moderate pollution (2.1 4.0)

h i

= severe pollution	(4.1 - 8.0)
= very severe pollution	(8.1 - 16.0)

= excessive pollution

(<16.0)

the organic materials				
Parameter	Soil	PE	CS	PR
Sand (g kg ⁻¹)	819	-	-	-
Silt (g kg ⁻¹)	60	-	-	-
Clay (g kg ⁻¹)	121	-	-	-
Textural class	Sandy- loam	-	-	-
pH (1:2.5 H ₂ O)	4.6	-	-	-
pH (0.01MKcl)	3.4	-	-	-
Organic Carbon (%)	1.20	36.4	48.7	60.0
Total N (%)	0.081	2.7	1.0	1.1
C/N ratio	14.8	13.5	48.7	54.6
Available P (mgkg ⁻¹)*/ % P ^a	8.67^{*}	1.2ª	0.6 ^a	1.1 ^a
Exchangeable bases (cmolkg ⁻¹)*				
Na	0.55	-	-	-
K*/ % K ^b	0.02^{*}	2.7 ^b	1.1 ^b	1.6 ^b
Ca	1.14	-	-	-
Mg	3.10	-	-	-
Exchangeable acidity (cmolkg ⁻¹)				
Al ⁺³	1.23	-	-	-
H^+	2.31	-	-	-
ECEC (cmolkg ⁻¹)	8.35	-	-	-

Table 1: Some characteristics of the top	(0 - 20 cm) soil of the experimental site and
the organic materials	

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PE = palm oil mill effluent, CS = cassava peels and PR = palm bunch refuse. *Figures with, a and b indicate unit of parameter for corresponding values.

RESULTS AND DISCUSSION

Properties of the experimental soil and organic amendments

The characterization of the experimental soil (Table 1) indicated that it was sandy-loam, acid in reaction with low nutrient status whereas PE was a richer nutrient source compared to the other organic amendments (CS and PR). The C/N ratio of the organic materials suggests that PE will incorporate and mineralize relatively faster compared to the other amendments. Organic materials with low C: N ratio decomposed faster than those with higher ratios (Nahrawi *et al.*, 2011).

Distribution of Heavy metals and contaminant/pollution limit (C/P index)

The results in Table 2 shows that waste crank-case oil contamination (1 - 3 %) increased Zinc (Zn) concentration of the plots from 20.02 to 27.76 mg kg⁻¹ three (3) months after application. This increase however did not exceed the normal range in soils (Alloway, 1990). Complete biodegradation of Zn was achieved under PE and CS treated plots within 30 months while biodegradation in PR treated plots was about 90 % in 36 months. The Zn reduction under NA plots was however, marginal.

It was observed that Pb concentration in the main plots increased with increase in oil contamination and decreased with time (Table 3). The increase was of the order: 3 % > 2 % > 1 % > 0 % and the differences in treatment means were significant at 5 % probability level. The concentration of Pb under 3% oil treated plots ranged from $6.26 - 11.38 \text{ mg kg}^{-1}$ and concentration under 2 % oil treatment was from 9.65 - 4.95 mg kg⁻¹ while under 1 % oil treatment the values were from $3.07 - 6.14 \text{ mg kg}^{-1}$. For the 0 % oil treatment the concentration ranged between $1.16 - 1.44 \text{ mg kg}^{-1}$.

According to Alloway (1990) the values all fall within normal range in soil. This implies that though the spent oil used in this experiment led to significant increase in the concentration of Zn and Pb, no adverse effect was expected on crops, micro-flora and -fauna following their low concentrations. This observation should not be generalized for waste crank-case oils since "the proportion and type of these heavy metals depend on the process generating the waste crank-case oil" (Edebiri and Nwanokwale, 1981). All the amended plots generally showed evidence of significant (P < 0.05) reduction in Pb concentration relative to unamended plots. In the first 12 months plots treated with PE showed significant decrease in Pb relative to plots under other organic amendments and the un-amended. In the 3 months following contamination, plots under CS, PR and NA did not vary (P < 0.05) in their Pb content. In the 6^{th} month there was significant drop in Pb concentration in CS plots relative to PR and NA with further reduction in Pb concentration in the 12^{th} month. Between 18 - 36 months the organic amendments reduced Pb concentration in the plots following the order: PE > CS = PR > NA.

