Journal of Environmental Science and Resources Management **Volume 4, June 2012**

www.cenresin.org
ISSN 2277-0097

RECYCLING BIODEGRADABLE WASTE USING COMPOSTING TECHNIQUE

Buba Apagu Ankidawa and Emmanuel Nwodo
Department of Agricultural and Environmental Engineering
Modibbo Adama University of Technology, Yola, Nigeria
Email Address – ankidawa03@yahoo.com

ABSTRACT

The objective of this research was to recycle household biodegradable waste using composting as a technique. Mixtures of organic materials which are components of biodegradable wastes were recycled by decomposing them under a controlled environmental condition. The initial moisture content of each of the materials make up the compost mixture was computed and classified as wet and dry materials, and the average moisture content for both wet and dry materials was computed. The dry materials were weighed as they were collected and were found to weigh 18kg with an average moisture content of 34.9% and a chosen moisture goal of 50%. Other results obtained showed that the weight and average moisture content of wet materials were 64.7kg and 54.2% respectively. The compost mixture was scaled down to half its quantity for easy turning. With an optimal environmental condition of moisture content (50%), adequate proportion of both the dry and wet material to meet the required Carbon/Nitrogen (C/N) ratio, and an appropriate volume of air in the pore spaces of the compost pile and microbial decomposition was initiated. At the end of the decomposition, a stabilized organic matter which can be used as fertilizer supplement by horticulturists, landscapers, orchardists, Farmers etc, was obtained.

Key Words: Biodegradable waste, Composting, Organic materials, Aeration, Environment condition, Moisture content.

INTRODUCTION

Composting, the recycling of organic waste such as vegetation and food waste reduces the amount of waste going to landfill and is therefore a rapidly growing sector. The residual compost has been described as the stable, sanitized and humus-like material rich in organic matter and free from offensive odours resulting from the composting process of separating collected biowaste (EC, 2001). Recycling is widely assumed to be environmentally beneficial, because allowing organic waste to decay in landfills has a negative impact both environmentally and economically. The elements of household waste most commonly collected for recycling are garden waste for composting, then paper and third glass Postnote (2005). Metals cans make up only 1% by weight of the material collected for recycling, but recycling them offers high energy and material savings (Table 1). Land application of composted household waste can be one of the most economical and attractive methods to two problems: waste disposal and the necessity to increase the organic matter content of soil (Giusquani et al., 1988; Changa et al., 2003; Bernal et al., 2008). Composting is a natural process which involves the aerobic biological decomposition of organic materials under controlled conditions (Mac' Safley at al., 1992; Pace et al., 1995; Misra et al., 2003). Composting is a nutrient rich soil-like material created by the biological decomposition of organic materials such as vegetative debris and livestock manures (Peter Moon, 1997). Composting can improve soil fertility, extent fertilizers, save water, suppress plant diseases, and boost soil tilt (Peter Moon, 1997). Composting gives organic farmers a way to recycle manures and plant residues that otherwise might present some environmental problems (Baldwin and Greenfield, 2000). A good composting program allows farmers to save money by eliminating or trimming the need for farm fertilizers and other expensive inputs (Baldwin and Greenfield, 2000). Compost can work wonders on farm soil figure 1. During composting organic matter from the biodegradable wastes is microbiologically degraded, resulting in final product containing stabilized carbon, nitrogen and other nutrients in the organic fraction, the stability depending on the compost maturity (Zwart, 2003).

Table 1: Impact of recycling for different materials (Postnote, 2005)

Material	**% of household waste**	**Energy**	**Emissions**	**Raw material save/tonne recycled**
Paper	18	28-70% less	95% less air pollutants	
Glass	7	18% less	30% less	1.2
plastic	7	up to 66% less		1.8
Cans (Fe)	3	70% less	86% less	2
Can (Al)	3	95% less	95% less	4

Figure 1: Compost Material for Farm use (CEC, 1999)

The variety of composting technologies is extensive as composting can be carried out in private garden (home composting) to advanced, highly technological centralized plants (Crowe et al., 2002). The most appropriate composting method depend on land availability, the nature and quantity of biodegradable waste to be treated, financial considerations and available workforce, the desired quality of the end product, and the amount of the time available for processing (Evans, 2001). Various methods for composting household waste include static pile, windrow, In-vessel, vermicomposting, figure 2. For the purpose for the research static pile method was adopted.


