J.Soil Sci. and Agric. Eng., Mansoura Univ., Vol. 2 (12): 1229 - 1242, 2011

RAPID COMPOSTING OF RICE STRAW WITH SOME AGRICULTURE GREEN RESIDUES AND ANIMAL WASTE UNDER FULL CONTROL SYSTEMS

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ABSTRACT

The objective of the research is to study the composting process of rice straw in closed vessels, and to study the influence of adding the green agricultural residues to compost mixture, study some physical and chemical properties of raw materials and compost during the composting operation, study of the microorganism activity by monitoring differences in biomass temperatures and reducing the time requirement by minimizing fermentation time from 6- 24 weeks to about 4 weeks only and minimizing the area requirement by using in-vessel vertical bioreactor.. Three identical bioreactor vessels were designed, constructed, and installed to study and test their performance in rapid composting of chopped rice straw. Experiments were carried out to under aeration rate (0.007 m^3/min) and particle size of chopped rice straw (2.0-12.0 mm).Laboratory tests were also executed to examine and evaluate some chemical properties of the raw materials; Temperature profiles; physical and chemical properties of produced compost. The obtained results showed that, the peak temperatures at the three mixtures compost were 57.3, 58.6 and 57.6 ^{0}C. The maximum ash, Organic Carbon, C/N ratio, pH, EC, Total Nitrogen, Phosphorus, and Potassium content were 32.34 %, 45.09 %, 58.51, 7.28, 0.870 S/m, 2.3%, 0.38% and 4.5% for mixture 1, 34.33 %, 45.05 %, 40.96, 7.08, 0.864 S/m, 2.5%, 0.40% and 4.9% for mixture 2 and 36.47 %, 44.78 %, 49.20, 7.12, 0.804 S/m, 2.39%, 0.36% and 3.70% for mixture 3 respectively.

Keywords: composting; in-vessel bioreactor; bioengineering; temperature profiles; physical; chemical.

INTRODUCTION

A large amount of solid field residues remains after the harvesting operations of different crops. Egypt cultivates about 1.67 millions feddans rice every year, which produce 3.39 million tons of rice straw. This quantity presents a sizable problem to the farmers, government and the environment. (CMAE 2001). These residues are commonly moved to dumps, where they pose a threat of environmental pollution. Treatment of these residues either by aerobic or anaerobic fermentations produces, biogas, digested slurry, and compost which is mainly used as a good growth media for different vegetable crops. Therefore, the utilization of field residues became as an important topic for different researchers in numerous countries and international regional associations. The bioengineering methods for recycling agricultural wastes in an embryonic stage. Composting is a method for the biochemical degradation of organic material. Composting methods are commonly employed on farms (open field) such as; passive composting, windrows, and aerated piles. These methods need a large areas to accomplish and take a long time (about 3 months in summer season and 4 months in winter season) to convert the raw materials into compost.

These methods are always followed without temperature control, aeration control, materials movement control, and odor control. There are usually two main types of parameters, which affect composting system performance. In-vessel composting refers to a group of methods which confine the composting materials within a building , container, or vessel.
In-vessel methods rely on a variety of forced aeration and mechanical turning techniques to speed up the composting process. Many methods combine techniques from the windrow and aerated pile methods in an attempt to overcome the deficiencies and exploit the attributes of each method. Engineering parameters (vessel design, aeration rate, shredding size of raw material, moisture content, and mechanical agitation intervals) and environmental conditions such as rainfall, and odor control. These parameters and their effect on composting system performance either for passive composting or windrows or aerated piles have been studied by several researchers (Hong and Ikeuchi (1985); Schuchardt, 1992; Vander Gheynst *et al* 1996; Sartaj *et al*., 1997 Walker *et al*. 1999). Experiments have shown that the process of grinding compost materials can increase the decomposition rate. Haug (1993) recommend a particle size of 1.3 to 7.6 cm (0.5 to 2 inches), with the lower end of this scale suitable for forced aeration or continuously mixed systems, and the upper end for windrow and other passively aerated systems.

The importance of temperature monitoring lies on the fact that it reflects the activity of microorganisms in the substrate and it represents an indicator of the proper evolution and occurrence of the composting process (Diaz and Savage, 2007). According to Hassen *et al*. (2001) substrate temperature determines the rate at which biological processes take place and plays an important role in the evolution and succession of the micro-organisms population.

In-vessel methods rely on a variety of forced aeration and mechanical turning techniques to accelerate the composting process. Gaby *et al*. (1972) showed that the composted wastes were turned over every 5 to 7 days and finished in 49 days. Initially the process was anaerobic and required 6 months for completion to occur. The process was later modified by turning the pile over twice, which reduced the composting time to 3 months. Rynk, (1992) stated that factors affecting the composting process include oxygen and aeration; nutrients (C:N ratio), moisture, porosity, structure, texture, and particle size.

