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Assessment of Compost Production Parameters of Waste using a Cylindrical Production Device.

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ABSTRACT

This study aims to manufacture an integrated automatic control unit for the production of organic fertilizer in all steps of production for the fermentation period, by adjusting parameters throughout the process. There are 5 main components, namely: the frame is carrying the cylindrical body - power transmission system - water supply system - ventilation system - control system connected to sensors. The first mixture was made C1 and consists of cattle dung, shredded paper and field residues in proportions of 5: 1: 2.5 and the second mixture C2 was assembled from field residues, sugar cane residues and rabbit dung, the mixtures were made by 1: 0.5: 1.8. These percentages are determined according to the nitrogen carbon ratios of each waste type, which must be adjusted in aggregate to an appropriate entry ratio of 1:30. The variables studied are the speed of the stirring system with four levels (17, 22, 27 and 32 rpm), 3 levels of angles (45, 50 and 55 degrees) as well as three levels of processing time (600, 1200 and 1800 sec). To verify the efficiency of the mixing and mixing were identified 8 points and measure the moisture homogeneity in these points after stirring and add the amount of water initially fit the pile. It was concluded that better moisture distribution resulted from a 50-degree angle with a speed of 22 rpm and a 1200 sec processing time are the best parameters, That give a mixing efficiency.

Keywords: Waste fermentation, Compost coefficients, Physical and chemical properties, Moisture distribution, Coefficient of variation.

INTRODUCTION

Many researchers are studying several systems of compost production like Windrow and enclosed (in-vessel) system. These systems aim to exploit the waste in a way that achieves more benefit rather than disposal it and pollution to the environment. (FAO, 2016) explain that There are many types of residues that can enter the compost industry and these kinds of problems and problems facing the community by the field residues as well as residues of plants and agricultural residues as well as residues of cattle, rabbits, goats and horses, including city residues such as institutional residues. (Zhang and Sun, 2018) explained that there is also a tendency to use paper and its waste which produced in large quantities of institutional processes in compost production as a kind of recycling, that the article is kneaded and reproduced and again as another paper product suitable for writing such as paper , but remained less efficiently and is often dealt with paper after this stage any waste paper recycled by disposing of it either by burning or compression of it. Paper components are studied to find out the possibility of including it of this process. It known from paper contains high rates of carbon. It could be used as a nitrogen equivalent if it increased. There is also a trend to use residues of other varieties of plants such as sugar beet as reported in some studies.

(Chattha *et al.*, 2019) some experiments have tended to dispose of or recycle Sugar cane residues that are produced in large quantities by the squeeze processes that produce cane juice and leave behind these residues. (Biswas and Narayanasamy, 2002) explained that the windrow system is the most common, and the least cost which is a process in which a mixture of organic waste plant and animal is proportionally stacked in rows called rows of longitudinal piles and the process of ventilation in this system by rotating piles either manually or mechanically.

(Gavilanes-Terán *et al.*, 2016) these disadvantages and the exploitation of large areas of land has attracted insects and rodents, as well as the problems the odors emitted and numerous Workers required for this process and a real essential problem faced by this system, is the problem of the inability to fully control the heaps.

As a result, satisfied with the conditions of climate and volatile air (Van Haaren *et al.*, 2010), moreover, it was additionally found that the advantages of this strategy that it is more control for temperature and decrease emanations of carbon dioxide, nitrogen oxide by these frameworks, and in this manner is a technique that is extra viable yet more expensive than previously. But one of its most significant drawbacks remains the inability to fully control it only by regular follow-up and workers to adjust those values.

(Tanpanich *et al.*, 2009) adjusted the C/N ratio in the range of 30:1 in each container used, after calculating the proportions of the elements of each substance in addition to achieving this is 200 kg rice straw and 625 kg dairy cow residue by absorption per box 825 kg.

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(Chennaoui *et al.,* 2018) conducted a study on a horizontal reactor with a capacity of 200 litres of metal with a thickness of 1 mm and an existing valve to enter the air with a hole from the top To enter the organic matter to be converted to manure. The temperature and pH were as indicators of the progress of the process and checked the effectiveness of the device, which gave satisfactory results under verification of the entry of compatible C/N ratio, which gave good results in terms of space-saving and prove the possibility of accelerating production by focusing on providing the best conditions for the product and closest to the standards.

(Kucbel *et al.,* 2019) conducted study on automatic composter, the composting process was controlled by the composter, composting took place at NatureMill for about seven days. The composter operates during the whole period of composting at the temperature of 55–65 °C (input 1 kg/week). After this time, the compost was transferred to the curing container in the composter and stayed there for one week at the temperature 35–45° C. Subsequently, it poured onto a free area where it matures for three months or more in the Green Good composter, the composting process is controlled will automatically until the composter filled and the content is processed (14–21 days) at the temperature over 70 °C (average input 2 kg/day).

(Koné *et al.*, 2010, Shrestha *et al.*, 2011, FAO, 2016) explained that the Ideal range of mature compost is C/N ratio (10:1 – 15:1), moisture content (30% - 40%), oxygen concentration (~10%), Particle size (<1,6 cm), PH (6,5 – 8,5), temperature (ambient temperature), density (<700 kg/m3), organic matter (Dry base) (>20%) and total Nitrogen (Dry base) (~1%).

