Influence of Wastes on Some Properties of Soil around Ajakanga Dumpsite in Ibadan, Southwestern Nigeria

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ABSTRACT

Due to the high demand in agricultural produce, farmers have migrated to the use of municipal solid wastes as compost for enrichment of deteriorated soil since they are a good source of nitrogen and organic matter. This study investigated the effect of wastes on the soil properties around the vicinity of a dumpsite as related to sustainable ecosystems. Soil samples collected from three different locations (dumpsite, downslope, and upslope which serve as control) were analyzed for gran size distribution, bulk density, porosity, permeability, electrical conductivity, pH, organic matter content, total nitrogen, and available P, Na, K, Ca, Mg, Fe, Zn, Cu, Pb, Ni, and Mn. Results showed significant changes at $P< 0.05$ for the determined soil properties with the exception of soil texture while lower values of determined properties with the exception of bulk density were obtained in the control soil samples. This study thus shown that the municipal solid wastes have enormous positive impact on soil physical and chemical properties which suggest its usefulness as compost for deteriorated farmlands. However, recycling, reuse and sorting of waste should be done to reduce the phytotoxicity of heavy metals.

(Keywords: dumpsites, soil properties, compost, re-use, nutrients, agricultural impact)

INTRODUCTION

Management and discarding of solid wastes have become a foremost predicament in most developing nations of the worlds. At present, about 1.3 billion tons per year of solid wastes are being generated by 3 billion urban residents of the world and according to Hossain *et al.* (2017) by 2025, this population may increase to 4.3 billion residents generating about 2.2 billion tons per year.

The rate at which the wastes are being generated according to Hornweg and Bada-Tata (2012) will be greater than twice what is being generated now over the next decade in the developing countries of the world. Thus, the ever-increasing large waste generation volumes are calling for innovative solutions since the wastes are environmentally- and public health-related.

Nowadays, the use of bio-wastes for agricultural purposes for improvement of deteriorated soils and increases in crop production is a welcome method for the overall management of wastes. Currently, the growing requirements of conservation and sustainability for natural resources and energy have significantly pointed towards the importance of recycling, re-use, and reducton of the overall volume of wastes generated (Padmavathiamma *et al*., 2008). The use of organic fertilizers such as manure and compost has been the model of the day due to their richness in nutrient contents that improve the soil fertility and productivity.

Continuous tillage operations over the years have led to soil degradation and several studies have shown that the use of organic wastes such as municipal solid wastes helps in the restoration of degraded soils (Mackie *et al*., 2015; Pena *et al*., 2015; Puga *et al*., 2015). Thus, there is need for soil improvement by addition of organic wastes to increase the soil organic matter, moisture, and nutrient contents as well as improve the structure of the soil (Srivastava *et al*., 2016).

Zhang *et al.* (2014) stated that the quality of the soil can be improved by integrating organic wastes such as municipal solid waste (MSW), food waste, biowaste, manure, sewage sludge, among others, into the soils as composts. These wastes contain appreciable amounts of nutrients that have the ability to serves as organic fertilizers for agricultural production.

Several studies have been done in relation to organic amendments on soil properties by improving its productivity as well as providing essential nutrients for plant growth and yield (Molina-Herrera and Romanya, 2015; Srivastava *et al*., 2016; Wang *et al*., 2015; Ling *et al*., 2016). Municipal solid waste as well as sewage sludge have enormous and affirmative impact on soil properties and consequently increases the crop growth and yields (Ideriah *et al*., 2006; Weber *et al*., 2014).

These days, MSW as well as other organic wastes are being used in agriculture as a soil conditioner and fertilizer. Mbarki *et al*. (2008) reported that recycling of MSW as compost for agricultural activities is a better and more reliable way of waste disposal than landfilling which is associated with both economic and environmental issues. Thus, this study assessed the impact of the wastes on the soils properties in ascertaining its usefulness as compost for agricultural activities taking into consideration high concentration of heavy metals being released to the soil through decomposition of these wastes.