Moisture is necessary to support the metabolic processes of the microbes. Water provides the media for chemical reactions, transports nutrients and allows the microorganisms to move about moisture content range 40-65 % is a general recommendation that works well for most materials. Porosity, structure, and texture relate to the physical properties of the materials such as particle size, shape, and consistency affect the composting process by their influence on aeration. The composting process is relatively insensitive to pH. The preferred pH is in the range of 6.5-8.0, but the natural buffering capacity of the process makes it possible to work over a much wide range. Also, he stated that carbonaceous substrates should be mixed with nitrogenous ones at a ratio of 4:1 or less, but never lower than 1:1 (on a dry weight basis). Some possible combinations are:

- 3 parts rice straw - 1 part horse manure
- 4 parts rice straw - 1 part chicken manure
- 4 parts grasses - 1 part legume materials + 1 part manure

MATERIALS AND METHODS

Experimental Equipment:

This study was carried out in Port Said Research Station during summer season 2011-2012**.** Three 0.147 m^3 reactor vessels were fabricated so concurrent composting tests could be run. Each bioreactor is cylindrical in shape, and made from stainless steel sheet 1 mm thick. The gross dimensions of the bioreactor are 50 cm in diameter (interior diameter) and 75 cm high. Each reactor includes a perforated stainless steel screen plate was installed above the bottom of the composter (with 10 cm high) to aid in aeration and support of the compost mass.

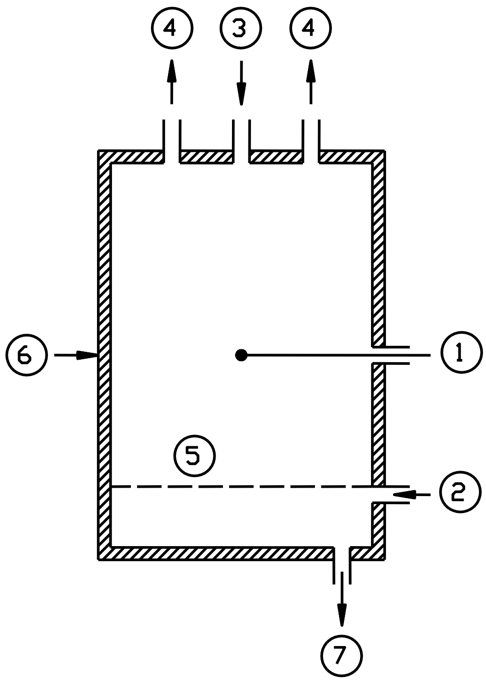

Figure (1): Schematic diagram of in-vessel system was designed for composting process.

Where: 1-Temperature sensor. 2- Air inlet. 3- Water inlet. 4- Gas outlet. 5- Perforated screen. 6- Insulation. 7- Extract outlet.

The screen holes were (0.3 cm ID), and the opening area was > 40% of total plate area *according to Hong et al., 1984*. Air moves through a 50 mm ID plastic PVC pipe. The small fan supplies a constant air flow through the compost to meet requirements for oxygen. Each reactor is equipped with small ports to facilitate temperature measurements in the center of the composter. Air can be supplied from either fan on an intermittent basis by using timer. Each reactor was wrapped with 50 mm (thickness) of steel cap was placed on the top. Each cap having three ports, two to exhaust wet water vapour which uptaking during composting process and one for water and organic manure additions (whenever need that), as shown in Figure (1). A similar design and size have been used by Hansen *et al*., (1989); Seki (2000). In the exterior circumference of each reactor, 25 mm of fiberglass wool insulation was placed to reduce the heat losses from the curved surface of the reactor.

Instrumentation:

Temperature measurement:

The temperature in each composter and ambient air were measured by the continuous self-recording data logger with K-type thermocouple probe (Testo 177-T4, temperature data logger, 4 channels,), the data logger was designed to allow temperature measurement at 4 locations.

Acidity (pH) meter:

The acidity (pH) of the composting media was measured using pH meter (Misura line ML 1010 pH meter made in Romania). To measure the pH of composting media, a 5 grams of mixture was placed in a glass beaker (50 cm^3), and 30 ml of water was added and agitated together according to (ASAE, 1997).

Electrical conductivity meter:

The salinity of raw materials was measured using electrical conductivity (EC) meter (model 470 Cond. Meter JENWAY made in the E.U.).

Raw Materials for Composting Process:

Small particle sizes of raw materials create more surface area. Surface area is an important component when we are talking organic technology. Surface area influences not only compost temperatures and rate of decomposition; surface areas influence pot-substrate water retention and cation exchange capacities for nutrients *Perr et al. (1982)*.

Rice straw: were used as one of the raw materials for composting media. This raw material was collected and brought from the field after harvesting operation. Rice straw and other large objects cannot be composted without size reduction. Conventional threshing machine was employed to break and shred the rice straw when they reached a moisture content of 7.4 - 9 %(wb). Four different sieves were used to classify and sort the shredded straw into category of particles size (2.0 ≤ category ≤ 12.0 mm).

Water hyacinth: is a floating aquatic plant with fibrous root system and dark green round leaves. The stalks are swollen into spongy, bulbous structure. The stalks and the leaves contain air filled tissue which enable them to float on water (Olal *et al*., 2001). He described it as the most predominantly, persistently and troublesome aquatic weed in the world and has posed ecological and biological problem in several countries of the world.

This raw material was collected from drainage beside EL-Redwan village Port said Governorate.

Alfalfa: the first-cutting of alfalfa were used as one of the green raw materials for composting media. This material was collected and brought from fields at EL-Redwan village Port said Governorate.

Cattle manure:

Fresh cattle manure was collected and moved from dairy cattle farms of Port said Governorate to the composting unit.