Therefore, the study aims to try to design a device capable of full control of these transactions and manage the process. It was designed from the coverage area with a layer of strengthened plastic as well as the insulation of the edges to ensure full control in measurements and not affected by any external conditions, which improves the provisions of control.

MATERIALS AND METHODS

The first step during this study designs and manufacture of a cylindrical unit for compost production (CUCP), that can fill a good quality of manure as shown in Fig.(1). It was designed and produced at workshop of Agriculture Engineering Department, Mansoura University. Which consists of a cylinder. Frame, water unit, transmission system, power source, blower, sensor, control unit.

1-The gate of vessel. 2-Transmission gear. 3-Frame. 4-Gear box. 5-The control unit. 6- reverse movement unit. 7- The motor. 8- water tank. 9- Impeller.

Fig.1. The components of cylindrical unit for compost production (CUCP).

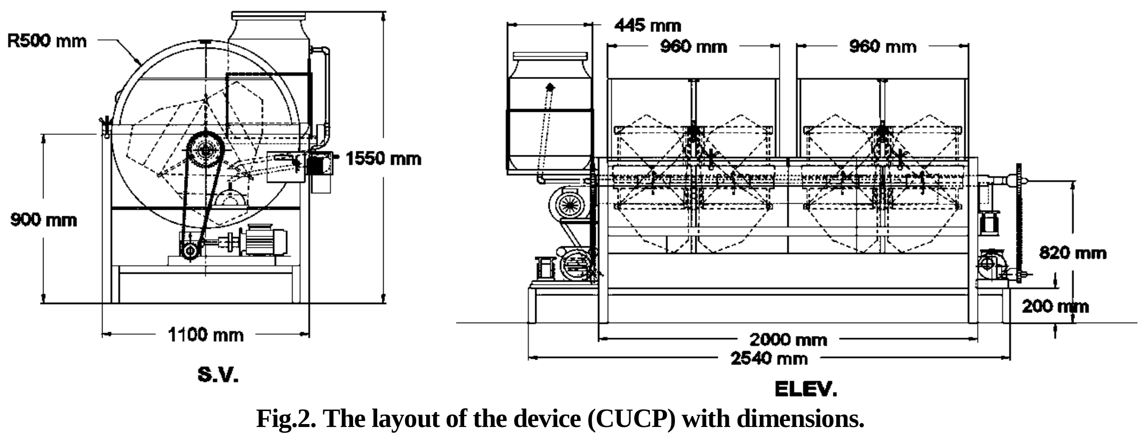


Fig.2. The layout of the device (CUCP) with dimensions.

- The device components:

- **The frame:** The frame consists of a set of 2-inch iron to form the frame which is a 200 × 110 × 90 cm length, width and height respectively, in addition to two additional parts to install the Movable base in the right and left of the device, which is located right side 20 cm protrusion from the frame With the same width of the machine 110 cm and have spaces ready to install the base of the motor.

- **The gate of vessel:** It is a gate made of (reinforced plastic) with a thickness of 5 mm transparent color and covers all sides of the two rooms individually as each room has a separate gate and it is supported by a structural network of iron on which the plastic is fixed, and the gate is opened at an angle of up to 110 degrees so as to ease the filling and unloading.
- **Body of device:** The device consists of two identical cylindrical units, the outer dimension of the cylinder is 100 cm in diameter and length 100 cm, with a net volume of 0.79 m3 per unit. Each arc welded in circumference of two flange at a constant distance of the vessel.

Fig.3. The Body of device.

