Moor Journal of Agricultural Research 13(1). 11 - 30 2012

Influence of different types of Organic Materials on Soil Remediation and Performance of Maize (*Zeamays* L.) Grown on a Lead Contaminated Soil

Adejumo,S.A.[1] Togun,A.O[1] and Adediran, J.A[2]

[1]*Crop Protection and Environmental Biology Department, University of Ibadan, Ibadan. Nigeria.*
[2]*Institute of Agricultural Research and Training, Moor Plantation, Ibadan. Nigeria.*
Corresponding author's email address: nikade_05@yahoo.com.

Abstract

Accumulation of heavy metals in agricultural soils results in long term environmental problem, elevated heavy metal uptake by crops and food poisoning. Remediation of sites contaminated by heavy metals is therefore pertinent. Incubation and greenhouse studies were conducted to test for the effects of different types of compost on soil remediation and the growth of maize planted on remediated battery wastes contaminated soil. Composts made from five different plant materials (Soyabean stover (SS), Maize Stover (MS), Mexican Sunflower (SW), Cassava Wastes (CW) and Neem Seeds (NS) as well as Poultry Manure (PM) alone and Organo-mineral fertilizer (OM) were used. Each was applied at the rate of 20 t/ha. Pre-cropping soil chemical compositions showed that lead concentration (148000 mg/kg) was significantly higher than the permissible level (300 $mgkg^{-1}$) at the study site. Results of incubation studies revealed a progressive reduction in heavy metal concentrations for the sampling periods. MSW and CW composts significantly reduced soil lead by 39% and 38% respectively followed by SS (33%), MS (28%), PM (26%), NS (25%) and OM (23%). Application of compost to the contaminated soil also enhanced vegetative growth of maize when compared with control. SS, CW, NS, MS, MSW, OM, and PM increased the dry matter yield by 49%, 60%, 56%, 24%, 68%, 55% and 27% respectively over control. Unlike the maize plants grown on organic amended contaminated soil, control plants started showing toxicity symptoms such as necrotic lesions, chlorosis, wilting and eventual death. Organic amendment also increased nutrients uptake by maize crop compared to control plants. Generally organic amendments proved effective in remediation of heavy metal contaminated soil and had ameliorative effects on crop growing on contaminated soil. Among the organic amendments, MSW and CW performed better.

Keywords; Bio-remediation, Compost, Soil fertility, Battery wastes, Heavy metals

Introduction

Increase in urbanization and industrialization has been blamed for the contamination of the environment by toxic heavy metals such as Hg, As, Pb, Cd Cr, and Zn. This according to UNEP (2000) was attributed to the indiscriminate disposal of wastes containing heavy metals without proper treatment. For example, when batteries are improperly disposed of, they pose environmental and human health hazards. The general effects of heavy metals most especially lead on the environment have been extensively reported (Pallavi and Dubey, 2005; Ogundiran, 2007) and this poses significant threat to public health through food chain. Soil degradation, air and water pollution are some of the ecological consequences (Aina and Adedipe, 1996) of heavy metal contamination. It damages the ecosystem and has serious negative effects on agricultural activities. A number of studies have shown that heavy metals can cause serious problems to plants through reduction in photosynthesis, unbalanced nutritional status and excessive production of reactive oxygen species which in turn induces oxidative stress (Seregin *et al.*, 2004).

With increasing awareness of the consequences of land contamination by heavy metals, several attempts have been made by environmentalists to remediate contaminated soil and enhance crop growth. These have been carried out through the use of different techniques such as bioremediation, chemoremedia-tion escavation and landfilling, phytoremediation, soil washing and flushing (Chaney *et al.*, 2000; Cao *et al.*, 2003; Clemente *et al.*, 2006; Ogundiran, 2007). These methods however, are either expensive or ecologically unacceptable. Moreover, a major objective of remediation of contaminated site is to ensure that the area can be put to other acceptable uses without causing further damages. There is thus the need to device an efficient but cheap method of soil reclamation. Consequently, remediation of lead (Pb) contaminated soils has been carried out by many authors through changing of the soil chemistry and structure with the application of microbial and organic amendments (Tordoff *et al.*, 2000; Cao *et al.*, 2003; Clemente *et al.*, 2006; Renevan *et al.*, 2007). Plant based organic amendment generally are known to contain high levels of organic matters, nitrogen, phosphorous and potassium in varying degrees depending on the type of plant (Parr *et al.*, 1984; Adetunji, 1997; Togun *et al.* 2003) and have the ability to bind heavy metals in the soil (Chaney *et al.*, 2000) most especially when used as compost.

Compost is said to be rich in organic compound and its application to soil has been found to improve soil fertility (Guidi *et al.*, 1988; Adediran *et al.*, 1999; Togun *et al.* 2003) remediate heavy metal contaminated soil through immobilization and complexation (Dale *et al.* 2006; Han *et al.* 2008). They also act as buffer system for pH value and ion concentrations (Petruzzel *et al.* 1989). Addition of green waste compost was found to reduce the concentration of heavy metals like Zn and Cd in the leachate and highest reduction obtained at the highest level of Green waste compost (Renevan *et al.*, 2007). The dry matter production of Rye grass grown on soil contaminated with high level of heavy metals amended with compost was increased. The leaf concentration of heavy metals was also found to be significantly reduced with compost amendment and the root concentration of Cd, Pb and Zn decreased by up to 47% compared to control (Renevan *et al.*, 2007). Addition of household waste compost and wood chips also reduced the concentration of free Cu^{2+} in the soil and water but increased the concentration of complexed Cu^{2+} (Kiikkila *et al.*, 2002). By composting selected plant materials a microbial active humic substrate are said to be generated. Some of which support vast numbers of soil inhabiting organisms and transform certain unwanted chemicals and biological entities into end products generally harmless to man, animals and plants (Chaney *et al.*,2000).

Different types of compost have been reported to have different effects on growth parameters (Arthur, 1994). For example, *Tithonia divesifolia* (Mexican Sunflower) have shown a dramatic improvement in crop yield when the biomass was applied as compost (SACRED, 2007). According to Radwanski and Wickens (1981), neem is a special tree with high medicinal values. It has the ability to control crop pest and at the same time increase the fertility of the soil. For example, neem seeds powder when mixed with soil gave the highest dry matter yield in nematode-infected soyabeans when compared with karate and control treatments (Adejumo, 2004). Maize-stover compost reportedly produced taller plants with more leaves while cowpea stover compost produced more branches and dry matter per plant (Adediran *et al*.,2003). Compost has been reported to improve the growth of maize (Akanbi, 2002). Maize has also been reported to be tolerant to heavy metals (Luo *et al.*, 2005; Koma'rek *et al.*, 2007). There is paucity of informa-tion at the moment, especially in Nigeria, on the use of compost for remediation of heavy metal-contaminated soil to enhance revegetation and crop growth Hence, this research work was designed to test for the efficacy of different types of organic materials on the remediation of heavy metal contaminated soil and the performance of maize planted on such soil.

Maize crop *(Zea mays* L.) was used as a test crop on this contaminated soil because of its popularity most especially in Nigeria and Sub-saharan Africa.

Materials and Methods

Source of experimental soil, collection and pretreatments

Contaminated soil for these experiments was collected from battery wastes dumpsite at Kumapayi village, Ibadan, Oyo State, Nigeria where battery slag wastes were illegally dumped by a defunct battery manufacturing company several years ago (Plate 1). The soil was sampled at 0-15cm depth from five equidistant points. Mixed thoroughly, air-dried, crushed and sieved through 2mm meshes and composite sample taken for physico-chemical analysis such as pH (H_2O), Exchangeable bases, total nitrogen (N), percentage carbon, phosphorous (P), copper (Cu), zinc (Zn), cadmium (Cd), chromium (Cr) and lead (Pb) as well as Organic Carbon, Exchangeable acidity and exchangeable cation. Total nitrogen was determined using Kjedahl method (Bremmer, 1965). Available P(mg/kg) by the Bray 1 method and total P(mg/kg) by Vanado-Molybdate method.