MATERIAL AND METHODS

Study Area Description

The study area, Ajakanga dumpsite, is a major open waste disposal site and is located between 7˚18´41.32˝ N (Latitude) and 3˚50´29.34˝ E (Longitude) within Oluyole Local Government Area, Ibadan south-western Nigeria (Figure 1). The Increase in population and rapid urbanization has opened the dumpsite to build up areas. The study area falls within the humid and tropical climate of southwestern Nigeria with a mean annual rainfall of about 1270 mm and a mean maximum temperature of 32 ºC. The study area is well drained by rivers and streams and the drainage pattern is dendritic (Akintola *et al*., 2020).

Geologically, the study area falls within the basement complex terrain of southwestern Nigeria (Figure 2).

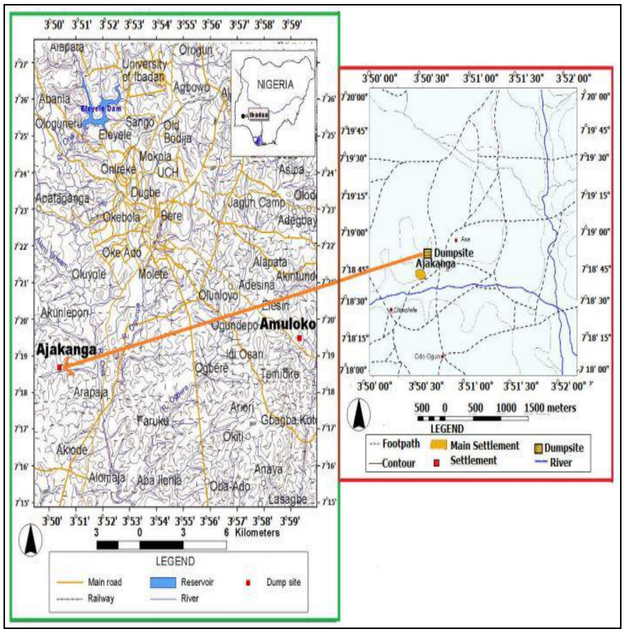

Figure 1. Location Map of the Study Area after Ewemoje et al., (2017).

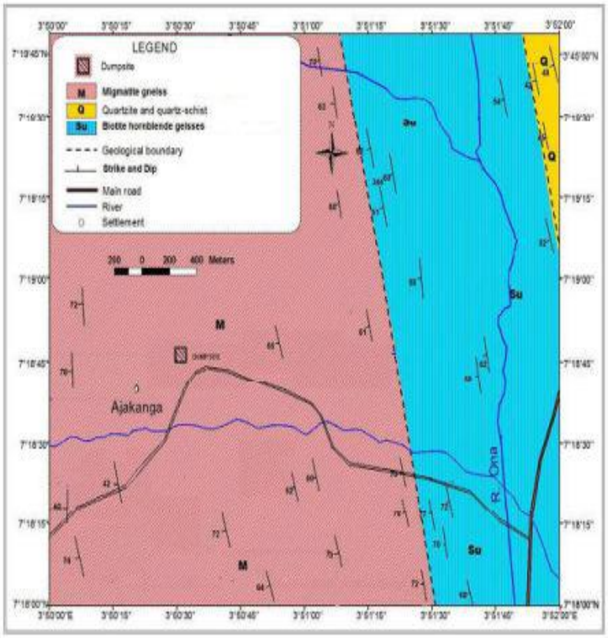

Figure 2. Geological Map of the Study Area after Ogunseiju et al., (2015).

The basement complex rocks consist of crystalline igneous and metamorphic rocks forming part of the African crystalline shield (Akintola *et al*., 2020). Ajakanga waste dumpsite and its environs are underlain by biotite-hornblende gneiss, migmatite gneiss, and quartzite (Ogunseiju *et al*., 2015). The vegetation is tropical rain forest with thick undergrowth. The study area is drained by River Ona and its tributaries. The drainage pattern is dendritic.

Sampling Collection and Analysis

Ten soil samples (0-20cm) each were collected from three different sampling locations (upslope, 0-500m from dumpsite, which serve as the control sample), dumpsite, and downslope (0-500m from dumpsite). Five sub-samples were taken from a sampling point and then mixed to form one composite soil sample. The samples were air dried and sieved to less than 2 mm to remove the larger stones and other root materials, and then the samples were passed through a 100–mesh sieve.

