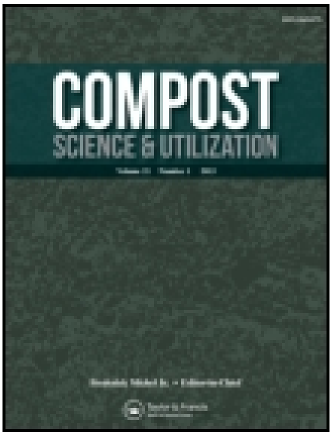

Compost Science & Utilization
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/ucsu20

Effects of Aeration and C:N Ratio on Household Waste Composting in Egypt

S. Sadaka[a] & A. El - Taweel[a]
[a] Agricultural Engineering Dept., Faculty of Agriculture, Alexandria University, Egypt
Published online: 23 Jul 2013.

Compost Science & Utilization, (2003), Vol. 11, No. 1, 36-40

Effects of Aeration and C:N Ratio on Household Waste Composting in Egypt

S. Sadaka and A. El – Taweel
Agricultural Engineering Dept.,
Faculty of Agriculture, Alexandria University, Egypt

The goal of this research was to investigate the effects of aeration and C:N ratio on the composting of Egyptian residential waste. Controlling aeration and carbon to nitrogen ratio may help in enhancing the performance of the composting process. Three airflow rates (0.000, 0.003 and 0.006 m^3/h/kg) and carbon to nitrogen ratio (11, 26 and 39) were studied using a laboratory scale composting unit. Increasing the compost time resulted in a peak of the temperature up to the thermophilic range between the second to third weeks. The compost temperature reached its maximum value of 68°C at the aeration level of 0.003 m^3/h/kg and C:N ratio of 26. At this temperature, the plant and animal pathogens may be killed or at least suppressed to acceptable levels. Moisture content of compost material was reduced during the composting process. The reduction of the moisture content of the compost material due to change in C:N ratio was small except in the case of no aeration. Moisture content reached its minimum value of 20% d.b after four weeks at aeration level of 0.006 m^3/h/kg and C:N ratio of 39. The pH values of the household waste were near neutral showing insignificant increase with composting time. At the lower level of initial C:N ratio (11), composting time did not affect the C:N ratios. The maximum reduction of the C:N value (33.1%) was observed with aeration rate of 0.003 m^3/h/kg and initial C:N of 39.

Introduction

Egyptian household wastes contain kitchen residues and other refuse. Besides nitrogen (N), phosphorus (P) and potassium (K), household waste contains calcium and magnesium, which are important for their fertilizing value. Recycling these elements in the soil through composting greatly reduces the difficulty of meeting the yearly NPK deficient.

Composting involves actions of enzymes, microorganisms and oxygen. It is important to maintain aerobic conditions during the composting process through continuous aeration. The main objective of supplying air is to provide oxygen for aerobic biodegradation as well as to remove excess water vapor, heat and gases.The recommended range of aeration in literature is quite wide, with suggested rates as low as 0.04 to 0.08 L air/min-kg of volatile solids (Lau *et al.* 1992), up to 0.87 to 1.87 L air/min-kg of volatile solids (Hong *et al.* 1983). Mathur (1991) stated that the optimal rate is considered to be a supply of 0.6 - 1.8 m^3 air/day/ kg volatile solids during the thermophilic stage of composting.

Mathur (1991) and Barington *et al.* (1997) stated that different materials have to be mixed or layered to achieve an optimal C:N ratio, and thus optimal composting. The activity of microorganisms involved in composting is directed at synthesizing microbial protoplasm which contains about 50% C, 5% N and 0.25% P on a dry weight basis (Alexander 1977). The effects of C:N ratio on composting were investigated by many researchers and the range of 20 to 30 is generally recommended as the optimum C:N ratio.

Moisture content of Egyptian household waste varies depending upon the waste type, collection method, and geographical site. Moisture content represents a significant characterization in the growth of microorganisms and in the composting process. Sadaka and Engler (2000) reported an increase in volatile solids and chemical oxygen demand reductions as initial moisture content in the reactor increased. Posey *et al.* (1999) evaluated biodegradation of waste with moisture contents ranging from 13 to 75% in a landfill system. They found that biodegradation of waste began after 7, 14 and 21 days for moisture contents of 80, 73 and 65%, respectively. Waste biodegradation was minimal after 70 days at moisture contents of 50% or less.

The aim of this research was to investigate the effects of aeration and initial carbon to nitrogen ratio on household waste composting as measured by temperature, moisture content, pH and C:N.

