Co-composting of Biodegradable Solid Waste and Cow Dung using Termite Mound as Bulking Agent

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Abstract

This research evaluated the effects of addition of termite mound on composting time, and the compostability of biodegradable municipal waste and cow dung using termite mound as bulking agent with a view to reducing the amount of solid waste going into landfills or open dumpsites. Co-composting of cow dung, biodegradable waste and termite mound was carried out using pit method of composting for a period of 70 days, between January and April 2016. Five composting pits (pit 1 to pit 5) of 1 m^3 each were dug. The proportion of composting was 0, 5, 10, 15 and 20% termite mound 95, 90, 85, 80 and 75% biodegradable waste and 5% cow dung in all the composting pits. Bulk density, moisture content, pH, temperature, total organic carbon, nitrogen, phosphorous and potassium of the compost were monitored. Bulk density, pH, and total nitrogen ranged from 410 to 790 kg/m^3, 6.6 to 6.7, and 0.8 to 1.21%, respectively whereas total phosphorous and potassium ranged from 1.53 to 2.88, and 15.3 to 28.13 g/kg, respectively. The time required to achieve maximum temperature ranged from 5 to 18 days. Use of termite mound as bulking agent was found to decrease the composting time and increase the nutrient content of the compost. The compost produced can be used as nutrient supplement on farmlands, especially where synthetic fertilizers are expensive or scarce.

Keywords: Bulking agent; co-composting; cow dung; municipal solid waste; termite mound

INTRODUCTION

Managing the ever-increasing waste materials produced in our society has become an essential area of concern in recent years, a major component of waste materials organic fractions such as food waste originating from households, restaurants, and food processing factories can be reclaimed as compost for agricultural use.

Composting involves a deliberate effort to convert organic waste into manure called compost for agricultural purposes. According to Asomani-Boateng and Haight (2007), the practice of using taki (local name for compost from household waste, street sweeping and ash) as fertilizer material by peri-urban farmers in Africa has gone on for centuries.

Although composting is currently implemented in some develop countries such as part of Canada, the United States and throughout the European Union, composting has not reached its potential in these countries (Brinton, 2000). The application of composting in both developed and developing countries has potentials as well as many challenges, composting is an effective method of waste recovery and waste reduction.

Municipal solid waste can be defined as a non-liquid and non-gaseous product of human activities that is regarded to be useless; it could take the form of biodegradable and non-biodegradable (Leton and Omotosho, 2004). The composition and characteristics of municipal solid waste is influenced by certain factors which include the area (residential, commercial etc.), the economic level (differences between high and low income areas) the season and weather, differences in the amount of population during the year, tourist places and culture of people living or doing business in the area, high income areas usually produce more in organic materials such as plastics, while low income areas produce relatively more of organic waste (Bichi and Amotobi 2013).

Municipal solid waste management is an important part of the urban infrastructure that ensures the protection of the environmental and human health (World Bank, 2002). The problem of municipal solid waste management in Nigerian cities has been attracting the attention of researchers, the waste create feeding and breeding grounds for pest and vectors that spread diseases and thus creates a myriad of related health economic, social and infrastructural problems (Nabegu, 2010).

With no well-articulated and implemented waste management policy in Nigeria, most growing and developing municipalities are therefore faced with the difficulty of managing and controlling municipal solid waste. With no proper waste management strategy, municipal solid waste dumps are therefore increasing both in size and number. Problem of poor waste management strategy exposes community to adverse economic, health, environmental and social consequences. Nabegu, (2010) observed that in Kano metropolis solid waste is disposed in a more or less uncontrolled manner. In some cases, dump sites develop quickly at any empty space including metropolitan roads.

It has been suggested that efficient recycling and composting could save 18.6% in waste management cost and 57.7% in land fill cost (Agunwamba, 1998). Agunwamba (1998) also recommended that Nigerians should accept recycling as a step towards adopting an integrated solid waste management approach.

