The Potentials of Solid Wastes Utilization for Agriculture in Imo State, Nigeria

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Abstract– **Soils from solid waste dumpsites in Owerri municipality were analyzed to determine their possible use for agriculture. Samples were taken from profile pits dug at Egbeada, Aladinma and Nekede Saw Mill dumps and control sites at depths of 0-15cm, 15-30 and 30-45cm. They were analyzed for particle size distribution, pH, organic carbon, organic matter, nitrogen, phosphorus, Ca, Mg, K, Na, exchangeable base, base saturation and cation exchangeable capacity. Results of the mechanical analysis showed that all soil samples at the various horizons in all sites are sandy loam in texture. At the 0 – 15cm horizon, there was an elevation of soil pH at Egbeada (4.86 to 7.07); Aladinma (4.25 – 6.05); but decreased at Nekede (6.94 – 6.03). Levels of organic carbon, organic matter, nitrogen, Ca, Mg, K, Na, exchangeable base, base saturation and cation exchangeable capacity were found to be high in the horizon between 0.15 and 15-30cm higher than those of the controls but there was an inconsistency in variation in the total phosphorus content of the soil in the three sites and their controls. Soil cation exchange capacities for all dumps increased above their control site values at all three horizons implying an increased soil fertility, resilience and soil aggregation which reduce the chance of soil erosion and crusting. The presence of the dump improved the soil structure and its use in agriculture. Urban solid waste management can be valuable in improving soil fertility and alleviating the over-cultivation effects of Imo State agricultural soils.**

Keywords– Solid Waste, Biodegradation, Nutrient Release, Aggregation, Soil Structure, Fertility and Agriculture

I. INTRODUCTION

Wastes management is a major problem facing developing countries of the world (Talashilkar, 2001; Akhionbare, 2009a,b; Akhionbare et. al., 2010;). Population increase, industrialization and urbanization lead to generation of large volumes of solid wastes in urban environment (Akhionbare et. al., 2008; Akhionbare, 2009a). Heavy metals, chemicals, organic chemicals and/or pathogens present in them can have adverse effects on environment, human health, soil, air and water quality (Talashilkar, 2001). In developing countries, a good proportion of the city garbage is dumped in low lying areas which easily become a source of groundwater pollution (Vimal and Talashilkar, 1985; Ojiako, 1988; Akhionbare, 2009b). Runoff from the garbage mass causes pollution of surface water. The gases produced during decomposition of garbage under anaerobic conditions and incineration under aerobic conditions also results in air pollution (Kirov, 1972; Brunner and Keller, 1972).

The release of nutrients during the decomposition of urban compost in soil is similar in effect to that of other manures. Substantial improvement in pH, organic matter, major, secondary, and micro – nutrients have been observed on the application of garbage compost on soil (Tarjan, 1977; Banerjee *et al,* 1979; Khan *et al*, 1981; Hortenstine and Rothwell, 1972; Misra, 1979 and Kattal and Sharma, 1979). Its application increases the biological activity of soil by acting as food substrate to the native soil microflora, as reflected by CO_2 evolution, ammonification and nitrification. A good deal of work has been carried out on the use of garbage compost for optimizing agricultural production under limited availability of fertilizers (Terman, 1970; Giordario *et al*, 1975; Tietjen, 1975; Pelletin *et al*, 1986; PEIC, 2003 and Rodriguez, 2006). The value of organic products is not only as biofertilizers but also its possible bio-stimulant action and / or biopesticide (Rodriguez, 2006).

An estimated urban refuse of 3500 m^3 is generated daily in Nigeria (Ojiako, 1988). Wastes from urban environment can help in improving soil structure, control soil erosion and enhance the nutrient value of soils. Imo State of Nigeria, the study area, is known for poor crop yields, a situation which is attributed to limited farmland resources and over-cultivation of the available ones. The use of chemical fertilizers has been encouraged but there are still constraints of adequate provision and distribution to desiring farmers. Organic fertilizers have been recommended for use in land under intensive cultivation to improve soil structure, increase the water holding capacity and nutrient availability to plants. These have been used since ancient times and their influence on soil fertility has been demonstrated, although their chemical composition, the contribution of nutrients to crops and their effect on soil vary according to origin, age, and content management humidity (PEIC, 2003). Moreover, the value of organic matter has great advantage that can hardly be achieved with inorganic fertilizers. At present, the structure of soil is the main factor that determines the fertility and productivity of agricultural land. This study focuses on the effect of solid waste dump on soil fertility and its agricultural implication in Imo State, Nigeria. Soil samples from three major municipal solid waste dumps were studied for variations in physical and chemical properties occasioned by the presence of the dump in these sites. These variations observed, as compared with control points, were evaluated on the basis of their effects on improving soil structure, organic matter as well as critical parameters necessary for effective agricultural practices and crop yield enhancement.