Materials and Methods

Three wood boxes (40 x 40 x 40 cm) were constructed in the Agricultural Engineering Department workshop, Faculty of Agriculture, Alexandria University. A perforated plate was placed at the bottom of the box. Each box was divided into nine sections to offer twenty-seven experimental units. The boxes were insulated to reduce the heat loss. Bulk density, moisture content and C:N ratio of the initial waste material averaged between 345±47 kg/m^3, 45±4% and 11, respectively. Air was supplied by small pre-calibrated air pumps to supply positive pressure to the compost. Three-air flow rates namely 0.000, 0.003 and 0.006 m^3/h/kg waste and three carbon to nitrogen ratios namely 11, 26 and 39 were used as shown in Table (1). The required carbon to nitrogen ratios were achieved by adding the needed amount of sawdust. Each box contained three C:N ratios and was subjected to a single air flow rate under the perforated plate. Three replicates were used for each treatment.

Temperature, moisture content, pH and carbon to nitrogen ratio were measured during the experimental run. Temperatures were measured using a digital thermometer (Comark, 9006, Beaverton, Oregon, USA) and thermocouple with accuracy of ± 0.1°C. The thermocouple was injected to the center of the experimental unit. Adequate time was taken to read the temperature until no further temperature changes. A known volume (50 cm^3) of compost was taken and oven dried. The dried materials were weighed and the moisture content (d.b.) was determined. The pH and carbon to nitrogen ratio were found in the Soil Laboratory (Alexandria University, Alexandria).

TABLE 1.
The experimental design

Air Flow Rate (m^3/h/kg waste)	Carbon To Nitrogen Ratio	Initial Moisture Content % (d.b.)*
0.000	11	49.2 ± 1.1
	26	47.4 ± 0.9
	39	45.3 ± 1.2
0.003	11	47.6 ± 1.3
	26	45.5 ± 0.8
	39	46.4 ± 0.9
0.006	11	45.2 ± 1.1
	26	43.1 ± 0.7
	39	41.4 ± 0.7

*Measured, n = 3

Results and Discussion

Composting temperature profile is a very good indicator of the composting competency. The results of the effects of aeration level and C:N ratio on the composting temperature are shown in Figure 1. The results show that increasing the compost time resulted in a peak of the temperature up to the thermophilic range between the second to the third weeks. After three weeks these temperatures began a gradual decline. The results also showed that, increasing the aeration level from 0.000 to 0.003

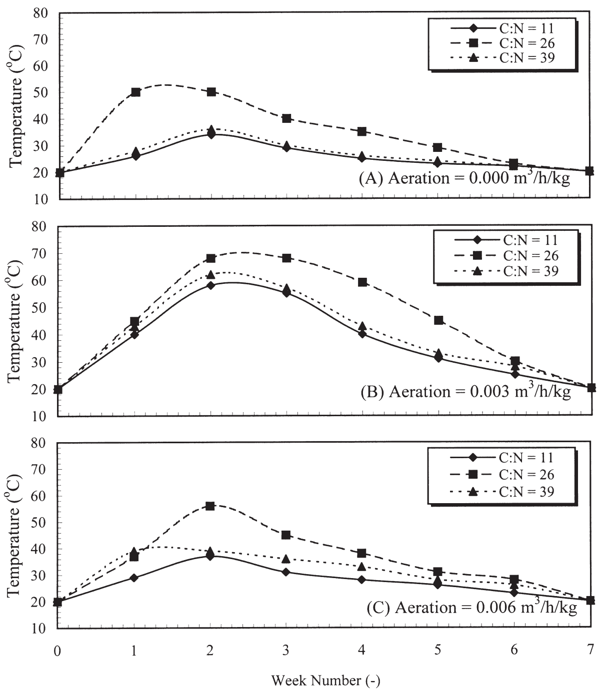

Figure 1. The effects of composting time on composting temperature at different initial carbon to nitrogen ratios and aeration levels.

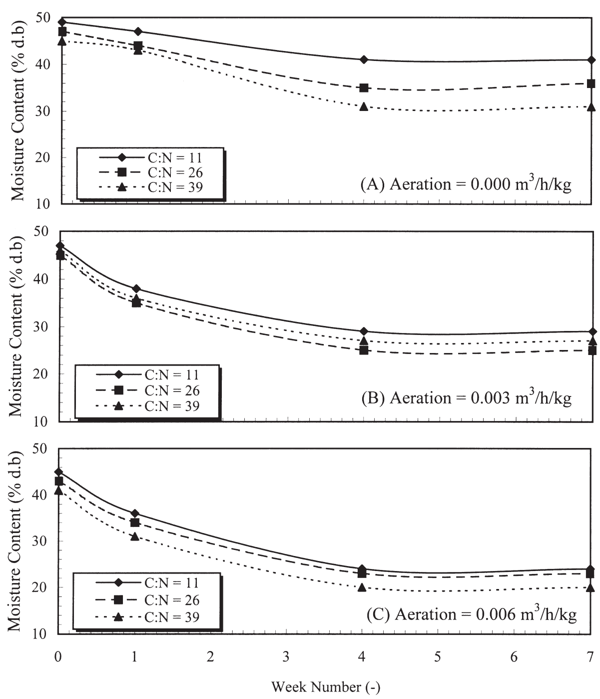

Figure 2. The effects of composting time on composting moisture content at different initial carbon to nitrogen ratios and aeration levels.