- **Transmission system:** Transmission system: There is a transmission system for each unit separately from each other where each unit operates at a different speed. The transmission system in the first unit adjacent to the control unit consists of a gearbox used to move the movement horizontally to the main gear mounted on the driveshaft and reduces the speed (from 1 to 10) and consists of 38 teeth and the gear is installed on the gearbox consists of 18 teeth and can be changed to adjust Speed rate. The second unit adjacent to the water tank consists of a transmission system that reduces the speed in the same way as the first unit depending on the gearbox and the number of teeth of the gears 38 and 18 teeth respectively. It is mentioned that gears with different teeth (16-18-20-22 teeth) were used Gives speeds (17-22-27-32 rpm) until the optimal gear is installed 18 teeth.
- **Source of power:** The source of motion and the flipping column rotation is a motor per unit, it is a 2-phase motor with 1.12 kW (1.5 hp) and 1400 rpm rotation. The rotation direction of the flipping column can be reversed through the reverse movement unit.
- **Water unit:** The water unit consists of a tank with dimensions of 65 * 42 cm and a capacity of up to 80 liters. Inside the tank, a submersible water pump was installed from the aquarium pumps and installed at the bottom of the tank from the inside operates on a 220-volt current and 50 Hz frequency with a water flow rate of 1000 liters per hour The unit also has a water pipe length of 192 cm and a diameter of 3/4 inch (19 cm) extended to the right side of the device and rise from the ground by 81 cm and branching at the center of each unit branch pipes length of 42 cm and then bends down at 126 degrees from the vertical axis to become The total length of the pipe inside the unit is 52 cm in the middle between the edges of the plates by a height above the ground at the end of the pipe with a value of 65 cm.
- **Control unit:** Is responsible for controlling the movement of the transmission system and the management of motors, it was connected to the other small control box which in turn which receives the reading of the sensors inside to determine the temperature and humidity**.**
- **Sensor "DHT 22 ":**Sensor has many features that make it the ideal choice for temperature and humidity readings in surrounding unit, used to accurately measure humidity ± 2% in the range of 0-100% RH. The temperature measurement accuracy is ± 0.2 °C and measures the temperature in the range of -40° C to 125° C (Pasha, 2016).
- **Ventilation system:** (ASYZ9-9) centrifugal blower motor was used, it operates at 220 volts and 50 Hz and the fan speed is 1100 rpm**,** it was connected with tube by diameter of three inches (7.62 cm) which extends on the side of the device up to a distance of 179 cm. There are be branches distributed so that each branch enters the unit to pump air and adjust the level of ventilation and humidity, these pipes extend into the basin at an angle to the bottom and the total entry of the pipe is 50 cm where the pipe bends from the entrance at an angle of 99 degrees. Then, after 47 cm there is another tendency at an angle of 36 degrees on the horizontal to be the total length of the pipe within the unit 50 cm. in the basin and a diameter of 3/4 inch (1.905 cm).

The raw materials: Five sorts of wastes are raw materials were studied under this study:

1- Cattle dung and Rabbit dung: Which were obtained fresh directly from the ranching farm, Faculty of Agriculture, Mansoura University.

2- Field wastes: It was collected from different gardens at Mansoura University, the necessary coefficients of cutting operations and fragmentation of small pieces of known size were then performed in ranges (3-5) cm through shredding by shredder machine. It was driven by an electric motor (3.73 kW "5 hp" - 1420 rpm), and another machine was used to chop the large-diameter parts and screened with different diameters driven by an electric motor (3.73 kW "5 hp" - 1420 rpm). used two machines in the Department of Crops, Faculty of Agriculture, Mansoura University.

3- Shredded paper: The paper was chopped by a manual dough cutting machine of more than one size. The paper was cut into longitudinal slices with different widths of (0.5-3) cm. By changing the cutting face of the paper milling unit, which contains a number of different sizes based on two opposite columns, including interference causing the paper milling, this treatment was carried out to reduce the surface area of the paper and increase the chances of decomposition more easily.

4- Sugar cane residues: It was collected from the cane juices shops adjacent to the University of Mansoura, which is a remnant and residues of the process of the squeezing of cane, and was treated cane by chopping with the same shredder machine.

Several tests were conducted to judge the performance of the device in terms of stirring angles, power consumption, mixes and the best product.

Samples were selected to measure both humidity and temperature to calibrate the sensor and ensure its working accuracy as shown in Figure 3. Moisture ratios were monitored in laboratory experiments and experimental piles to ensure correct measurement. This is done by random changes in humidity, stirring, changing the homogeneity of materials, then measured at the specified points and compared with sensor readings, in terms of humidity readings taken at 8 points at 3 levels A, B, and C by a moisture meter shown in Fig.5. and temperature measuring device is also shown in Fig.6.

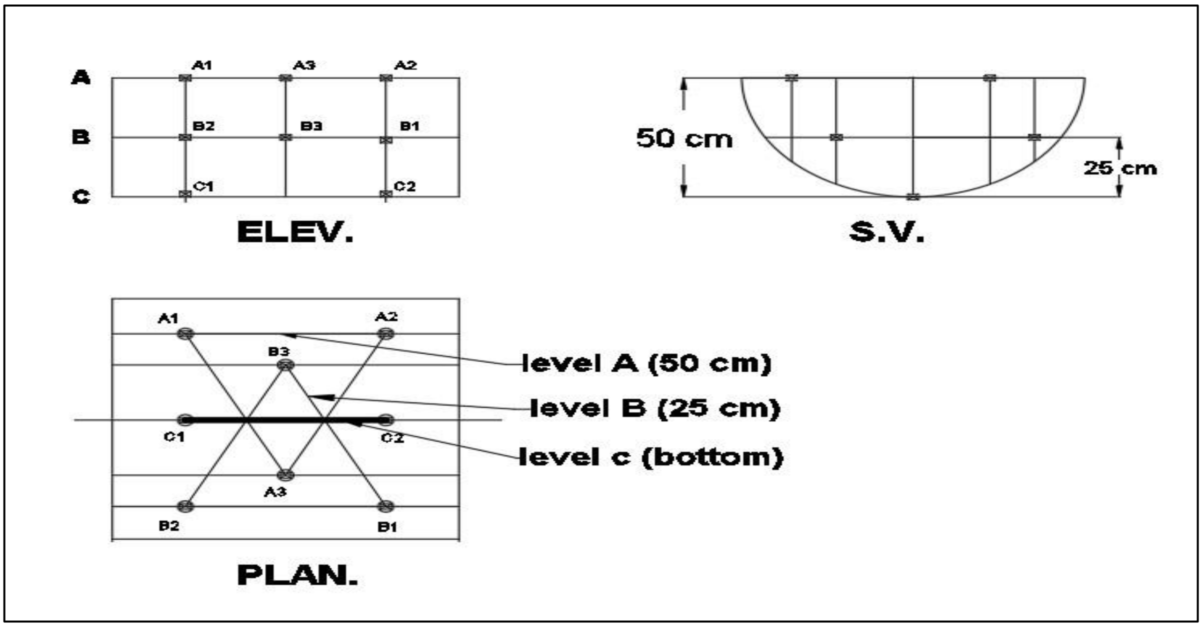


Fig.4. Sampling location.