The Compost Mixtures:

Table (1) showed the raw materials of different mixtures. Different mixtures were mixed together at a ratio of 0.3 parts of water hyacinth and Alfalfa to 1 part of straw (by weight). Mixture operation of raw materials was manually executed on a plastic sheet placed on the concrete floor using handle shovels. The mixture of raw materials was weighed at the beginning and end of each test.

Table (1): The three mixtures tested in the test.

Ingredients	Mixture 1	Mixture 2	Mixture 3
Rice straw, kg	7	6.5	6.5
Cattle manure, kg	15	14	14
Alfalfa, kg	0	0	2
Water hyacinth, kg	0	2	0
Water, kg	0.75	1	1.5
Total weight, kg	22.75	23.5	24

For the duration of the experimental work, all treatments of the composting media were leaved in the bioreactor for just 28 days only to be composted. After composting period the composted material was removed from the bioreactors to store under natural conditions (at room ambient temperature) for curing stage.

Laboratory Analysis of Compost:

All laboratory analyses were executed according to (ASAE, 1997). Approximately 0.8 kg samples were collected from six arbitrarily selected points for each vessel at the start and at the end of each run. Some Chemical properties of raw materials were listed in Table (2).

Table (2): Some Chemical Properties of Raw Materials.

Determination	Manure	Rice straw	Water hyacinths	Alfalfa
Moisture content, %(wb)	86.0	9.0	86.6	58.0
pH (-)	7.97	6.05	7.03	7.84
EC, mg L^{-1}	1224	564	884	747
VS %	81.09	91.0	54.0	83.17
Ash %	18.91	9.0	46.0	16.83
TC %	45.13	47.30	30.0	46.20
TN %	0.93	0.30	1.97	2.25
C/N (-)	48.44	157.68	15.23	20.54
Phosphorus, P %	0.17	0.13	0.19	0.24
Potassium, K %	0.32	0.29	0.41	0.67

Carbon: Nitrogen Ratio (C/N):

Because of the carbon: nitrogen (C/N ratio) of fresh compost was very high (Table 2), addition of nitrogen was necessary to achieve the desired C/N ratio. Therefore, the amounts of fertilizer were 5 and 14 kg/ton of super phosphate and urea were added respectively. A similar amount to that, used by Sadaka and Sabbah (1999) and many others.

Moisture content: was determined by comparing the weight of a sample before and after drying at 70 ^{0}C for 48 hours, in an electrical oven. The moisture content (MC, %) was determined as follow:

Moisture content (MC, %) = [(Mw – Md) / Mw]*100 % (3.1)

Where: Mw = weight of the wet sample;

Md = weight of the dry sample.

The moisture content of mixed materials at the beginning of each experiment was about 65 % (w.b).

Volatile solids (Vs) and fixed solids (Ash): inorganic matter was determined by weighing the ash remaining after burned of an approximate 2g dried sample at 700 ^{0}C for 2 h in an electrical furnace. Volatile matter content for each raw material and mixed materials was computed according to the method of soil organic content test (Vander Gheynst *et al*., 1996; Eldridge *et al*., 1993).

Volatile matter content = (Ma – Mb / Ma-Mc) x 100, % (3.2)

Where: Ma = sample and crucible mass, g;

Mb = ash and crucible mass after intensive heating at 700 ^{0}C for 2h, g;

Mc = crucible mass, g.

Carbon content (TC): the sample used for moisture content, volatile solids, and fixed solids (ash) determination was also employed to estimate carbon content. The carbon content was calculated using the following formula (Chang *et al*, 1980).

Carbon = (100 - % ash) / 1.8 (db), % (3.3)

Carbon / Nitrogen ratio (C/N): was calculated after the amount of carbon and total nitrogen in the composting media was assessed.

The Density and bulk density: were calculated by dividing the weight of the substance on the volume that occupies. The bulk weight is expressed in the wet mass of material per unit volume.

The bulk density is the dry mass of the material per unit volume of solids and voids occupied by the original material. Bulk density can be found from the following equation (ASAE, 1997).

Bulk density (g/cm^3) = ((density (g/cm^3) x dry matter (%)) *100 (3.4)

Specific gravity of the solids: defined as the dry mass of solid particles per unit volume of water displaced by them (ASAE, 1997).

Porosity (P): is the air space occupied by both water and air. The porosity in the table was calculated using the following formula (Inbar and Hadar, 1993):

Porosity = 100 x (1- (bulk density / specific gravity)), % (3.5)

Air space of porosity (A): was obtained using the following formula (Inbar and Hadar, 1993):

Air space = porosity (1- moisture content / 100), % (3.6)

Major nutrients: nitrogen (N), phosphor (P), and potassium (K) contents of the raw materials, fresh compost and in the cured compost were assessed at the Unit of Analysis and Studies, Soil, Water and Environment Res. Institute, Agricultural Research Center.

The power consumption in aeration:

Total consumed power (kW) during aeration operations was estimated by using (WSE, Bedienungsanleitung LVM 210) energy consumption meter.