m^3/h/kg increased the composting temperature. A further increase in airflow rate reduced the maximum temperature. The higher temperature might lead to higher substrate decomposition. The compost temperature increased due to the activity of the thermophilic bacteria. Increasing the airflow rate reduced the temperature due to the heat transfer by convection with air and may be due to reduction of microorganisms. Aeration conditions were achieved throughout the second box after the second week as suggested by the rapid temperature rise. Generally, temperature remained in the thermophilic range from week two to four for most of the experiments.

The compost temperature reached its maximum value of 68°C at the aeration level of 0.003 m^3/h/kg and C:N of 26. Either increasing or decreasing the C:N ratio resulted in decrease in maximum composting temperature. The temperature did not reach the desired temperature of 68° in the case of C:N of 39 may be due to the lack of biodegradable carbon and nitrogen. Whereas, a C:N of 26 improved microbial activity, despite nitrogen losses. Increasing the C:N ratio from 11 to 26 gave a better nutrient balance for the microorganisms to be active and increase in composting temperature. Further increase in C:N ratio to 39 reduced the available nitrogen for the microorganisms to multiply. The results also show that the composting temperature reach the room temperature at the seventh week.

As with C:N ratio, proper moisture content is also necessary to support microbial activity. However, no moisture was added to the compost throughout the course of this study. The initial moisture contents were in the range of 40-50% d.b. The effects of aeration level and C:N ratio are presented graphically in Figure 2. The moisture content reduction rate was sharp at the beginning of the composting period. This reduction of moisture content could be attributed to the activity of the microorganisms. A second reason is the ability of air, to dry the moist material at the beginning. The temperature rise at the first two weeks contributed to material drying. After five weeks, moisture content reached an almost steady state for all experiments.

The difference between the moisture content of the compost material due to change in C:N ratio was small except in the case of no aeration. The results showed that the moisture content reached its minimum value of 20% (d.b.) after four weeks at aeration level of 0.006 $m^3/h/kg$ and C:N ratio of 39. It can be observed that, the higher the aeration level the lower the moisture content. The results are in agreement with Rynk *et al.* (1992). They reported that composting reduced moisture content. Also, Sartaj *et al.* (1997) observed that moisture content decreased from 76 to 70.2% while composting poultry manure.

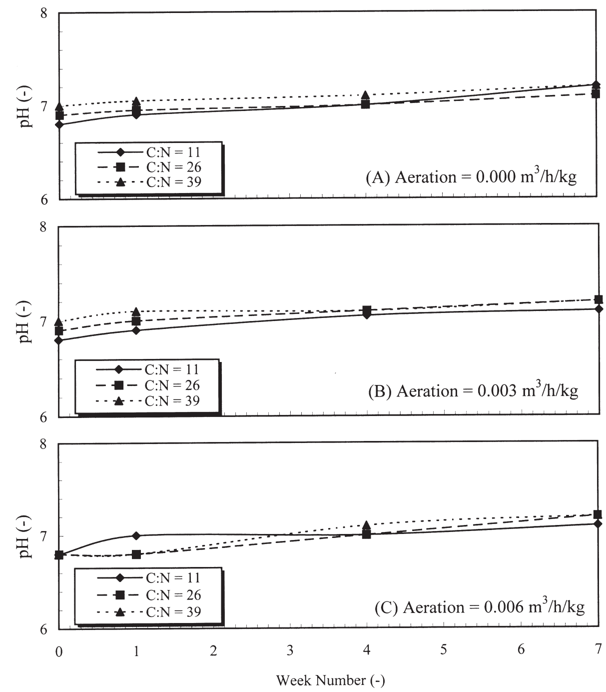

Figure 3. The effects of composting time on composting pH at different initial carbon to nitrogen ratios and aeration levels.

