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COMPARISON STUDY BETWEEN STATIC PILE AND TURNED WINDROW METHODS FOR COMPOST PRODUCTION

BY

El-Ghozoli, M.A.*; Ali, S.A. and El-Sayed, G.A.M.***

* Soils, Water and Environment Research Institute, Agric. Res. Center, Giza, Egypt
** Agric. Engineering, Fac. Agric. at Moshtohor, Benha Univ.

ABSTRACT

This work was carried out to compare the quality of produced compost from 90 days composting of rice straw, maize stocks and cattle dung using two different methods and to evaluate the need for sieving the compost and its influence on its quality. Two different methods were used i.e. static and turned to examine some of the factors affecting the compost quality parameters i.e. organic matter, C/N ratio as well as rapid production process and study the effect of sifting process on the quality of final compost product. Two sieves granules (10 and 15mm) were used throughout static and turned compost experiments.

The obtained results can be summarized as follows:

- Temperature showed higher rates during thermophilic phase which began two days after the compost and lasted about 50 days in static and about 30-35 days in turned compost, which rose temperatures reaching a maximum (60-70°C) during the first twenty days of the beginning composting of all piles.
- Mesophilic phases continue more than one day of the experiment and then start back again after the end of the thermophilic phase and lasted for about 40-45 days in static while 28 days in turned compost.
- Concentration of NH_4-N decreased by increasing time of compost from 481 $mgkg^{-1}$ to 48 and 31 $mgkg^{-1}$ at the end of static and turned compost. While, NO_3-N increased to reach greater values than those at initial time of composting. The increases NO_3-N in turned windrow was more obvious rend than that of the static piles.
- Value of C/N ratio was in showed a gradual narrowing during the composting process and reached to lowering 20:1 after 30 days for the turned pile while it reached after 60 days in case of the static one.
- Cation exchange capacity (CEC) increased from 36.1 at the start of the experiment to 89.0 and 68.9 meq/100g for both turned and static compost at the maturity stage. The greater increase in values of CEC occurred in turned pile than that static one.
- Available P, Fe, Mn, Zn and Cu increased during the composting process in both static and turned heaps. The magnitude of this increase in case of turned compost was higher than that of the static one.
- The sifting process removed the granules greater than 15mm which containing a part degradable or humus and the main reasons to reduce the organic matter content and nutrients of the final product.

Key word: Static – windrow – compost- sifting

INTRODUCTION

In Egypt, the agricultural wastes are annually increased, though the disposal systems did not meet their huge volume. Therefore, the field residues are now the main cause of the most critical problems in air, ground and water pollution. The Egyptian soils demand for organic fertilizers (El-Shimi, 1997).

The recycling of agricultural wastes through composting increased nowadays to minimize environmental pollution and as a away for bio- organic farming system to be used in sustainable agriculture instead of ecologically undesirable mineral fertilization (Miller, 1993). Bioconversion of part of such accumulated rice straw into a value- added compost may have the potential to improve soil productivity and reduce environmental pollution. Rice straw is among certain organic materials which are resistant to microbial attack, since it contains 30%, 35% and 10%, hemicellulose, cellulose and non soluble fraction, respectively (Abd- El- Malek *et al.*, 1978). In addition to a very wide C/N ratio and the high content of lignocellulose (Diaz *et al.*, 1993).

To encourage composting of agriculture wastes, certain factors must be considered, e.g. size of particles, source of major available nutrients, microbial inoculants and composting strategy (aerobics or anaerobics) (Tengerdy and Szakacs, 2003).

Although there exists a number of different composting methods and technologies, there are three main systems of centralized composting aerated static pile process, windrow process and enclosed systems (Martin and Gershuny, 1992).

Turning machines are used in composting plants and its capital cost is high for small farmers. While, static compost pile is more practical for small farmers. Composting plants normally sieve the compost before selling it.

The main objectives of this study are (1) make a comparison between two types of composting process static and turned (2) effect of sieving operation on compost quality.

MATERIALS AND METHODS

Materials:

Rice straw and maize stalks were obtained from Moshtohor surrounding farms, fresh cattle dung which added as a source of composite nutrients and as a starter of microorganisms active in composting process was collected from Moshtohor, Fac. of Agric. Farm, Qalyoubia Governorate. Rice straw and maize stalks were air dried and chopped to small pieces (3-5cm) to increase the surface area for direct contact with microorganisms of these crop residues. The characteristics of organic materials used are shown in Table (1).