RESULTS AND DISCUSSION

Temperature Profiles of Produced Compost:-

Composting process essentially takes place within the two ranges known as methophilic phase (10-40 ^{0}C) and thermophilic phase (greater than 40 ^{0}C). Although mesophilic temperature allows effective composting, most experts suggest maintaining temperatures between 40 and 58 ^{0}C (thermophilic phase). Temperature curves for the various mixtures during composting process are shown in (Figure 3). The temperature of the raw materials during composting process is considered as an action indicative of the degree of microbial decomposition activity. The temperature of the compost rose rapidly within 24 hours after mixtures was placed in the composters and reached a peak (58.6 ^{0}C) within about 8 days. The downward in the temperature histories are indicative of when turning occurred. Temperature recovery occurs in about 24 hours after compost is turned at the three mixtures. The turning frequency was scheduled for turning three times during the 28 days test. After the thermophilic phase, the compost temperature drops. Maintaining aerobic conditions can be accomplished by mechanical mixing or turning. Mixing and turning increase aeration by loosening up and increasing the porosity of the composting mixture. Results showed that the temperature was greater than 45 ^{0}C since the second day of the experiment, this rise in temperature lasted for about twenty days for the three mixtures. The peak temperatures were 57.3, 58.6 and 57.6 ^{0}C for producing compost mixture (Mix 1= shredded rice straw, cattle manure and water); (Mix 2= shredded rice straw, cattle manure, water hyacinth and water) and (Mix 3= shredded rice straw, cattle manure, Alfalfa and water) respectively under particle size of (2-12 mm) and aeration rate of 0.007 m^3/min. The relationship between compost materials temperature and time, day (T) can be represented as: Mix 1 = 50.5 - 0.184 T, Mix 2 = 48.4 - 0.048 T, and Mix 3 = 50.9 - 0.207 T

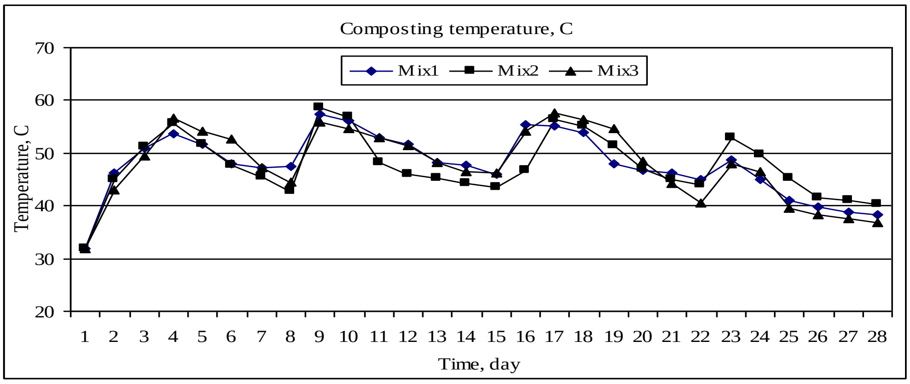

Fig. (4-1): Temperature Profiles of Compost Materials (Mix1, Mix2, and Mix3).

Physical Properties of Produced Compost:-

Physical properties of the three mixtures is summarized and tabulated in Table (2). It showed that, moistures content were 65, 68.8 and 68.11% at the beginning of the experiment and became 49.8, 47.17 and 50.03% at the end for the three mixtures 1, 2 and 3 respectively. The percentages of reduction in the moistures content were about 23.38, 30.88, and 26.55% for the three mixtures 1, 2 and 3 respectively. The bulk weight of the compost was always less than that of the initial admixture. Bulk weights were 0.276, 0.308 and 0.304 g/cm3 at the beginning of the experiment and became 0.553, 0.557 and 0.538 g/cm3 for finished compost of mixtures 1, 2 and 3 respectively. The bulk densities of the finished compost were 0.278, 0.294 and 0.269 g/cm3 for mixtures 1, 2 and 3 respectively. The percentages of increasing in the bulk densities were about 65.11, 66.67, and 63.94 % for the three mixtures 1, 2 and 3 respectively. Also, results showed that the air spaces were 33.41, 30.39 and 30.44 % at the beginning of the experiment and became 43.66, 45.54 and 43.66 g/cm3 for finished compost for mixtures 1, 2. and 3 respectively. Porosity is an expression for the air space occupied by both water and air As the amount of surface area is increased with smaller particles size, the rate of aerobic decomposition also increased making the compost process more rapidly and more efficient. The porosity of the finished compost were 86.97, 86.19 and 87.38 %. The percentages of reduction in the porosity were about 8.89, 9.64, and 8.45 % for the three mixtures 1, 2 and 3 respectively. Figure (2) reveals moisture content, density, porosity and air space of composting materials under particle size of (2-12 mm) and aeration rate of 0.007 m^3/min. The maximum moisture content, density, porosity and air space were 68.14%, 308 kg/m^3, 95.46 % and 33.41% for mixtures 1, 2 and 3 respectively. The relationship between compost types (Mix) and moisture content (MC), density (D), porosity (P) and air space (A) can be represented as: Mix = - 30.0 + 0.478 MC, Mix = -11.6 +46.1 D, Mix = 736 - 7.7 P and Mix = 17.6 - 0.497 A

Table (2): Some physical characteristics of the compost material during process.