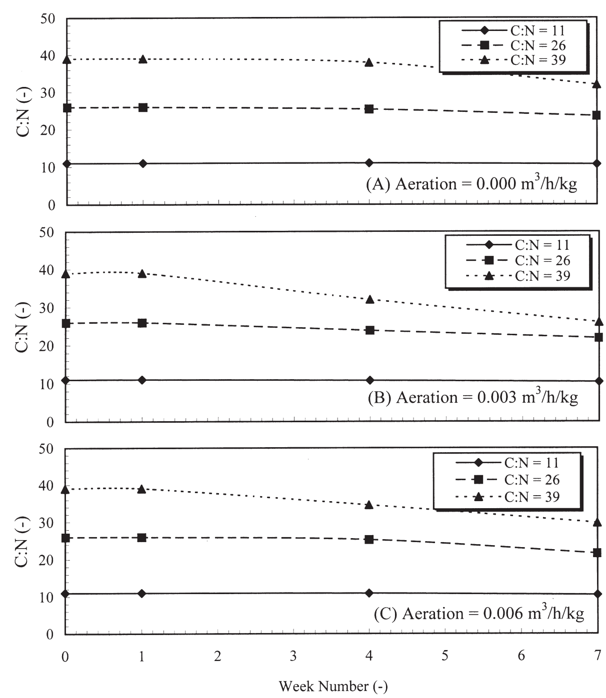

Figure 4. The effects of composting time on the composting C:N ratio at different initial carbon to nitrogen ratios and aeration levels.

The pH trends as affected by aeration level and C:N are shown in Figure 3. The initial pH of the waste material was (6.8 - 7.0). The pH values of the medium increased slightly with time for all treatments. The effects of aeration and C:N were not pronounced. The results showed that adjustments of pH may not be necessary. Mathur (1991) reported that most household refuse is between 5.0 and 7.0, more towards the lower number if the material is partly putrefied as decomposition initially releases organic acids. On the other hand, if the compost material is high in substances like proteins, urea and uric acid, enzyme hydrolysis initially will release ammonia, thus raising the reaction to alkalinity.

The effects of the composting time on the carbon to nitrogen ratio are presented graphically in Figure 4. Neither aeration nor the composting time affects the C:N ratio of the material at the initial C:N ratio of 11. Composting time affects the C:N ratio for the initial C:N of 39. Rodrigues *et al.* (1995) and Martin *et al.* (1993) observed that a compost with C:N of 20 - 35 is preferred ratio for composting. When C:N ratio is low, the available carbon may be fully utilized and excess nitrogen may be lost in the form of ammonia. If C:N ratio is high, nitrogen becomes the limiting factor and the process slows down. Therefore, the C:N ratio of 26 is the optimum condition for composting.

Conclusions

It can be concluded that Egyptian household waste is a valuable material if it is composted and converted to useful fertilizer. Aeration affects compost temperature. A maximum temperature of 68°C was achieved at the air flow rate of 0.003 m^3/h/kg and C:N ratio of 26. Moisture content of compost material can be reduced by the means of composting technology to reduce transporting costs. From the experiments, it can be concluded that the optimum condition of Egyptian household waste composting process is aeration level of 0.003 m^3/h/kg and C:N ratio of 26 and moisture content of 45% (d.b).

References

Alexander, M. 1977. Soil Microbiology. New York, New York: John Wiley and Sons.

Barington, S.F., K. ELL. Moueddeb and B. Porter. 1997. Improving small-scale composting of apple waste. *Canadian Agricultural Engineering*. 39(1):9-16.

Hong, J.H., J. Mastsuda and Y. Ikeuchi. 1983. High rapid composting of dairy cattle manure with crops and forest residues. Transactions of the ASAE. 26(2):533-545.

Lau, A.K., K.V. Lo, P.H. Liau and J.C. Yu. 1992 . Aeration experiments for swine manure composting. *Bioresource Technology*. 41:145-152.

Martin, A.M., J. Evans, D. Porter and T.R. Patel. 1993. Comparative effects of peat and sawdust employed as bulking agents in composting. *Bioresources Technology*. 44:65-69.

Mathur, S.P. 1991. Composting Process. *In:* Bioconversion of Waste Material to Industrial Products. New York. Elsevier *Appl. Sci.*, pp. 147-183.

Posey, J.S., D.B. Parker, D.L. Williams, B.W. Auvermann and N.A. Cole. 1999. Production of biogas in landfill cells using beef cattle manure collected in open lots. A paper presented at the 1999 ASAE Annual International Meeting, July 18-21, Toronto, Ontario, Canada, Paper No. 994084, ASAE 2950 Niles Rd., St. Joseph, Michigan 49085-9659 USA.

Rodrigues, A.M., L.J. Ferreira, A.L. Fernando, P. Urbano and J.S. Oliveira. 1995. Composting of sweet sorghum biomass with different nitrogen sources. *Bioresources Technology.* 54:21-27.

Rynk, R. 1992. *On farm composting handbook*. NRAES-54.Ithanca, N.Y. Northeast Regional Agricultural Engineering Services.

Sadaka, S.S. and C.R. Engler. 2000. Anaerobic composting of swine, poultry and beef manure with biogas recovery. A Paper presented at the ASAE Annual International Meeting. Milwaukee, Wisconsin. Paper No. 004146.

Sartaj, M., L. Fernandes and N.K. Patni. 1997. Performance of forced, passive and natural aeration methods for composting manure slurries. Transactions of the ASAE. 40(2):457-463.