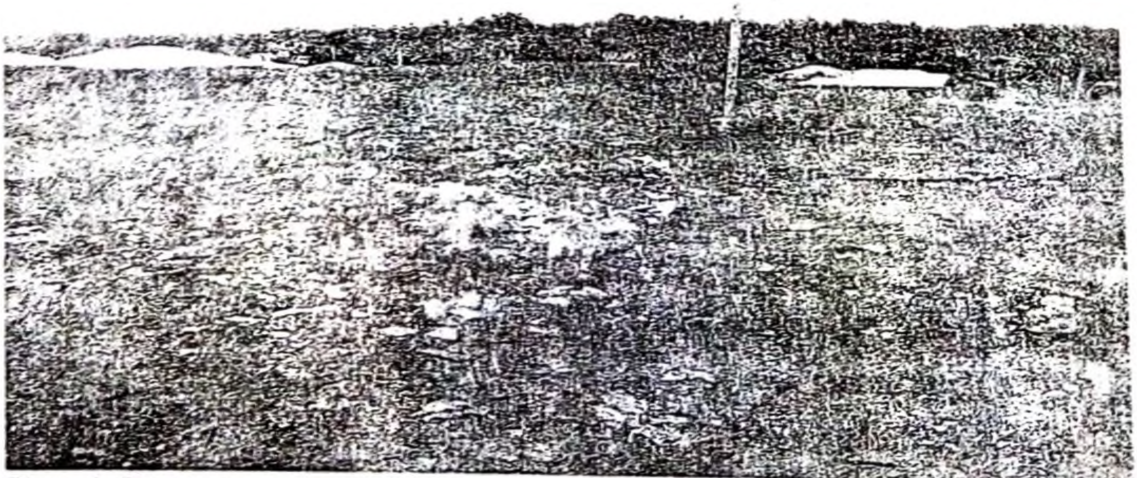

Plate 1. The battery wastes contaminated dump-site at Kumapayi, Ibadan, Nigeria

Percentage organic carbon was determined by chromic acid digestion (i.e Walkley and Black method) by adding 10 mls of potassium dichromate solution (1N $K_2Cr_2O_7$) from an automatic burrette to 1g of soil sample. Thereafter, 20 mls of Concentrated H_2SO_4 from an acid dispenser was added carefully, shaken gently and left to cool. 10mls of 4% $BaCl_2$ was then added and allowed to stand for 6hrs to separate the solution from soil particles. The supernatant was then decanted and percentage organic carbon content determined colorimetrically. The percentage organic matter was calculated by multiplying %C by a factor of 1.724 (IITA, 1979). Ammonium acetate (pH 7) 1N was used to extract exchangeable bases from soil samples after shaking for 30mins and the cations determined using the flame photometer. Total concentration of heavy metals such as Pb(mg/kg), Cu(mg/kg), Zn(mg/kg), Cd(mg/kg), and Cr(mg/kg) were determined using Atomic Absorption Spectrophotometer under different wavelength after wet digestion. The wet digestion was done by adding 10ml of 2M HNO_3 into 1g of already sieved soil inside a covered 50ml centrifuge tube and heated for 2hours in a water bath at 90 – 100°C. This was later cooled and filtered through Whatman filter paper. The resulting solution was then diluted to predetermined volume and stored in cleaned polyethylene bottles in a refrigerator at -4°c until analysis (Ogundiran, 2007). Also, soil pH was measured using a pH meter-Electrometric Method in 1:1 w/v of soil to water. This was repeated for post-cropping soil analysis.

Organic materials and their preparations

Eight treatments; Control (i.e. only contaminated soil), Soyabean straw compost, Maize stover compost, Cassava waste compost, Mexican Sunflower compost, Neem seeds compost, Poultry manure alone and Organo-mineral fertilizer (OM) were used. Compost were prepared from different plant materials namely; Neem seeds (NS), Soyabean stover (SS), Maize stover (MS), Cassava wastes (CW) and Mexican sunflower (MSW). These were mixed separately with Poultry manure (PM) in ratio 3:1 using Partially aerated composting technology (Adediran et al., 2003) and composted for two months. Samples of matured composts were also analysed separately for heavy metals (Pb, Cu, Zn, Cd and Cr), P, N, K, Ca and Mg using standard procedure (Akanbi, 2002). Organomineral fertilizer and PM were also used separately.

Experimental procedure

The experiment consisted of the incubation and greenhouse studies. Incubation study was carried out at the Land and Water Resources Management Programme Laboratory of the Institute of Agricultural Research and Training, Ibadan, Nigeria (IAR&T) under normal room conditions to determine the direct effects of organic materials on heavy metal concentrations in soil-compost mixture. Only contaminated soil was used for this experiment without planting of a test crop. Specific quantity of 1 kg dry weight soil was sieved into a beaker and watered with distilled water to field capacity after it had already been mixed with each type of organic material. The treatments were arranged in Completely Randomized Design (CRD) and replicated four times. Changes in heavy metal concentrations were studied for the period of 8 weeks and the beakers were watered as required using distilled water. During this period, samples were taken from each beaker for analysis following standard procedure. The first sampling was done on the day of application of treatments. Others were at one week, four weeks and eight weeks after application of treatments. The experiment lasted for the period of 8weeks.

Greenhouse study

To determine the effect of different organic materials on the remediation of heavy metal contaminated soil and performance of maize crop grown on it, a greenhouse/pot experiment was also carried out at the greenhouse of I.A.R&T., Moor Plantation, Ibadan, Nigeria. The soil collected from the contaminated site was also used. It was first sieved using 2mm diameter sieve and 5kg soil was then mixed thoroughly with organic materials before packing it into each pot (5-litre capacity with 22cm surface diameter). Application rate of 20t/ha was used for all the organic materials, equivalent to 50g/5kg soil. The soil was watered to field capacity and left for one week before planting. The pots were arranged in Completely Randomized Design (CRD) and replicated four times. Four maize seeds were then planted inside each pot. The emerging maize seedlings were later thinned down to two per pot at two weeks after planting. The experiment was terminated at eight weeks and repeated for residual test in the same pots.

Data collection in the greenhouse

Data on the following growth parameters of maize were collected starting from two weeks after planting and at two weeks interval. Stem height, number of leaves, and leaf area. The leaf area was measured by taking the maximum length and breadth at midleaf of the green leaves of the 2 plants in the pot and multiplying their products by 0.75 (Francis *et al.*, 1969). The stem height was taken with a tape rule from the ground level to the base of the youngest unfolded leaf for the 2 plants/pot and the mean height/plant was obtained. At harvesting (8weeks after planting) the plants were cut from the soil surface. The roots were carefully uprooted and washed in a bucket of water to loosen and recovered maximum root. The shoots were partitioned into leaves and stems before oven-drying at 80^{0}C to a constant weight. They were later weighed to know the dry matter yield.

Plant tissue Analysis

Chemical analysis of the ash content was also carried out to know the concentration of heavy metals in the plant. The oven-dried plant materials were milled in a Willey mill to pass through 1mm sieve. 1.0g of dried finely ground plant samples was weighed into porcelain crucibles for dry ashing at 450°C for 18 hours and dissolved in 10mls of 2M HNO_3. The aliquot was filtered and the filtrate was put in 25ml volumetric flask and made up with distilled water (Ogundiran, 2007). The samples were analysed for Pb, Cu, Zn, Cd, Cr, Ca, Mg, P, Na and P. For total N determination, the milled samples were subjected to Kjeldahl digestion at 360°C for 4 hours with concentrated sulphuric acid using selenium catalyst. Total N was

Table 2. Chemical compositions of different types of organic materials used for the experiments.