		Some Physical Characteristics					
Raw Materials	**Time, day**	**MC, %**	**Dry matter, %**	**Bulk Weight, g/cm3**	**Bulk Density, g/cm3**	**Porosity, %**	**Air Space, %**
	1	65.00	35.00	0.276	0.097	95.46	33.41
	7	61.13	38.87	0.359	0.172	93.13	35.97
Mix1	14	55.40	44.60	0.449	0.187	91.25	38.55
	21	51.15	48.85	0.516	0.232	89.09	40.97
	28	49.80	50.20	0.553	0.278	86.97	43.66
	1	68.14	31.86	0.308	0.098	95.39	30.39
	7	62.34	37.66	0.370	0.147	93.12	34.21
Mix2	14	54.61	45.39	0.432	0.195	90.79	36.89
	21	49.22	50.78	0.494	0.246	88.47	41.15
	28	47.17	52.83	0.557	0.294	86.19	45.54
	1	68.11	31.89	0.304	0.097	95.44	30.44
	7	62.23	37.77	0.363	0.140	93.49	33.76
Mix3	14	56.98	43.02	0.421	0.189	91.46	37.42
	21	52.36	47.64	0.491	0.226	89.04	40.83
	28	50.03	49.97	0.538	0.269	87.38	43.66

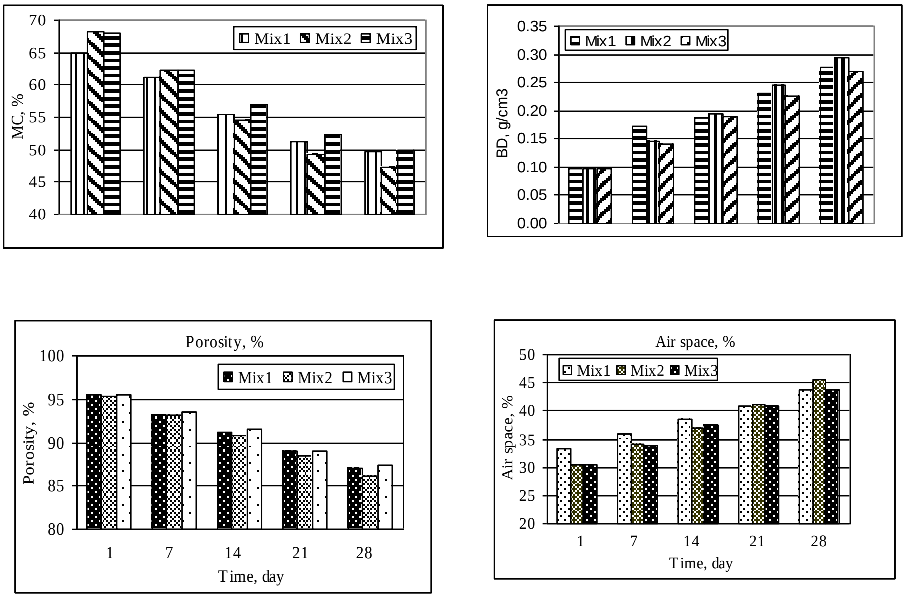

Fig. (2): Physical Properties of Compost Materials.

Chemical Properties of Produced Compost:-

Chemical properties of composting substances under different components is tabulated in Table (3) and demonstrated in Figure (3). Results showed that, changes in volatile solids of the admixture and produced compost was different from the C/N ratio. The produced compost was decreased to volatile solids from that of initial value. The loss in carbon contents amounted to around 16.63, 19.02 and 21.19 % for mixtures 1, 2 and 3 respectively. Changes of the total solids (TS, %) resulted from evaporation of water in the compost mass and decomposition of volatile solids. As the initial C/N ratio was too high, (Table 3), addition of nitrogen was necessary to achieve the desired C/N ratio.

Also, the addition of agricultural green wastes with a high content of nitrogen to raw materials at the beginning of the experiment. When the initial C/N ratio was to low, carbon became the limiting factor and the decomposition rate becomes slow. The initial C/N ratios were 58.51, 40.96 and 49.20 and became 16.34, 14.59 and 14.77 of the finished compost for mixtures 1, 2 and 3 respectively. The percentages of reduction in C/N ratios were 72.07, 64.38 and 69.98 % for mixtures 1, 2 and 3 respectively. Addition of agricultural green wastes with a high content of nitrogen such as water hyacinth and alfalfa to raw materials at the beginning of mixtures 2 and 3 respectively led to increasing the total nitrogen (TN, %) of the compost of mixtures 2 and 3 than that the compost of mixture 1. So, the influence of the nitrogen fertilizer component on the decomposition was very important. A higher decomposition rate was found at 1.10 % of influent nitrogen (in mixture 2) that at 0.77 % and 0.91 % (in mixtures 1 and 3 respectively). The pH of the produced compost remained nearly the same as its initial condition. The initial pH of the admixtures was 7.02, 6.99 and 6.87 for mixtures 1, 2 and 3 respectively.

Table (3): Some chemical properties of composting mixtures.

