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Effects of Landfill Wastes on Mineral Elements of Soil and Mineral Elements Speciation

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Abstract: The effects of domestic waste dumping on rural soil samples on the mineral content (s) of the soil was studied. The use of different chemical extractants to specify the state of each mineral in the soil was also investigated. The results showed that the total mineral elements in various states Viz: Exchangeable, oxidisable and soluble states in the 2 rural soil samples increase significantly when compared to non-dumping soil samples collected 1 km distance away from the two land fill sites within the same locality. Some of the mineral elements: Zinc, manganese, calcium and potassium showed more than tenfold increase in the total mineral elements due to the presence of leachates from the land fills.

Key words: Mineral elements, landfills, extractant, chemical speciation

INTRODUCTION

The use of composite manure as fertilizers by local farmers is a common practice in Nigeria and most west-African sub-regions. The contributions of these domestic wastes obtained mostly from landfills to soil mineral enrichment as well as increased metal pollutant over load have been a source of concern to both soil chemists and environmentalist alike (Okoronkwo *et al*., 2005a, b). Of great concern is the use of composite manures from land fills as fertilizers is the mineral content (s) distribution, chemical states and availability to plants and corps (Ikem *et al*., 2002). The availability of these mineral elements from composite manures depends to a great extent on the total mineral elements present, their chemical states: Ox disable, exchangeable and soluble. The soluble mineral elements are most useful mineral to crops and plants as they are readily available as either as micro or macro nutrients (Perrezcid *et al*., 2001; Maiz *et al*., 2000; Schramel *et al*., 2000; Hall, 1991). There is the need, therefore to specify the various chemical states of these mineral elements in the soil samples, due to leachates from landfills and the amount of each of these mineral elements in the soils. There are lot of scientific methods available for this singular purpose: Sequential extraction, partitioning method, single chemical extraction to mention but a few. Each of these speciation methods, uses different chemical solvents known as extractant with varying concentrations (Tessier *et al*., 1979; Igwe and Abia, 2005; Taiwo *et al*., 2003; Brandy, 1974; Ademorati, 1996; Rose, 2002; Lasat, 2002; Jung *et al*., 2001).

In this study, we report the effects of Landfill wastes On mineral elements of soil and their chemical speciation.

MATERIALS AND METHODS

This research was carried out in the month of October 2006 at the pollution control laboratory unit of chemistry department Michael Okpara University of Agriculture Umudike Umuahia Abia State Nigeria.

Sample collection: Five sampling points were randomly selected and soil samples collected at 0-15cm depth from each sampling point at Ihie-Ndume Ibeku landfill site in Umuahia North L.G.A, Abia State Nigeria. A composite soil sample was obtained by mixing each soil sample collected from the five sampling points and stored in a labeled plastic bag. Similarity, five sampling points were randomly selected and soil samples collected at 0-15cm depth from each of sampling points at Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria. A composite soil sample was obtained by mixing each soil sample collected from the five sampling points and stored in a labeled plastic bag.

Control soil sample: Five sampling points were randomly selected and soil samples collected at 0-15 cm depth from each of the sampling points as a distance of 1 km away from the Ihie Ndume-Ibeku landfills. A composite soil sample was obtained by mixing each soil sample collected from the 5 sampling points and stored in a plastic bag labeled control soil sample. On the other hand,

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5 sampling points were randomly selected and soil samples collected at 0-15 cm depth from each of the sampling point at distance of one kilo meter away from Michael Okpara University of Agriculture, Umudike landfills.

A composite soil sample was obtained by mixing each of soil samples collected from the 5 sampling points and stored in a labeled plastic bag as control soil sample.

All chemicals used are analytical grade reagents from may and baker chemical LTD, London.

Soil sample preparation: Each of the four soil sample types collected was air-dried for 7 days. There after, each dried soil sample was sieved using 2mm-steel sieve to obtain a fine powder of soil sample. Each of the fine powder. Soil sample, thus obtained was stored in a clean labeled plastic container until required for analysis.

Chemical extraction of mineral elements: The following chemical digestions were carried out using each of the 4 soil sample types:-

Total mineral elements: Two gram of each of the four soil sample types was weighed out and each taken into each of the four labeled conical flasks. Twenty mililiter of Conc. HNO3 each was measured out and added into each of the four conical flasks. Each of these four flasks was placed on a heating mantle the regulated at 80°C inside a fume chamber, initial heating was allowed for 30 min. Then 20 mL of double distilled deionised water was added into each of the heating conical flasks, stirred and heating continued for 2 h, at adjusted temperature of 100°C. Thereafter, each of the four flasks was removed from the heating mantle, allowed to cool, to ambient temperature and filtered into a 100 mL volumetric flask appropriately labeled using No. 40 what man filter paper. Each of the 100 mL volumetric flask was made up to mark with double distilled deionised water. Twenty five milliliter of each of the filtrates was transferred from each of the 100 mL volumetric flasks into a labeled reagent bottle for total mineral elements analyses using AAS and flame photometer.