Table (1): Characteristics of organic materials used in compost

Organic Materials / Characters	Cattle dung	Maize stalks	Rice straw
Bulk Density kg/m^3	1128.4	54.03	72.16
Moisture Content%	81.08	7.55	5.34
Total Nitrogen %	1.53	1.09	0.49
Total organic Carbon %	44.95	46.58	44.94
C/N Ratio	29.37	42.73	91.71
Total Phosphorus%	0.73	0.067	0.34
Total Potassium%	1.43	0.284	0.52

* on oven dry basis

Experimental procedures:

Six piles were constructed at the training center for Recycling of Agricultural Residues (TCRAR) at Moshtohor, Soils, water and Environment Res. Institute. Agric. Res. Center. The amounts of rice straw (23 kg), maize stalks(15 kg) and cattle dung (12 kg) were calculated to give a mixture of C/N ratio about 30:1. The materials of each pile were thoroughly mixed and stacked in several layers upto about 2.25m. wide X12m. long X 1.70m high. The previously mentioned mixture of organic materials were used in preparing compost by two different methods, i.e. static pile and turned windrow. Either three static piles or three turned piles were pyramidal in shape and covered with 5cm layer of mature compost. Water content of all piles was adjusted to 60% at the beginning and moistened with tap water, if needed.. Aeration in static pile system is provided by means of blowers and air diffusers. Two sets of pertorated plastic pipes 2m. long (> pile width) were placed horizontally parallel two the pile width on 2m. apart and at 20 cm from the bottom of the pile. While the second sets of pipes with similar diameter were placed vertically between each two horizontal pipes, the height of each was 2m. (Fig. 1). In the turned piles, turning was carried out by turning machine when the CO_2 and temperature were more than 10% and 60°C, respectively. Temperature, moisture content and CO_2 evolved were measured every day.

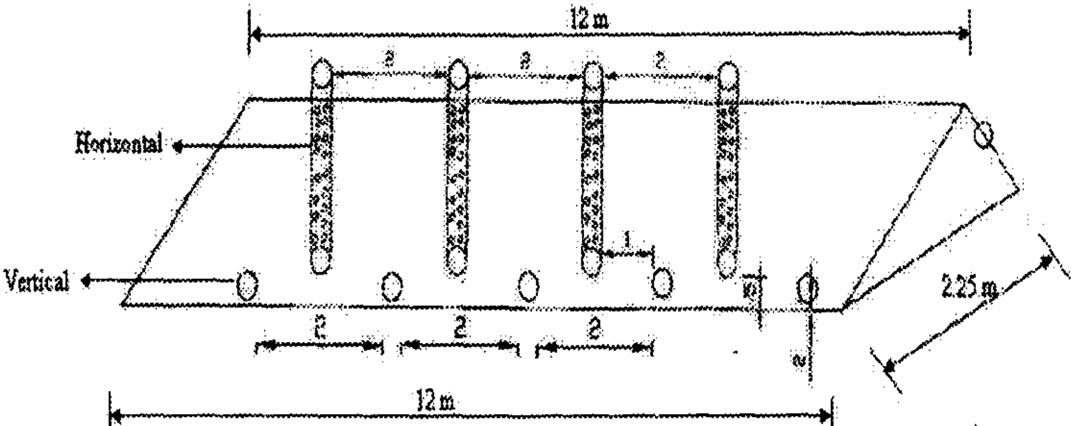

Figure (1): Static compost design showing vertical and horizontal pipes

Sifting process:

To study the effect of sifting process on the quality of final product, two sieves (10 and 15 mm) were used to evaluate compost quality, nutrient content and organic matter.

Methods:

Temperature degrees were recorded at different depths (20, 40 and 60cm) at the heap center using a thermocouple thermometer, moisture content was determined as described by Page *et al.* (1982), pH Value and EC were measured in a suspension of 1:10 compost: water (Richards, 1954). Organic carbon was determined according to standard methods of (APHA, 1989).

Carbon dioxide was measured according to Page *et al.* (1982). Bulk density was calculated according to Vomocil, (1965). Ammoniacal and nitrate nitrogen were determined using the recommended methods of Page *et al.*(1982). Total nitrogen, phosphorrus and potassium were determined according to Jackson (1967), Page *et al.* (1982) and Chapman and Pratt, (1961), respectively. Cation exchange capacity (CEC) was assessed according to Harada and Inoko, (1980). Fe, Mn, Zn and Cu were determined using atomic absorption spectrophotometer, Perkin Elmer model 3110.