Increase in waste crank-case oil concentration led to increased Cr concentration in contaminated soils which declined with time (Table 4). Soils under organic amendments generally showed greater reduction in Cr content compared to the un-amended plots. The results generally showed that PE treated plots showed the highest reduction in Cr concentration (20.69 - 34.66 mg kg⁻¹) in 36 months. Over this period (36months) Cr concentration in CS treated soils ranged from 22.77 - 38.16 mg kg⁻¹ and that in PR treated soils from 25.05 - 38.76 mg kg⁻¹ whereas that in NA plots ranged from 38.24 - 39.22 mg kg⁻¹.

Table 2: Effect of organ	ic amendment on Zinc concentration (mg kg ⁻¹) of a spent crank-case oil contaminated top-soil
Oilconcentration	Months	

onconcentration				monuns				
(A) %								
	0	3	6	12	18	24	30	36
0	20.20	19.46	19.34	19.06	18.33	18.16	17.22	16.13
1	20.20	24.74	24.16	23.11	22.84	22.11	20.74	19.74
2	20.20	26.68	26.68	25.26	24.80	24.37	23.31	22.68
3	20.20	27.76	27.76	25.97	25.61	24.58	22.57	19.94
LSD _{0.05}	Ns	1.35	1.58	1.86	2.03	1.55	1.21	1.46
Organic								
amendments (B)								
NA	20.20	25.33	25.27	25.24	25.21	25.14	25.12	25.05
PE	20.20	23.32	22.03	21.87	20.30	21.24	15.74	15.60
CS	20.20	24.82	23.93	22.25	22.11	20.68	20.00	17.64
PR	20.20	25.17	24.98	24.03	23.96	23.16	23.00	20.20
LSD _{0.05}	Ns	1.38	1.15	1.10	1.49	1.20	1.52	1.66

NA = Control, PE = Palm oil mill effluent, CS = Cassava peels and PR = Oil Palm bunch refuse. ns = non significant

Table 3: Effect of organic amendment on Lead concentration (mg kg⁻¹) of a spent crank-case oil contaminated top-soil

Oil				Months					
concentration									
(A) %						/			
	0	3	6	12	18	24	30	36	
0	1.50	1.44	1.41	1.38	1.34	1.31	1.26	1.16	
1	1.50	6.14	5.74	4.76	4.43	3.62	3.51	3.07	
2	1.50	9.65	9.12	8.77	7.88	7.31	6.47	4.95	
3	1.50	11.98	10.90	10.31	9.46	8.33	7.68	6.26	
LSD0.05	Ns	0.57	0.63	0.84	0.72	0.95	0.61	0.50	
Organic									
amendments									
(B)									
NA	1.50	7.83	7.82	7.79	7.77	7.75	7.71	7.68	
PE	1.50	5.33	5.12	5.07	3.34	3.35	1.94	1.86	
CS	1.50	7.67	6.89	5.92	5.43	4.47	4.36	2.75	
PR	1.50	7.76	7.40	6.43	6.20	5.01	4.92	3.16	
LSD _{0.05}	Ns	1.38	1.15	1.10	1.49	1.20	1.52	1.66	
			/	·					

NA = Control, PE = Palm oil mill effluent, CS = Cassava peels and PR = Oil Palm bunch refuse. ns = non significant

Table 4: Effect of organic amendment on Chromium concentration (mg kg⁻¹) of a spent crank-case oil contaminated topsoil

Oil concentration				Months				
(A) %		/						
	0	3	6	12	18	24	30	36
0	25.28	/ 24.77	23.66	23.10	22.40	21.17	20.14	19.99
1	25.28	36.95	33.89	33.15	31.15	29.89	27.19	26.23
2	25.28	40.23	38.02	37.01	35.37	33.51	29.90	27.13
3	25.28	48.84	47.57	46.31	44.53	44.53	39.15	33.90
LSD _{0.05}	Ns	2.98	3.44	3.26	3.02	3.18	3.75	3.51
Organic	/							
amendments								
(B)								
NA	25.28	39.22	39.00	38.97	38.92	38.87	38.76	38.74
PE	25.28	34.66	33.42	33.26	29.12	28.96	22.03	20.69
CS	25.28	38.16	34.77	33.03	31.96	28.91	26.77	22.77
PR	25.28	18.76	35.94	34.30	33.71	31.37	28.82	25.05
LSD _{0.05}	Ns	2.37	2.10	2.10	2.25	2.11	2.10	2.08