Fig.5. Moisture content and pH measuring device.

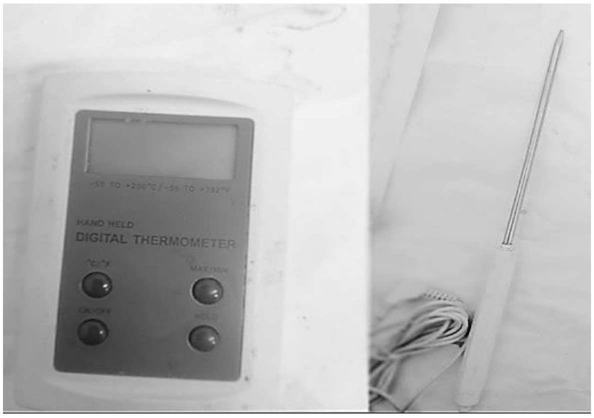


Fig.6. Digital thermometer.

Comparing these readings with sensor readings for 12 continuous hours to see the sensor's effectiveness in reading accuracy. As for the mixing experiments, the factors of stabilization angle study were selected at three levels (45-50 and 55 degrees) based on reducing the load facing the slice and facing it with side inclinations that allow stirring. The speed at four levels (17-22-27 and 32 rpm) based on the average volatility of the solid components is within this range. Rotation time (600-1200 and 1800 seconds) on the basis that the maximum stirring time is within this range to suit the energy consumed and taking into account the role of the ventilation system after setting effective limits for the role of stirring in the processes of temperature and humidity adjustment.

The moisture distribution measurements were taken to ensure the effectiveness of the stirring operations in achieving uniform distribution throughout the stack. The measurements were taken with the humidity meter shown in Fig.4. at the 8 points specified on 3 levels.

RESULTS AND DISCUSSION

The samples were sampled from the points shown in Fig.4. which were in 3 levels:

- Level A, which was 50 cm from the bottom with three points (A1, A2, A3).
- Level B, which was 25 cm high and represented by three points (B1, B2, B3).
- Level C is two points (C1, C2) located at the bottom.

At these 8 points in each unit, the moisture level readings were taken to reflect the ability of the impeller to distribute the value of 50% moisture added to the heap at all heap points.

In Fig. (7), the red dots represent the best average moisture distribution for each operating period the curve shows that the speeds 17 and 22 rpm have a relatively large dispersion and variation with a 45 degree angle where there is no balance regarding diffusion and distribution of materials in equal proportions, this may be due to angle 45, which faces a greater load due to the slope of the slide at an angle that increases the stirring load and increases energy consumption, agglomerating the material at the sides causing fluctuations in readings.

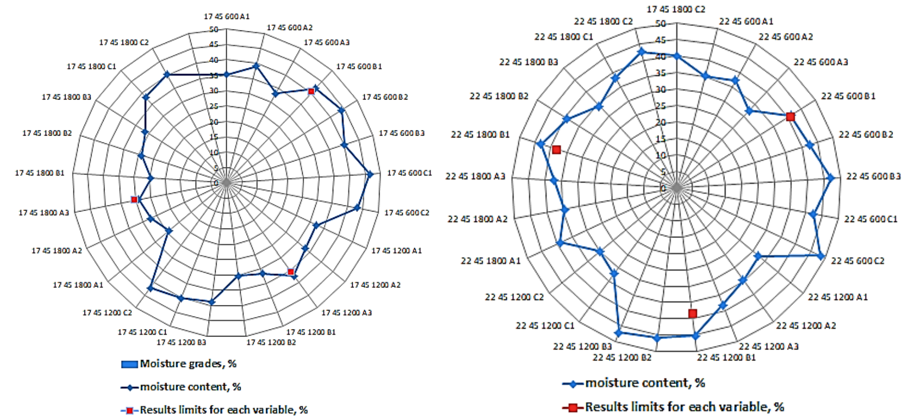


Fig. 7. The moisture distribution in the pile caused by mixer revolution 17 and 22 rpm and operating periods (600, 1200 and 1800 sec) and angle 45°.

In Fig. (8), there was a significant variation between the humidity levels at each point and the greater fluctuation between the level of red dots better in the moisture distribution and diffusion around them. This fluctuation is due to the irregularity of the angle facing the material as well as the high-speed which causes random dispersion of the components as a result of the large-angle incompatibility with stirring and pile and increasing speed dispersion increased, reducing the efficiency of mixing significantly.