Chemical properties	MS	NS	CW	SS	MSW	PM	OM
N(%)	1.44	1.46	1.93	1.63	2.17	0.48	1.22
P(mg/kg)	2170	1680	930	1070	2470	1380	1950
K(cmol/kg)	128	107	110	67.0	61.5	2.11	55.1
Ca(mg/kg)	25700	22300	36300	31200	37100	36400	20700
Mg(mg/kg)	5220	4190	5290	5600	12900	4960	6110
Na(cmol/kg)	22.10	16.90	20.30	4.45	32.90	20.40	35.70
Cr(mg/kg)	5.25	10.00	6.00	10.80	10.30	27.50	10.80
Pb(mg/kg)	0.20	0.20	0.20	0.20	0.20	10.00	ND
Cu(mg/kg)	42.60	37.60	24.90	28.90	23.40	44.10	33.50
Zn(mg/kg)	213	174	141	190	162	551	504
Cd(mg/kg)	0.93	0.98	0.83	1.05	0.88	1.45	0.95

MS=Maize Stover Compost; NS=Neem Stover Compost; CW=Cassava Waste Compost; SS=Soyabean Stover Compost; OM=Organomineral; PM=Poultry Manure; MSW=Mexican Sunflower Compost; ND=Not Detected

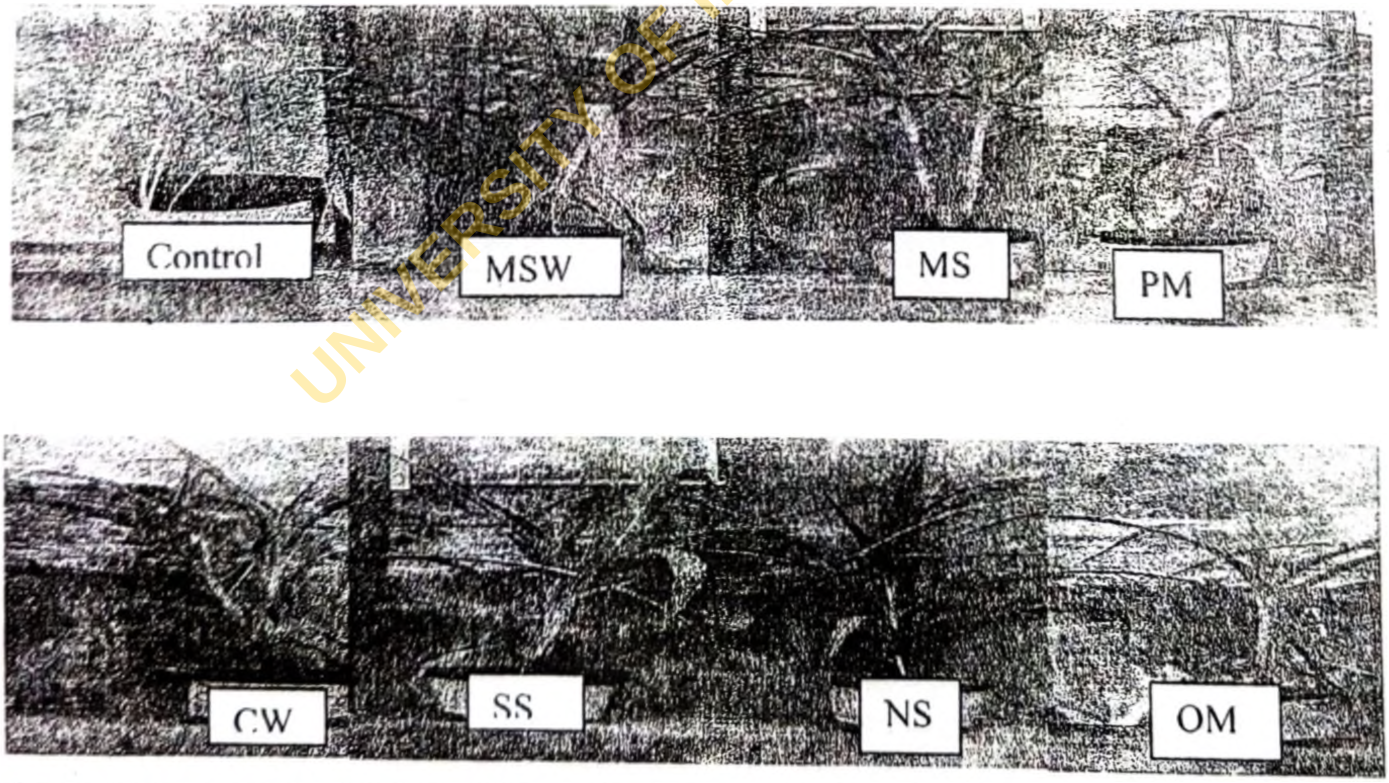

Plate 2. Maize seedlings in all the treatments at four weeks after planting

determined from the digest by steam distillation with excess NaOH.

Statistical analysis

Data were analyzed statistically using analysis of variance and Duncan multiple range test was used to separate the significant treatment means.

Results

Pre-cropping soil analysis

The soil was highly contaminated with lead (Pb). The level of which was abnormally high (138000mg/kg) compared to the acceptable/ tolerable level (0-300 mg/kg) by European Union Standard (2002) in unpolluted agricultural soil. The soil was acidic with pH (H_2O) of 4.33. and low in all the essential elements such as nitrogen, phosphorous, potassium and organic carbon, the values were: 0.10 %, 8.8 mg/kg, 0.03 cmol/kg and 1.22 % respectively. All these suggested that the soil was highly contaminated with heavy metals and low in essential macro elements (Table 1).

Nutrient composition of matured composts used for the experiment

Among the five types of compost used, the percentage nitrogen (N%) was highest in MSW (2.17 %) followed by CW (1.93%), SS (1.63%), NS (1.46%) MS (1.44%) and OM (1.22 %). The lowest was recorded in PM (0.48%) while potassium was highest in MS (127.74 cmol/kg). Also, P, Ca and Mg were the highest in MSW with 2470mg/kg, 37100mg/kg and 12900mg/kg respectively. Lower concentrations of Fe, Zn and Cu were observed in MSW and CW composts. The highest values of all the heavy metals (Cr, Pb, Cu, Zn and Cd) were recorded in PM (27.50 mg/kg, 10 mg/kg, 44.1 mg/kg, 550 mg/kg and 1.45 mg/kg respectively) while the lowest were recorded in MSW, CW and NS composts. Overall, the concentrations of all the heavy metals tested for in these composts are below the permissible levels (Han *et al.*, 2008). The maximum permissible concentrations in the compost are set for Cd, Pb, Cr, Cu and Zn, with values of 5, 150, 300, 500 and 900 mg/kg, respectively. Fe concentration in OM fertilizer (5750 mg/kg) and PM (5,550 mglkg) were higher than the concentration in other materials while the lowest was recorded in CW and MSW of 650 mg/kg and 550 mg/kg respectively (Table 2).

Table I. Precropping soil physico-chemical characteristics

Soil physic-chemical properties	Values
pH	4.33
Exchangeable Bases (cmol/kg)	
Ca	4.30
Mg	1.48
K	0.03
C(%)	1.22
N(%)	0.10
P (mg/kg)	8.8
Mn(mg/kg)	74.3
Pb (mg/kg)	138,000
Cd(mg/kg)	34.0
Cu(mg/kg)	612
Cr (mg/kg)	8.00
Zn(mg/kg)	1990

Heavy metal concentration in soil at different sampling periods during incubation study

There was a significant difference in the lead (Pb) concentrations of all the compost amended soils and control starting from the day of application of treatments (DOA) to eight weeks after compost application (8WACA). The lead concentrations were reduced in these soils compared with control. From one week (1WACA) to four weeks (4WACA) and eight weeks after application of compost (8WACA). There was a significant reduction in the Pb concentration of all the compost-treated soils whereas, the Pb concentration in the control soil remained constant. Application of MSW, CPW, SS, OM and NS composts however reduced the Pb concentration more than PM and MS composts at 4WACA. At 8WACA, MSW, SS, NS and CPW treated soils had the Pb concentrations which were not significantly different from each other but were significantly lower than other treatments (Table 3). At DOA, there was a reduction in the Cd concentration of all the compost amended soil except in PM treatment where the Cd concentration was even higher than that of control. Like Pb, the concentration of Cadmium also started dropping from 1WACA and continued to 8WACA. At 8WACA, the concentration had reduced significantly in all the compost amended soil with the lowest recorded in MS followed by NS. The concentrations of copper and zinc were also affected during incubation studies. Cu was reduced considerably in the soil treated with poultry manure at 8weeks after compost application while the highest was recorded in the soil treated with soyabean stover at this period. The lowest Zn concentration was recorded with the application of MSW and the highest was recorded in the control at 8WACA (Table 4).