Figure 2: Vermicompost (Kokkora, 2008)

Composting is the microbial degradation of organic solid material that involves aerobic respiration and generally includes a thermophilic stage (Finstein and Morris, 1975). Home composting (HC) is traditionally considered as a horticultural recreational activity, however, more recently it has been identified as a potential major opportunity for managing part of the domestic, biodegradable waste stream, to minimize the amount of waste collected for landfill disposal and therefore contribute to achieving compliance with reductions in biodegradable waste disposal to landfill required by the landfill directive (CEC, 1999). The biodegradable waste materials are aerobically digested at a stabilized organic fraction that can be recycled for agricultural uses (Fehr, 2009).

Food waste represents a fraction of the biodegradable that historically has received less attention, although it is the most likely waste stream to contaminate other waste fractions and has been the major contributor to methane production in landfill (Gromez et al., 2008). Composting and other biological treatment technologies are not new but have not often been applied to the treatment of food waste because of health concerns relating to the spread of diseases and negative public perception (Gray, 2006). If the compost is used as soil improver in Agriculture, Carbon dioxide emissions per ton of waste are saved in avoided manufacture of commercial fertilizer, substitution of peat and long term storage of organic carbon in the soil (Rynk et al 1992). Biodegradable materials represent approximately 70% of the urban waste stream in emerging economies. Several official and private organization in different countries have established standards and specifications for compost quality to improve crop production and to protect public health and environment (De Bertoldi, 1993; AS99, 1999; Brinton, 2000). Some of the develop compost standards are those produced by California Compost Quality Council (CCQC, 2002) and British Standards, PAS-100-2005 (BSI, 2005).

In discriminate disposal of refuse is a common sight in many big cities and villages across Nigeria, these refuse decay and the produced odours pollute the environment where they are disposed. Runoff into streams and rivers washed these decayed refused, thereby altering the quality of water sources from streams, rivers, lakes etc, which can be harmful to humans if consumed. The aim of this research is to recycle household biodegradable waste using composting as a technique and specific objectives are as follows

i. Determine the biological and chemical processes and management factors that control the effectiveness of composting biodegradable household waste in small compost bins
ii. Assess the end-use of the material as a soil conditioner and fertilizer product and as an alternative to peat.

MATERIALS AND METHODS

The compost mixtures comprises of household waste such as tomatoes, pumpkin leaves, oranges, peppers, onions, rice husk, woodchips and sawdust. For composting to occur in an optimum manner five key factors need to be controlled, temperature, moisture content, oxygen content, material particle size and nature of the feedstock with particular importance to carbon over nitrogen (C:N) ratio (Pace et al., 1995; Evans, 2001; Last, 2006). The compost pile was sheltered in a structural roof. Turning of the compost to achieve aeration was done using shovel. During the turning, nose mask and hand gloves was won for the protection purposes. The combination of the turned windrow and the aeration static pile methods was used for the composting. This is a passive system in which feed stocks are mixed with bulking agents to provide a mixture suitable for composting. The mixture was formed into a concave pile, this enhanced water retention and aeration of the compost materials. Aeration was achieved by turning the compost material with a shovel, figure 3 to figure 5. The pile begins to decompose at a temperature of (44.7°) under proper conditions of adequate supply of oxygen, at initial moisture content of 50%, particle size of approximately $^{1}/_{8}$ to 2 inches in diameter and a Carbon to Nitrogen Ratio between 20:1 and 40:1 respectively (Rynk et al., 1992).

Generally materials that are green and moist tend to be high in Nitrogen, while those that are brown and dry are high in Carbon. The high Nitrogen materials are Tomatoes, Oranges, Pumpkin leaves, Onions and Peppers, while the high Carbon materials are Sawdust, Woodchips and Rice husks, of the compost materials. Moisture content of the resulting mixture is one of the critical factors in the proportions of various materials to mix to form the compost. The equation below was used to design the initial mixture to achieve suitable moisture level for the optimal composting.

$$M_n = [(W_w - W_d)/W_w]\, X\, 100 ------------------------ 1$$

Where M_n = Moisture content of the Material (%)
M_w = Wet Weight of the Material (g)
W_d = Weight of the Material after drying (g) [16]

Moisture goal was computed by using equation below

$$G = \frac{Q_1M_1 + Q_2M_2}{Q_1 + Q_2} ------------------------------ 2$$

Where G = Moisture goal, Q_1, Q_2 are mass of dry & wet material for the compost mixture respectively; M_1, M_2 are moisture content of dry & wet material for the compost mixture respectively (Rynk et al., 1992). Movement of oxygen in the compost pile was facilitated by turning the pile with shovel at regular intervals, this was done when the compost temperature exceeds normal, and this was observed by noting a rotten egg smell of hydrogen sulfide gas emissions from the compost material.