The physical analyses (such as moisture content, grain size distribution, bulk density, permeability, and soil porosity tests) and chemical analyses (such as electrical conductivity, pH, organic matter content, total nitrogen, available phosphorus, Na, K, Ca, Mg, Fe, Cu, Zn, Pb, Cd and Mn) were conducted on the collected soil samples.

The moisture content of the collected disturbed soil samples was estimated by subtracting the weight of the dried soil from weight of the wet soil and then divides by the weight of the dry soil. Grain size distribution test was conducted using hydrometer method following Brown (2003), while bulk density of the soils was determined using a method described by Blake and Harge (1986) in which the undisturbed core samples were dried to a constant weight at 105°C and then divided by its volume. Permeability test was done using permeater. The tests were carried out in accordance with standard guidelines given in BSI (2015). The porosity of the soil samples was determined by saturation method as described by Matko, (2003) and measured by dividing the amount of water added to the soil samples by total volume of the soil samples, multiplied by 100.

The pH of the soil samples was measured using an electrode pH meter in 1-1 water-soil solution while soil electrical conductivity was measured using a standard portable conductivity meter (MW301, Milwaukee, Wisconsin USA) on extract from 1:2.5 soil to water. Soil organic carbon contents were determined using Walkely and Black (1934) method and then multiplied by 1.724 for soil organic matter content determination. Total nitrogen and available phosphorus were determined by micro-Kjeldhal digestion-distillation methods (Bramner, 1965) and electro-photometer method (Bray and Kurtz, 1945), respectively. The concentration of sodium, potassium, calcium, and magnesium were determined by the method of analysis given by Black (1998). The concentrations of heavy metals Fe, Cu, Zn, Pb, Cd, and Mn) were determined using Atomic Absorption Spectrophotometer (AAS) model Accufys 211.

Data Analysis

The data obtained in this study were analyzed using SPSS version 15 for windows. Descriptive statistics were used in this study. And one-way analysis of variance (ANOVA) was used to compare the mean values of the determined parameters in soils from three location sites in and around the dumpsite.

RESULTS AND DISCUSSION

Impact of Wastes on Physical Properties of Soil

The results of some determined soil physical properties from the three location sites in and around the waste dumpsites were presented in Table 1.

The particle size distribution characteristics of the soil as indicated in Table 1 showed that the mean value of the particle sizes of the soil from the different locations were not significantly different from each other texturally at $p<0.05$. The soils from each locations have their particle sizes as follows: upslope [gravel (8.06 - 10.22 %); sand (54.89 – 63.21%); silt (17.09 -18.69%); clay (10.98 - 14.44)]; dumpsite [gravel (5.11 - 7.22 %); sand (55.21 - 62.88%); Silt (16.45-16.57%) ; clay (10.22-14.04)] and downslope [gravel (7.12- 9.56 %); sand (56.01 - 62.55%); Silt (16.66 -17.99%); clay (11.02 -13.34)].

Since the soils were not significantly different from each other, it can thus be stated that the wastes have no effect on the texture of the studied soil samples.

Table 1: Statistical Values of Physical Properties of the Soil Samples from Location Sites.

Determined parameters	Statistical parameters	Location sites		
		Upslope (Control)	Dumpsite	Downslope
Moisture content (%)	Minimum	12.99	19.01	15.50
	maximum	15.45	23.45	20.11
	Mean	13.01^{c}	20.01^{a}	18.91^{b}
Gravel (%)	Minimum	5.11	8.06	7.12
	maximum	7.22	10.22	9.56
	Mean	7.56	8.68	8.21
Sand (%)	Minimum	55.21	54.89	56.01
	maximum	62.88	63.21	62.55
	Mean	62.31	62.56	62.27
Silt (%)	Minimum	16.45	17.09	16.66
	maximum	16.57	18.69	17.99
	Mean	16.09	16.28	16.18
Clay (%)	Minimum	10.22	10.98	11.02
	maximum	14.04	14.44	13.34
	Mean	12.99	12.61	13.01
Permeability (m/s)	Minimum	1.22×10^{-06}	2.05×10^{-06}	1.86×10^{-06}
	maximum	2.11×10^{-06}	3.11×10^{-06}	2.78×10^{-06}
	Mean	1.31×10^{-06c}	2.67×10^{-06a}	2.18×10^{-06b}
Bulk density (%)	Minimum	1.25	1.05	1.18
	maximum	1.31	1.17	1.22
	Mean	1.28^{a}	1.09^{b}	1.21^{a}
Porosity (g/cm^3)	Minimum	45.11	62.11	54.21
	maximum	49.09	65.67	60.61
	Mean	46.72^{c}	61.81^{a}	58.67^{b}