NA = Control, PE = Palm oil mill effluent, CS = Cassava peels and PR = Oil Palm bunch refuse. ns = non significant,

The organic amendments showed significant reduction of Fe concentration which increased due to oil contamination of the plots (Table 5). The order of reduction of Fe

concentration in the amended and un-amended plots followed the order PE > CS > PR > NA. It was observed that PE and CS amendments reduced Fe concentration in plots

significantly faster than PR and this may be related to their comparatively lower C: N ratio. Organic materials with low C: N ratio decomposed faster and hence provided binding bases for heavy metals in the soil (Jones et al., 1997). The concentration of Fe in PE, CS, PR and NA plots from the 3rd - 36th month ranged from 4517 - 6290 mg kg⁻¹, 4929 - 6458 mg kg⁻¹, 5223 - 6492 mg kg⁻¹ and 6424 - 655mg kg⁻¹ respectively.

Shown in Tables 6 to 9 are the contaminant – pollution indices (C/P index) calculated for Zn, Pb, Cr and Fe. Table 6 shows that oil contamination did not change the precontamination (moderately contaminated with Zn) status of the experimental soil. In 30 months following treatment, the Zn concentration in oil contaminated but PE amended plots dropped to slight contamination while plots under PR attained the "slight contamination" level in 36months. Only the 3 % spent oil treatment slightly contaminated the plots with Pb and even without organic amendment, the plots were decontaminated within 3 months (Table 7). The mean concentration of Pb in the plots ranged from 0.01 - 0.12 mg kg⁻¹. From Table 8 it was observed that the 2 and 3% oil levels led to severe contamination of plots with Cr within 3 months following oil impact in all the plots that were not PE

amended. However Cr concentration in plots treated with PE was moderate while plots under CS and PR amendments showed moderate Cr contamination in 6 months.

Three (3) months after oil application, it was observed that the 1 % oil treatment did not lead to appreciable contamination of plots with Fe (Table 9), whereas the 2 % and 3 % oil levels led to severe and very severe contamination of plots. Nevertheless, amending the plots with PE restored the contaminated soils back to its moderate contamination level after 36 months. Un-amended but contaminated plots remained under severe Fe contamination through the experiment.

In appraising the levels of soil contamination and pollution with waste crank-case oil-induced heavy metals, a distinction between soil contamination range and soil pollution range was established by means of contamination/pollution index (C/P). This index represents the ratio of the heavy metal content effectively measured in soil by chemical analysis and the toxicity criteria (the tolerable levels). The C/P index lower than 1 characterizes soil contamination range while values higher than 1 characterize the pollution range (Lacatusu, 1998).

 Table 5: Effect of organic amendment on Iron concentration (mg kg⁻¹) of a spent crank-case oil contaminated top-soil

 Oil

0.1				1010110					
concentration									
(A) %					/				
	0	3	6	12	18	24	30	36	
0	4520	4492	4474	4440	4369	4322	4116	3937	
1	4520	5007	4906	4825	4782	4703	4212	3974	
2	4520	7215	7022	6769	6767	6600	6223	5810	
3	4520	9076	8916	8657	8657	8515	7927	7372	
LSD _{0.05}	Ns	391.6	372.7	330.0	386.2	279.1	185.6	208.8	
Organic									
amendments									
(B)			/						
NA	4520	6551	6540	6535	6535	6530	6527	6424	
PE	4520	6290	6097	5703	5703	5695	4561	4517	
CS	4520	6458	6295	6094	6094	5860	5544	4929	
PR	4520	6492	6386	6241	6241	6055	5846	5223	
LSD _{0.05}	Ns	225.5	196.3	150.6	145.4	161.0	165.8	186.2	

NA = Control, PE = Palm oil mill effluent, CS = Cassava peels and PR = Oil Palm bunch refuse. ns = non significant