Development of vegetative characters in maize plant.

Though, 100% germination was recorded in all the treatments including control, but from two weeks after seedling emergence, the maize plants in the control started showing toxicity symptoms such as necrotic lesions, chlorosis, wilting and eventual death while the maize plants in the soil treated with organic materials were luxuriant (Plate 2). Application of organic materials enhanced the vegetative growth of maize in all the ammended soils with significantly higher number of leaves, plant height and leaf area over control. Soil amendment with MSW and CW composts enhanced leaf area production and plant height more than other compost types (Table 3). The number of leaves in maize plants grown on soil treated with MS, PM and OM were not significantly different from each other but were superior to control ($P<0.05$) (Table 5).

Dry matter accumulation

Dry matter accumulation was influenced by the application of compost. There was a significant increase in the total dry matter accumulation of maize plant grown on compost treated soil over that of control. Application of compost prepared from MSW and CW gave the highest dry matter yield of 18.96 and 18.05 g/pot respectively in maize. These were higher than the total dry matter produced by maize plants grown on soil treated with NS (17.61 g/pot) and SS (16.84 g/pot) composts. Control plant had the lowest dry matter (11.31 g/pot) followed by the plants treated with PM and MS compost of 13.95 g/pot and 14.07 g/pot respectively. Overall, SS, CW, NS, MS, MSW, OM, and

Table 3. Effects of compost on Pb and Cd concentrations at different sampling period during incubation study

Treat-ments	DOA	1WACA	4WACA	8WACA	DOA	1WACA	4WACA	8WACA
			Pb(g/kg)			Cd(mg/ kg)		
Control	137.4^{a}	141.0^{a}	137.0^{a}	138.0^{a}	32.5^{a}	26.7^{b}	28.3^{a}	23.0^{a}
PM	127.5^{b}	96.6^{b}	93.8^{b}	91.4^{c}	37.8^{a}	29.3^{a}	25.4^{b}	21.6^{b}
CPW	128.2^{b}	80.7^{cd}	83.1^{c}	84.5^{d}	28.5^{a}	18.5^{d}	17.5^{d}	18.5^{c}
MSW	121.1^{b}	88.2^{c}	96.9^{b}	84.0^{d}	26.4^{c}	20.5^{c}	19.5^{c}	17.6^{d}
MS	126.5^{b}	94.5^{b}	96.1^{b}	97.4^{b}	24.1^{d}	24.9^{f}	20.6^{c}	13.6^{f}
SS	122.3^{b}	97.1^{b}	92.4^{b}	89.8^{d}	23.9^{d}	21.4^{c}	17.0^{d}	17.0^{d}
NS	126.2^{b}	87.0^{b}	90.3^{b}	88.3^{d}	27.8^{c}	23.0^{f}	13.1^{e}	15.4^{e}
OM	122.1^{b}	87.6^{c}	93.0^{b}	93.2^{c}	23.7^{d}	21.3^{c}	19.3^{c}	20.5^{b}

Means followed by the same letter in a column are not significantly different from each other at $P<0.05$ by DMRT
OM=Organomineral; MS=Maize Stover Compost; NS=Neem Seeds Compost; CPW=Cassava peel waste Compost; SS=Soyabean Stover Compost;
PM=Poultry Manure Compost; MSW=Mexican sunflower Compost
DOA=Day of application of compost, 1WACA= One week after compost application, 4WACA= 4weeks after compost application, 8WACA= 8 weeks after compost application.

Table 4. Effects of compost on Cu and Zn concentrations at different sampling period during incubation study

Treatments	DOA	1WACA	4WACA	8WACA	DOA	1WACA	4WACA	8WACA
			Cu(g/kg)			Zn(g/kg)		
Control	0.4^{b}	0.4^{c}	0.4^{b}	0.4^{c}	2.7^{a}	2.7^{a}	2.9^{a}	2.7^{a}
PM	0.4^{b}	0.4^{c}	0.4^{b}	0.1^{c}	2.8^{a}	2.7^{a}	1.3^{c}	1.2^{b}
CPW	0.4^{b}	0.4^{c}	0.3^{c}	0.4^{c}	1.7^{c}	1.6^{cd}	1.8^{b}	1.0^{c}
MSW	0.4^{b}	0.3^{d}	0.3^{c}	0.5^{b}	2.5^{b}	1.2^{d}	1.0^{c}	1.0^{c}
MS	0.7^{a}	0.5^{b}	0.3^{c}	0.4^{c}	1.9^{c}	1.8^{c}	1.5^{b}	1.0^{c}
SS	0.4^{b}	0.2^{d}	0.4^{b}	0.6^{a}	2.8^{a}	1.9^{b}	1.0^{d}	1.0^{c}
NS	0.7^{a}	0.6^{b}	0.5^{b}	0.3^{d}	1.8^{c}	1.2^{d}	1.0^{d}	1.0^{c}
OM	0.4^{b}	0.9^{a}	0.9^{a}	0.3^{d}	2.8^{a}	2.2^{b}	1.0^{d}	1.0^{c}

Means followed by the same letter in a column are not significantly different from each other at $P<0.05$ by DMRT
OM=Organomineral; MS=Maize Stover Compost; NS=Neem Seeds Compost; CPW=Cassava peel waste Compost; SS=Soyabean Stover Compost;
PM=Poultry Manure Compost; MSW=Mexican sunflower Compost
DOA=Day of application of compost, 1WACA= One week after compost application, 4WACA= 4weeks after compost application, 8WACA= 8weeks after compost application.

Table 5. Effects of different types of organic materials on growth characteristics

Treatments	Number of leaves	Leaf area (cm^{2})	Plant height (cm)
SS	11.90^{a}	210^{b}	88.60^{a}
CW	12.10^{a}	219^{a}	89.30^{a}
NS	11.50^{a}	212^{b}	84.00^{ab}
MS	11.80^{a}	217^{a}	84.30^{ab}
MSW	12.00^{a}	220^{a}	89.70^{a}
CONTROL	9.90^{b}	158^{c}	68.60^{c}
PM	11.30^{a}	209^{b}	79.90^{b}
OM	11.20^{a}	211^{b}	82.60^{ab}

Means followed by the same letter in a column are not significantly different from each other at $p<0.05$ by DMRT. MS=Maize Stover Compost; NS=Neem Stover Compost; CW=Cassava Waste Compost; SS=Soyabean Stover Compost; OM=Organomineral; PM=Poultry Manure; MSW=Mexican Sunflower Compost

Table 6. Dry matter partitioning and accumulation in maize plant parts in g/pot

Treatments	Leaf (g/pot)	Stem (g/pot)	Root (g/pot)	Total (g/pot)
SS	6.80^{a}	5.74^{ab}	4.29^{b}	16.84^{a}
MSW	6.52^{ab}	6.22^{a}	4.21^{a}	18.96^{a}
CW	6.93^{a}	4.86^{bc}	4.86^{b}	18.05^{a}
PM	5.24^{b}	4.75^{bc}	3.96^{c}	13.95^{b}
OM	6.34^{ab}	6.19^{a}	4.71^{b}	17.24^{a}
NS	6.35^{ab}	5.29^{ab}	5.98^{a}	17.61^{a}
MS	5.53^{abc}	4.84^{bc}	3.70^{ab}	14.07^{b}
CONTROL	4.64^{d}	3.88^{c}	2.79^{c}	11.31^{c}

