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Windrow Composting of Yard Wastes and Food Waste

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ABSTRACT

Composting is a natural method of recycling organic waste into new soil that can be used for planting flowers or vegetables and for landscaping. The most commonly used composting method for yard waste is windrow composting, which consists of placing a mixture of raw materials into long narrow piles that are turned and re-mixed on a regular basis. The objective of this study is to monitor the windrow composting-process parameters of mixed yard and food wastes (1:1 ratio by volume), including the moisture content, pH, temperature and C/N ratio. This monitoring study was conducted for 5 weeks using Effective microbes (EM) Takakura (10%: pile A, 30%: pile B and 50%: pile C, by volume) to accelerate the maturation of the compost. The observations and experimental results regarding the composting parameters reveal that the compost requires more than five weeks for mature. Therefore, identifying the pile that reaches maturity will take longer than five weeks.

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INTRODUCTION

Presently, we face the problem of increased waste generation, especially of organic waste. Because organic waste has a high percentage of solid waste (JPSPA 2007), the best way to reduce this type of waste is by using composting technology. Compost is a waste-treatment technology that facilitates the reduction of the waste sent to landfills and is one way to recycle the organic materials from biological waste land (Cecilia Sundberg, 2012). Composting methods are the only way to decompose solid organic waste to obtain a final product known as compost (Elvi Yenie, 2008). This method can be adapted to treat organic waste, such as food waste (Chanakya, H.N., 2007), which is increasingly generated in school cafeterias or institutions of higher education. The availability of a composting system will encourage the reuse of organic waste, rather than the filling of landfills, and is expected to give returns as a source of income.

Food waste is very moist and rich in organic matter (Chung-Jung Tsai, 2008). The water content in food waste is 65.0%-69.5%, while the organic content ranges from 13.5%-17.4% (Leow Kim Teck, Aminah Abdullah, 2010). Composting of food waste produces good products for crops. Additionally, composting is an alternative to reduce the demand for waste-disposal area (Sullivian, D.M., 2002). The carbon to nitrogen ratio (C/N) of food waste is in the range of 20-25, which is suitable for effective composting. According to Golueke (Golueke, C.G., 1992), for effective composting, food waste with a low pH value should be mixed with other components approaching neutral conditions (pH approximately 6.5-7.5) so that the initial pH value of the substrate for composting can be set in the range of 6.0-7.5.

According to Habsah (2006), yard waste is one component of municipal solid waste. The components of yard waste used in the composting process are leaves, grass, weeds and plant parts that have been reduced in size. Yard waste contains relatively large amounts of cellulose and lignin, and the concentrations of saccharides, amino acids, proteins, and carbohydrates within this waste are relatively low. Therefore, the incubation time required for plant waste is longer than that for other compost materials (Hua-Shan Tsai, Wei-Hsiung He, 2006)].

Experimental Procedure:

Windrow Composting:

The windrow composting method does not employ any machines or reactors during the composting process. The compost is turned manually using scrapers or shovels and is aerated naturally. According to Nor Habsah (2008), this method of composting is simple and can be modified according to the place and

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circumstances. In this method, the organic waste is formed into a large pile and elongated. A static windrow pile may be made in the form of a triangle, called a delta windrow, to reach 2 meters in height with a width between 2.5 meters and 3 meters. In addition, an elongated rectangular pile, called a trapezoidal windrow, can grow up to 3 meters with a width between 10 meters and 12 meters.

In the present study, the yard waste that was collected was shredded to a small size. The shredded yard waste was mixed with food waste to form a pile for the composting process. Each pile was mixed with yard waste and food waste in a 1:1 ratio by volume. The mixed waste was treated with EM Takakura and piled in static piles. The compost piles were returned to the barn for a few weeks and were turned at 3- or 4-day intervals.

Table 1: Pile composition of waste and EM Takakura.

