Effects of compost application on remediation and the growth of maize planted on lead contaminated soil

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Abstract
A field experiment was conducted in 2008 and 2009 to test for the effects of Mexican Sunflower (SW) and Cassava waste (CW) composts as well as inorganic fertilizer on the growth of maize planted on lead contaminated soil. Different application rates of 0t/ha, 20t/ha and 40t/ha were used for the two types of compost while inorganic fertilizer and 0t/ha were used as checks. The experiment was laid out in Randomized Complete Block Design with four replicates. It was observed that compost application increased significantly the vegetative and yield parameters of maize and performed better than inorganic fertilizer ($P<0.05$). Higher dose (40t/ha) of MSW compost gave the highest plant height, dry matter yield, leaf area and grain yield. More importantly, the experiment shows that there was a reduction in the final concentration of lead in soils of all the compost treated plots by 50-70%. Though, application of compost did not restrict the uptake of lead by the maize crop the concentrations were lower than those of control and inorganic fertilizer plants. Higher concentrations were also detected in the root than other plant parts. This method of remediation could be recommended for restoration of lead contaminated sites.

Key Words
Soil, compost, heavy metals, contamination, maize.

Introduction
Lack of and reduction in cultivable and productive land has been attributed to soil contamination from high rate of industrialization and urbanization (UNEP 2000). UNEP (1992) calculated that 2 billion hectares of land that was once biologically productive has been irreversibly degraded in the past 100years due to contamination and inaccessibility. Land contamination/degradation is a threat to sustainable agricultural development and food security in developing countries. Among all the degraded lands, those contaminated with heavy metals are largely irreversible and where reversibility is attempted, it is at high cost (Oldema, 1994). It has therefore become imperative that the environment and its resources should be managed judiciously to enhance sustainable national and socio-economic development. Efforts have been made by different researchers to remediate contaminated soils using different methods. However, it is very important that any method used should be environment-friendly and cost-effective. This explains the present promotion of compost-bioremediation for land reclamation (USEPA 1997). However, there is dearth of information on the use of compost on contaminated land in Nigeria. This research work was designed to test for the efficacy and optimum application rates of composts and inorganic fertilizer on the performance of maize grown directly on the field contaminated with battery wastes.

Methods
Description of experimental site;
In this study, the dumpsite of the defunct Lead - Acid Battery Manufacturing Company in Ibadan, Nigeria was used (Figure 1). Initial soil analysis for environmentally available form of heavy metals such as Pb, Cu, Zn, Cd, and Cr in mg/kg using model 210A of the Buck Scientific Atomic Absorption Spectrophotometer series with Air-Acetylene gas mixture as oxidant under different wavelengths after hot digestion with 2M HNO_3 (Ogundiran, 2007) was carried out before application of compost.

Experimental procedure
The treatments used include CONTROL (without compost or inorganic fertilizer), SWR2 (Mexican Sunflower compost at 20t/ha), SWR5 (Mexican Sunflower compost at 40t/ha), CWR2 (Cassava waste at 20t/ha), CWR5 (Cassava waste at 40t/ha) and F1 (Inorganic fertilizer - NPK at 100KgN/ha) using experimental design of Randomized Complete Block (RCBD) and replicated four times. Data were collected on the vegetative parameters and grain yield of maize, Post-harvesting soil and plant tissue Pb

concentrations. Analysis of variance and Duncan's multiple range test of Statistical Analysis System package (1998) was used to analyze the data.

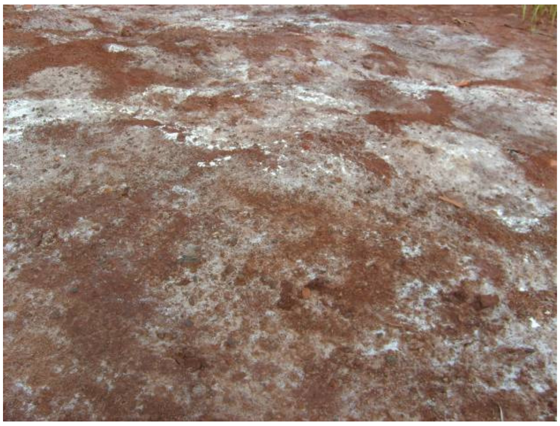

Figure 1. Experimental site before demarcation.

Results

The level of lead and Cd were extremely high in this soil while those of Zn, Cu, and Cr are relatively high (Table 1) when compared with the levels of these metals in uncontaminated soil (Kabata-Pendias and Pendias, 2001; Ogundiran and Osibanjo, 2009). Based on the mean values of the growth and yield of maize, application of compost produced significantly taller plants, higher number of leaf and leaf area over control and inorganic fertilizer (Figure 2) due to the ability of compost to supply the soil with required nutrients (Sadovnikova, 2002). Among the two types of compost applied at the rate of 40t/ha, mexican sunflower compost gave the highest maize yield (Figure 3). Application of sunflower compost at the rate of 40t/ha reduced the level of Pb in the soil by 72% followed by that of cassava waste compost, also applied at the same rate (67%) (Figure 4) due to reduction in the solubility and mobility of trace metals in the soil with appreciable content of organic matter (Williams *et al.* 1980; Renevan *et al.* 2007). The total level of Pb in the maize plant tissues from all the compost treated plots were significantly lower than those treated with inorganic fertilizer and control ($P<0.05$) (Table 2).

Table 1. Pre-cropping soil physico-chemical analysis.

Properties	Pb	Cu	Zn	P	Cr	Cd	pH	OC	N	Ca	Mg	K
	(--------------------------		mg/kg			--------------------------)		(%)	(%)	(-----cmol/kg-----)		
Soil	138,000	612	990	138	8	34	4.2	1.03	0.1	4.3	1.48	0.03

Conclusion;

It could be concluded that application of compost improved soil fertility and increased the plant resistance to heavy metal toxicity thereby enhancing plant growth and dry matter yield of maize in heavy metal polluted soil.

