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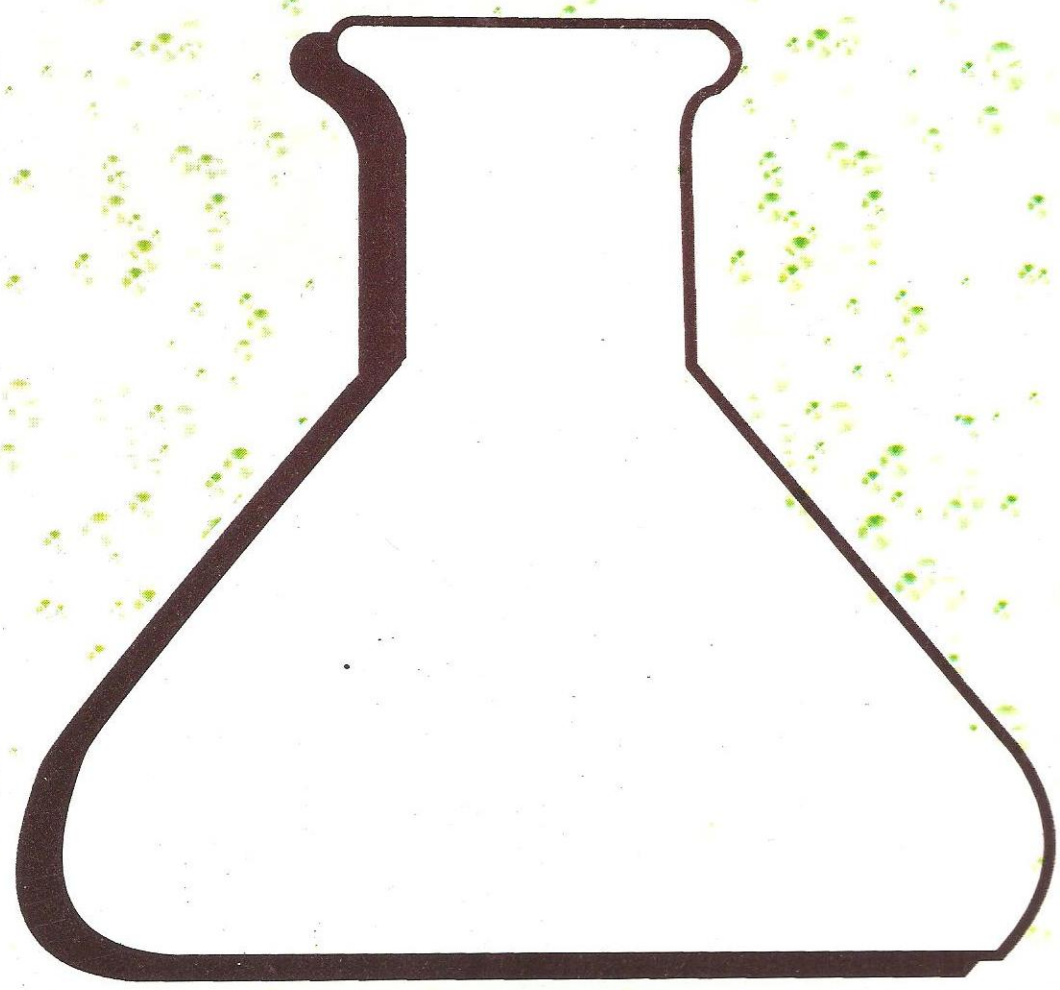

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Evaluation of Physicochemical Properties and Heavy Metals Concentration in Municipal Dumpsite Compost in Kano Metropolis, Nigeria.

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ABSTRACT

Physicochemical properties of municipal dumpsite compost in Kano metropolis and concentration of heavy metals were investigated. Analysis was carried out by atomic absorption spectrometry (Buck Scientific VPG 210). The results shows that the compost pH (6.63-8.19), electric conductivity of compost (638-933µs/cm), total organic carbon(6.28-8.65%) and organic matter/humus (10.86-14.95%).The heavy metals analysis of municipal dumpsite compost it contained Zn(52.18-547.82mg/kg), Cu(34.50-262.06mg/kg), Fe(18.18-109.08mg/kg), Ni(9.5276.19mg/kg), Mn(12.40-73.45mg/kg) Pb(13.80-62.07mg/kg), and Cd(2.5-7.5mg/kg). Heavy metals concentrations (mg/kg) in studied compost were below the maximum allowable total metal concentration in compost compared with USEPA, Indian Compost Standards, Italy and USA Compost Regulations.