Bulking agent or amendment is a material generally used to control the moisture content or provide porosity to the feed stock. It can be organic or inorganic to provide structural support to enhance aeration or air movement through the feed stock (Epstein, 2011).

Termite mound is a very common where termite operates as decomposers, which is known as "ecosystem engineers" (Dangerfield *et al*., 1998). It is documented that termite mound is rich in different plant nutrients (Seymour *et al*., 2014) and can be used for different purposes like vegetable beds and charcoal kilns (Miyagawa *et al*., 2011). Termite mound due to its higher density and its ability to absorb moisture can be used as a bulking agent (Tonmoy *et al*., 2014).

The volume of solid waste generated due to increase in population and urbanization is so enormous that it is becoming a threat to public health. The proportion of organic waste in the municipal solid waste is high that, there is need to have a controlled method of managing its decomposition so as to avoid methane gas to the atmosphere which contributes to climate change and also management of municipal solid waste consume a lot of resources in view of this there is need to add value to the waste for another use.

Solid waste has become a menace to most cities in Nigeria and this adversely affects public health due to indiscriminate disposal. Conventional approaches to municipal solid waste management concentrate on the use of advanced technology on collection and disposal - its capital intensive nature leads to their avoidance. Therefore there is need to develop a cheaper-alternative method that is environment-friendly and economically viable.

MATERIALS AND METHODS

Composting Materials and Pits

This study began with collection and sorting of the municipal solid waste (MSW) to separate the biodegradable from the non-biodegradable. Five composting pits were constructed; the dimension of the pit been 1.0 m × 1.0 m × 1.0 m (length × breadth × height). Pit 1 served as the control. Polythene sheet was placed at the base as well as in the wall of the pit to prevent leaching; the total volume of each pit was 1 m^3.

The pits were filled with the mixture of cow dung; termite mound and biodegradable MSW waste after the materials were crushed into 1.5 – 2 cm pieces using mortar and pestle based on the ratios shown in Table 1. These materials were thoroughly mixed and then water was sprayed until the moisture content reached about 60%. Table 1 shows detailed proportions of the composting materials. To enhance the chemical and biological activities for speeding up the degradation to achieve uniform breakdown and adequate oxygen supply (Goyal *et al*., 2005), the materials were periodically mixed in the pits.

Table 1: Material Composition for the Compost

Pit	Cow dung (%)	Termite mound (%)	Biodegradable MSW (%)
1	5	0	95
2	5	5	90
3	5	10	85
4	5	15	80
5	5	20	75

Sampling

Composite samples were taken every three weeks interval. The sample were air-dried and then sieved with 1 mm standard sieve for analysis of physico-chemical properties according to Karak *et al*. (2014).

Analytical Tests

Analyses and measurement of different physical and chemical parameters were carried out in the laboratory. The physico-chemical parameters determined include temperature, moisture content, bulk density, pH, total nitrogen, total phosphorous and total potassium.

Bulk density and moisture content of the samples were measured according to ASTM D1895B and ASTM D2216, respectively. Temperature and pH were measured using thermometer and pH metre, respectively. Total nitrogen, phosphorus and potassium were measured using Macro-Kjeldahl, per chloric acid digestion, and extraction with ammonium acetate methods, respectively in accordance with APHA (2005).

RESULTS AND DISCUSSION

Characteristic of the Composting Materials

Table 2 shows the initial characteristics of the raw materials used for the field composting experiments. It can be seen that the termite mound contains nutrients that are essential for plant growth. Its bulk density makes it suitable for use as a bulking material to provide structural support to enhance aeration or air movement through the compost (Epstein, 2011).