Means followed by the same letter in a column are not significantly different from each other at $p<0.05$ by DMRT. MS=Maize Stover Compost; NS=Neem Stover Compost; CW=Cassava Waste Compost; SS=Soyabean Stover Compost; OM=Organomineral; PM=Poultry Manure; MSW=Mexican Sunflower Compost

PM increased the dry matter yield by 49%, 60%, 56%, 24%, 68% , 55% and 27% respectively over control. On dry matter partitioning, diversion of dry matter to leaf was enhanced in maize plant grown on soil treated with CW and SS composts with 6.93g and 6.80g respectively. There were no differences (P<0.05) in the dry matter accumulation in the leaves of maize plants grown on soil treated with NS compost (6.35 g/pot), OM (6.34 g/pot) and MSW compost (6.52 g/pot). These however, were significantly higher than those treated with PM (5.24 g/pot) , MS (5.53 g/pot) and Control (4.64 g/pot). Accumulation of dry matter in the root was enhanced with the use of NS compost (5.98 g/pot) which was higher than those obtained from applying SS, CW and SW composts. PM and OM produced root dry matter yield which were not different from each other but were superior to control (Table 6).

Total nutrients and heavy metal concentrations and distribution in the maize seedlings at harvesting

The results of the concentrations of nutrients and heavy metals in maize seedlings after harvesting showed that, Lead (Pb) concentration was the highest in all the treatments. This was followed by calcium (Ca) and the lowest was Magnesium (Mg). All the heavy metals except Cr, Cu and Mn were more in the control plant. The highest concentrations of Cu and Mn were recorded in plant treated with Organomineral fertilizer (OM) while Cr was more in the plant treated with CW. On the other hand the essential elements like Nitrogen, Phosphorous, Magnesium and Calcium were higher in the plants treated with composts. SS treatment increased the nitrogen and calcium concentration in maize seedlings while PM increased P, Pb and Mg concentrations in maize plants more than other treatments. Total concentrations of Cadmium and Zn, were higher in Control plants. On the cumulative lead accumulation in the whole

Table 7 Effects of organic materials on the total nutrient concentrations in the maize plant tissue

Treatments	N(%)	P(%)	Mg(%)	Ca(%)	Cd(mg/kg)	Zn(mg/kg)	Cu(mg/kg)	Pb(%)	Cr(mg/kg)	Mn(mg/kg)
CW	2.31^{g}	1.24^{b}	0.82^{d}	0.95^{g}	91.90^{c}	478^{c}	294^{c}	7.17^{d}	47.00^{a}	362^{c}
SS	3.71^{a}	0.84^{d}	0.63^{f}	1.66^{a}	105^{b}	476^{c}	310^{bc}	8.98^{c}	25.00^{bc}	204^{e}
NS	3.20^{d}	0.43^{g}	0.89^{c}	1.28^{d}	105^{b}	484^{c}	316^{bc}	8.98^{c}	27.00^{bcd}	403^{b}
MS	3.44^{b}	0.48^{f}	0.74^{e}	1.13^{e}	104^{b}	432^{d}	254^{d}	8.14^{c}	13.00^{de}	356^{c}
OM	3.08^{e}	0.53^{e}	0.65^{f}	1.42^{b}	105^{b}	553^{b}	337^{a}	8.77^{c}	23.00^{cde}	453^{a}
PM	2.50^{f}	1.48^{a}	1.14^{a}	1.02^{f}	95.90^{bc}	421^{d}	328^{ab}	9.71^{b}	23.00^{g}	366^{c}
MSW	3.38^{c}	0.52^{e}	1.01^{b}	1.25^{d}	77.60^{d}	425^{d}	211^{e}	5.89^{f}	11.00^{e}	333^{d}
CONTROL	0.89^{h}	0.81^{c}	0.76^{e}	1.33^{c}	120^{a}	585^{a}	328^{ab}	9.77^{a}	36.50^{ab}	352^{c}

Means followed by the same letter in a column are not significantly different from each other at $P<0.05$ by DMRT
OM=Organomineral; MS=Maize Stover Compost; NS=Neem Seeds Compost; CW=Cassava Waste Compost; SS=Soyabean Stover Compost;
PM=Poultry Manure Compost; MSW=Mexican sunflower Compost

plant tissue, the plant treated with MSW recorded the lowest Pb percentage of (5.55%) which was followed by those of SS (6.98%), NS (7.08%), MS (7.14%) and CW (7.17%). The Pb concentrations in the control plant was the highest (9.77%) followed by those of the plants treated with PM (9.71%). The lowest level of Cu, Cd, Cr, Mn, Zn and Pb were recorded in the maize seedlings treated with MSW-compost compared with other treatments (Table 7).

In term of distribution, the concentrations of the entire elements analyzed for were highest in the roots compared to leaves and stems in the descending order except for Zn and P where the concentrations in the stems were higher than those of the leaves. Chromium was only detected in the stem of maize seedlings treated with CW-compost and control. Highest concentration of N was recorded in the leaves of plant treated with MSW compost. PM treated plants had the highest concentration of Pb and Mg in their leaves. The concentration of Cu, Zn, and N were the lowest in the leaves of plant treated with CW-compost Copper (Cu) was not detected in the stem but was present in the leaves with the highest concentration in the root. Likewise, Chromium also was not detected in the stem of maize seedlings of all the treatments except those of control and CW-compost treatments (Data not shown).

Effects of different types of organic amendment on the concentration and mobility of lead in the maize plant parts.

Generally, lead accumulation was highest in the root of all the plant while the concentrations in the shoot was low. The concentration of Pb in the leaves was in turn higher than those of the stems. The same trend was observed in all the treatments including Control. However, the Pb accumulation in the root of the maize plant grown on MSW, NS, MS, SS, CW, OM and PM ammended soil was reduced by 45.5%, 29.2%, 28.9%, 28.5%, 27.8%, 12.6% and 2.6% respectively compared with Control.

In the stem, the concentration of Pb were reduced in all the treatments including control to 0.02%, 0.01%, 0.04%, 0.02%, 0.02%, 0.02%, 0.07% and 0.02% in OM, PM, MSW, CW, NS, SS, MS and control respectively compared to the root (Table 5). The highest percentage of 0.07% was recorded in the stem of the plant treated with MS. The leaf of the plant treated with SS had the lowest percentage of lead (0.07%) while the highest percentage was recorded in OM (0.33%) and PM (0.32%) when compared with others including control (Table 8).

General effects of organic materials on post-cropping soil chemical characteristics.

Organic amendment had significant effects on the soil chemical characteristics. In the first planting application of organic materials increased the nitrogen, calcium, magnesium, copper and phosphorous contents of the contaminated soil more than control. Phosphorus content was generally increased by the application of compost with the highest recorded in Mexican sunflower-compost (MSW) followed by NS-compost. A remarkable reduction in the Pb concentration was however, obtained with organic amendments. MSW and CW composts significantly reduced soil lead by 39% and 38% respectively followed by SS (33%), MS (28%), PM (26%), NS (25%) and OM (23%). Higher concentration of P (335 and 312mg/kg) were recorded in soil treated

Table 8. Concentration and distribution of lead in the maize plant parts.