		Chemical Characteristics during composting process									
Raw Materials	**Time, day**	**Ash, %**	**Carbon, C %**	**T.N, %**	**T.K, %**	**T.P, %**	**C/N, (ratio)**	**MC, %**	**TS, %**	**p H, (-)**	**EC, mg L^{-1}**
	1	18.91	45.09	0.77	2.90	0.13	58.51	65.00	35.00	7.02	685.00
	7	19.80	44.55	1.27	3.14	0.18	35.08	61.13	38.87	7.28	769.00
Mix1	14	20.00	44.44	1.76	3.76	0.27	25.25	55.40	44.60	6.86	804.00
	21	29.70	39.05	2.01	4.13	0.31	19.43	51.15	48.85	7.06	742.00
	28	32.34	37.59	2.30	4.50	0.38	16.34	49.80	50.20	6.95	870.00
	1	18.91	45.05	1.10	3.20	0.23	40.96	68.14	31.86	6.99	779.00
	7	20.93	43.93	1.56	3.05	0.25	28.16	62.34	37.66	7.08	806.00
Mix2	14	25.25	41.53	1.84	4.11	0.28	22.57	54.61	45.39	6.96	864.00
	21	30.35	38.70	2.14	4.42	0.34	18.08	49.22	50.78	7.08	824.00
	28	34.33	36.48	2.50	4.90	0.40	14.59	47.17	52.83	7.08	848.00
	1	19.40	44.78	0.91	3.10	0.16	49.20	68.11	31.89	6.87	697.00
	7	21.35	43.70	1.22	3.12	0.19	35.82	62.23	37.77	7.12	712.00
Mix3	14	22.39	43.12	1.64	3.30	0.21	26.29	56.98	43.02	7.04	804.00
	21	30.35	38.70	2.11	3.43	0.29	18.34	52.36	47.64	7.08	705.00
	28	36.47	35.29	2.39	3.70	0.36	14.77	50.03	49.97	7.11	736.00

The final pH became 6.95, 7.08 and 7.11 at the end of the experiment for mixtures 1, 2 and 3 respectively. The evolution of electrical conductivity (EC) during composting process of rice straw with cattle manure is listed in Table (3). Data shown that the EC of the mixtures was 685, 779 and 697 mgL-1 respectively. The obtained results indicated that in all treatments, electrical conductivity values remained nearly the same as its initial condition during composting process. The obtained Figure (3) reveals ash, Organic Carbon, C/N, ph, EC, Total Nitrogen, Phosphorus, and Potassium of composting materials under particle size of (2-12 mm) and aeration rate of 0.007 m^3/min.The maximum ash, Organic Carbon, C/N, pH, EC, Total Nitrogen, Phosphorus, and Potassium were 19.4 %, 45.09 %, 58.51, 7.02, 0.779 S/m, 1.1%, 0.23% and 3.2 % respectively. The relationship between compost types (Mixtures) and ash, Organic Carbon, C/N, ph, EC, Total Nitrogen (TN), Phosphorus (TP), and Potassium (TK) can be represented as:

Mix = - 56.4 + 3.06 ash, Mix = 252 - 5.56 Carbon, Mix = 4.99 - 0.0604 C/N, Mix = 84.9 - 11.9 pH, Mix = 0.3 + 2.3 EC, Mix = - 0.36 + 2.55 TN, Mix = 1.01 + 5.7 TP and Mix = - 11.1 + 4.29 TK.

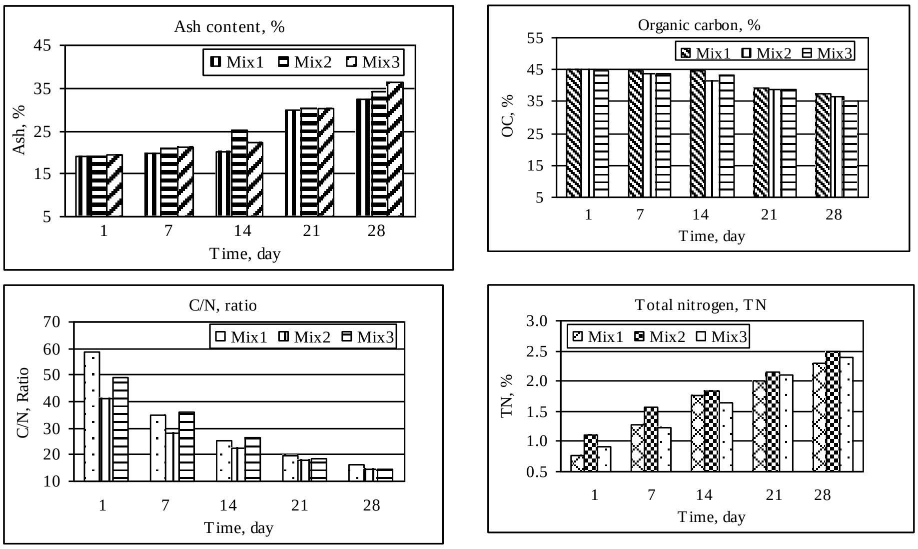

Fig. (3): Chemical Properties of Compost Materials.

The power consumption in aeration:

Total consumption power at aeration rate of 0.007 m^3/min was 0.343 kW for each reactor vessel.