Exchangeable mineral elements: One and half gram of each of the 4 several soil samples was weighed out and each taken into each of the four labeled conical flasks. Thirty mililiter of O.IM hydroxylamine hydrochloride solution was measure out and each taken into each of the 4 flasks, shaken vigorously for complete mixing. The pH of each of flask content(s) was adjusted to pH 2.OO using few drops of Conc. HCl and each of the flasks stoppered. Each of the four flasks was placed on an electric malt plate shaker (Binatone model), regulated at 35 rpm, allowed to continuously shake for 12 h. Thereafter, each of the flasks was removed from the shaker, filtered into a labeled 100 mL volumetric flask, using No 40 what man filter paper. Each of the volumetric flasks was made up to mark with double distilled deionised water. Twenty five mililiter of each of the filtrates was transferred from each of flasks into a labeled reagent bottle for exchangeable mineral elements Analysis using AAS and flame photometer.

Oxidisable mineral elements: Two gram of each of the four soil samples was weighted out and taken into each of the 4 labeled conical flasks. Twenty milliliter of 30% hydrogen peroxide was measured out and each added to each of the 4 conical flasks. The pH of the flask content was adjusted to pH2.50, using few drops of Conc. HCl. Each of these four flasks was stoppered, placed on an electric multiplate shaker (binatone model) regulated at 35 rpm, allowed for continuous shaking for 12 h.

Thereafter each of the flask content (s) was filtered into a 100 mL volumetric flask using No. 40 what man filter paper. Each of the volumetric flasks was made up to mark with double distilled deionised water.Twenty five mililiter of each of the 4 filtrates was transferred into a labeled reagent bottle for oxidisable mineral elements using AAS and flame photometer.

Soluble mineral elements: Eight gram of each of the 4 soil samples was weighed out and each taken into each of the four conical flasks. Twenty five mililiter of 0.1M calcium chloride solution was measured out and each added to each of the four flasks. Each of the four flasks was stoppered, placed on an electric multiplate shaker (binatone model) regulated at 35 rpm, allowed for continuous shaking for 8 h. There after, each of flask content (s) was filtered into a 100 mL volumetric flask using No 40 what man filter paper and the volumetric flask made up to mark with double distilled deionised water. Twenty five mililiter of each of the 4 filtrates was transformed from each of four flasks into labeled reagent bottle for soluble mineral elements Analyses using AAS and flame photometer.

Residual/non-residual mineral elements: One and half gram of each of the four soil samples was weighed out and each taken into each of the four labeled flasks. Thirty mililiter of 0.5 m HCl was measured out and added to each of the four flasks, each of the flasks stoppered, placed on an electric multiplate shaker (binatone model) regulated at 35 rpm and allowed for continuous shaking for 8 h. Thereafter, each of the flask contents was filtered into a 100 mL volumetric flask using No 40 what man filter paper. Each of the volumetric flasks was made up to mark with double distilled deionised water.Twenty five mililiter of each of the 4 filtrates was transferred from each of the volumetric flasks into a clean labeled regent bottle for residual non- residual mineral elements Analyses using AAS and flame photometer.

Flame and atomic absorption spectrophotometric analyses: All the collected filtrates were analysed for different mineral elements using multipurpose air acetylene flame atomic absorption spectrophotometer (Unicam Model 969) by the standard calibration method. Batch precision and accuracy were monitored with a 10% insertion rate of sample duplicates, blanks and spikes. Results from each batch were accepted if the control samples were within 10% of the control samples were within 10% of the accepted value of the sample being analysed (Brandy, 1994; Pardo, 2002; Barabara *et al.*, 2002).

RESULTS AND DISCUSSION

The effects of landfill wastes on mineral element content (s) of soil samples were studied. The chemical states of these mineral elements specified using different chemical extract ants were reported in Table 1 and 2, respectively. From Table 1, is was observed that the total more than ten folds when compared to the non-landfill soils collected a 1 km distance away from the landfill sites, within the same locality. The exchangeable mineral elements: Zinc, manganese, calcium and potassium were high in the landfill soils compared to the non-landfill soils (Table 1). The high calcium concentrations in the land fill soils is attributable to the nature of the west in land fill which are mostly domestic

Table 1: Concentrations of mineral elements in soil samples from Micheal Okpara university of Agriculture, Umudike dumping sites