Treatments	Stem Pb(%)	Root Pb(%)	Leaf Pb(%)	Cumulative Pb(%)
CW	0.02	6.95	0.20	7.17
NS	0.02	6.82	0.24	7.08
SS	0.02	6.89	0.07	6.98
MSW	0.04	5.25	0.21	5.55
MS	0.07	6.85	0.22	7.14
Control	0.02	9.63	0.12	9.77
OM	0.02	8.42	0.33	8.77
PM	0.01	9.38	0.32	9.71

MS=Maize Stover Compost; NS=Neem Stover Compost; CW=Cassava Waste Compost; SS=Soyabean Stover Compost; OM=Organomineral; PM=Poultry Manure; MSW=Mexican Sunflower Compost

Table 9. Effect of organic amendments on post-cropping soil chemical composition

Soil chemical characteristics	CW	SS	MS	NS	MSW	CONTROL	OM	PM
Pb (%)	7.78^{d}	8.56^{cd}	9.28^{bc}	9.57^{bc}	7.76^{d}	10.8^{a}	9.90^{ab}	9.50^{bc}
Cr(mg/kg)	9.50^{c}	10.30^{a}	10.80^{a}	10.80^{a}	7.50e	9.85^{b}	9.00^{c}	8.25^{d}
Zn(mg/kg)	1210^{a}	1210^{a}	1190^{a}	1190^{a}	1190^{a}	1200^{a}	1190^{a}	1190^{a}
Cu (mg/kg)	415^{a}	420^{a}	412^{a}	420^{a}	432^{a}	397^{b}	435^{a}	405^{a}
Cd(mg/kg)	53.61^{a}	53.40^{a}	47.80^{bc}	46.50^{bc}	43.00^{c}	53.50^{a}	47.10^{bc}	51.00^{ab}
pH	5.20^{b}	5.05^{b}	5.10^{b}	5.20^{b}	5.60^{a}	4.10^{c}	5.20^{b}	5.30^{ab}
P(mg/kg)	312^{ab}	287^{abc}	247^{bc}	301^{abc}	335^{a}	216^{c}	243^{bc}	223^{c}
C (%)	2.28^{b}	2.44^{ab}	2.35^{ab}	2.49^{ab}	3.15^{a}	0.64^{c}	2.18^{b}	2.07^{b}
Ca(cmol/kg)	7.51^{b}	7.88^{b}	7.86^{b}	8.76^{ab}	8.07^{ab}	6.57^{c}	8.80^{a}	8.86^{a}
Mg(cmol/kg)	2.96^{b}	2.80^{b}	2.08^{c}	3.31^{a}	3.06^{a}	1.11e	2.27^{cd}	2.26^{d}
K(cmol/kg)	1.07^{ab}	1.33^{a}	1.41^{a}	0.98^{abc}	1.39^{a}	0.38^{c}	0.82^{abc}	0.38^{bc}
N(%)	0.22^{c}	0.21^{c}	0.26^{a}	0.23^{abc}	0.24^{dbc}	0.03^{d}	0.24^{abc}	0.25^{ab}

Means followed by the same letter in a row are not significantly different from each other at $P<0.05$ by DMRT. MS=Maize Stover Compost; NS=Neem Stover Compost; CW=Cassava Waste Compost; SS=Soyabean Stover Compost; OM=Organomineral; PM=Poultry Manure; MSW=Mexican Sunflower Compost

with MSW and CW respectively compared with other treatments. Phosphorus content was generally increased by the application of compost with the highest recorded in Mexican sunflower-compost (MSW) followed by NS-compost. Addition of compost to contaminated soil increased the organic carbon content of already degraded soil with MSW compost superior to other compost types. There was no changes in the OC content of control soil. Soil pH was only increased slightly with the application of compost when compared with control. The pH in all the compost amended soil ranged from 5.0 to 5.6. The concentrations of Zn and Cu were also reduced even in the control soil. Conversely, organic amendment rather than reducing Cd concentration in the soil, compared to initial concentration, an increase was observed in all the treatments including

Table 10. Residual effects of organic materials on the growth characteristics of maize grown in the pot experiment.

Growth characteristics	Main planting	Residual planting
Plant height (cm) at 4WAP	40.80^{b}	62.80^{a}
Plant height(cm) at 8WAP	117.00^{a}	65.20^{b}
Leaf area(cm^2) at 4WAP	225.50^{a}	87.60^{b}
Leaf area(cm^2) at 8WAP	325.90^{a}	108.90^{b}
Number of leaves at 4WAP	6.13^{b}	7.50^{a}
Number of leaves at 8WAP	10.80^{b}	12.20^{a}
Leaf dry weight(g)	13.10^{a}	4.10^{b}
Stem dry weight(g)	13.30^{a}	1.95^{b}
Root dry weight(g)	9.06^{a}	2.86^{b}

Means followed by the same letter on the same row are not significantly different from each other at $P<0.05$ by DMRT
WAP = Weeks After Planting

control except in the soil treated with MSW (Table 9).

Residual effects of organic materials on the growth of maize in the pot experiment.

In residual experiment, application of compost also had significant effect on all the growth parameters compared with control. However, the results of all the growth parameters taken (i.e leaf number, leaf area, plant height and dry matter yield) when compared with those of the first planting showed that maize growth was enhanced in the first planting more than residual as the values obtained in the first planting were significantly higher than those obtained in the residual planting. The reductions were mostly noticed in the plant treated with MS and OM. The difference between the main and residual planting with respect to dry weight of leaf stem and root were 9.00g, 11.4g and 6.19g respectively. The mean height per plant in the first planting at 8 weeks after planting and leaf area were reduced by 51.602cm and 217.828cm^2 respectively. The plants in all the treatments were stunted with yellow leaves and premature wilting. Conversely, in the residual planting the numbers of leaves in all the treatments were increased considerably and were significantly higher than those of the main planting except in control (Table 10).

Residual effects of organic materials on post-harvesting soil chemical characteristics

In residual planting, initial treatments of contaminated soil with organic amendments increased the concentrations of macronutrients in the soil compared to control. Addition of MSW increased significantly the level of Phosphorous and pH more than all other treatments, while Pb, Zn and Cd were significantly reduced when compared with that of control and other treatments. All the organic amendments except MSW and CW increased significantly the residual concentration of Pb in this soil more than control treatment with the highest recorded in OM treatment. Amendment with poultry manure increased the residual contents of soil carbon, phosphorus and calcium though not significantly different from other organic amendments but magnesium and nitrogen concentrations were significantly increased by this treatment (Table 11).

Discussion

Application of compost improved growth and dry matter accumulation in maize plant and proved effective in remediating heavy metal polluted soil. Differences in nutrients and heavy metal concentrations of different types of organic material used in this study were similar to what was previously reported (Webber and Webber, 1983; Tiquia *et al.*, 2002). This can be explained by the non-homogeneity in compost materials. The presence of heavy metals in the compost was said to be derived from PM due to the feed additives used in preparing animal feeds that contained high levels of Pb, Zn and Cu (Han *et al.*,2008). This could also be the reason for high level of Pb in PM. In addition, most of the dietary Zn and Cu is not absorbed in animal bodies but excreted in animal manures (Sims and Wolf, 1994; Nicholson *et al.*, 1999). The heavy metal contents of all the composts used in this study were however

Table 11. Residual effects of organic materials on post-harvesting soil chemical characteristics