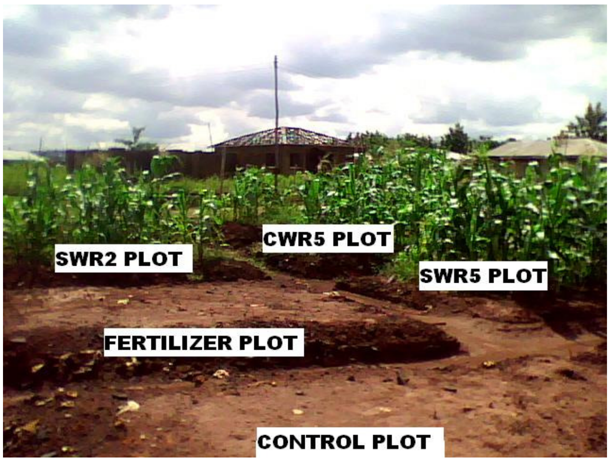

Figure 2. Experimental site at twelve weeks after planting showing the plants in control plot and the plots treated with inorganic fertilizer, Mexican sunflower compost at 20t/ha (SWR2), Mexican sunflower compost at 40t/ha (SWR5), Cassava waste compost at 20t/ha (CWR2) and Cassava waste compost at 40t/ha (CWR5).

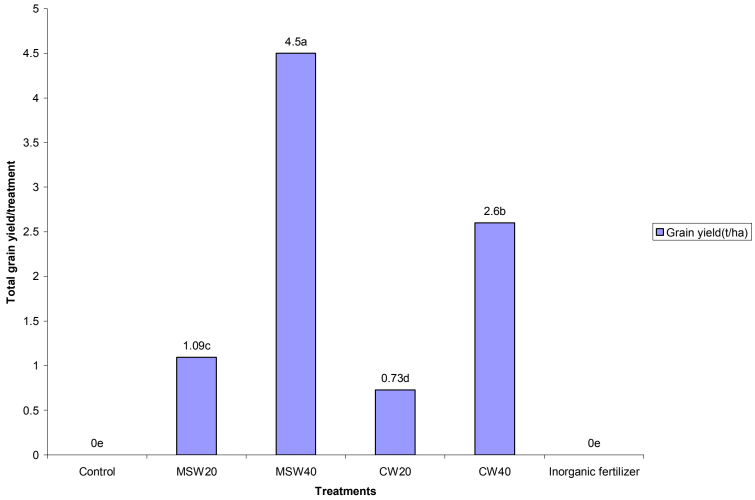

Figure 3. Effects of compost source and rates on total grain yield by maize
Bars carrying the same letter are not significantly different from each other at 5% level of significance
F1= Inorganic fertilizer, MSW20= Mexican Sunflower at 20t/ha, MSW40= Mexican Sunflower at 40t/ha, CW20= Cassava waste at 20t/ha, CW40= Cassava waste at 40t/ha.

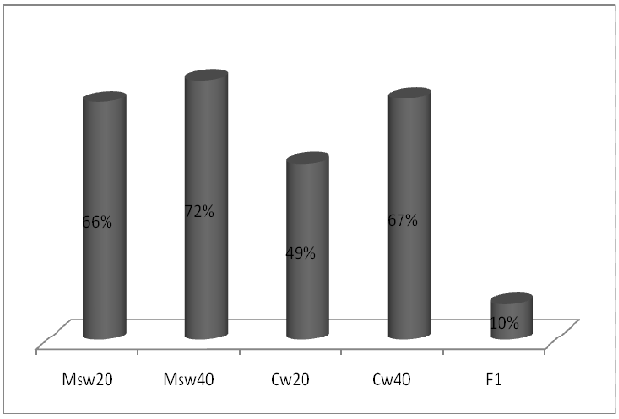

Figure 4. Effects of compost and inorganic fertilizer on percentage reduction in Pb concentration of post harvesting soil; F1= Inorganic fertilizer, MSW20= Mexican Sunflower at 20t/ha, MSW40= Mexican Sunflower at 40t/ha, CW20 = Cassava waste at 20t/ha, CW40 = Cassava waste at 40t/ha.

Table 2. Effects of different rates of sunflower, cassava waste compost and inorganic fertilizer on the Pb(%) concentration in maize plant parts at harvesting on the field.

Treatments	Seed (%)	Cob	Sheath	Leaf Pb	Stem	Root	Total
Control	0.02^b	0.01^a	0.02^b	0.05^b	0.03^c	1.34^a	1.46^a
MSW_{20}	0.02^b	0.01^a	0.01^c	0.02^c	0.02^d	1.12^b	1.25^b
MSW_{40}	0.02^b	0.01^a	0.02^b	0.05^b	0.03^c	1.14^{ab}	1.26^b
CW_{20}	0.03^a	0.00^b	0.03^a	0.02^c	0.04^b	1.14^{ab}	1.27^b
CW_{40}	0.03^a	0.01^a	0.03^a	0.02^c	0.12^a	0.87^c	1.07^d
F1	0.02^b	0.01^a	0.02^b	0.06^a	0.03^c	1.35^a	1.47^a

Means followed by the same letter in a column for the treatments and weeks are not significantly different from each other at $P<0.05$.
MSW20= Mexican sunflower compost at 20t/ha, MSW40= Mexican sunflower compost at 20t/ha, CW20= Cassava waste compost at 20t/ha, CW40= Cassava waste compost at 20t/ha, F1=Inorganic fertilizer.

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