Table 2: Physico-chemical properties of the raw materials

Parameter	Cow Dung	Termite Mound	Municipal solid waste
pH	6.14	6.05	6.77
Bulk density (kg/m^3)	429	920	259
Organic carbon (%)	19.72	1.45	8.49
Total nitrogen (%)	0.665	0.295	0.175
Total phosphorous (g/kg)	427	61	312
Total potassium (g/kg)	446	193	222

Temperature

Temperature is one of the most frequently reported parameters in composting studies (Karak *et al*., 2014). Figure 1 shows the changes in temperature monitored in the composing pits. It clearly indicates that the experiment moved through the three classic temperature phases: thermophilic, mesophilic and cooling (Epstein, 2011). Maximum temperature values 59.2, 65.4, 57.8, 71.3 and 69.5 ^{o}C were reached on day 18, 12, 9, 8 and 5 in pits 1 through 5, respectively. The control pit, having no termite mound, took longest time to reach the maximum temperature. Towards the first mixing, fall in temperature was observed in all of composting pits. The mixing appeared to have accelerated the compost temperature for some days due to further decomposition up to the second mixing on day 42. Subsequently, there was slight increase in temperature for short duration and there after the pit temperatures decreased slowly towards ambient level. Similar trend in temperature variation in composting pits was reported by Goyal *et al*., (2005).

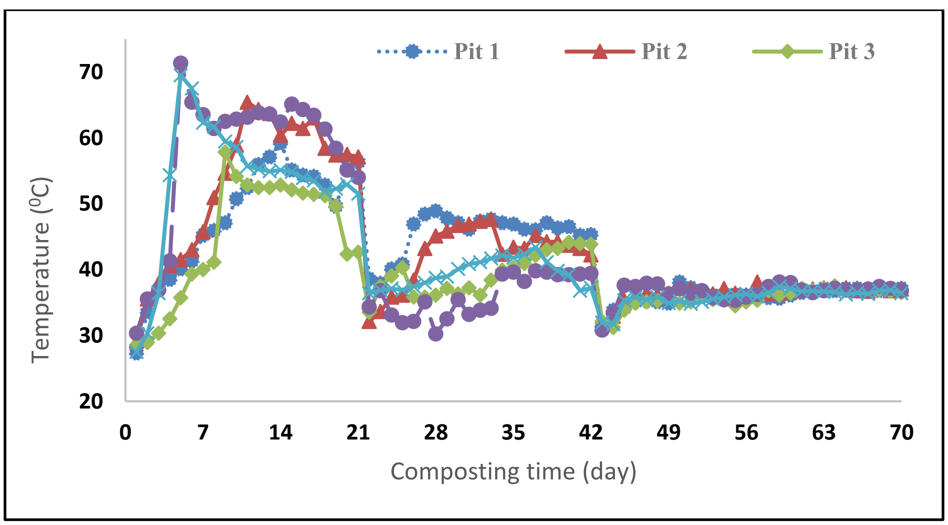

Figure 1: Temperature variation in the composting pits

pH

At the beginning of composting, the pH values of the mixtures were within the range of 6.55 to 6.67 as shown in Figure 2. After 21 days, there was decrease in pH in all of the composting pits. This could be due to partial oxidation and production of organic acid derived from the composting mixture as reported by Goyal et al (2005). Afterwards, the pH begins to rise to slightly neutral which could be due to ammonification and mineralization of organic matter by the activities of microorganisms as observed by Wong *et al*. (2001). Towards the end of the composting, there was marginal change in pH.