Compost heat was produced as a by-product of the microbial breakdown of organic material. As the compost begins to cool, turning the pile will result to increase of temperature to peak, because of the replenished oxygen supply and the exposure of organic matter not yet thoroughly decomposed. After the thermorphilic phase the compost temperature drops and does not restored by turning or mixing, at this point, decomposition takes over by mesophilic microbes through a long process of curing phase, where chemical reactions continuous to occur, which makes remaining organic matter more stable and suitable for plant use (IPTS, 2011).

Figure 3: Compost Materials after Ten (10) Days

Figure 4: Compost Materials after Twenty (20) Days

Figure 5: Compost Materials at Final Stage

RESULTS AND DISCUSSION

The results obtained from the analysis are shown in Table 2 and interpreted in figures 6 below.

Table 2: Initial Moisture Content of the Compost Mixture Materials

SN	Samples	Weight of Empty Can (g)	Weight of Can + Wet Sample (g)	Weight of Wet Sample (g)	Weight of Can + Dry Sample (g)	Weight of Dry Sample (g)	Moisture Content (%)
1	Sawdust	87.60	150.00	62.40	124.00	36.40	41.70
2	Woodchips	85.90	155.20	69.30	135.80	49.90	28.10
3	Rice husks	86.60	150.00	63.40	147.20	60.60	4.40
4	Peppers	90.50	137.50	47.00	99.30	8.80	81.30
5	Tomatoes	75.80	230.10	154.30	185.10	109.30	29.20
6	Onions	92.50	161.30	68.80	125.50	33.00	52.00
7	Pumpkin Leaves	93.70	173.20	79.50	139.50	45.80	42.40
8	Oranges	76.90	236.30	159.40	187.30	110.4	30.70