CONCLUSION

The objective of the research is to study the composting process of rice straw in closed vessels, and to study the influence of adding the green agricultural residues to compost mixture, study some physical and chemical properties of raw materials and compost during the composting operation, study of the microorganism activity by monitoring differences in biomass temperatures and reducing the time requirement by minimizing fermentation time from 6- 24 weeks to about 4 weeks only and minimizing the area requirement by using in-vessel vertical bioreactor. The peak temperatures at the three mixtures compost were 57.3, 58.6 and 57.6 ^{0}C. The maximum ash, Organic Carbon, C/N ratio, pH, EC, Total Nitrogen, Phosphorus, and Potassium content were 19.4 %, 45.05 %, 58.51, 7.02, 0.779 S/m, 1.1%, 0.23% and 3.2 % respectively. Experiment has shown the possibility to speed up the process of compost produced from rice straw. Also, it proved the possibility of increasing the content of nitrogen of the finished compost by the addition of agricultural wastes green with a high content of nitrogen to raw materials at the beginning of the experiment, and reduces the time required to process from about six months to four weeks only. Addition of agricultural green wastes with a high content of nitrogen such as water hyacinth and alfalfa to raw materials at the beginning of mixtures 2 and 3 respectively led to increasing the total nitrogen (TN, %) of the compost of mixtures 2 and 3 than that the compost of mixture 1. So, the influence of the nitrogen fertilizer component on the decomposition was very important. A higher decomposition rate was found at 1.10 % of influent nitrogen (in mixture 2) that at 0.77 % and 0.91 % (in mixtures 1 and 3 respectively).

Bulk weights became 0.553, 0.557 and 0.538 g/cm3 for finished compost of mixtures 1, 2 and 3 respectively. The maximum moisture content, density, porosity and air space were 68.14%, 308 kg/m^3, 95.46 % and 33.41% for mixtures 1, 2 and 3 respectively. The maximum ash, Organic Carbon, C/N, pH, EC, Total Nitrogen, Phosphorus, and Potassium were 19.4 %, 45.09 %, 58.51, 7.02, 0.779 S/m, 1.1%, 0.23% and 3.2 % respectively.

REFERENCES

ASAE Standards D541.4 1997. Methods of determing density, specific gravity, and mass-moisture. ASAE, St. Joseph, Michigan.

Chang, C. S.; Lai, F. S. and Miller, B. S. (1980) “Composting of grain dust” TRANSACTION of the ASAE 23(4):709-711.

CMAE (Central Management of The Agricultural Economy). 2001. Estimations of the agricultural crops. Ministry of Ag. and Land Rec., Egypt.

Diaz, L. F. and Savage, G. M., (2007). Bioremediation. in: L. F. Diaz, M. de Bertoldi, B. W. and S. E. (Eds.), Compost Science and Technology, Elsevier, Amsterdam, pp. 159-176.

Eldridge, R., Collins, J. and Shane, C. P. 1993. Development of composting recipe for swine manure. Presentation at International Summer Meeting Sponsored by ASAE, Spokane Center, Spokane, Washington, June 20-23, 1993, Paper No. 934033.

Gaby, N. S.; Creek, L. L. and Gaby, W. L. (1972) “A study of the bacterial ecology of composting and the use of proteus as an Indicator organism of solid waste develop”. Ind. Microbial. 13:24-29.

Haug, R.T., 1993. Practical Handbook of Compost Eng'g. Lewis Publishers, Boca Ratan, FL. p.411

Hong, J. H.; J. and Ikeuchi, Y. 1985. An overview of compost maturity during soild composting in mixture of dairy manure and crop residues. Journal of Society of Agricultural Structures, Japan Vol. 16, No. 1 pp: 6-13.

Hasen, R. C.; Keener, H. M. and Hoitink, H. A. J. 1989. poultry manure composting: An exploratory study. TRANSACTIONS of the ASAE 32 (6): 2152-2157.

Hassen, A., Belguith, K., Jedidi, A., Cherif, A., Cherif, M. and Boudabous, A., 2001. Microbial characterization during composting of municipal solid waste, Bioresource Technology 80 217-225.

Hong, J. H.; Matsuda, J and ikeuchi, Y. 1984. Astudy on the improvement of animal waste composting operation in Korea. Jour. Korean Soc. Agric. Machinery 9 (1): 62-70.

Inbar, Y., Hadar, Y. 1993. Recycling of cattle manure: The composting process and characterization of maturity. Journal of Environmental Quality. Vol. 22(4): 857-863.

Minitab Reference Manuel (release 15), Minitab Inc. State University Michigan.

Olal, M. A., M. N. Muchilwa and P. L. Woomer, 2001. Water Hyacinth, Utilizations and Use of waste Material for Handicaraft Production in Kenya. In: Micro and Small Enterprises and Natural Resource Use. Nightingale, D. L. M. (Ed.). Micro-Enterprises Support Programme, UNRP< Nairobi, pp: 119-127.

Perr, J. F.; Willson, R. L.; Chaney, L. J.; Sikora, L. J. and Tester, C. F. (1982) “Effect of certain chemical and physical factors on the composting process and product quality”. FAO Soils Bulletin 45:pp. 66-78.

Rynk, R. (1992) “On-farm composting handbook”, NRAES-54. Northeast Regional Agricultural Engineering Service, Ithaca, New York.

Sadaka, S. S. and Sabbah, M. A. 1999. Enhancing composting process by fertilizers addition. Misr J. Agric. Eng., 16(2):293-305.

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

Schuchardt, F.1992. the composting of organic residues in agriculture. Third workshop of the working Group on biogas production for Energy, baader, W. (ed.): REUR Technical Series 21; Bratinschweig 5.-7.5.

Seki, H. 2000. Stochastic modeling of composting processeso with batchoperation by the FOKKER-PPLANCK EQUATION. Transactions of the ASAE Vol. 43 (1): 169-179.