Pile	Composition of waste mixture and EM Takakura (by volume)
A	90 % Waste Mixture* : 10% EM
B	70% Waste Mixture* : 30% EM
C	50% Waste Mixture* : 50% EM

*waste mixture refers to 50% yard waste and 50% food waste

Takakura EM Preparation:

The EM Takakura was prepared as follows:

i. Preparation of fermentation liquid: There are two solutions used in the preparation of the fermentation liquid. The first is a red sugar solution consisting of 15 liters of water and 40 grams of brown sugar mixed with a variety of fermented foods, in this case, 225 grams of bean paste, 200 grams of fermented soy, 125 grams of baker's yeast (yeast), and 250 grams of yogurt. All the ingredients were blended into an airtight bottle or jar. The liquid was left to ferment for 3 to 5 days. The second solution is a saline solution. This solution consists of 4 liters of water and 15 grams of salt mixed with raw vegetables, including eggplant, cabbage and cucumbers, and fruits, such as the skins of apples, grapes and oranges. The liquid was left to ferment for 3 to 5 days.

ii. Preparation of a soil medium for fungi: Sawdust and rice husks were mixed until smooth. The two fermentation-liquid solutions were added to the sawdust/rice mixture until the mixture formed lumps. The moisture content of the mixture was controlled to achieve the appropriate level, between 40% to 60% water content.

iii. Preparation of seed compost: The resulting mixture, named seed compost, was stored in containers at room temperature (27 ºC) with sunlight for 3-5 days until the occurrence of white mold growth on the surface of the mixture.

Parameters monitored during the composting process pH:

The sample’s pH was determined using an electronic pH meter. Ten grams of the sample was diluted with 100 ml of distilled water, and the electrode was rinsed with distilled water before and after the measurements. The readings were taken three times to obtain a precise pH value.

Moisture content:

In this test, the container used for the test was weighed first. Then, the container was weighed together with a sample mixture of food waste and garden waste that had been crushed into smaller samples. This weight of the waste-mixture samples was labeled as the sample wet weight, w_1. Next, the samples were placed in an oven at 110 °C for 24 hours. The resulting weight was labeled as the dry weight of the sample, w_2.

The moisture content (as a percentage) of the mixed samples of food and garden waste was calculated using the following formula:

$$\frac{(w1-w2)}{w1}\ x\ 100\%$$

Where:

w_1 = Weight of the wet sample = (weight of container + wet sample) – weight of container
w_2 = Weight of the dry sample = (weight of container + dry sample) – weight of container

Carbon to nitrogen ratio (C/N):

A mixture of compost from food waste and garden waste was prepared and heated at 70 °C for 24 hours. Next, the samples were removed from the oven, cooled and ground into a powder. A total of 2 grams of waste samples taken from the blended mixture were placed in a small aluminum cone, and a CHNS-O analyzer was used to determine the carbon to nitrogen ratio.

RESULT AND DISCUSSION

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This observational study demonstrates that the windrow approach is the simplest composting method, requiring no special tools or bins. However, open piles can easily become too wet if uncovered, can dry out, or can be disturbed by pets or other animals. Therefore, this method requires monitoring of the important parameters, including the temperature, moisture content, pH and C/N ratio. However, in this study, the results are only reported for the first 5 weeks, and the composting process had still not achieved the curing stage (i.e., required more than 5 weeks) for every pile.

Temperature:

Temperature is the main parameter that controls microbial activity during the composting process. The temperature change during the composting process occurs in three stages: the mesophilic (20ºC–45ºC), termophilic (45ºC–70ºC) and curing stages (cooling stage) (Elvi Yenie, 2008). In the termophilic stage, microbes are active (45ºC-70°C) until the compost reaches a certain stage of decomposition. Then, the temperature will drop to the initial temperature. The temperature decreased during the composting process for each pile (Figure 1). The beginning of the composting process can be observed in the termophilic phase, and in a few weeks, the temperature decreased until it reached the mesophilic phase (week 5). Based on the temperature at week 5, every pile had almost achieved the curing stage.

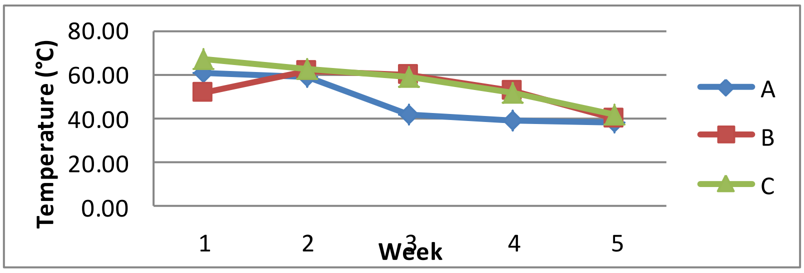

Fig. 1: Graph of composting temperature throughout the experiment.

