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Effect of Wastes on Selected Soil Properties in Abakaliki Southeastern Nigeria

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Author's contribution

The study was designed, analyzed and discussed by the author. The author takes full responsibility for the whole study including data collation, manuscript drafting and editing.

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ABSTRACT

Soil samples were collected from three different dumpsites and a non-dumpsite (control) and used for the determination of the effect of waste dumpsites on selected soil properties. Treatments were replicated five times and data collected were analysed using ANOVA for RCBD and means separated using F-LSD. Results showed a significant ($P>0.05$) change in all the soil properties studied in all the dumpsites. Non-dumpsite recorded the highest bulk density of 1.49gcm^{-3}. This observed bulk density was higher than the bulk density in municipal, rice mill and timber waste dumpsites by 32, 12 and 21%, respectively. The order of increase in the total porosity is municipal waste dumpsite > timber waste dumpsite > rice mill waste dumpsite > non-dumpsite. Non-dumpsite recorded the lowest value of moisture content which was lower than that municipal, rice mill and timber waste dumpsites by 133, 54 and 111%, respectively. The order of increase in the value of Pb is Rice mill waste dumpsite > Municipal waste dumpsite > Timber waste dumpsite > Non-dumpsite. The lowest value of Cu was recorded in non-dumpsite. This recorded value was lower than Cu in municipal, rice mill and timber waste dumpsites by 71, 79 and 50%, respectively. Non-dumpsite also recorded the lowest value of Cd concentration of 0.6mgkg^{-1} while that of dumpsites ranged between 0.65 – 0.80mgkg^{-1} with rice mill waste dumpsite recording the highest value. The order of increase in SO_4^{2-} is timber waste dumpsite > municipal waste dumpsite > rice mill waste dumpsite>non-dumpsite. Non-dumpsite recorded the lowest NO_3^- value of 0.25gkg^{-1}. This observed

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NO_3^- value was higher than the concentration of NO_3^- in municipal, rice mill and timber waste dumpsites by 20, 112 and 24%, respectively. Similarly, the lowest NH_4^+ content of 0.36gkg^{-1} was recorded in non-dumpsite whereas that of dumpsites ranged between 0.42 – 0.62gkg^{-1}. The result showed that waste dumpsites improve soil properties without causing any harmful effect to the soil. Therefore, organic wastes should be used as a substitute for inorganic fertilizers to amend and improve soil properties.

Keywords: Dumpsite; improvement; organic waste and soil properties.

1. INTRODUCTION

Solid waste handling and disposal is a major environmental problem in many urban centres in Nigeria [1]. When rice waste management is properly carried out and carefully monitored to supply the nutrients need by crops, it reduces the cost of crop production and saves the cost of wastes disposal. At a time when environmental quality and food production are of major concern, a better understanding of the behaviour of elements in the air-soil-plant system seems to be particularly important. [2] observed that soils differ in their response to organic waste amendments and that it is important to investigate more closely the influence of these organic wastes on a range of soil physical and chemical properties. Organic wastes differ widely in their properties and characteristics [3]; therefore, each organic waste has a unique property that could be thoroughly investigated. According to [4] the application of organic residues influences soil physical properties. [5] reported a decreased bulk density and increased total porosity and aggregate stability in a dystric leptosol in southeastern Nigeria after using sewage sludge and animal wastes (cow dung, poultry and pig manure) as soil amendments. The improvement in soil physical properties is attributable to an increase in soil organic matter content [6]. [7] reported that organic wastes quantity has a larger effect on splash detachment, shear strength, and aggregate stability than organic waste type. [8] showed that long-term pastures are ideal for improving soil aggregation and change overtime because of their organic matter content. Once these waste materials enter the soil, they become part of the biological cycle that affects all forms of life.

Wastes have the potential of polluting or contaminating soil when the presence of heavy metals, nitrate, sulphate, and other substances in them are above the acceptable level. Soil physiochemical properties are largely affected by high concentrations of these substances; for instance excess heavy metals render soils unsuitable for crop production [9-11]. The metals can also be transferred into the food chain and affect human health as they are transported from the soil into groundwater and crops growing on contaminated soils [12,13]. According to [14] the presence of pollutants threatens land, water, air, plants, animals and human health. Similarly, inorganic plant nutrients such as nitrate, phosphate, sulphate, chemical fertilizers and organic manures pollute water by supplying excess nutrients through a process of euthrophication for aquatic life.

Therefore, this study aimed at determination of the effect of organic waste application on selected soil properties.