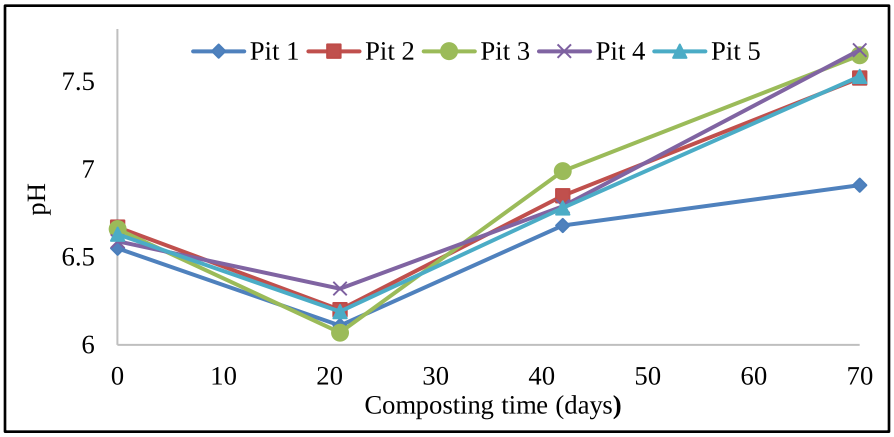

Figure 2: Variation of pH with composting time

Bulk Density

Figure 3 shows the bulk density for all of the compost analyzed from the pits. Values ranging from 410 to 790 kg/m^3 were recorded for the composting mixtures in the pits. The bulk density increased with increase in composting time. It also varied with increase in the amount of termite mound added to the mixture. This variation could be due to high amount of termite mound as bulking agent (Karak *et al*., 2014).

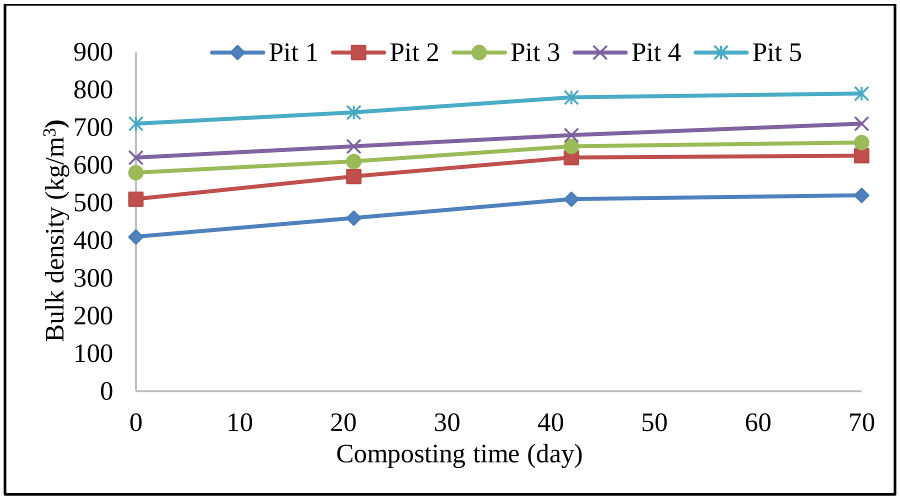

Figure 3: Variation of bulk density with composting time

Total Organic Carbon, Nitrogen, Phosphorus and Potassium

Figure 4 shows the variation of total organic carbon, nitrogen, phosphorus and potassium with composting time in the experimental pits. The initial organic carbon of the composting mixtures varied from about 17 to 36%. Initially, part of the organic carbon in the feed mixture is usually converted to CO2, water, and energy (Nakhshiniev *et al*., 2014). Subsequently, the total organic carbon decreased with increase in composting time which could be due to utilization of easily biodegradable organic matter by thermophiles (Bernal *et al*., 2009).

Total nitrogen composting mixtures ranged from 0.8 to about 1.2% in the composting mixtures for the study period. There was decrease in total nitrogen at early stage of composting in all the pits which could be due to loss of nitrogen in the form of ammonia and this in turn might depend upon the type of material and its carbon to nitrogen ratio (Goyal *et al*., 2005) or nitrogen utilization by microorganisms for protein synthesis (Epstein, 2011).