Moisture content:

The moisture content increased for every pile within the optimum level of 20% to 70% (Figure 2). Pile B had the highest moisture content, and pile C had the lowest. Values of the optimum moisture content for the composting process range from 25% to 80%, and typically within the range of 50% to 70% (Abdelhadi Makan, Mohammed Mountada, 2012). The moisture content is related to aeration and temperature. In an aerated windrow, heat will be lost during the composting process due to the evaporation of water. A moisture content that is less than optimal reduces the level of oxygen during the process and affects the temperature. To meet the oxygen requirement, the compost piles were turned.

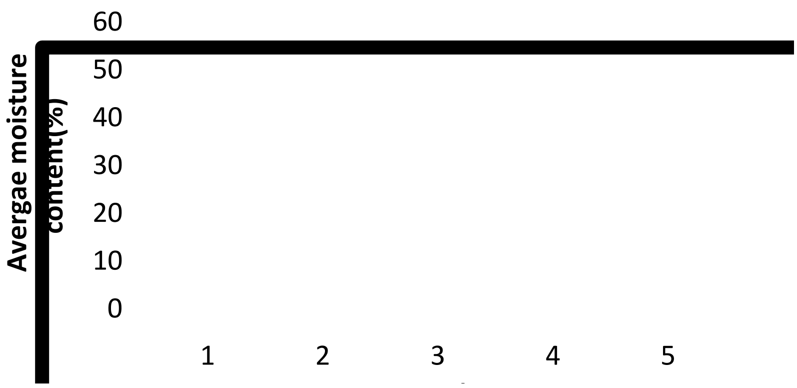

Fig. 2: Graph of moisture content of the compost throughout the experiment.

pH value:

The pH value for each pile in week 1 was between 7.31 and 7.40. The pH decreased in week 2 for piles A & C but still remained in neutral-phase values. Pile B had a higher pH value (7.94) in week 2, but the pH declined in the acidic phase from week 3 until week 5 (6.96-6.82). The pattern differed for pile A, which remained in the neutral phase until week 5.

C/N ratio:

In the composting process, the ratio of carbon to nitrogen in the plant substance is important. If the carbon to nitrogen ratio is high at the beginning of the composting process, the decomposition of organic material will be slower [11]. Table 2 shows the C/N ratio for each of the piles. According to Henry *et al*. (2009), soil usually contains a carbon to nitrogen ratio (C/N) of 10:1. A suitable material for composting will contain 30 parts carbon to 1 part nitrogen, with 20 parts of carbon entering the atmosphere as CO_2 and leaving 10 parts of the total carbon in the compost material to form a ratio with nitrogen of 10:1.

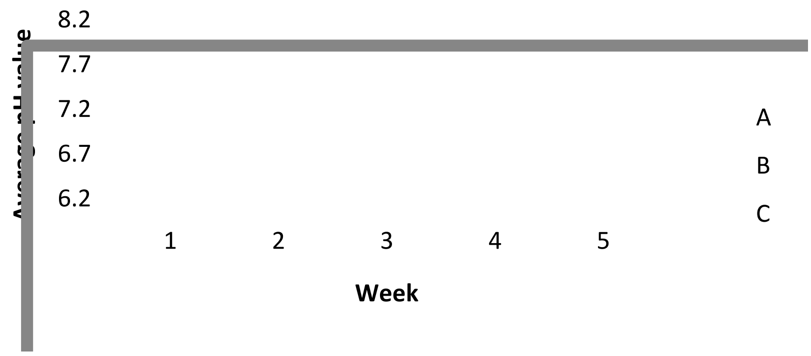

Fig. 3: Graph of pH value throughout the experiment.

Table 2: Ratio of Carbon to Nitrogen (C/N).

	Pile A	Pile B	Pile C
Carbon content (%)	38.5264	28.7200	21.9611
Nitrogen content (%)	5.3480	4.6264	4.9596
C/N ratio	7 : 1	6 : 1	4 : 1

Conclusion:

Based on the observations and experimental results of this monitoring study, the system requires more than 5 weeks of process duration to achieve maturity.

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