2. MATERIALS AND METHODS

2.1 The Study Site

The experiment was carried out in 2010 cropping seasons at Abakaliki. The area is located at latitude 6° 19’ N and longitude 8° 06’ E in the derived savannah of the southeast agroecological zone of Nigeria. It has a mean annual rainfall of 1700 – 1800 mm. The rainfall pattern is bimodal between April – July and September – November with short dry spell in August. According to [15] the minimum and maximum temperatures of the area are 27℃ and 31℃ respectively. The relative humidity is typically between 60 – 80%. The soil belongs to the order Ultisol and is classified as Typic Haplustults [16].

2.2 Soil Sampling

Soil samples (core and auger samples) from three different dumpsites and non-dumpsite in the study area were collected for laboratory analysis at the depth of 0 – 20cm. The dumpsites were a municipal waste dumpsite, a rice mill waste dumpsite, a timber waste dumpsite and a control (a non-dumpsite). Soil samples were collected five times in each location and taken to the laboratory for both physical and chemical properties analysis.

2.3 Physical Properties

Fresh undisturbed core soil samples were weighed and oven dried at 110ºC for 24 hours. They were then weighed again to get the oven dry weight and were used for the determination of the following soil physical properties.

2.3.1 Percentage water content (%MC)

$$\%MC = \frac{\text{Weight of fresh undisturbed soil} - \text{Weight of oven dried soil}}{\text{Weight of Oven Dried Soil}} \quad \text{..equation 1 [17].}$$

Bulk density (Db): Bulk density was determined as described by [18].

$$Db = \frac{\text{Weight of oven-dried soil}}{\text{Volume of the undisturbed soil}} \quad \text{...... ...equation 2}$$

Total porosity: This was calculated from bulk density using the formular:

$$Tp = 100\,(1 - Db/Dp) \quad \text{....................equation 3 [18]}$$

Where:

Dp is particle density assumed to be 2.65 gcm^{-3}
Db is bulk density, Tp = Total porosity

2.4 Chemical Properties

The soil chemical properties determined were:

2.4.1 Sulphate (SO_4^{2-})

The sulphate content of soil samples was determined using the turbidimetric method [19].

2.4.2 Nitrate (NO_3^-)

This was determined using the colorimetric method [20].

2.4.3 Ammonium (NH_4^+)

The NH_4^+ content of the soil samples was also determined using the Indol-phenol blue colorimetric method [20].

2.4.4 Heavy metals (Pb, Cu and Cd)

The soil contents of Pb, Cu and Cd were determined from the soil samples using atomic absorption spectrophotometer after digestion with concentrated HNO_3 [21].

2.6 Data Analysis

Statistical analysis of the data was carried out using the General Linear Model of SAS software for Randomized Complete Block Design [22].

3. RESULTS AND DISCUSSIONS

3.1 Effect of Waste on Soil Bulk Density, Total Porosity and Moisture Content

Table 1 shows the effect of waste on selected soil physical properties. There was a significant ($p<0.05$) change in the selected soil physical properties in all the waste dumpsites studied. Control recorded the highest bulk density of 1.49gcm^{-3}. This observed bulk density was higher than the bulk density in municipal, rice mill and timber waste dumpsites by 32, 12 and 21%, respectively. This is in line with the study of [23] who observed higher bulk density in non-dumpsite than timber waste dumpsite in their study of changes in physical and chemical properties of soil in a timber saw mill dumpsite in Abakaliki, Southeastern Nigeria. This study is also in line with that of [24] who observed that the introduction of urban wastes to soil reduces bulk density and increases total porosity.

Table 1. Effect of waste on bulk density, total porosity and moisture content

Dumpsites	Bulk density (gcm^{-3})	Porosity (%)	Moisture content (%)
Non- dumpsite	1.49	43.75	15.23
Municipal waste	1.13	69.97	35.49
Rice mill waste	1.33	49.90	23.49
Timber waste	1.23	57.52	32.09
F-LSD (0.05)	0.14	2.43	1.45

The order of increase in the total porosity is municipal waste dumpsite > timber waste dumpsite > rice mill waste dumpsite > control. The differences in soil total porosity may be due to differences in organic matter content of the sites. This is because higher organic matter helps to build soil aggregates and increasing pore space. [25,1]. From the result, high porosity and low bulk density of dumpsites are an advantage because they will encourage easy root penetration and facilitate plant establishment and growth [26,25]. Non-dumpsite recorded the lowest value of moisture content which was lower than that of municipal, rice mill and timber waste dumpsites by 133, 54 and 111%, respectively. Among all the soils studied the non-dumpsite recorded the highest bulk density and lowest total porosity and moisture content. This showed that the non-dumpsite had a very low capacity to retain water. Thus, confirming the fact that biodegradable waste when applied to the soil enhances the capacity of the soil to hold water. It also supports the assertion [23] that the ability of organic wastes to improve moisture content depends among other things on organic matter content and improved pores spaces.