II. MATERIALS AND METHODS

A. Study Area

The study area Owerri Municipal is in Imo State of Nigeria. It lies between Latitudes 5^o 15'E and 5^o 50' N, and Longitude 7^o 0'E and 7^o 15W. The population of the area is estimated to be about 116,000. The annual rainfall ranges from 200-250mm with a mean daily maximum temperature is between 28^oC-33^oC. The soil is deep and rich in humus, but due to heavy rainfall, basic cations are leached out making the soil acidic. The economic activities in the area include commerce and industry activities which result to constant generation of wastes of different kinds. These wastes are dumped in selected dumpsites while some are dumped indiscriminately leading to environmental nuisance.

III. SAMPLING AND ANALYSIS

Soil samples were collected at three dump sites in the study area namely: Egbeada, Aladinma and Nekede saw mill. A control site was located within the vicinity of each dump site but away from it. A profile pit was dug at each location and samples were collected at depths of 0 – 15cm, 15 -30cm and 30 -45cm and sent to the laboratory for analysis.

Soil samples were crushed with wooden roller, dried through spreading at room temperature for four days and sieved with 2mm diameter. Particle size was determined by hydrometer method (Boyoucous, 1965), soil pH with a glass electrode pH Meter, organic carbon by the Walkley-Black's titration method (Jackson, 1973), the organic matter was digested with excess potassium dichromate and sulphuric acid and the residual unutilized dichromate back-titrated against standard ferrous ammonium sulphate solution. Total nitrogen was estimated by semi-micro Kjeldahl's distillation method (Mishra,1970), available phosphorus was measured colorimetrically using bicarbonate solution as extract medium (APHA, 1985), exchangeable cations (Ca^{++}, Mg^{++}, K^+, Na^+) by ammonium acetate extraction method for (Ca^{++}, and Mg^{++}) and Digital Flame Photometer for (Na^+ and K^+), exchangeable acidity by KCl extraction method , cation exchange capacity by summations of cations and exchangeable acidity, and percentage base saturation(%B.S.) (APHA, 1985).

IV. RESULTS AND DISCUSSION

A. Variation in Soil Physical Properties

Tables 1, 2 and 3 show the variation of soil quality in the three dump sites studied as well as the control locations. Results show that all soil samples at the various horizons in all sites are sandy loam in texture. The top soil at the dump sites had been transformed by the presence of the solid waste at the site. Soil samples collected at horizons 0-15 and 30-45 of the dumpsites and controls are highly sandy in nature with the mixture of silt and clay in which the texture class is sandy loam.

B. Variation in Soil Chemical Properties

At Egbeada site, differences were found in an elevation of pH from 4.86 at the control site to 7.07 at the 0 – 15cm horizon of the dump site indicating a favourable condition of acidity which supports the growing of certain crops at the dump site. At Aladinma, pH was also raised from 4.25 – 6.05; but at Nekede dump site, pH decreased from 6.94 – 6.03 at the 0 – 15cm horizon indicating that the presence of the dump increased acidity of the soil. Soil pH influences nutrient availability and the activity of microorganisms and disease organisms in the soil (PEIC, 2003; Akhionbare, 2009b).

Other critical parameters in agriculture that were elevated by the presence of the dump in the 0 – 15cm horizon include organic C, organic matter, total nitrogen, Ca, Mg, K, Na, etc giving rise to a percentage base saturation of 99.9 for Egbeada, 98.7 for Aladinma and Nekede dump sites (Tables1, 2 and 3). Similar trends were observed for three and their respective controls site values as these were found to be high in the horizon between 0.15 and 15-30cm of the dumpsites than those of the controls indicating better conditions that support agricultural practices than at the control sites. The dumps were physically observed to have large masses of completely decayed organic materials on the soil. Organic matter improves soil structure and increases the soil's ability to hold water (PEIC, 2003). The nutrient balance will improve as organic matter level increases and with it, yield potential. Improved soil structure also increases air pore space and helps soils resist compaction which reduces soil productivity and yields, restricting water infiltration, air movement in the soil and root growth. This is especially recommended for land that is under intensive cultivation as found in Imo State agricultural areas (Rodriguez, 2006).

The soil cation exchange capacities for the three dumps were found to have increased above the control sites at all three horizons (Tables 1, 2 and 3). Cations are held on the negatively charged surfaces of organic matter where they act as nutrient resource, constantly re-supplying the soil solution with nutrients needed by plants (PEIC, 2003). A high cation exchange capacity increases soil fertility and resilience. It also helps soil aggregation which reduces the chance of soil erosion and crusting. The presence of the dump has thus improved the soil structure and efficacy in agricultural activities in the three locations.

The total phosphorus content of the soil in the three sites and their controls did not show any consistency in variation at the three horizons studied. While there was a reduction in total P (from 12.0 to 10.0 mg/kg) at the 0 – 15cm level and increase (8.0 – 30.0mg/kg) at the 15 – 30cm and 16.0 – 40.0mg/kg at the 30 – 45cm levels in Egbeada site, Aladinma showed no variation in total P at all levels and Nekede dump showed an increase (18.0 – 20.0; 10.0 – 30.0; 18.0 – 20.0 mg/kg) in total P at all levels. This increase at Nekede dump positively correlated with the observed decrease in pH observed in that site contrary to observations in the other two sites (Table 1,

Table 2 and Table 3). Increase in total P definitely implies better productivity of the soil.