Table 6: The	C/P (Zinc) index	x of the top-s	oil as influen	ced by waste	crank-case oi	l contaminat	ion and orga	nic amendment
Oil				Months				
concentratio	on 🦯							
(A) %								
	0	3	6	12	18	24	30	36
0	0.29°	0.29 ^c	0.28 ^c	0.27°	0.26 ^c	0.26 ^c	0.25 ^c	0.23°
1	0.29 ^c	0.35°	0.35°	0.33°	0.33°	0.32 ^c	0.30 ^c	0.28 ^c
2	0.29 ^c	0.38 ^c	0.37 ^c	0.36 ^c	0.36 ^c	0.35 ^c	0.34 ^c	0.33°
3	0.29 ^c	0.40 ^c	0.38 ^c	0.37°	0.37°	0.35 ^c	0.33°	0.39°
Organic								
amendments	s (B)							
NA	0.29 ^c	0.36 ^c	0.28 ^c	0.27 ^c	0.26 ^c	0.26 ^c	0.25°	0.23 ^b
PE	0.29 ^c	0.33°	0.35°	0.33°	0.33°	0.32 ^c	0.30 ^c	0.28°
CS	0.29 ^c	0.36 ^c	0.36 ^c	0.36 ^c	0.36 ^c	0.35 ^c	0.34 ^c	0.33°
PR	0.29 ^c	0.36 ^c	0.37°	0.37°	0.37°	0.35 ^c	0.33°	0.29 ^c

NA = Control, PE = Palm oil mill effluent, CS = Cassava peels and PR = Oil Palm bunch refuse.

b

с

$$=$$
 slight (0.1 - 0.25)

$$=$$
 moderate (0.26 - 0.50)

Response of Heavy Metals Contaminated Ultisol to Organic Amendments

Oil				Months				
concentration								
(A) %								
	0	3	6	12	18	24	30	36
0	0.02 ^a	0.01 ^a	0.01 ^a	0.01 ^a	0.01 ^a	0.01 ^a	0.29 ^c	0.27°
1	0.02^{a}	0.06^{a}	0.06^{a}	0.05 ^a	0.05 ^a	0.04 ^a	0.36 ^c	0.35°
2	0.02^{a}	0.07^{a}	0.09 ^a	0.09 ^a	0.09 ^a	0.07 ^a	0.40 ^c	0.36 ^c
3	0.02^{a}	0.012 ^a	0.11 ^b	0.01 ^a	0.10 ^a	0.01 ^a	0.52 ^d	0.45 ^c
Organic								
amendments (H	3)							
NA	0.02^{a}	0.08^{a}	0.08^{a}	0.08^{a}	0.08^{a}	0.08^{a}	0.08^{a}	0.08^{a}
PE	0.02 ^a	0.05 ^a	0.05 ^a	0.05 ^a	0.03 ^a	0.03 ^a	0.02^{a}	0.02 ^a
CS	0.02^{a}	0.08^{a}	0.07^{a}	0.06^{a}	0.07^{a}	0.05 ^a	0.04 ^a	0.03 ^a
PR	0.02^{a}	0.05 ^a	0.07^{a}	0.07^{a}	0.06 ^a	0.05 ^a	0.05ª	0.03 ^a

Table 7: The C/P (Lead) index of the top	o-soil as influenced b	y waste crank-case oi	l contamination and or	ganic amendment
					0

NA = Control, PE = Palm oil mill effluent, CS = Cassava peels and PR = Oil Palm bunch refuse.

b с d

=	slight contamination (0.1 - 0.25)
=	moderate contamination (0.26 - 0.50)
=	severe contamination $(0.51 - 0.75)$

Table 8: The C/P (Chromiu	m) index of t	the top-soi	l as influenced	by wast	e crank-ćase o	oil contamination	and organic
amendment							

Oil	Months								
concentration (A) %									
	0	3	6	12	18	24	30	36	
0	0.34 ^c	0.33°	0.32°	0.01 ^a	0.30 ^c	0.29 ^c	0.29 ^c	0.27°	
1	0.34 ^c	0.50 ^c	0.45°	0.44 ^c	0.42 ^c	0.40 ^c	0.36 ^c	0.35°	
2	0.34 ^c	0.54 ^d	0.51 ^d	0.49 ^c	0.47°	0.45°	0.40 ^c	0.36 ^c	
3	0.34 ^c	0.65 ^d	0.64 ^d	0.62^{d}	0.59 ^d	0.45 ^c	0.52 ^d	0.45°	
Organic									
amendments (B)									
NA	0.34 ^c	0.52 ^c	0.52 ^d	0.44 ^c	0.52 ^d	0.39°	0.52 ^d	0.52 ^d	
PE	0.34 ^c	0.46 ^c	0.45°	0.37°	0.39°	0.39 ^c	0.30 ^c	0.28 ^c	
CS	0.34 ^c	0.51 ^d	0.47°	0.37°	0.43°	0.39°	0.36 ^c	0.30 ^c	
PR	0.34 ^c	0.52 ^d	0.48°	0.38 ^c	0.45°	0.42 ^c	0.39°	0.34 ^c	
			/						