In Fig. (9) represent the moisture distribution of measurement points in operational periods, three levels of time in which greater uniformity and convergence of values were observed at all measurements points, this is due to the use of a 50°angle to install flipping plates. In Fig. (10) The uniformity was greater in the speed curve 22, which is one of the best curves to achieve balance overall operational periods. Especially the 1200 period which achieved relatively better values at all speeds and angles, and have the best angle 45 degrees.

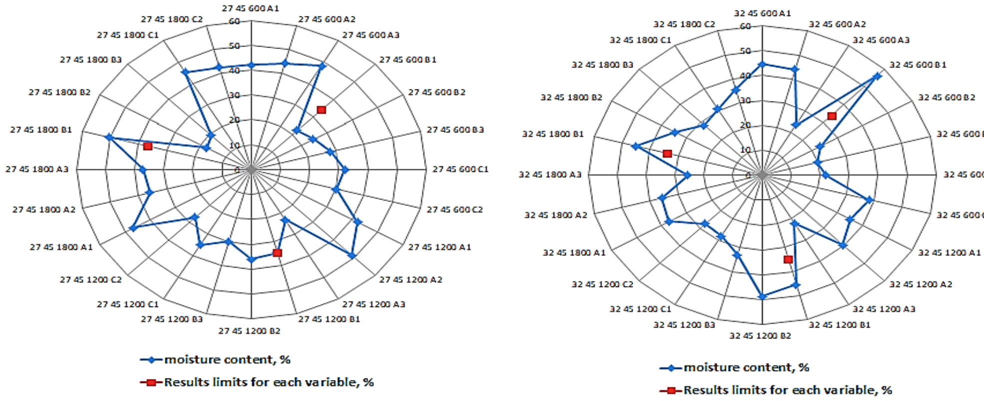


Fig. 8. The moisture distribution in the pile caused by mixer revolution 27 and 32 rpm and operating periods (600, 1200 and 1800 sec) and angle 45°.

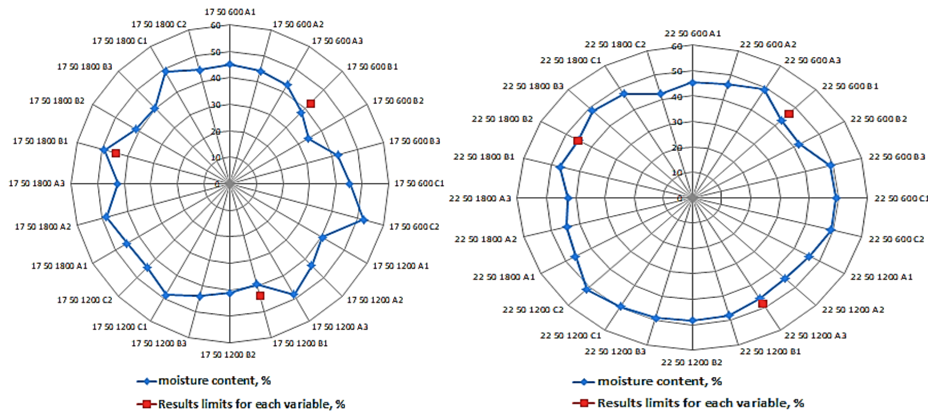


Fig. 9. The moisture distribution in the pile caused by mixer revolution 17 and 22 rpm and operating periods (600, 1200 and 1800 sec) and angle 50°.

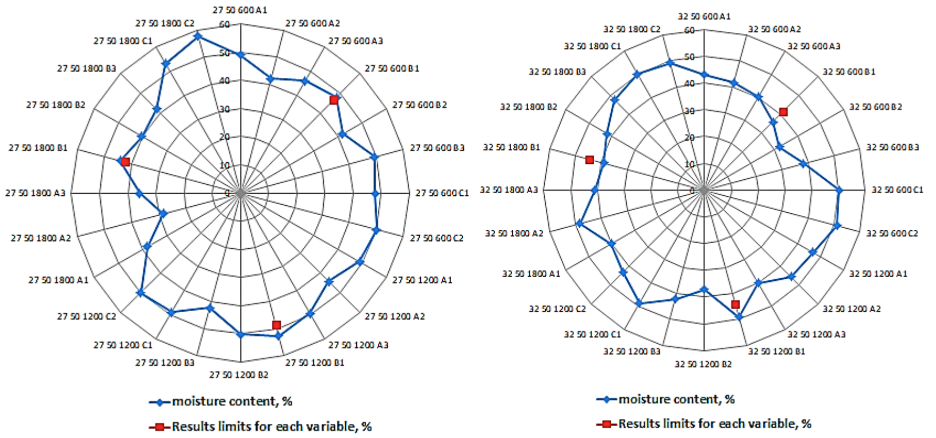


Fig. 10. The moisture distribution in the pile caused by mixer revolution 27 and 32 rpm and operating periods (600, 1200 and 1800 sec) and angle 50°.