Values with different letters were significantly different from each other at $p<0.05$

This agreed with similar works carried out by Akintola *et al*. (2021) and they stated that though the texture was not affected but the wastes may affect the structure of the soil due to the presence of high organic matter from the decomposition of wastes on the dumpsite soils. Also, the higher percentage of amount of fine particles (silt and clay) recorded for the dumpsite soils can be attributed to the smaller particles emanating from the high organic matter in the dumpsite soil (Akintola *et al*., 2020). This agreed with the findings of Ugwu et al. (2018) and Estabragh *et al*. (2014). According to Akintola *et al*. (2020), it can be inferred that the chemical and biological activities that occurred during decomposition of wastes in the dumpsite affect the physical properties of soils. Based on the particle sizes of the soil, the studied soil samples can be classified as sandy loam. The nature and the quality of the soils structure form the dumpsites can be strongly affected by the amounts of organic matter (Indorial *et al.,* 2017), thus soils from the dumpsite are expected to be more stable, have good aggregate structures, high moisture content, and porosity with low soil strength and bulk density. Thus, the dumpsite soils will provide adequate supports needed for the plant root growth soils (Gurber *et al.,* 2014; Hatten and Lilles, 2019).

The moisture content values of the soils from dumpsite has the highest values ranging between 19.01 and 23.45% with the mean value of 20.01% followed by the soil collected from the downslope location which havs its values ranging between 15.50 and 20.11% with mean value of 18.91%, while those from the upslope side of the dumpsites have the lowest values ranging from 12.99 to 15.45% with mean value of 13.01%. However, there were significant differences in the mean values of the mean values of the soil samples from the studied locations at $P<0.05$ (Table1). These values were higher than the values obtained from similar studies conducted by Akintola *et al*. (2021). This may be due to the age of the dumpsite, study location, rate of decomposition, and types of deposited wastes among others.

The respective mean values of bulk density and porosity in the studied location soils were; dumpsite (1.09 g/cm^3; 61.81%); downslope (1.21 g/cm^3; 58.67 %); and upslope which is the control

(1.28 g/cm^3; 46.72%). It was observed that the bulk density of the soil decreases with increase in the moisture content and porosity of the soils and this is similar to the findings of Akintola *et al*. (2021). Significant differences were also notice in the mean values of the bulk density and the porosity of the soils from the three locations at $P<0.05$.

The mean values of permeability characteristics of the soils were: dumpsite (2.67×10^{-06}m/s), downslope (2.18×10^{-06}) and upslope (1.31×10^{-06}). These values according to Akintola *et al*. (2020) are higher than the stipulated values given for the soil to be used as liner materials for landfill (Clayton and Hue, 1973; Allen, 2000; Mark, 2002). Since the permeability of the soil is high, infiltration of rainwater, water already present in the waste, and water generated by biodegradation from the waste dump will percolate into the soils, thereby increasing the moisture content of the soils, soil organic matter, and the nutrients.

Significant differences were observed among the sampling locations with respect to moisture content, bulk density, permeability, and porosity and could be ascribed to the differences in soil organic matter content that enhances pore spaces and puts soil aggregates together (Brevik, 2014). The significant lower bulk density, high moisture content, permeability, and porosity values recorded from the dumpsite soils when compared to other location sites is in line with similar work conducted by Njoku (2015), Agbeshie *et al.,* (2020) and Akintola *et al.* (2021). Thus, the determined physical conditions from dumpsite soils are greatly affected by wastes when compared to soils from downslope and upslope (Karmakar *et al.,* 2016; Indorial *et al.,* 2017).