Keywords: Compost, Dumpsite, Heavy Metal, Metropolis, Municipal

Introduction

The United States Environmental Protection Agency, defined solid waste as any useless, unwanted or discarded materials with insufficient liquid content to be free flowing. According to FEPA (1995), solid wastes are useless, unwanted or discard materials that arise from man's activities and cannot be discarded through a sewer pipe. The non-free flowing or sticking nature of the solid waste gave rise to the accumulation of solid waste on some habitable parts of the earth surface.

Places with accumulated solid wastes are called refuse dumps, but a designed place for dumping of refuse is known as dumpsite (FEPA, 1998). The municipal solid waste is heterogeneous in nature and contains paper, plastic, rag, metal, glass piece, ash and compostable matter. In addition, other substances as scrap materials, waste papers, dead animals, discarded chemicals, paints, hazardous hospital waste and agricultural residue are also categorized under municipal solid waste (Lauber, 2005).

This solid waste disposal causes serious environmental problem. The burning of solid waste creates heavy smoke and dust pollution on inhalation this results in various respiratory problems among the habitats (India states of the environment, 2006).

According to Anikwe and Nwobodo (2001), municipal wastes increase the nitrogen, pH, cation exchange capacity, percentage base saturation and organic matter. Organic waste can provide nutrients for increase plant growth, and such positive effect will likely encourage continued land application of these wastes (Anikwe and Nwobodo, 2001; Nyles and Ray 1999).However excessive waste in soil may increase heavy metal concentration in the soil and underground water. Heavy metals may have harmful effects on soils, crop and human health (Nyle and Ray 1999; Smith et al., 1996).

The objectives of this study were to evaluate the physicochemical properties of municipal dumpsite compost and to assess its heavy metals concentration.

Materials and Methods

Study Area and Sample Collection

The composts samples were collected from twelve different – sampling points (0-15cm depth) in Kano metropolis dumpsites into polyethylene bags with plastic spoons. Samples were immediately taken to the laboratory, extraneous materials were removed; the samples were air-dried, crushed and ground to a fine powder in a mortar passed through a 0.20mm sieve. The compost samples were homogenized and stored in clean polyethylene bags in a dessicator until the analysis. Precautionary measures were taken to avoid contamination during sampling, grinding, sieving and storage (Tokalioglu *et al*., 2003).

Reagents: Analytical reagent grade chemicals and de-ionized water were used for preparing all solutions. Stock solutions containing 1000mgL^{-1} of

the analytes were prepared from nitrate salts of Pb, Cu, Fe, Cr, Cd, Zn, Mn and Ni in 1% of HNO_3 into calibrated flasks.

Working standard solutions were prepared by appropriate dilutions of the stock solutions. Blank determinations were run using the same reagents in equal quantities without the sample as described in the analysis procedure throughout the experiments. Analysis of the extracts was carried out by atomic absorption spectrometry (Buck Scientific VPG 210).

Compost pH Determination

Exactly 10g of compost was weighed and transferred into 100cm^3 beaker, 50cm^3 of 1M KCl solution was added and the suspension stirred several times for 30 minutes. The suspension was allowed to stand for 30 minutes to settle. The clear supernatant solution was decanted into a clean 50cm^3 beaker and the pH was measured using the Denver pH/conductivity meter (Chatain, 2004).

Electric Conductivity Measurement

Exactly 10g of compost was weighed and transferred into 100cm^3 beaker, 50cm^3 of deionized water was added and the suspension stirred several times for 30 minutes. The suspension was allowed to stand for about 30 minutes to settle. The clear supernatant solution was decanted into a clean 50cm^3 beaker and the conductivity was measured using the Denver pH/conductivity meter (Mathieu and Peltain, 2003).