Fig. (11) shows that the dispersion was at its most extreme with the poor distribution of the mixture resulting from increasing the angle to 55, which resulted in piles and clusters of the product at more than one point and no distribution. Fig. (12) showed, with all periods, a large increase in the dispersion due to the increase in speed, which usually causes an increase in the separation of materials, in the case of angle 55 with large speeds has caused the largest dispersion ratios as well as more energy consumption. So the best time to adjust the stirring operations is 1200 seconds with a 50 degree angle and a speed of 22 cycles per minute.

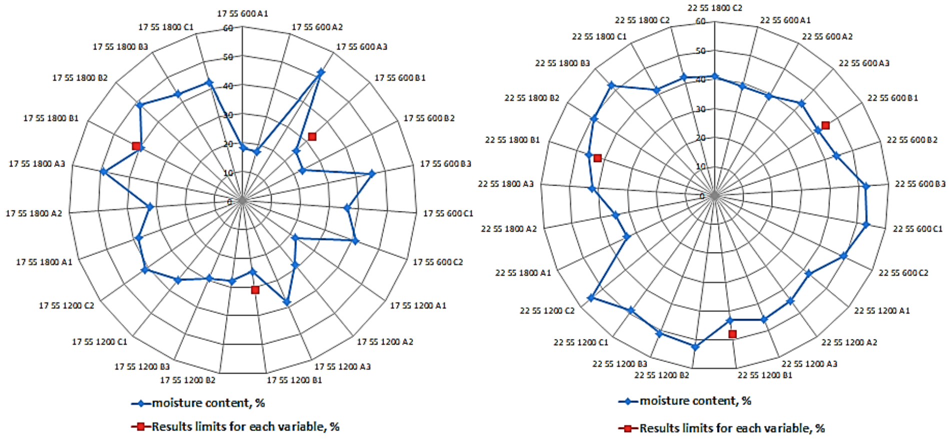


Fig. 11. The moisture distribution in the pile caused by mixer revolution 17 and 22 rpm and operating periods (600, 1200 and 1800 sec) and angle 55°.

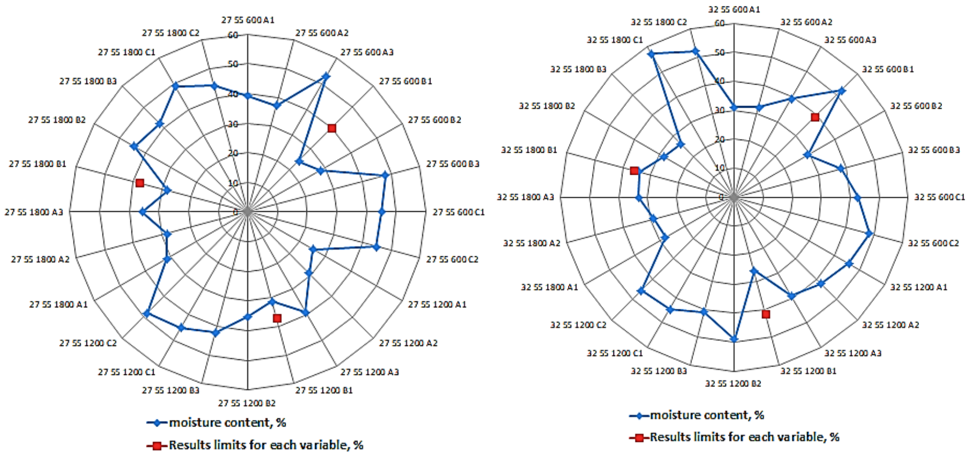


Fig. 12. The moisture distribution in the pile caused by mixer revolution 27 and 32 rpm and operating periods (600, 1200 and 1800 sec) and angle 55°.

Judgment on the compost quality

The first mixture was made C1 and consists of cattle dung, shredded paper and field residues in proportions of 5: 1: 2.5 where Paper is a high moisture absorption component as well as a high carbon content and is put in a low (1), the residues of the field due to the high carbon content is set from (2.5) against the nitrogen lifting factor which is cattle waste by (5), the total of 85 kg was

50 kg cattle dung versus 10 shredded paper and 25 field waste.

As for the mixture C2 was assembled from field residues, suger cane residues and rabbit dung, the mixtures were made by 1: 0.5: 1.8 as the residues of the field were carbonated by (1) the cane residue of (0.5) is equivalent to a nitrogen mine of (1.8) for rabbit 25.8 kg of field residues, 12.8 kg sugar cane residues, 46.4 kg rabbit dung. This 2 mixture ensures some physical and chemical composition of the raw materials compost mixture as the data tabulated in Table (1).

Table 1. Some physical and chemical properties of mixed compost.