The results of the determined physical properties in this study agreed with the reports of Angin *et al*. (2013) that soil physical properties were improved by the decomposition of MSW and percolation of the decomposed into the soil, thus reducing the bulk density, increasing the soil aggregate stability and permeability characteristics of the soil and consequently improving the soil quality.

Impact of Wastes Physicochemical Properties of Soil

The results of some determined physicochemical properties of soil from the three location sites in and around the waste dumpsites were presented in Table 2.

The pH of the studied soils ranged from 6.65 to 8.01 (Table 2). The soils from the three locations were slightly acidic to alkaline in nature. These values were lower than those recorded from similar studies by Akintola et al (2021) but higher than the values obtained by Obianefo *et al*., (2017) and within the earlier findings of Mouhoun-Chouaki *et al*. (2019), Enerijiofi and Ekhaise (2019), and Agbeshie *et al*., (2020).

Table 2: Statistical Values of Physicochemical Properties of the Soil Samples from Location Sites.

Determined parameters	Statistical parameters	Location sites		
		Upslope (Control)	Dumpsite	Downslope
pH	Minimum	6.65	7.21	7.01
	maximum	6.89	8.01	7.68
	Mean	6.72	7.34	7.22
Electrical conductivity (EC) In µS/cm	Minimum	401.02	868.79	688.21
	maximum	648.99	1198.96	987.52
	Mean	527.45^{c}	989.76^{c}	701.28^{b}
Organic matter content (OMC) in %	Minimum	1.28	4.81	1.56
	maximum	1.79	6.18	3.01
	Mean	1.32^{c}	5.99^{a}	2.88^{b}
Total nitrogen (TN) In %	Minimum	0.47	1.02	0.72
	maximum	0.68	1.21	0.98
	Mean	0.52^{c}	1.15^{a}	0.85^{b}
Available phosphorus (AP) in %	Minimum	0.21	0.45	0.28
	maximum	0.33	0.98	0.49
	Mean	0.28^{c}	0.79^{a}	0.51^{b}

The higher pH values recorded in the dumpsite soils could be attributed to the presence of high quantity of liming material, and biological activities (soil microorganisms) on the solid wastes (Kebede *et al.,* 2016; Agbeshie *et al.,* 2020; Akintola et al, 2021).

No significant different was noticed among the three locations. Mean values of EC from dumpsite, downslope and control soil samples were 989.76, 701.28 and 527.25 µS/cm. The significantly high mean EC values recorded in dumpsite soils can be attributed to the presence of more cations and anions in the dumpsite as (Mekonnen *et al.,* 2020; Akintola *et al*., 2021).

The values of EC in the studied soils were lesser to similar studies conducted on dumpsites (Agbeshie, 2020, Mekonnem *et al.,* 2020; Akintola *et al.*, 2021). These, according to Akintola *et al*. (2021) could be attributed to the age of the dumpsites, waste types, decomposition rates, and study locations.

Respective Values of Organic Matter Content (OMC)

Total Nitrogen (TN) and Available Phosphorus (AP) in the studied soil samples from the three location sites were 1.28 - 3.01%; 0.47 – 0.98%; and 0.21-0.51%. There were significant differences at $P<0.05$ in the mean values of OMC. TN and AP of the soil samples among the studied locations.

Higher values of organic matter content, total nitrogen, and available phosphorus observed from dumpsite soils when compared to soils from other locations could be due to the decomposition of organic wastes in the dumpsites.

Obute *et al.* (2010) and Amos-Tautua *et al. (*2014) reported that soil microbial activities increase the soil organic matter contents which serve as major source of nitrogen and phosphorus for plant growth. The results also agreed with the finding of the previous researchers (Obianefo *et al.,* 2017; Agbeshie *et al.,* 2020, Akintola *et al*., 2021).

Impact of Waste Chemical Properties of Soil

The results of the determined chemical elements in the studied soils were presented in Table 3. The concentrations of exchangeable cations in the studied samples from the location sites were presented in Table 3.