Mineral elements	Chemical state of the metals	Specific extractant	Concentrations in dumping	mg kg^{-1} Non-dumping
Zinc	Total	CONC. HNO_3	4. 208	0.854
“	Residual and non-residual	0.5M HCl	4. 267	0. 688
“	Exchangeable	0.1M NH_2OH-HCl	4. 313	1. 779
“	Oxidisable	30% H_2O_2	3. 163	0. 133
“	Soluble	0.1MCa Cl_2	0. 475	0. 525
Manganese	Total	CONC. HNO_3	4. 288	0. 532
“	Residual and non- residual	0. 5M0 HCl	0.875	0.154
“	Exchangeable	0.1M NH_2 OH- HCl	10. 25	0. 155
“	Oxidisable	30% H_2O_2	Not detected	Not detected
“	Soluble	0. 1M Ca Cl_2	0. 480	0. 137
Calcium	Total	CONC. HNO_3	3. 140	0. 413
“	Residual and non-residual	0.5M HCl	60. 50	0. 331
“	Exchangeable	0.1M NH_2 OH-HCl	68. 50	1. 322
“	Oxidisable	30% H_2O_2	12. 560	3. 550
“	Soluble	0.1M Ca Cl_2	25. 20	22. 50
Potassium	Total	CONC. HNO_3	6. 635	2. 81
“	Residual and non-residual	0. 5M HCl	5. 380	0. 438
“	Exchangeable	0.1MNH_2OH-HCl	5. 090	0. 516
“	Oxidisable	30% H_2O_2	4. 214	0. 440
	Soluble	0.1M $CaCl_2$	6. 340	0. 500

Values are means of 4 determinations

Table 2: Concentrations of mineral elements in soil samples from Ihie Ndume Ibeku dumping site

Mineral elements	Chemical state of the metals	Specific extractant use for speciation	Concentrations in dumping	mg kg^{-1} Non-dumping
Zinc	Total	CONC. HNO_3	3. 991	3. 758
“	Residual-residual	0.5M HCl	3. 230	0. 954
“	Exchangeable	0.1M NH_2OH-HCl	3. 029	0. 945
“	Oxidisable	30% H_2O_2	0. 529	0. 010
“	Soluble	0.1M Ca Cl_2	0. 050	0. 204
Manganese	Total	CONC. HNO_3	3. 120	0. 910
“	Residual and non-residual	0. 5M HCl	1. 350	0. 172
“	Exchangeable	0.1M NH_2 OH- HCl	1. 612	0. 103
“	Oxidisable	30% H_2O_2	0. 050	Not detected
“	Soluble	0.1M Ca Cl_2	Not detected	0. 051
Calcium	Total	CONC. HNO_3	10. 740	0. 330
“	Residual and non-residual	0. 5M HCl	44. 380	1. 570
“	Exchangeable	0.1M NH_2 OH- HCl	66. 70	5. 950
“	Oxidisable	30% H_2O_2	13. 470	3. 960
“	Soluble	0.1M Ca Cl_2	327. 270	176. 360
Potassium	Total	CONC. HNO_3	11. 640	2. 890
“	Residual and non residual	0. 5M HCl	6. 860	0. 854
“	Exchangeable	0.1M NH_2 OH-HCl	6. 820	0. 930
“	Oxidisable	30% H_2O_2	6. 270	0. 510
“	Soluble	0.1M Ca Cl_2	8. 047	0. 660

Values are means of 4 determinations

waste comprising mostly bones food remains vegetable waste and crop peels. The mean value of 68.5 mg per kg of exchangeable calcium ion in the land fill soil compare to 1.322 mg kg^{-1} of the same exchangeable calcium ion in the non land fills (control soils sample) significantly demonstrated that the land fill waste have effect on the mineral elements content of the soil. This observation is applicable to other mineral elements investigated with the exception of soluble zinc ion which was slightly higher in the non land fill soils. This may also be due to he nature of the waste that are mainly domestic waste and not industrial waste.

The high proportion of exchangeable cations in the landfill soils may influence the acidicity of the soil making the soils harmful to some acid-sensitive crops and plants within the vicinity (Jung *et al*., 2002; Dilek and Maynard, 2003; Okoronkwo *et al*., 2005b). The high proportion soluble mineral elements for instance soluble calcium 12.56 mg kg^{-1} compared to 3.55 mg kg^{-1} from landfill soils and non-landfill soils (Table 1), respectively. This may enhance the leaching of this element far beyond the reach of crops and plant within the vicinity of the landfills, (Ikem *et al*., 2003; Maiz *et al*., 2000; Taiwo *et al*., 2003; Rose, 2000). From Table 2, it was observed that there was increase in the mineral elements from the landfill soils when compared to the non-landfill soils. There is more oxidisable calcium ion in the landfill soils 13.47 mg kg^{-1} compared to 3. 96 mg kg^{-1} calcium ion obtained from the non-landfill soils (Table 2). The high concentrations of residual/ non-residual mineral elements in the landfill soils suggest anthropogenic sources as the sole contributor (Ikem *et al*., 2002; Igwe and Abia, 2006). The results obtained from Table 1 and 2 have demonstrated that the presence of domestic waste in any particular soil location use as landfill site enhances the availability of mineral elements in the soil when compare to non land fill soil. The results obtained in this work have explained the basis for the traditional use of domestic waste from such land fill soil as organic manures. The result have also demonstrated significantly the possibility of partitioning of mineral elements in both landfill soil samples non land fill soil samples into their various chemical state of ox disable, exchangeable soluble and residual/non residual mineral elements, respectively when suitable extracting agents are used.

We are still investigating the effects of the use of landfill soils as organic manures as fertilizers on the mineral elements of plants and crops. This is with the review to make a scientific input in this increased advocacy of green chemists and environmental campaigners for the use of organic manures in place of synthetic fertilizers.

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