A COMPARATIVE STUDY OF THREE COMPOST AERATION METHODS

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Abstract

The aim of this study is to determine the influence of three aeration methods in compost production and quality. The studied treatments were: (natural aeration, manual turning using hand shovels, and mechanical turning using self propelled turning machine) with two agitation rates used once and twice a week. The final properties of the produced compost were different in M.C., C/N, pH, particle size, odor, and time of composting. Generally, the results showed that, using an agitation method (manual or mechanical) afford good quality of compost in a short composting period compared with the natural aeration. The final investigation results indicated that, using mechanical turning may give best properties of compost compared with natural or manual aeration. The heap 4 that was aerated using mechanical turning once a week has optimum properties of compost especially in C/N (23/1) and pH (7.5) beside an average particle size (12mm).

Key words: *Compost, Agitation, Turned, Aeration Methods, Waste recycle.*

INTRODUCTION

Nowadays, two reasons may lead to the increase of compost production and utilization. First, the increase of agricultural production, will mean the increase of agricultural waste. The second reason will increase the concern about the environmental pollution. Composting is now seen as a means to turn waste materials such as sewage sludge, municipal solid wastes, and agricultural wastes into valuable products that could be recycled back to the land. Composting is, in broadest terms, the biological reduction of organic wastes to humus. Whenever a plant or animal dies, its remains are affected by soil microorganisms and larger soil fauna and are eventually reduced to an earth like substance that forms a beneficial growing condition for plant roots. Compost offers several potential benefits including improved manure handling, enhanced soil tilth and fertility, and reduced environmental risk. The composting operation produces heat, which drives off moisture and destroys pathogens and weed seeds. Egypt imports about 1.5 million metric ton per year of chemical fertilizers. This amount will increase according to the increase in agricultural land area. On the other hand, 25 million ton of crop waste and 12 million of livestock waste produced yearly. Only 18 % of total amount of agricultural waste is used in bio-fertilizers production.(Agricultural statistics Abstract 2003).

Ellis (1992) stated that, there are various techniques for ensuring aeration. The most common and obvious being to turn the pile at regular intervals. The more frequent the turning, the faster will the raw material decomposes since air is the most often the limiting factor in this process.

Balitas (1992) reported that, composting can be defined in the terms of availability of oxygen. Aerobic decomposition means that the active microbes in the heap require oxygen, while in anaerobic decomposition; the active microbes do not require oxygen to live and grow. When compost heaps are located in the open air as most are, oxygen is available and the biological processes progress under aerobic conditions. Rynk (1992) mentioned four general groups of composting methods which are in use on farms: passive composting, windrows, aerated piles, and a group of methods known collectively as in – vessel composting. Passive composting involves simply stacking the materials in piles to decompose over a long period with little agitation and management. In the windrow methods, the materials are formed into long narrow piles. The windrows are periodically turned using a bucket loader or special turning machine. The turning operation mixes the composting materials and enhances passive aeration. Other methods eliminate the need for turning by providing air to the materials via pipes, which serve as air ducts. The aerated static pile uses blowers to force air through the pipes and into the pile. In vessel methods, the material is contained within reactors or buildings, which range from simple aerated bins to elaborate systems that combine the mechanical agitation of windrow composting and the forced aeration of aerated static piles.

Haug (1997) mentioned aeration in closed composting systems, such as drums. Three main functions are performed (1) removing moisture from composting mass (drying demand), (2) removal of heat to control process temperatures (heat removal demand) and (3) supplying oxygen for biological decomposition.

Jacques (2002) indicated that, the two most important factors to control, during fermentation, are the moisture of the material and air supply. To assure enough air supply the compost has to be turned periodically. The turning frequency depends on the material and on the dimension of the pile. The turning frequency has to be once to twice per week. Later, when the biological activity decreases, the turning frequency can be reduced. To follow the activity of the process, it is important to measure periodically the temperature in the hot point of the compost pile and to protocol it. The evaluation of the temperature tells us if the fermentation happens properly and how advanced, the process is.

The aim of the present work is, to study the performance characteristics of three aeration methods natural aeration, manual aeration, and mechanical aeration with two agitation rates, and their influence on compost quality and composting operation

MATERIALS AND METHODS

1. Raw materials

Five types of raw materials, rice straw 20%, corn stalks 30%, vegetables wastes 30%, manure, 15% and mixed slaughterhouse waste, 5%. These raw materials were chopped and divided into five heaps. The dimensions of each heap was 1.3 X 0.7 X 40 m (width, height, length) were prepared. Fig. (1) and (2)