3.2 Effect of Waste on Heavy Metals (Pb, Cu and Cd)

The effect of wastes on Pb, Cu and Cd is presented on Table 2. The table also, showed a significant (0.05) difference in Pb, Cu and Cd concentration among all the dumpsites studied. Observed values of Pb, Cu and Cd were within acceptable levels [27]. The order of increase in the value of Pb is Rice mill waste dumpsite > Municipal waste dumpsite > Timber waste dumpsite > Non-dumpsite. The lowest value of Cu was recorded in non-dumpsite. This recorded value was lower than Cu in municipal, rice mill and timber waste dumpsites by 71, 79 and 50%, respectively. Non-dumpsite also recorded the lowest value of Cd concentration of 0.6mgkg^{-1} while that of dumpsites ranged between 0.65 – 0.80mgkg^{-1} with rice mill waste dumpsite recording the highest value. The higher concentration of heavy metal in dumpsites than non-dumpsite could be attributed to the influence of urban wastes that are dumped in them which have been observed to increase the concentration of these heavy metals in the soil. The observation made in this work was also in agreement with the work done by [1] in which they reported higher heavy metals concentration in dumpsites than a non-dumpsite. Since the values of the heavy metals studied are higher in the dumpsites than non-dumpsite and are within acceptable level, organic wastes can be safely used to supply these nutrients to the soil. Metal levels in soils can increase over time with continued application of metal-containing materials and may also decrease when application of those materials ceases [28].

Table 2. Effect of waste on Pb, Cu and Cd (mgkg^{-1})

Dumpsites	Pb	Cu	Cd
Non- dumpsite	4.95	2.40	0.60
Municipal waste	14.35	4.10	0.65
Rice mill waste	15.15	4.30	0.80
Timber waste	12.80	3.60	0.70
F-LSD (0.05)	0.102	0.301	0.477
Acceptable level	2-300	2-1500	0.01-20

Acceptable level in soil [27]

3.3 Effect of Waste Dumpsite on SO_4^{2-}, NO_3^- and NH_4^+

Table 3 shows a significant (P > 0.05) change on SO_4^{2-}, NO_3^- and NH_4^+ in all the dumpsites studied. The order of increase in SO_4^{2-} is timber waste dumpsite > municipal waste dumpsite > rice mill waste dumpsite > non-dumpsite. [5] recorded higher SO_4^{2-} in organic waste amended plots than unamended in their study of accumulation of pollutants in an Ultisol amended with burnt and unburnt rice mill waste which is in agreement with this study. Non-dumpsite recorded the lowest NO_3^- value of 0.25gkg^{-1}. This observed NO_3^- value was higher than the concentration in NO_3^- municipal, rice mill and timber waste dumpsites by 20, 112 and 24%, respectively. From the result it is observed that waste dumpsite may not cause any toxic effect on plants with respect to NO_3^- but it is a potential risk for contamination of the groundwater due to nitrate leaching. Similarly, the lowest NH_4^+ content of 0.36gkg^{-1} was recorded in non-dumpsite whereas that of dumpsites ranged between 0.42 – 0.62gkg^{-1}. This plays the same role as NO_3^- but unlike NO_3^-, NH_4^+ is a cation and is attached with clay micelle where it cannot be easily released to contaminate the environment except that some may be converted to NO_3^- by nitrifying bacteria.

Table 3. Effect of urban waste on SO_4^{2-}, NO_3^- and NH_4^+ (gkg^{-1})

Dumpsites	SO_4^{2-}	NO_3^-	NH_4^+
Non- dumpsite	0.34	0.25	0.36
Municipal waste	2.19	0.30	0.42
Rice mill waste	1.79	0.53	0.62
Timber waste	3.30	0.31	0.42
F-LSD (0.05)	0.02	0.05	0.04

4. CONCLUSION

In conclusion, disposing organic waste on agricultural land improves soil physical and chemical properties. Improved soil properties help to boost the soil fertility level, soil productivity, and soil organisms which provide cementing polysaccharides that act as binding agents for mineral particles, thus, enhancing aggregation and improving soil structure for easy root penetration which in turn facilitates plant growth. The results also showed that dumpsite wastes increased Pb, Cu, Cd, SO_4^{2-}, NO_3^- and NH_4^+ of the soils to non-hazardous levels as their values lie within acceptable levels in soils [27].

COMPETING INTERESTS

Author has declared that no competing interests exist.

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