NA = Control, PE = Palm oil mill effluent, CS = Cassava peels and PR = Oil Palm bunch refuse. Лb

с

d

slight contamination (0.1 - 0.25) =

moderate contamination (0.26 - 0.50)= =

severe contamination (0.51 - 0.75)

Table 9: The C/P (Iron) index of the top-soil as influenced by waste crank-case oil contamination and organic amendment Oil

OII				Monuis					
concentration									
(A) %									
/	0	3	6	12	18	24	30	36	
0	0.41 ^c	0.41 ^c	0.41 ^c	0.40 ^c	0.40 ^c	0.39 ^c	0.37°	0.36 ^c	
1	0.41°	0.45 ^c	0.45°	0.44 ^c	0.43 ^c	0.43 ^c	0.38°	0.36 ^c	
2	0.41°	0.65 ^d	0.64 ^d	0.61 ^d	0.61 ^d	0.60^{d}	0.56^{d}	0.53 ^d	
3	0.41 ^c	0.82 ^e	0.81 ^e	0.80 ^e	0.79 ^e	0.35 ^c	0.72 ^d	0.67 ^d	
Organic									
amendments (B)									
NA	0.41°	0.59 ^d	0.58 ^d	0.59 ^d	0.59 ^d	0.59 ^d	0.59 ^d	0.58 ^d	
PE	0.41°	0.57 ^d	0.55 ^d	0.55 ^d	0.52 ^d	0.52 ^d	0.41°	0.41 ^c	
CS	0.41°	0.59 ^d	0.57 ^d	0.56^{d}	0.55 ^d	0.53 ^d	0.50°	0.45°	
PR	0.41°	0.59 ^d	0.58 ^d	0.57 ^d	0.57 ^d	0.55 ^d	0.53 ^d	0.47°	

NA = Control, PE = Palm oil mill effluent, CS = Cassava peels and PR = Oil Palm bunch refuse.

b

= slight contamination (0.1 - 0.25)

- = moderate contamination (0.26 0.50)
 - = severe contamination (0.51 0.75)
 - very severe contamination (0.76-1.00)
 - composting process. *Afri. J. Biotechnol.* 9(16): 2427 2436.
- though the oil contamination brought about significant increase in heavy metals concentration, the increases were still within tolerable levels for soil micro-fauna, -flora and higher plants (Lacatusu, 1998) since the contamination threshold was not exceeded. Nevertheless in nonexperimental conditions where there may be increased presence of the studied heavy metals in the soil system due to accident or improper disposal of waste crank-case oil and other heavy metals laden domestic and industrial wastes, the PE organic amendment has shown high efficacy for decontamination of soil borne heavy metals. According to Azhari et al. (2010) PE is composed of high organic content, mainly oil and fatty acids and is able to support bacterial growth to reduce pollution. It was reported that PE application to soil can result in some beneficial soil chemical and physical characteristics, such as increases in organic matter, organic carbon, major nutrients like N and P, waterholding capacity and porosity (Logan et al., 1997; Mantzavinos and Kalogerakis, 2005). Nwaugo et al. (2008) found that light application of POME caused significant increase in total heterotrophic, phosphate solubilizing, nitrifying and lipolytic bacteria counts. These effects of PE on soil Physical, chemical and biological properties, reported by earlier researchers is thought to have contributed to remarkably higher heavy metal decontamination observed in PE treated soils.

The results obtained, therefore, generally showed that

c d

e

=

CONCLUSSIONS

The waste crank-case oil used led to significant increase in Zn, Pb, Cr and Fe in the treated soil; however the concentration of these heavy metals were found to be within tolerable limits for soil. The PE amendment was the most effective in heavy metals decontamination of the treated soil. **REFERENCES**

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