Fig. 1. Chopping the raw materials

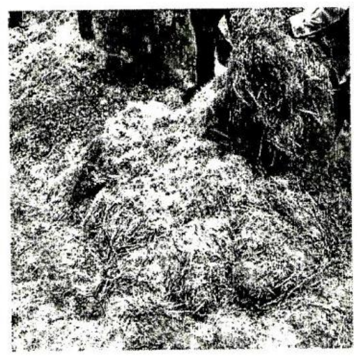

Fig. 2. Preparing the windrows

2. Tools and instruments

a. A locally manufactured turning machine was used with the following specifications

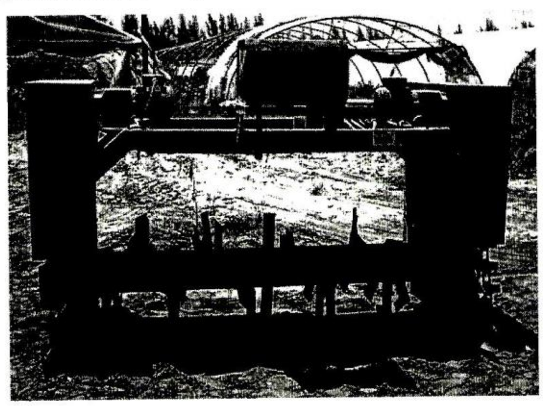

Fig. 3. The electric turning machine

Manufacturer : Egypt " Tanta motors"

Width: - Front: 250 cm

Rear: 180 cm

Height: 100 cm

Power: Electric 4*1.1 kW motors.

Forward speed: 500m/h

b. Measuring instruments

- Portable k type – thermocouples to measure temperatures (range 0 to 99 ^{o}c).
- Husk moisture content meter (range 12% to 75%).
- PH meter (range 1 to 15).

3. Aeration methods

The main purpose for supplying air is to provide enough oxygen for aerobic biodegradation as well as to remove excess water vapor, heat, and gases. Three aeration methods were selected to study and evaluate the performance characteristic of each one; natural aeration, aeration using manual turning and mechanical aeration to be carried out. From the previous review, it was decided to:

* Not to start turning unless core temperature reachs 60-70 ^{o}C.

* Turning frequency is to be carried as follow:-

1-natural aeration (without any agitation)	heap 1
2-manual turning once a week,	heap 2
3-manual turning twice a week,	heap 3
4-mechanical turning once a week,	heap 4
5-mechanical turning twice a week	heap 5

4. Sampling

According to *Sartaj, et. al. (1996) and Zue, et. al.(2004)* who analyzed samples, measured locations were taken at different points of the heaps including bottom (25 cm from bottom), core and surface (25 cm to surface), every 8m of the heaps length.

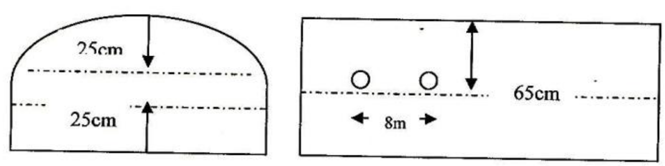

Fig. 4. Samples and measured points locations

RESULTS AND DISCUSSION

1. Properties of the initial raw materials

At the start and after preparing and mixing the five heaps 10 samples were taken from each heap and analyzed (Table 1)

Table 1. Properties of the initial raw materials:

Heap, No, / Properties	Heap 1	Heap2	Heap3	Heap4	Heap5
Temp °c	27 ± 0.8	27.5 ± 0.9	27.7 ± 1.0	27.2 + 0.8	27 ± 0.9
M .C %	29.3% ±1.1	31% ± 0.9	29.5% ± 1.0	30.2% + 0.9	30% ± 1.0
C / N ratio	40/1 ±1.6	41/1 ± 1.3	41/1 ± 0.9	40/1 + 1.0	40/1 ± 1.1
pH	5.7 ± 0.5	6.0 ± 0.4	6 ± 0.4	5.8 + 0.5	5.8 ± 0.3
Texture	Rough and tumble	Rough and tumble	Rough and tumble	Rough and tumble	Rough and tumble
Color Intensity	unlimited	unlimited	unlimited	unlimited	unlimited

(Samples analyzed in arid land agricultural research unit)

Analysis showed that, the five heaps are homogeneous and almost equal in the properties at the beginning of the study.

2. Temperature profiles

The temperature during composting process determines the rate at which many of the biological processes play a selective role on the succession of microbiological communities.

The process of aerobic composting may be divided into three phases

- A mesophilic- heating phase
- A thermophilic phase
- Cooling phase

Fig.(5) shows the temperature profile for the five heaps (windrows), indicating that, at the beginning of composting operation (about4-6 weeks) the temperature rise exceeded 70 ° C. Thus the generation of heat can be used as an indicator of the composting performance and it is very important for killing of pathogens and weed seeds in the compost.