Vander Gheynst, J. S.;Vander Gheynst, G. B. and Walker, L. P. 1996. Development and analysis of oxygen sensingprobes for in-situ monitoring of solid-state biodegradation processes. Journal of Air and Waste Mangament. 9 (1): 39-50.

Walker, L. p.; Nock, T. D.; Gossett, J. M. and Vander Ghyeynst, J. s. 1999. The role of periodic water addition in managing moisture limitations during high-solids aerobic decopostion. Process Biochemistry 34 (6-7): 601-6120.

عملية الإنتاج السريع للسماد العضوي من قش الارز مع بعض المخلفات الزراعيية الخضراء والمخلفات الحيوانية تحت نظم التحكم الكامل

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توجد كمية كبيرة من المخلفات الزراعية تنتج بعد عمليات الحصاد للمحاصيل المختلفة. مصر تزرع حوالى 1.67 ملايين فدان أرز سنويا، والتي تنتج حوالى 3.390.000 طن من قش الأرز .هذه الكمية تمثل مشكلة كبيرة للحكومة، والمزارعين والبيئة .وعادة يتم نقل هذه المخلفات إلى مقالب، حيث أنها تشكل تهديدا للبيئة وتلوثها. معالجة هذه المخلفات إما عن طريق التخمر اللاهوائي لانتاج الغاز الحيوي (البيوجاز) ، أو التخمير الهوائى لانتاج السماد العضوي (الكمبوست) الذي يستخدم بشكل رئيسي لانتاج محاصيل الخضار العضوية ذات القيمة التصديرية والاقتصادية العالية.

يهدف هذا البحث إلى دراسة عملية انتاج الكمبوست من قش الارز وروث البقر داخل الاوعية المغلقة ، ودراسة تأثير إضافة مخلفات نباتية خضراء الى خليط الكمبوست (مثل نبات ورد النيل والذى يعتبر من أهم مشاكل الرى نظراً لكثافة نموة فى قنوات الرى والصرف وكذلك الحشة الاولى للبرسيم والتى تلجأ كثير من المزارع الكبيرة للتخلص منها ببيعها بثمن بخس نظراً لقلة أهميتها بالنسبة للحشات التالية). ايضا دراسة بعض الخواص الطبيعية والكيميائية للكمبوست اثناء عملية التخمر. كذلك دراسة النشاط الميكروبى أثناء عملية انتاج الكمبوست والتى يعبر عنها ارتفاع درجة حرارة الكتلة الحية.

التجربة اثبتت امكانية الاسراع من عملية الكمبوست المنتج من قش الارز وتقليل الزمن اللازم والذى يستغرق عادة من 4 إلى 6 شهور إلى حوالى 28 يوما فقط وبجودة عالية، وذلك باستخدام نظام التحكم الكامل داخل الاوعية المغلقة والتى تتيح حفظ درجة حرارة الكتلة الحية والناتجة عن النشاط الميكروبى، حيث تقوم الكائنات الحية الدقيقة بالتغذية على المواد العضوية وتحليلها مما ينتج عنة فى النهاية تحويل المخلفات الى سماد عضوى (كمبوست) عالى القيمة السمادية. كما اثبتت النتائج امكانية زيادة المحتوى من النيتروجين عن طريق اضافة مخلفات زراعية خضراء ذات محتوى عالى من النيتروجين مثل نباتات ورد النيل والحشات الاولى من البرسيم.

كما أوضحت التجربة ان نسبة النيتروجين فى المواد الخام كانت فى بداية التجربة 0.77، 1.1 و0.91 % وأصبحت النسبة فى الكمبوست الناتج 2.3، 2.5 و 2.39 % بزيادة مقدارها 66.52، 56.0 و 61.92 % وذلك لكل من الخليط 1 ، 2 و 3 على التوالى.

كذلك أوضحت التجربة ان اضافة مخلفات زراعية خضراء قد حسنت من جودة الكمبوست الناتج وذلك بتحسين بعض الخواص الطبيعية والكيمائية للكمبوست الناتج من الخلطات الثانية والثالثة والتى تحتوى على مخلفات نباتية خضراء.

وأظهرت النتائج أن النشاط الميكروبى كان عالياً وذلك للثلاث خلطات وهذا ما عبر عنه درجات الحرارة والتى كانت أكبر من 45 ^{5}م منذ اليوم الثاني من التجربة ، وهذا الارتفاع في درجة الحرارة استمر لمدة عشرين يوما للخلطات الثلاثة . الكثافة الظاهرية للكمبوست أصبحت 553، 557 و 538 كجم / م3 للكمبوست النهائي.

كان الحد الأقصى للمحتوى الرطوبى والكثافة والمسامية والفراغات الهوائية 68.14 ٪، 308 كجم/م3، 95.46 ٪ و 33.41 ٪ للخليط 1 ، 2 و 3 على التوالي وذلك عند بداية التجربة. و كانت أقصى نسبة مئوية للرماد والكربون العضوي، ونسبة الكربون الى النيتروجين ودرجة الحموضة، ودرجة التوصيل الكهربائى والنيتروجين الكلى ، الفوسفور ، والبوتاسيوم19.4 ٪، 45.09 ٪ ،58.51، 7.02 ، 0.779 مليموز/لتر ،1.1 ٪،0.23 ٪ و 3.2 ٪ على التوال.

قام بتحكيم البحث

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