V. CONCLUSIONS

This study, which centered on the major urban waste dumps in the Imo State capital city Owerri, shows that urban wastes are resource materials which can help improve soil structure and properties needed in agriculture. The problem of urban waste management which has been quite challenging can be translated into a valuable resource which will help in meeting a part of fertilizer requirements for Imo State. It will however be necessary to research further into the nature and levels of possible pathogens, parasites, heavy metals and toxic organic compounds which could be present in such soils prior to their use in agriculture.

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Table 1: Variation of Soil Quality in Egbeada Dump Site

Location	Soil Depth (cm)	% Sand	% Silt	% Clay	Texture class	pH	Organic C %	Organic matter mg/kg	Total N mg/kg	Total P mg/kg	Ca mg/kg	Mg mg/kg	K mg/kg	Na mg/kg	Exch. Acidity cmole/kg	% Base saturation	ECEC meq/100g
	0-15	83.80	1.10	15.10	SL	7.07	0.71	1.23	0.056	10.0	22.40	10.80	0.533	0.313	Trace	99.9	34.076
Egbeada	15-30	82.80	3.10	14.10	SL	7.59	0.93	1.61	0.056	30.0	39.20	9.20	0.748	0.339	Trace	99.9	49.497
	30-45	85.80	1.10	13.10	SL	7.66	0.26	0.45	0.056	40.0	8.00	4.40	0.374	0.235	0.40	97.0	13.019
	0-15	83.80	1.10	15.10	SL	4.86	0.41	0.71	0.042	12.0	3.60	2.00	0.148	0.244	0.40	93.7	6.392
Control	15-30	83.80	1.10	15.10	SL	5.16	0.41	0.71	0.042	8.0	2.80	2.40	0.154	0.218	0.40	93.3	5.972
	30-45	81.80	1.10	17.10	SL	5.19	0.22	0.39	0.056	16.0	2.80	1.60	0.183	0.235	0.40	92.3	5.220

Table 2: Variation of Soil Quality in Aladinma Dump Site

Location	Soil Depth (cm)	% Sand	% Silt	% Clay	Texture class	pH	Organic C %	Organic matter mg/kg	Total N mg/kg	Total P mg/kg	Ca mg/kg	Mg mg/kg	K mg/kg	Na mg/kg	Exch. Acidity cmole/kg	% Base saturation	ECEC meq/100g
	0-15	76.80	5.10	18.10	SL	6.05	0.46	2.51	0.126	16.0	8.80	5.60	0.246	0.278	0.20	98.7	15.124
Aladinma	15-30	78.80	3.10	18.10	SL	6.38	0.78	1.35	0.034	8.0	5.60	4.80	0.215	0.244	0.20	98.1	10.317
	30-45	81.80	1.10	17.10	SL	6.24	0.49	0.84	0.028	8.0	4.80	2.80	0.215	0.244	0.20	97.6	8.259
	0-15	81.80	3.10	15.10	SL	4.25	0.93	1.61	0.034	16.0	2.00	1.20	0.143	0.252	0.20	94.7	3.788
Control	15-30	85.80	1.10	13.10	SL	4.88	0.63	1.09	0.056	8.0	2.00	1.60	0.113	0.235	0.40	90.8	4.348
	30-45	81.80	1.00	17.20	SL	5.18	0.60	1.03	0.028	8.0	3.20	2.00	0.128	0.600	0.30	95.2	5.153

Table 3: Variation of Soil Quality in Nekede Dump Site

Location	Soil Depth (cm)	% Sand	% Silt	% Clay	Texture class	pH	Organic C %	Organic matter mg/kg	Total N mg/kg	Total P mg/kg	Ca mg/kg	Mg mg/kg	K mg/kg	Na mg/kg	Exch. Acidity cmole/kg	% Base saturation	ECEC meq/100g
	0-15	85.80	3.10	11.10	SL	6.03	1.72	8.96	0.96	20.0	9.60	40.80	0.169	0.244	0.20	98.7	15.013
Nekede	15-30	87.90	5.10	7.10	SL	6.33	1.68	2.90	0.262	30.0	15.20	8.00	0.164	0.235	0.20	99.4	28.199
	30-45	85.80	5.10	9.80	SL	6.53	1.23	2.12	0.056	20.0	11.60	4.00	0.225	0.235	0.40	97.6	15.46
	0-15	75.80	3.10	21.10	SL	6.94	0.34	0.58	0.70	18.0	5.50	2.80	0.108	0.235	0.40	95.7	9.143
Control	15-30	79.80	3.10	17.10	SL	7.68	0.30	0.51	0.280	10.0	8.00	5.80	0.158	0.235	Trace	99.9	14.004
	30-45	81.80	1.10	17.10	SL	5.21	0.26	0.45	0.042	18.0	7.60	5.60	0.123	0.19	Trace	99.9	13.523