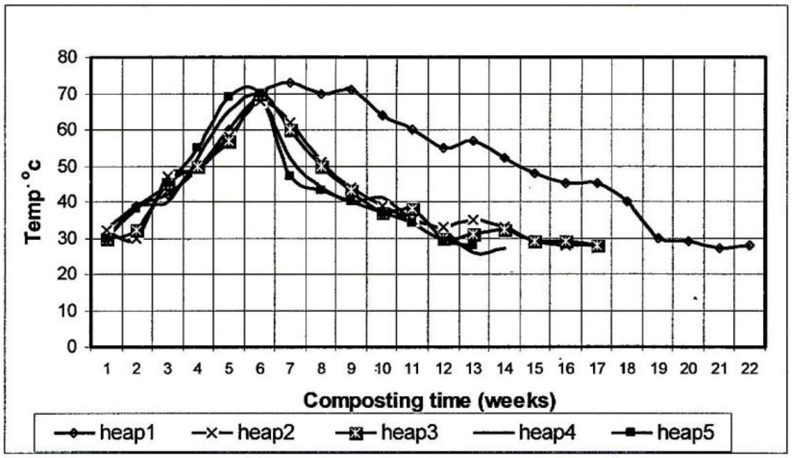

Fig. 5.Temperature profile during composting operation.

According to the temperature data the aeration process started after the 6th week for heaps 2, 3, 4 and 5. The results also showed that, the temperature decreased after the start of the aeration process for heaps 2, 3, 4, and 5 and reached near the atmospheric temperature after 14 weeks for heap (4), 13 weeks for heap (5), and 17 weeks for heaps (2 and 3) while it decreased and became near atmospheric temperature after 22 weeks for the heap (1). Heap temperature is considered one of the most important indicators that may indicate when the compost is ready for use. Mstat-c2.1 program was used for statistical analysis. The average temperature profile showed significant difference between the agitation treatments and the natural aeration (F calculated 5.7 – Fcrit.3.1), while there is insignificant differences between the agitation methods, treatments (F calc. 1.2 – Fcrit. 4.1)

3. pH profiles

PH value increased significantly at the initial stage, 2-8 weeks then gradually decreased and tended to be stable. Fig. (6) . which showed that pH value was about (5 – to – 5.2) at the start , this value increased to (6-8) at the 12th weeks and it was between 7.5- to- 8.0 in the final stage. This last value is a sign for end of composting. Mstat-c2.1 indicated that, insignificant differences in ph value between the five treatments. (F calc. 1.9 – Fcrit. 2.8)

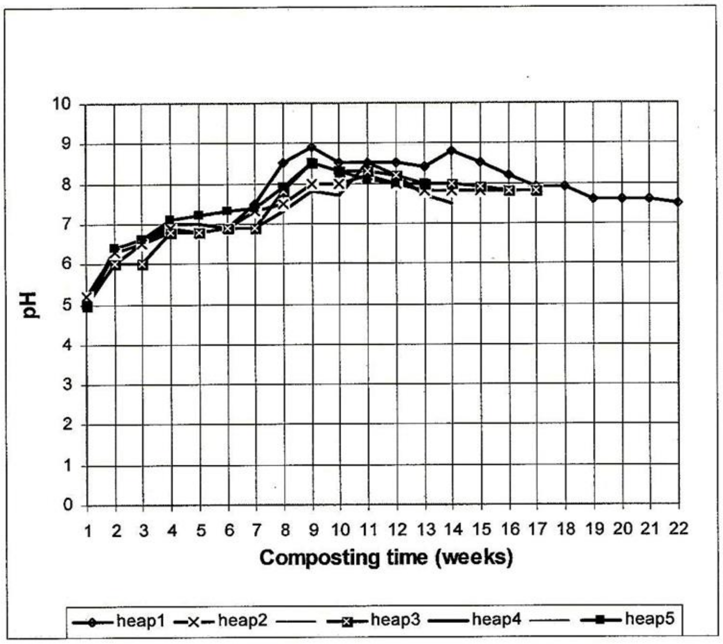

Fig. 6. pH profile during composting operation

4: Maturity stage

The temperature, pH, M.C phases beside intensity of extract color are the indicators of the end of composting operation. Final samples were analyzed to indicate and evaluate the properties of the final compost materials for the five heaps shown in table (2). Comparison of natural aeration , manual turning and mechanical turning according to the suggested indicators like wise temperature phase, pH, C/N, Texture color indicators, Odor, Particle size, and days of composting; indicated that, compost could be produced at about 22 ,17, 17,14, and 13 weeks for heaps 1,2,3,4,and 5 respectively. The final analysis of the samples indicated that, there are significant differences in properties between the three-aeration systems with different agitation rates especially in odor and C/N ratio beside the period of composting and particle size.