Properties	C1	C2
Moisture content, % (wb)	60.2	64.6
PH (-)	7.2	7.8
Ash %	15	17
C %	44.04	60.9
N %	1.56	2.1
Carbon / nitrogen ratio	25.06	29.2
Phosphore (P), %	0.213	0.465
Potassium (K), %	0.50	0.78
Iron (Fe), mg/kg.	45.8	52.4
Cupper (Cu), mg/kg.	4.8	6.35
Zink (Zn), mg/kg.	15.2	18.54

Physical properties

The product was obtained brown color as shown in the Fig. (13). The wet smell and other qualities were all within the optimal range of compost as a final product in terms of particle size, which was in almost all particles and throughout the pile with a value of 0.4 -1 cm which is Values of less than 1.6 cm. The humidity level at the exit was slightly high due to the presence inside the device, but this part was interpreted as a return to completely isolate the unit and at the exit, the humidity was around 40%, and it was acceptable because when it left immediately after 30 minutes the humidity value dropped to 30% and this was Valued for the two mixtures in two units.

Fig. 13. Compost from the fermentation process.

-Chemical properties test

All tests were conducted for the mixtures and the product in the research laboratory Faculty of Agriculture Atomic Detection Laboratory Faculty of Science Mansoura University.

Studies have shown a significant change in both of these elements, phosphorus and potassium where the value of phosphorus in the first mixture C1 was increased from 0.213% to 0.7%. The second mixture C2 was increased the value of phosphorus from 0.465% to 1.3%, this increase is due to the decrease of dry matter from the heap, which increases the proportion of other elements as shown in the Fig. (14-a).

There was also an increase in the levels of potassium due to lack of mass of the substance it was noted that the percentage increase in the first mixture C1 from 0.5% to 1.78%, while the second mixture C2 the value increased from 0.78% to 2.7%. It was noted that the increase in the value of the second mixture C2 potassium is higher than the first mixture C 1 because of the high sugar cane in the value of potassium, as well as the high value of potassium in rabbit manure as shown in the Fig. (14-b).

The value of C/N ratio was determined from the C1 mixture at the beginning which was worth 25.06 to gradually change during the course of the product and reach the end as a maturity indicator to 12.05 with a decrease of 48.1 % from its original value and this is consistent with what he said . (Ghaly *et al.*, 2006) as a result of microbes consuming carbon and getting energy, and (Flynn and Wood, 1996)that the ratio does not give a full indicator of the maturity of the fertilizer this is due to the variation of the material of the asset and is, therefore, a strong indicator in conjunction with other indicators. The C2 mix decreased from 29.2 to 14.7, with a decrease of 51% decrease it is within the ideal range of the product, These values are consistent with what he explained (Chen *et al.*, 2011), as shown in the Fig. (14-c).

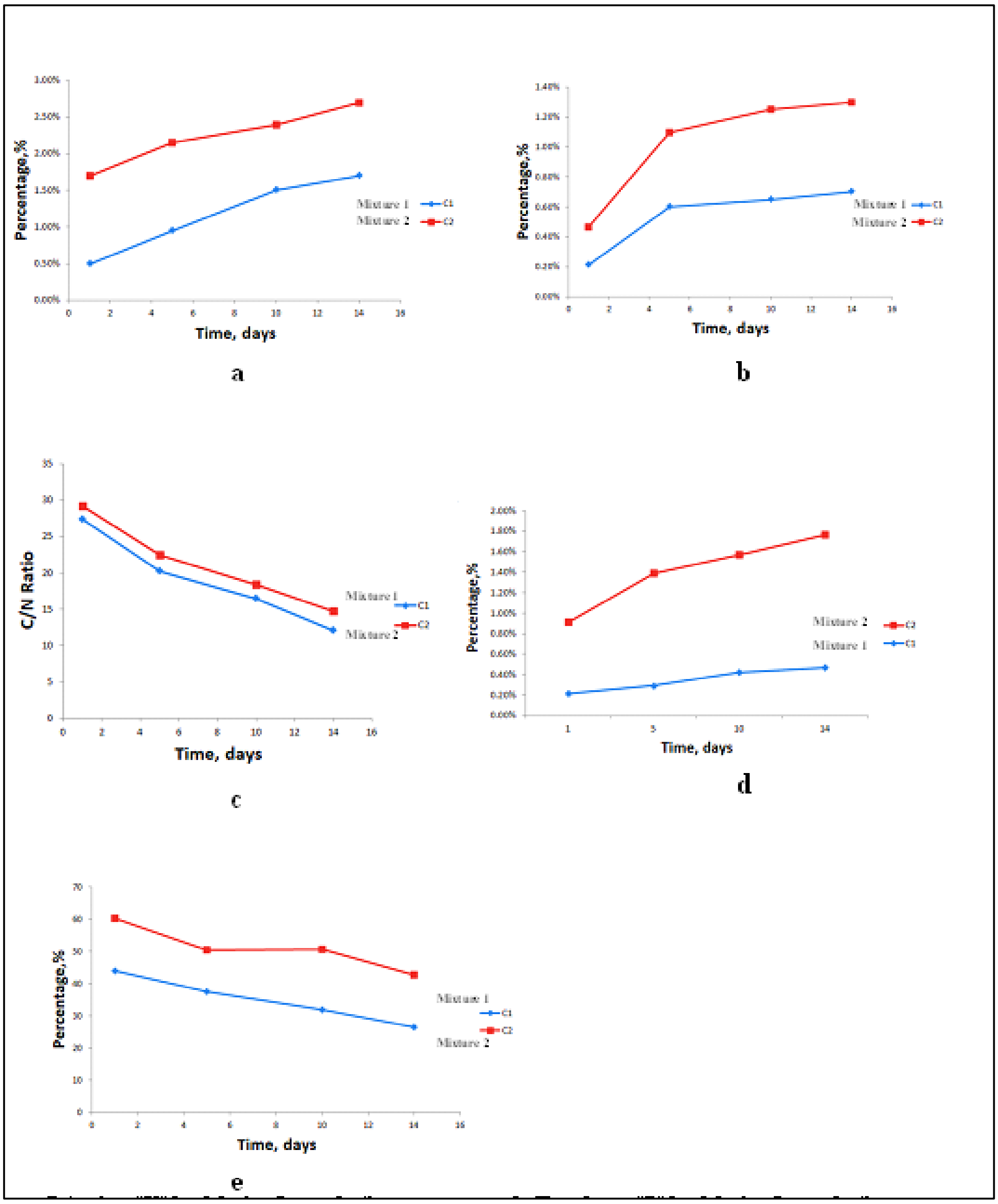
Nitrogen was measured in mixture C1 which initially had a nitrogen value of 1.56%. At the end of the fermentation period, after 13 days were tested for nitrogen and reached 2.2%.