Soil chemical characteristics	CW	SS	MS	NS	OM	PM	MSW	CONTROL
Pb (%)	8.21^{f}	9.18^{e}	10.00^{cd}	11.30^{a}	10.20^{b}	10.40^{b}	7.79^{g}	9.63^{d}
Mn(mg/kg)	253^{a}	240^{b}	239^{b}	239^{c}	245^{a}	230^{c}	245^{b}	234^{bc}
Cr(mg/kg)	3.25^{d}	3.50^{b}	3.50^{b}	3.25^{d}	3.00^{e}	2.75^{f}	7.50^{b}	3.75^{a}
Zn(mg/kg)	124^{b}	125^{ab}	125^{ab}	126^{ab}	125^{ab}	126^{a}	119^{ab}	123^{ab}
Cu(mg/kg)	420^{c}	460^{a}	430^{bc}	425^{cd}	422^{de}	397^{f}	432^{b}	427^{bc}
Cd(mg/kg)	50.70^{b}	50.30^{b}	49.50^{bc}	48.00^{bc}	48.70^{bc}	49.50^{bc}	45.20^{b}	55.90^{a}
pH	5.60^{a}	5.20^{b}	5.20^{b}	5.30^{b}	5.60^{ab}	5.30^{b}	5.70^{a}	4.60^{c}
P(mg/kg)	37.00^{c}	36.60^{bc}	39.00^{b}	37.40^{bc}	39.90^{bc}	38.20^{bc}	46.20^{a}	33.60^{d}
C(%)	2.36^{a}	2.25^{a}	2.53^{a}	2.11^{a}	2.46^{a}	2.64^{a}	2.24^{a}	0.63^{b}
Ca(cmol/kg)	8.36^{cd}	7.95^{de}	8.11^{cde}	6.96^{f}	9.53^{ab}	9.78^{a}	8.57^{bc}	7.42^{e}
Mg(cmol/kg)	3.73^{b}	2.77^{d}	3.30^{b}	2.11^{f}	3.78^{ab}	3.98^{a}	3.31^{b}	2.23^{e}
Na(cmol/kg)	3.93^{bc}	3.60^{d}	4.16^{a}	3.20^{e}	3.90^{c}	4.04^{ab}	3.90^{bc}	4.16^{a}
K(cmol/kg)	1.06^{b}	1.05^{b}	1.32^{a}	0.66^{c}	0.56^{c}	0.49^{d}	0.76^{c}	0.46^{d}
N(%)	0.21^{b}	0.22^{b}	0.21^{b}	0.20^{b}	0.10^{c}	0.24^{a}	0.20^{b}	0.09^{c}

Means followed by the same letter in a row are not significantly different from each other at $P<0.05$ by DMRT
OM=Organomineral; MS=Maize Stover Compost; NS=Neem Seeds Compost; CW=Cassava Waste Compost; SS=Soyabean Stover Compost; PM=Poultry Manure Compost; MSW=Mexican sunflower Compost

below the limits proposed by the regulatory agency (Han *et al.*, 2008),

Seed germination was not inhibited in this soil due to the fact that lead (Pb) which was the major contaminant has been reported to have less severe effects on germination (Koeppe, 1977) except in salt form whereby osmotic stress might likely be induced. However, The toxicity symptoms of stunted growth, chlorosis, necrotic lesions and wilting observed in the control plants could be attributed to the high level of lead in the soil as elevated concentration of either essential or non-essential elements in the soil is said to be phytotoxic. Nevertheless, the germination and initial survival of maize plant in the control experiment could also be attributed to the adaptability nature of maize crop as most crops belonging to carbon four (C4) plants (Grass species) are known to be tolerant to toxic environment (Daniel, 1997; Dale *et al*., 2006).

In all the growth parameters taken, compost treated soils gave the highest results due to the ability of compost to supply soil with all the essential nutrients (Togun *et al*. 2003). Overall, Mg, Ca, OC, K, P and pH were increased with compost amendments whereas Pb was significantly reduced most especially in the soil treated with MSW. The use of compost creates soil conditions that probably immobilized contaminants whilst providing favourable plant growth conditions in terms of nutrition and water retention. This confirms the findings of Chaney *et al* (2000), Clemente *et al.* (2003), and Dale *et al*. (2006) that application of compost no doubt contributed greatly to the plant growth in the treated soils more than control. Effectiveness of each compost was found to depend primarily on type of plant materials used. This correlates with the findings of Adediran *et al.,* (2001., Salati *et al.,* 2010). Production and stabilization of compost is highly important in agriculture. Higher dry matter yield observed in compost treated plants could be the outcome of increased leaf area development and longer sustenance of growth more than control irrespective of lead toxicity. While the lower dry matter yield in control could be as a result of high level of Pb in the leaves which had been reported to affects negatively the opening and closing of the stomata (Seregin *et al.*, 2004). This reduces the photosynthetic ability of the plant and subsequent storage of dry matter. Competition between the nutrient and toxic metal cations probably results in dilution of toxic metal concentration in plant tissues (Greeger *et al.*,1991). This also was probably responsible for stunted growth and yellow leaves observed in the control experiment where there was no such competition.

High calcium and phosphorous content in soils as reported by Chaney *et al.*, (2000) helps in reducing lead level and toxicity due to the formation of calcium and phosphorous complexes with lead thereby reducing its solubility. It is therefore not surprising that maize plant grown on soil amended with MSW compost with high concentrations of these cations had the lowest concentration of lead in their tissues. Also, higher nutrient contents of MSW could be responsible for the high leaf area, plant height and total dry matter yield recorded in the plant grown on contaminated soil treated with this compost. It has also been observed that nutrient enriched soil such as compost amended soil reduces the bioavailability of exchangeable fractions of metals thereby reducing their uptake due to the binding of the metals to nutrient anions (Timothy *et al.*,2001). Increase in the soil OC due to compost addition has also been reported to reduce the bioavailable fraction of Pb thereby preventing its uptake by plants (Kiikkila *et al.*, 2002). This according to Kabata *et al* (2001) was attributed to the high affinity of humic acid in the organic matter which is contained in the compost for Pb. The inselectivity nature of the plant root as a result of mass flow of nutrient in the rhizophere across the root cell wall could have contributed to high level of Pb in the root (Pallavi and Dubey 2005). The binding of lead has also been reported to occur more in lignified tissues of the root epidermis than non-lignified tissue (Greger *et al.*,1991; Agneta *et al.*,2004; Seregin *et al.*,2004). Small amount was detected in the vascular tissues which explain the poor movement to aerial parts.

The reduction in the growth parameters during residual trial was probably due to the rate of compost used which confirms the findings of Akanbi (2002) that effectiveness of organic manure is concentration and time dependent. It has also been previously reported by some researchers (Renevan et al., 2007; Salati et al., 2010) who criticized the use of compost for remediation of contaminated site that the heavy metals initially binded by organic materials might be made available for plant uptake in the long run. This actually was observed in the results of residual soil analysis with high Pb concentrations more than those recorded in the first planting and control treatment.

Conclusion

It is therefore concluded that, soil remediation technique that makes use of compost appears to have great potential for cleaning up of heavy metal contaminated soil better than organomineral or poultry manure applied alone. This method is environment - friendly and cost-effective. It avoids dramatic landscape disruptions, and preserves the ecosystem. Among the composts evaluated, MSW, SS and CW composts appeared to be the most effective. Although the heavy metal contents of all the composts used in this study were below the limits proposed by the regulatory agency, more frequent monitoring and strict standards for heavy metals are necessary in relation to compost quality control. Optimum application of the organic amendments must also be determined and effectiveness of different materials tested under field conditions.

References

Adediran J. A, Debact N., Mnken P.N.S., Kiekero L., Muyiwa N.Y.O and Thys A. (2001) Organic waste materials for soil fertility improvement in the Border Region of the Eastern Cape, South Africa. Biological Agriculture and Horticulture, pp, 283-300.

Adediran J.A., Taiwo L.B., Sobulo R. A. (2003). Effect of organic wastes and Method of composting on compost maturity, Nutrient composition of compost and Yields of two vegetable crops. *Journal of Sustainable Agriculture, 22 (4): 95-109*

Adediran, J.A., Taiwo, L.B. Akande, M.O. and Sobulo, R.A. (1999). Comparative effect of organic based fertilizer and mineral fertilizer in the dry matter yield of maize. *Bioscience Research Communications* 11(4): 17-24.

Adejumo, S.A. (2004). Comparative effects of powdered NS (*Azadirachta indica* a-juss) and Karate on growth yield and food components of nematode infected soyabean (Glycine max L.Merrill). M.Sc. Project. Department of Crop Protection and Environmental Biology. University of Ibadan. 156pp.

Adetunji, M.T. (1997). Organic Residue Management, soil nutrient changes and maize yield in a humid ultisol. *Nutrient cycling in Agroecosystem.* 47:189-195.