Compost Organic Matter Determination

Exactly 1.0g powdered compost was weighed in duplicate and transferred to 250cm^3 flasks. Exactly 10cm^3 of 1M potassium dichromate was pipette into each flask and swirled gently to disperse the compost followed by addition of 20cm^3 of concentrated Sulphuric acid. The flask was swirled gently until compost and reagents are thoroughly mixed. The mixture was then allowed to stand for 30 minutes on a glass plate to allow for the oxidation of potassium dichromate to chromic acid. Exactly 100 cm^3 of deionized water was added followed by addition of 4 drops of ferroin indicator, after which the mixture was titrated with 0.5M ferrous sulphate solution. A blank titration was similarly carried out. The percentage organic carbon and organic matter were calculated using the following equations. (CEAEQ, 2003).

$$\%\ Organic\ Carbon\ Compost = \frac{(meq\ K_2CrO_7 - meq\ FeSO_4)x\ 0.003\ x\ 100\ x\ f}{g\ of\ air - dry\ compost}$$

Where **f** = correction factor = 1.33 and **meq** = normality of solution × ml of solution used.
%Organic matter = %Organic carbon × 1.729

Heavy Metal Fractions:

Four different extraction fractions were used according to the modified Tessier's method (Blanchard, 2000), to establish the distribution of metal in the compost. The extractions were carried out at room temperature. After each extraction, the mixture was centrifuged (15min, 3000rpm) and the supernatant solution was filtered through no. 41 Whatman filter paper.

Water-soluble Fractions:

Each sample was extracted with 50cm^3 of deionized water. The mixture was shaken for 5h at 23°C and left to stand overnight.

Reducible Fractions:

Metals bound to iron and manganese oxide were extracted by adding 50cm^3 of 0.1M Hydroxyl ammonium chloride (adjusted to pH 2 with 2 molL^{-1} nitric acid) onto the residue from the water soluble fraction.

Oxidizable Fractions:

Exactly 50cm^3 of 1.0M ammonium acetate solution (adjusted to pH 2 with 2 molL^{-1} nitric acid) was added on to the residue from the reducible fraction.

Residual Fractions:

The residue from oxidizable fractions was dried in a dessicator for 7days; 0.25g of the dried residue was weighed and digested in a platinum crucible with 3cm^3 HNO_3, 2cm^3 HF and 1cm^3 H_2O_2 on a hot plate. The mixture was evaporated to dryness; 40cm^3 of 0.25M HNO_3 was added. The resulting solution was heated for about 10minutes, and then filtered into 60cm^3 plastic bottles. Finally, the extracts collected was analyzed using (AAS) to determine the concentrations of Pb, Cu, Fe, Cr, Cd, Zn, Mn and Ni metals in each of the fractions.

Results and Discussion

Physico-Chemical Properties of Compost

a. Compost pH

The result indicated that the pH values for the composts ranged from 6.63 – 8.19(Table 1), suggesting that the composts were mildly acidic to mildly alkaline in nature, and fall within recommended range of pH for compost,(6.9-8.3) reported by Bord(2003).

b. Electric Conductivity

The electric conductivity of the samples analyzed was found to be between 638 to

933µS/cm (Table 1). These high values of electric conductivity of the compost may be due to the degradation of solid waste in the dumpsite, resulting in more release of ions got into the compost.

c. Organic Matter

Organic matter content is a significant parameter that also controls the mobility of heavy metals (Bozkurt *et al.,* 1999). The compost of the dumpsites have considerable organic matter content that ranged from 9.79 to 14.95 %(Table 1). The relevance of organic matter to this study is its influence on mobility and flux of heavy metals in the composts. The range of organic matter found is an indication that the heavy metals in the composts would be available since heavy metals are known to form complexes with organic matter that influence their availability.