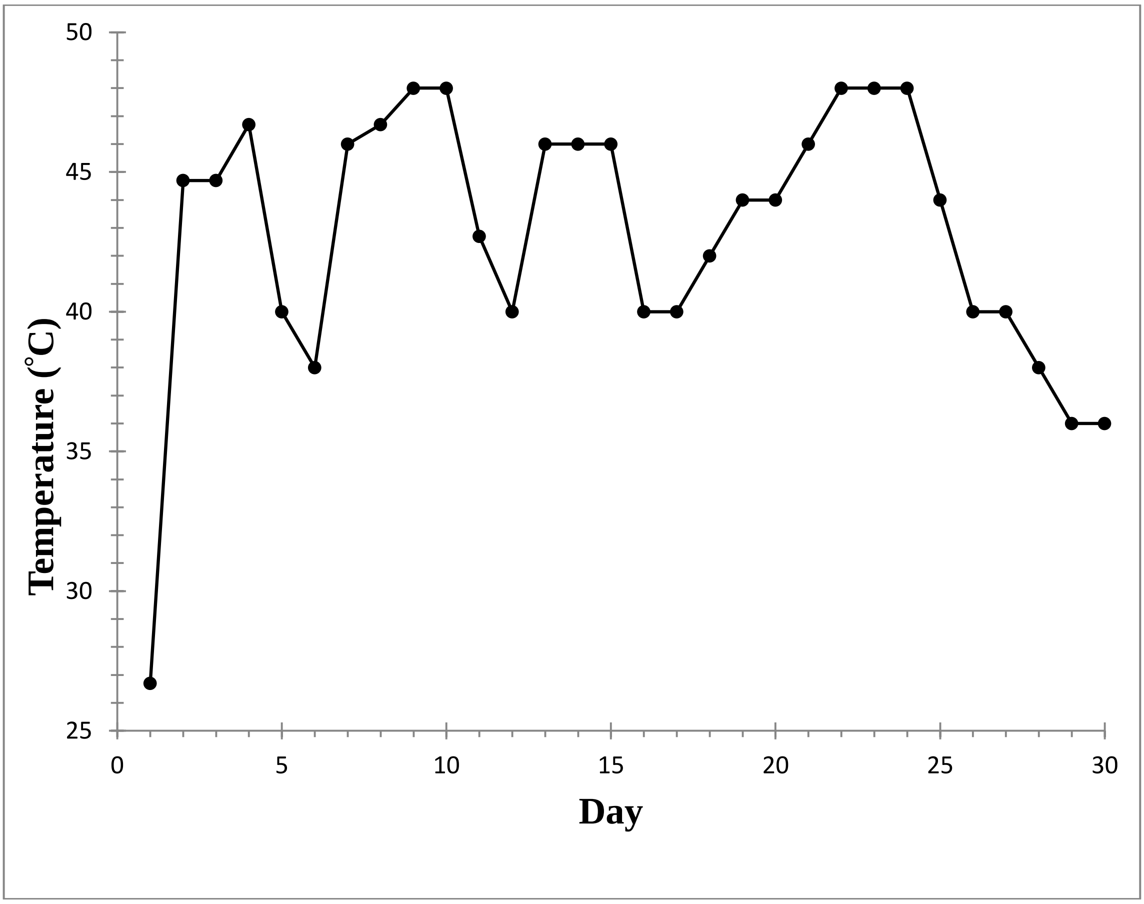

Figure 6: Temperature of composting days

The initial moisture content for each of the compost materials was computed by using equation one (Table 2), pepper has the highest moisture content while rice husks have the lowest moisture content, Sawdust, Woodchips, tomatoes, onion, Pumpkin Leaves and oranges have similar pattern of the moisture content. They were classified as wet and dry materials, the average moisture content for both wet and dry materials was computed. The dry materials were weighed as they collected and are found to weigh 18 kg with an average moisture content of 34.9%. A moisture goal of 50% was chosen (Fehr, 2009). The weight and average moisture content of wet materials were subsequently computed to be 64.7 kg and 54.2 respectively. The compost mixture was scaled down to half its quantity for easy turning. With an optimal environmental condition of moisture content (50%), adequate proportion of both the dry and wet material to meet the required C/N ratio, and an appropriate volume of air in the pore spaces of the compost pile, microbial decomposition was initiated. Heat was generated as a by-product of microbial breakdown of organic material. The heat generated was a function of the size of the pile, its moisture content, and aeration. Decomposition occurred rapidly during the thermophilic stage of composting, these accompanied by a rise in the temperature of the pile from day one to day two, figure 6, where temperature remained high for a few days (day two to day four); during this stage, thermo sensitive fly larvae and weed seeds were destroyed. Subsequently the compost begins to cool as indicated by the various depressions on the graph, figure 6. At this point 100 liters of water was added to increase the moisture content of the pile. The squeeze test was used to ascertain when to stop rewetting the compost. After the rewetting, a new temperature peak was reached and was maintained for another few days after which another depression was witnessed, at this time, oxygen was limited. Turning the pile resulted to a new temperature peak. After the thermophilic phase, the compost temperature dropped and was not restored by turning or rewetting. At this point, decomposition was taken over by mesophilic microbes through a long process of curing or maturation, this phase is indicated on the graph above by the permanent depression towards the end of the graph, figure 6.

CONCLUSION

Mixtures of organic materials which are components of biodegradable waste were recycled by decomposing them under a controlled environmental condition. However, thermal profile and losses of organic matter were lower compared to other composting processes (Bernal et al., 1996). At the end of the decomposition process, a stabilized organic matter which can be used as fertilizer supplement for horticulturists, landscapers, orchardists, farmers etc was obtained. This stabilized organic matter can also be used to control soil erosion. As suggested by Al-Turki (2010), the high variability of most important parameters of local composts suggests an urgent need for developing local compost quality standards in order to assure a good quality for land application, environmental and public health.

RECOMMENDATION

The following recommendations should be adopted

- Composting, if carried out in large scale can be packaged and sold to serve as a source of income
- Composting can also serve as medium of job creation

ACKNOWLEDGEMENT
The author's thanks gratefully to the Department of Agricultural & Environmental Engineering, School of Engineering & Engineering Technology, Modibbo Adama University of Technology, Yola, Nigeria for providing space for the research work.

References

Al-Turki, A.I. (2010). Quality Assessment of Commercially Produced Compost in Saudi Arabia Market. International Journal of Agricultural Research, 5(2), pp. 70 – 79.

AS99 (1999). Australian Standard Composts, Soil Conditioners and Mulches. Standards Association of Australia, Newbush.

Baldwin, K.R. and Greenfield, J.T. (2000). Composting on the organic farm, pp. 1 – 25, Available online at www.cefs.ncsuedu.

Bernal, M.P. Navarro, A.F. Roing, A. Cegara J. and Garcia, D. (1996). Carbon and nitrogen transformation during composting of sweet sorghum bagasse. Boil. Fert. Soils, vol. 22, pp. 141- 148.