Agneta G.,Greger G. Holm K.and Bengt-Erik Bengtsson (2004) Influence of Nutrient Levels on Uptake and Effects of Mercury, Cadmium and Lead in Water Spinach. J. Environ Qual.33:1247-1255.

Aina E.O.A. and Adedipe N.O. (Eds). (1996). *The petroleum industry and the environmental impact in Nigeria.* FEPA monograph 5. Federal Environmental Protection Agency Lagos

Akanbi W.B, (2002). Growth, Nutrient Uptake and Yield of Maize and Okro as influenced by Compost and Nitrogen fertilizer under different cropping systems. Ph.D Thesis, University of Ibadan 222 pp

Arthur W. (1994), Reasons why organic growers do not use synthetic compound fertilizers. *Commun soil sci. Plant Anal*. 25 (19-20): 125-128.

Bremmer, J.M. (1965). Total Nitrogen In: Block (Ed) Methods of analysis.

American society of Agronomy Madison Wi.pp 1149-1176.

Bremmer, J.M. (1965). Total Nitrogen In: Block (Ed) Methods of analysis. American society of Agronomy Madison Wi. pp 1149-1176.

Cao X. D.,Ma L.Q.,Shiralipour A. (2003). Effect of compost and phosphate ammendment on arsenic mobility in soils and arsenic uptake by the hyperaccumulator. *Pierris vitata* L. Environmental pollution 126; 157-167.

Chaney R.L., Brown S.L., Li Y.M., Angle J.S., Stuczynski T.I, Daniels W.L., Henry C.L., Siebelec G., Malik M., Ryan J.A., Compton H. (2000). Progress in risk assessment for soil metals, and in-situ remediation and phytoextraction of metals from hazardous contaminated soils. USEPA "Phytoremediation; state of science", May 1-2, 2000, Boston, MA.

Clemente R., Escolar A, and Bemal M.P. (2006). Heavy metal fractionating and organic matter mineralization in contaminated calcareous soil amended with organic materials. *Bioresource Technology* 97:1894-1901.

Clemente, R., Walker, D.J., Roig, A., Bernal, M.P., (2003). Heavy metals bioavailability in a soil affected by mineral sulphides contamination following the mine spillage at Aznalcollar (Spain). Biodegradation 14, 199-205.

Dale P, Jurate R., Loreta L., Albinas L. (2006). Growth and metal accumulation ability of plants soil polluted with Cu, Zn, and Pb. *EKOLOGIJA 2006. Nr. 1.P 48-52.*

Daniel B.B. and Edward A.K. (1997). *Earth as a living planet ,Environmental science*. Second Edition. John Wiley &Sons Inc. New York. Chapter 14:286-306.

European Union. (2002). Heavy Metals in Wastes, European Commission on Environment (http: //ec.europa.eu/ environment/waste/studies/pdf/heavy metals report.pdf).

Francis C.A., Rutger J.N. and Palmer A.F.E. (1969). A rapid method for plant leaf area estimation in maize (Zea mays L.) *Crop science* 9:537-557.

Greger M., Brammer E.,Lindberg S.,Larsson G. and Idestam-Almquist J. (1991).Uptake and physiological effects of Cadmium in sugar beet related to mineral provisions. *Journal of Experimental Botany* 42:729-737

Guidi, G. Pear, A., Giovannerlti, M., Poggio, G., and Bertoldi, M. (1988). Variations of soil structure and Microbial population in a compost amended soil. *Plant and soil* 106-133-11

Han J. Ko , Ki Y. Kim, Hyeon T. Kim, Chi N. Kim, M. Umeda (2008). Evaluation of maturity parameters and heavy metal contents in composts made from animal manure. *Waste Management* 28: 813-820.

IITA, (1979). Selected methods for Soil and Plant Analysis. IITA manual Series. No.1.IITA,Ibadan, Nigeria.

Kabata-Pendias, A and Pendias, H. (2001). Trace elements in soils and plants 3rd edn. CRC, New York.

Kiikkila, O., Derome, J., Brugger, T., Uhlig, C., Fritze, H., (2002). Copper mobility and toxicity of soil percolation water to bacteria in a metal polluted forest soil. *Plant and soil.* 238, 273-280.

Koeppe D.E. (1977). The uptake, distribution and effects of Cadmium and Lead in plants. *Sci. Total Environ.7;197-205.*

Koma‘rek, M., Tlustosˇ, P., Sza′kova′, J., Chrastnyb, V., Ettler, V., (2007). The use of maize and poplar in chelant-enhanced phytoextraction of lead from contaminated agricultural soils. Chemosphere 67, 640–651

Luo, C., Shen, Z., Li, X., (2005). Enhanced phytoextraction of Cu, Pb, Zn and Cd with EDTA and EDDS. Chemosphere 59, 1–11

Nicholson, F.A.,Chambers, B.J., Williams, J.R., Unwin, R. J. (1999). Heavy metal contents of livestock feed and animal manures in England and Wales. Bioresour. Technol. 70, 23-31.

Ogundiran M.B. (2007). Assessment and Chemical remediation of soil contaminated by lead acid Battery wastes in Lalupon village Oyo State. Nigeria. Ph.D Thesis, University of Ibadan. x+205pp.

Pallavi S. and Dubey, R. S. (2005). Lead toxicity in plants. *Brazillan journal of plant physiology* 17 (1).

Parr J. F., Miller R. H. and Colacicco D. (1984). Utilization of organic materials for crop production in developed countries In: Organic farming. Current Technology and its Role in a sustainable Agriculture ASA special publication No.46. *American Society of Agronomy,* Medison WI

Petruzzell, G., Lubrano, L., and Guide, G. (1989). Uptake by corn and chemical extrabilty of heavy metals from a four year compost treated soil. *Crop sci.* 29:78-85.

Radwanski S.A. and Wickens,G.E. (1981). Vegetative fallows and potential value of the Neem tree in the tropics. *Economic Botany* 35(4); 398-414.

Rennevan H., Tony R.H., Abir A., Andy J.M, Mike L. J and Sabeha K.O. (2007). Remediation of metal contaminated soil with mineral amended composts. *Environment pollution* 150:347-354

SACRED Africa (2007). Using tithonia as an organic fertilizer, sustainable agriculture center for research, and development in Africa, (SACRED Africa) Bungoma Kenya.

Salati S., Quadri G., Tambone F., Adani F. (2010). Fresh organic matter of municipal solid waste enhances phytoextraction of heavy metals from contaminated soil. *Environmental Pollution* 158 1899–1906

Seregin I.V., Shpigun L.K., Ivanov V.B. (2004). Distribution and toxic effects of Cd and Pb on maize roots. Russ. *J. plant physiology.* 51:525-533.

Sims J.T., Wolf D.C., (1994). Poultry wastes management: Agricultural and environmental issues. Adv. Agron. 52, 2-72.

Timothy J. Bricker, John Pichtel, Hugh J. Brown and Misty Simmons. (2001). Phytoextraction of Pb and Cd from a Superfund Soil: Effects of Amendments and Croppings to mineral provisions. *J. Exp. Bot.* 42:729-737

Tiquia S.M., Tam N.F.Y., (2002). Characterization and composting of poultry litter in forced aeration piles. Process Biochem. 41, 380-389.

Togun, A.O., Akanbi, W.B., and Dris, R. (2003) Influences of compost and nitrogen fertilizer on growth nutrient uptake and fruit yield of tomato (Lycopersicum esculentum). *Crop Research* 26(1):98-105.

Tordoff, G.M., Baker, A.J.M., Willis, A.J., (2000). Current approaches to the revegetation and reclamation of metalliferous mine waste. Chemosphere 41, 219-228

Webber M.D., Webber, L.R., (1983). Micronutrients and heavy metals in livestock and PMs. In: Farm animal manures in the Canadian Environment. Publication No. NRCC 18976 of the Environmental Secretariat, Ottawa, Canada. p.59.