Table 1: physicochemical properties of municipal dumpsite compost

S/N	Sample Code	Compost pH	Electrical conductivity µS/cm	Organic Carbon (%)	Organic Matter/Humus (%)
1.	GA	7.67	916	8.65	14.95
2.	GB	7.23	921	8.58	14.83
3.	GC	7.39	933	8.34	14.62
4.	GS	6.64	811	8.37	14.47
5.	KA	8.19	818	8.27	14.30
6.	KB	7.74	835	8.24	14.24
7.	KC	8.02	778	7.24	12.23
8.	KS	6.81	638	8.04	13.90
9.	IA	7.30	843	7.87	11.65
10.	IB	7.57	838	6.74	11.65
11.	IC	7.50	828	6.58	11.38
12.	IS	6.63	657	6.28	10.86
		Mean=7.40±0.5	Mean = 818±92.84	Mean=7.77%±0.83	Mean=13.27%±1.56
		Range = 6.63-8.19	Range = 638-933	Range= 6.28-8.65%	Range= 10.86-14.95%

Total Metal Contents

The total concentration of Zn obtained in this study ranged from 52.18 to 547.82mg/kg, while Cu concentration varied from 34.50 to 262.06mg/kg and Cr level was 30.76 to 107.68mg/kg. The Fe level ranged from 18.18 to 109.08mg/kg and the concentration of Ni varied from 9.52 to 76.19mg/kg. The level of Mn ranged from 12.40 to 73.45mg/kg, while concentration of Pb and Cd was found to ranged from 13.80 to 62.07mg/kg and 2.5 to 7.5mg/kg respectively (Table 2). All the compost samples analyzed showed highest Zn concentration followed by Cu. The Cd concentration was found to be the least as compared to other metals in all the compost samples. The predominance of Zn in the composts may be attributed to the stabilization of Zn oxides in the composts, as it was reported that Zn oxides in soils have high stability constant (Ma and Rao, 1997). While in the case of Cd it may be due to the weak adsorption nature of Cd in the soils (Mido and Satake, 2003). The mean values of the metals a analyzed in this work were lower than heavy metals levels reported by He *et al.* (1995) for compost in USA. In another report, the levels of Pb, Cu, Fe, Cr, Cd, Zn, Mn and Ni for compost in Italy (Giusguani *et al.,* 1992) were consistently higher than the corresponding mean values obtained for these elements in this study. Comparisons with USEPA and Indian compost standards revealed that the mean values of the metals analysed in this work were also lower than the compost standards (Table 2). It can therefore be suggested that, the relatively lower values obtained for Kano Municipal dumpsites composts compared to the above composts already mentioned may be due to the lesser impact of anthropogenic sources of pollution in the Kano Municipal Dumpsites areas.

Table 2: The Total Metal Contents from Municipal Dumpsite Compost with USEPA and Indian Composts Standards (mg/kg).

Metals	Kano Municipal Dumpsite Compost		Italy Compost (a)	USA Compost (b)	USEPA Compost Standards	Indian Compost Standards
Pb	13.8 - 62.07	(28.24)	863	234	300	100
Cu	34.50 - 262.06	(112.64)	421	281	1500	300
Fe	18.18 - 109.08	(59.08)	11993	-	-	-
Cr	30.76 - 107.68	(55.12)	86	76.0	1200	50
Cd	2.5 - 7.5	(3.5)	5	3.3	39	5
Zn	52.18 - 547.82	(207.95)	116	655	2800	1000
Mn	12.4 - 73.45	(28.26)	311	501	-	-
Ni	9.52 - 76.19	(27.19)	44	340	420	50

a = Giusquani *et al.,* (1992)
b = He *et al.,* (1995).
Average Values Given in Parenthesis

Conclusion

The total heavy metals concentrations in the municipal dumpsite compost obtained in this study showed values significantly lower than maximum allowable total metal concentrations set by USEPA, Italy, Indian compost standards. However, knowledge of the total concentration of heavy metals remains insufficient to estimate the mobility risk, and metal bioavailability for plants. Since the compost complied with the standards mentioned above, making it suitable for use as a fertilizer and soil conditioner.

Recommendation

A waste management treatment policy should be put in place for the dumpsites. Waste disposal must be put in place for the dumpsite and waste disposal must be controlled by pre-treatment before disposal. Finally, the comparison of the metals in the dumpsite were lower than USEPA and Indian compost standards.USA and Italy compost regulations; hence, control measures should be established to manage the state of the dumpsites.

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