Bernal, M.P. Albuqueque J.A. and Moral, R. (2008). Composting of animal manures and chemical criteria for compost maturity assessment: A review, Bioresour. Technol., vol. 100, pp. 5444 – 5453.

Brinto, W., 2000. Compost quality standards and guidelines. Final Report by Woods End Research laboratory for the New York State Association of Recyclers.

BSI, PAS 100:2005 (2005). Specification for Composted Materials. British Standards Instruction, London, ISBN-10: 0580405907.

California Compost Quality Council Compost Maturity Index (CCQC), (2002). Technical report.

Change, C., P. Wang, M. Watson and H. Hoitink, 2003. Assessment of the reliability of a commercial maturity to plant growth. Compost Sci. Utiliz., vol. 11, pp. 96 – 112.

Council of the European Communities (CEC) (1999). The landfill directive (1999/31/EC). Official Journal of the European Communities, pp. 1 – 19.

Crowe, M. Nolan, K. Collins, C. Carty, G. Donlon, B. Kristoffersen, M. Brogger, M. Carlsback, M. Hunmelshoj, R.M. and Thomsen, C.L. (2002). Part 3: Technology and market issues. Copenhagen: EEA.

De Bertoldi, M. (1993). Compost Quality and Standards Specifications: European Press Perspective. In: science and Engineering of composting, Hoitink, H.A.J. and H.M. Keener (Eds). Renaissance Publications Ohio, pp. 521 – 535.

European Commission (EC) (2001). Working Document on Biological Treatment of Biowaste, 2nd Draft.

Evans, G., 2001. Biowaste and biological waste treatment. London. James & James.

Fehr, M. (2009). Promoting life cycle thinking through recycling initiatives of biodegradable waste. Abstract accepted as poster by the waste and climate conference, ISWA-DAKOFA, Copenhagen.

Finstein, M.S. and Morris, M. (1975). Microbiology of Municipal Solid Waste Composting. Advanced Applied Microbiology, vol. 19, pp. 113 – 151.

Gray, D. (2006). Capturing public imagination, waste management World, 2006, vol. 7, pp. 75 – 80.

Giusquani, P.L. Marucchini C. and Businelli, M. (1988). Chemical properties of soil amended with compost of urban waste. Plant Soil, vol. 109, pp. 73 – 78.

Gromez, M.G.C. Grimes, S.M. and Moore, D. (2008). In-Vessel Composting of Food Waste – A catering Waste Management solution. CWRM, 9(1), pp. 19 – 23.

IPTS Sevilla Spain (2011). End-of-waste criteria on biodegradable waste subject to biological treatment first working document, pp. 1 – 152.

Kokkora, M.I. (2008). Biowaste and vegetable compost application to agriculture. PhD thesis Cranfield University, School of Applied Sciences National Soil Resources Institute.

Last, S. (2006). An Introduction to Waste Technologies. Waste Technologies UK Associates.

Mac' Safley, L.M., Dupoldt, C. Geler, F. Stettler D. and Murphy, T. (1992). Agricultural waste management system component design. In: Krider, J.N & Rickman, J.D., (Eds). Agricultural Waste Management Field Handbook, United States. Soil conservation service.

Misra, R.V., R.N. Roy and Hiraoka, H. (2003). On farm composting methods. Rome: FAO.

Pace, M.G., B.E. Miller, K.L. Farrel-Poe (1995). The composting process (AG-WM01). Available online at www.extension,usu.edu/files/agpubs/agwmo1.

Peter Moon, P.E. (1997). Basic on-farm composts manual, pp. 3 – 15.

Postnote (2005). Recycling Household Waste. Postnote recycling household waste, 252: 1 – 4.

Rynk, R., M, Van de Kamp, Wilson, G.G. Singley, M.E. Richard, T.L. Kolega, J.J. Gouin, J.J.F. Laliberty, L. Kay, D. Murphy, D. and Hoituik, H.A.J. (1992). Brinton, W.F., On-farm composting Handbook, R. Rynk (Ed.). NRAES, 54. Natural Resources, Agriculture and Engineering Service Ithaca New York, USA.

Zwart, K. (2003). Fate of C and N pools-experience from short and long term compost experiments. In: Anon., Applying composts benefits and needs. Brussels Federal Ministry of Agriculture, Forestry, Environment and Water Management, Austria and European Communities, pp. 77 – 86.