Table 2. The properties of the final compost materials

Heap, No, / Properties	Heap 1	Heap2	Heap3	Heap4	Heap5	*Quality guidelines*
Temp °c	28 ± 1.2	28 ± 1.0	28 ± 0.8	27 ± 1.0	28 ± 0.8	*Ambient*
M .C %	45 ± 0.9	42 ± 0.9	41 ± 1.1	40 ± 0.9	39 ± 0.9	*40 -50 %*
C \ N	32/1 ± 1.6	26/1 ± 1.1	28/1 ± 1.0	23/1 ± 0.8	26/1 ± 0.7	*20/1 – 30/1*
pH	7.5 ± 0.6	7.8 ± 0.4	7.8 ± 0.8	7.5 ± 0.8	8 ± 1.0	*6 – 7.6*
Texture	soft	soft	soft	soft	soft	*soft*
Color Intensity	Brown	Dark brown	Brown	Dark brown	Dark brown	*Dark brown to black*
Odor	Acceptable	Good	Good	Good	Good	*Good*
Mean of particle size (mm)	20 ± 3.2	15 ± 2.3	15 ± 2.5	12 ± 1.7	14 ± 1.6	*Less than 13*
Time of composting (weeks)	22	17	17	14	13	--------

Statistical analyses of the results showed significant differences between moisture content, pH, and C/N ratio at the five treatments, while it showed insignificant differences between moisture content with heap2 and heap 3, and insignificant differences between heap4 and heap5. Data analysis showed insignificant differences between pH at heaps 2, 3, 4, and 5. Compared between final properties of the produced compost with the compost quality guidelines Rynke (1992) indicated that, heap4 (mechanical turning once a week) would produce compost of good quality. Mechanical turning aeration once per week has the best C/N ratio (23/1) while it was not correspondent with the quality guidelines at the natural aeration. Compost odor resulted from natural aeration is acceptable but not good odor like the other one produced from the manual and mechanical turning. Finally, the three aeration methods produced acceptable compost but differences in some quality properties and differences in composting period 22, 17, 14 weeks for natural aeration, manual turning and mechanical turning, respectively.

CONCLUSION

Five windrows from several agricultural wastes constructed to study the effect of aeration methods and aeration rate on the composting quality and period of composting. The final investigation results indicated that, using mechanical turning may give best properties of compost compared with natural or manual aeration. The heap 4 that was aerated using mechanical turning once a week has optimum properties of compost especially in C/N (23/1) and pH (7.5) beside an average particle size (12mm). Although the composting operation finished in 13 weeks only for heap 5 that aerated by mechanical turning twice a week but compost produced was lower in quality properties compared with mechanical agitation once a week. To produce high quality compost under the same conditions of this study it is recommended to use the mechanical agitation once a week. Regular farmers are able to apply natural aeration or manual agitation techniques with heaps of the same characteristics of the described heaps which still can produce acceptable compost without any additional costs, but at a longer period.

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دراسة مقارنة لثلاث طرق لتهوية الكمبوست

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معهد بحوث الهندسة الزراعية – مركز البحوث الزراعية – مصر

تم خلال البحث دراسة تأثير ثلاث طرق للتهوية على جودة و إنتاجية الكمبوست هي (التهوية الطبيعية – التهوية بطريقة التقليب اليدوي – التهوية بطريقة التقليب الميكانيكي) واستخدم مع كل من التقليب اليدوي والميكانيكي معدليين للتقليب هما مرة كل أسبوع ومرتين كل أسبوع وتم إنشاء خمس مصفوفات مكونة من خليط من المخلفات الزراعية و الحيوانية لدراسة تأثير التهوية ومعدلاتها على جودة المنتج النهائي من الكمبوست. وتم كذلك خلال الدراسة قياس تغير درجات الحرارة والرطوبة ودرجة الحموضة خلال فترة الكمر وتقدير وقياس صفات الجودة للمنتج النهائي من المصفوفات الخمس شملت (درجة الحرارة – المحتوى الرطوبي –درجة الحموضة – نسبة الكربون إلى النيتروجين – القوام– اللون – الرائحة –أطوال جزئيات الكمبوست – فترة الكمر). وقد أثبتت الدراسة إن استخدام طرق التقليب لتهوية المصفوفات ينتج عنة مواصفات وصفات جودة أعلى للمنتج النهائي مقارنة بالتهوية الطبيعية وإتمام عملية الكمر في فترة اقل بحوالى من ٥ إلي ٩ أسابيع، وكان الكمبوست الناتج من التقليب الميكانيكي بمعدل مرة واحدة أسبوعيا أعلى في صفات الجودة وتميز بارتفاع القيمة السمادية له حيث كانت نسبة الكربون إلي النيتروجين ٢٣/١مع محتوى رطوبة ٤٠% ودرجة حموضة (pH) ٧,٥ و أطوال جزيئات ١٠-٢٠ مم إضافة إلي القوام الإسفنجي واللون البني الغامق و الرائحة المقبولة وهي صفات تشير إلي جودة عالية للكمبوست الناتج.