The concentrations of exchangeable cations in the studied soils from the site locations were Na (21.09-73.48), K (8.11-32.81), Ca (27.11-53.43) and Mg (16.25-49.81) in mg/kg. The mean concentration values of exchangeable cations were significantly different from each location sites.

The significantly higher values of exchangeable cations in the dumpsite site agreed with the findings of Akintola *et al*. (2021). This also affirms the uses of the dumpsite land area as farming as well as the use of the organic wastes as compost for nourishing the deteriorated soils.

The concentrations of determined metals in the studied soils were Fe (675.01 – 1012.16), Zn (29.01 – 46.22), Cu (5.86 – 28.01), Pb (8.56-36.07), Mn (50.22 – 112.07), and Ni (3.01 - 4.98) in mg/kg. The values obtained in this study were lower than the results of similar work conducted by Akintola *et al*. (2021). However, these values were within the recommended values given by Vecera *et al*. (1999) and FAO/WHO (2001).

Higher heavy metal concentrations observed in the dumpsite soils agreed with the findings of Njoku (2015), Agbeshie *et al.,* (2020), and Akintola *et al*. (2021). Generally, several researchers have reported that the addition of organic wastes such as MSW and food wastes are good sources of plant nutrients and influence chemical properties of soil (Castro *et al*., 2009; Funentes *et al*., 2010; *Achiba et al*., 2010; Blanchet *et al*., 2015, *Sabir et al*., 2015; and Akintola *et al.*, 2021). Thus, this study has demonstrated and confirmed the reason why some farmers choose the dumpsite area for their farming activities.

Table 3: Statistical Values of Chemical Properties of the Soil Samples from Location Sites.

Determined parameters (mg/kg)	Statistical parameters	Location sites		
		Upslope (Control)	Dumpsite	Downslope
Na	Minimum	21.09	91.80	48.21
	maximum	35.21	121.22	73.48
	Mean	29.11^{c}	99.88^{a}	51.72^{b}
K	Minimum	8.11	34.11	19.99
	maximum	13.78	46.29	32.81
	Mean	9.87^{c}	38.28^{a}	27.01^{b}
Ca	Minimum	27.11	121.3`	53.42
	maximum	41.92	156.89	81.29
	Mean	37.37^{c}	123.01^{a}	58.78^{b}
Mg	Minimum	16.25	45.89	28.37
	maximum	18.11	72.67	49.81
	Mean	17.61^{c}	56.38^{a}	31.95^{b}
Fe	Minimum	675.01	1021.09	897.45
	maximum	722.21	1229.98	1012.16
	Mean	688.92^{c}	1109.21^{a}	899.67^{b}
Zn	Minimum	29.01	56.22	28.99
	maximum	30.21	135.56	46.22
	Mean	29.68^{c}	87.67^{a}	36.65^{b}
Cu	Minimum	5.86	16.22	10.08
	maximum	8.28	68.88	28.01
	Mean	7.32^{a}	38.76^{b}	20.11^{c}
Pb	Minimum	8.56	25.21	23.11
	maximum	11.22	48.56	36.07
	Mean	10.04^{c}	32.58^{a}	25.45^{c}
Mn	Minimum	50.22	88.20	71.07
	maximum	52.01	220.08	112.07
	Mean	51.02^{c}	123.91^{b}	89.76^{b}
Ni	Minimum	3.01	4.91	3.56
	maximum	3.78	7.99	4.98
	Mean	3.35^{c}	6.81^{a}	4.88^{b}

CONCLUSION

This study has assessed some properties of soil in and around a dumpsite in Nigeria. It has been shown that wastes have no effect on the texture of the studied soil samples. However, the sandy nature of the soils indicated that the soils are not good as lining materials for landfills. It has also been revealed that the deposition and decomposition of wastes has led to significant impact on soil pH, bulk density, moisture content, porosity, electrical conductivity, and some important soil nutrients, thus enhancing soil fertility and productivity status of the soil for maximum plant growth. Continuous monitoring of the dumpsite should be done for assessment of heavy metals in the soil that can cause environmental pollution with time.

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