The second mixture, C2, was also observed to increase the values of nitrogen from 2.1 to 2.9, which also agrees with that hypothesis.

From the above, it is noted that the rate of increase in the level of nitrogen in the heap C1 was an average of 71% and in the second C2 at a rate of 72%, these values are explained by the fact that the second mixture, due to the presence of rabbits manure, has high values of nitrogen, which is more unique. But the amount of reed was faced with a high carbon value and yet it was higher in terms of increase Fig. (14-d).

Low carbon level was observed overtime during the fermentation process, in C1 mixture dropped from 44.04% to 26.51% at the end of the thirteenth day.

The C2 mixture also reduces the carbon content from 66.1% to 42.63% in the same duration. This is due to the use of carbon as a source of energy in production processes where it is lost through the activities of organisms in the form of carbon dioxide Fig. (14-e).



a: Potassium "K" level during the production process. **b: Phosphorus "P" level during the production process.**
c: The C/N ratio during the production process. **d: Total carbon Ratio during the production process.**
e: Total Nitrogen Ratio during the production process.
Fig. 14. Compost from the fermentation process.

CONCLUSION

From the results obtained, it was concluded that the machine operates at a speed of 22 rpm, set the plate at 50° on the horizontal axis, the maximum operating time of 1200 seconds for the motion system taking into account cutting the products 2.5 - 7 cm long, filling the machine by 65%, It achieved the fastest production process and highest balance in mixing and energy consumption, and the use of mixtures in the proportions specified in C1, C2 gave suitable values for the product as compost based on the ratio of C/N Ratio.

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تقييم معاملات إنتاج الكمبوست من النفايات باستخدام جهاز الإنتاج الأسطواني.

حسني الشبراوي المرسي ، ماهر إبراهيم عبد العال ومحمد نعيم الشِشتاوي
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تهدف هذه الدراسة إلى تصنيع وحدة تحكم أوتوماتيكي متكامل لإنتاج الأسمدة العضوية في جميع مراحل الإنتاج لفترة التخمير ، عن طريق ضبط المعلمات طوال العملية. هناك 5 مكونات رئيسية ، وهي: الإطار يحمل الجسم الأسطواني - نظام نقل الطاقة - نظام إمدادات المياه - نظام التهوية - نظام التحكم المتصل بأجهزة الاستشعار. لتحضير منتج السماد ، تمت معالجة خليطين , يتكون المزيج الأول من C1 ويتكون من روث الماشية والورق المقطوع ومخلفات الحقول بنسب 5: 1: 2.5 على التوالي , كما تم تجميع المخلوط الثاني C2 من بقايا الحقول ومخلفات قصب السكر وروث الأرانب ، وتم تصنيع الخلطة بنسبة 1: 0.5: 1.8على التوالي , وهذه النسب تحدد وفقا لنسب الكربون نيتروجين الخاصة بكل نوع مخلف والتي يجب ضبطها الخلطه اجمالا لتصبح بنسبة دخول مناسبة 1:30 .المتغيرات التي تمت دراستها هي سرعة نظام التحريك بأربعة مستويات (17 و 22 و 27 و 32 دورة في الدقيقة) و 3 مستويات من الزوايا (45 و 50 و 55 درجة) بالإضافة إلى ثلاثة مستويات من وقت المعالجة (600 و 1200 و 1800 ثانيه). للتحقق من كفاءة الخلط والخلط تم تحديد 8 نقاط وقياس تجانس الرطوبة في هذه النقاط بعد التحريك وإضافة كمية الماء التي تلائم في البداية كومة. تم تكرار كل اختبار 3 مرات ، وتم تحليل البيانات إحصائيا. استنتج أن توزيع الرطوبة الأفضل الناتج عن زاوية 50 درجة بسرعة 22 دورة في الدقيقة ووقت معالجة 1200 ثانية هي أفضل المعايير التي تعطي كفائة خلط .