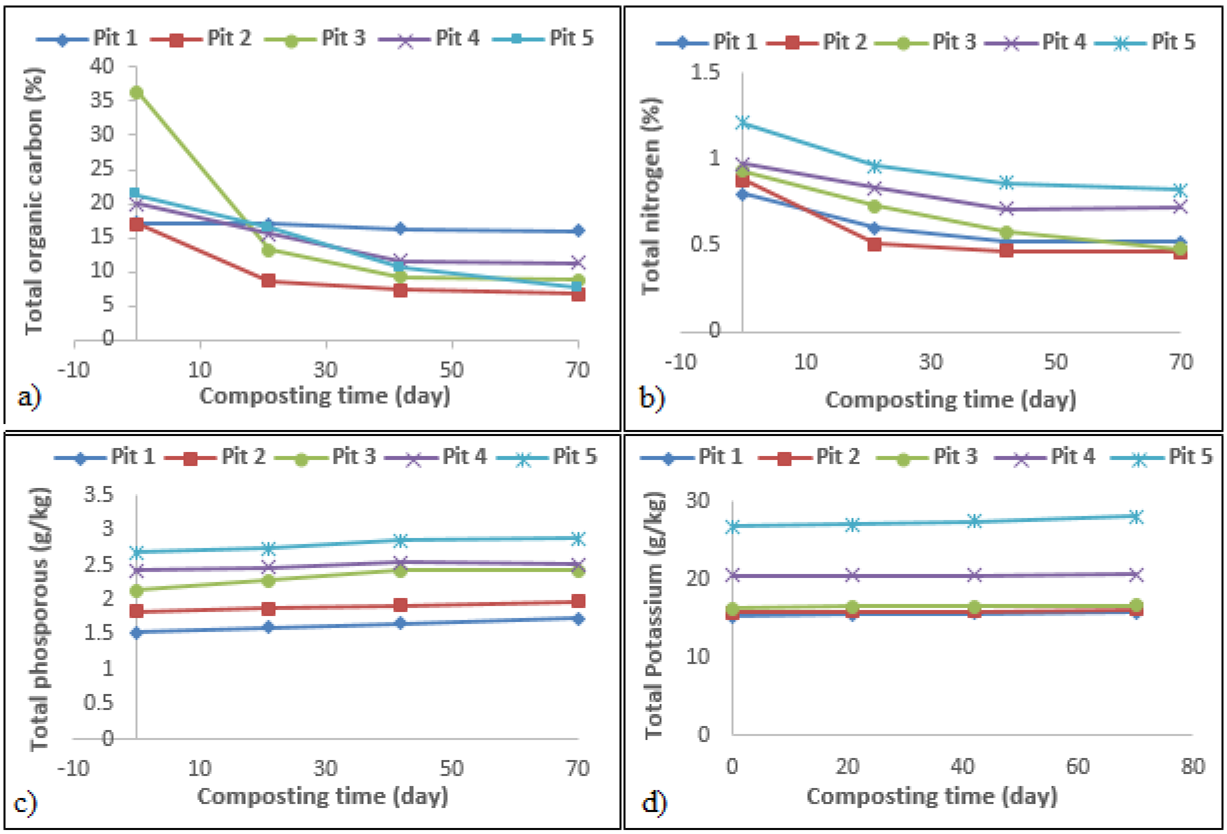

Figure 4: Variation of total, a) organic carbon, b) nitrogen, c) phosphorus and d) potassium with composting time.

Total phosphorous increased with increase in the amount of termite mound in all the composting pits. It ranged from from 1.53 to 2.88 g/kg in the composting pits. Phosphorus is an essential element in microbial cells metabolism and energy synthesis, playing a key role in the manufacture of ADP and its subsequent conversion to ATP (Muller *et al*., 2017). Total potassium ranged from 15 to about 23. g/kg in all the composting pits. It increased considerably during composting. This could be due to the high amount of potassium in termite mound as reported by Karak, (2014).

CONCLUSION

Co-composting of cow dung, biodegradable waste and termite mound as bulking agent was done using the pit composting method and physic-chemical properties of the compost mixtures ware determine during the progress of composting. The time taken to achieve maximum temperature in each composting pit decreased with increase in the amount of termite mound in the composting mixture. Use of the termite mound s bulking agent resulted in decrease in composting time. Addition of termite mound as a composting material has improved the nutrient content of the compost produced. The bulk density of the compost in all the composting pits increased with increase in the amount of termite mound in the composting mixture.

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