Microbial changes:

Some microbial groups were detected during the composting process. Samples were taken at the beginning, then every 20 days intervals. Plate count using suitable serial dilution and specific media was applied for estimation of the examined microbial groups. The media include:Bunt and Rovira medium (Abd El- Hafez, 1966) for *Bacillus*; *Nitrosomonas* media (Stephenson, 1930); *Nitrobacter* media (Allen, 1959); MacConkey bile salt agar medium (Difco Manual, 1977) for *E. coli*, agar medium for *Salmonella* and *Shigella*; Smibert and Krieg, (1981) medium for *Klebsiella*. Azospirillum count was determined according to MPN method (Vincent, 1970). Omeliansky's medium (Allen, 1959) for *Clostridium*. Ashby medium used for counts of *Azotobacter* (Allen, 1959)

The inoculated plates or tubes were incubated for suitable time for each bacterial group at 28-30°c for all mesophilic groups and 45°c for thermophilic bacteria, after which the growing cultures were examined for the specific growth characters of each microbial group.

Statistical analysis was conducted using Minitab program according to Ryan and Joiner (1994).

RESULTS AND DISCUSSION

Temperature profiles and degree of composting:

Temperature changes during the composting periods of the piles were recorded and illustrated in (Fig.2).

For static piles, the aeration was performed through piping system, it was found that the initial temperature was 18°C then gradually increased to 60°C during the first 20 days of composting, then gradually decreased to 44°C after 70 days. Thereafter the temperature reached 35°C at the end of composting process. The fluctuations in temperature markedly affect the species of microorganisms and the rate of their proliferation and the level of physiological activities they perform. This trend confirms those of Gohar *et al.* (2006).

Data presented in Fig 2 revealed that temperature changes in case of turned piles, at the beginning it was 19°C, then reached to 57°C after 20 days from starting of composting process and remained in the range between 39 and 40°C after 60 days and reached 32°C at the end of composing process. This characteristic pattern of temperature changes over time reflects the types of decomposition and stabilization as composting proceeds. These results were agreed with those obtained by Rynk (2000) who found that the temperature of composting materials followed a pattern of rapid increase to reach 55 to 60°C and remained near this thermophilic level for several weeks then, gradually droped to 38°C and finally droped to ambient air temperature.

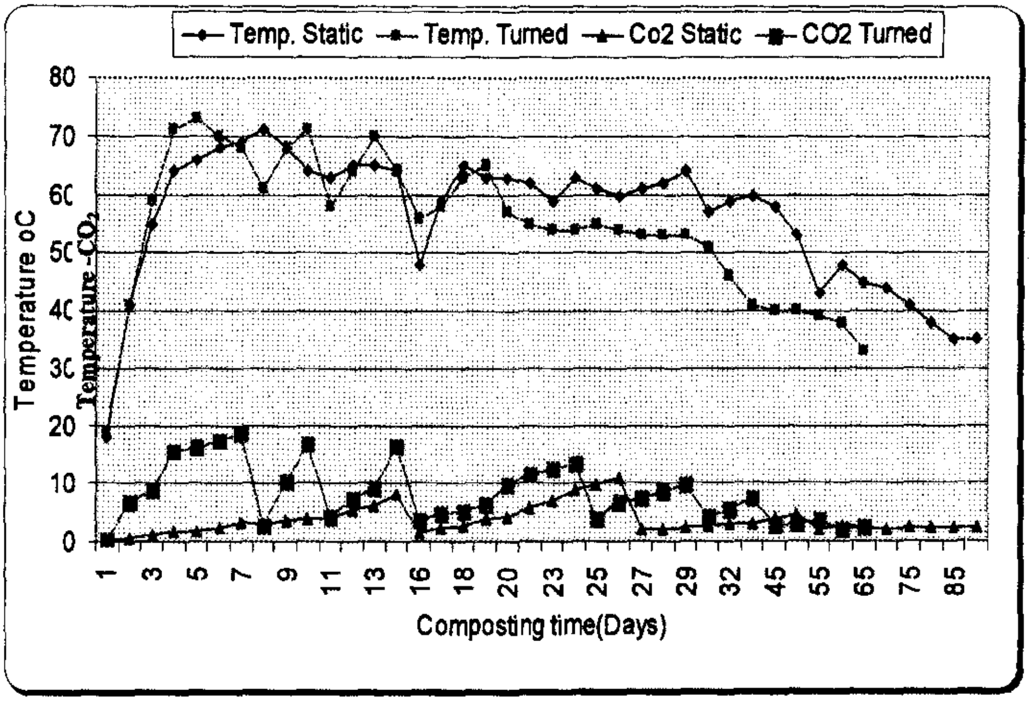

Fig. (2): Changes of temperature and carbon dioxide during composting process for static pile and turned windrow

- CO_2 evolved:

Data illustrated in Fig 2 show the changes in CO_2 evolved in both static and turned piles during composting periods.

In static compost, the CO_2 evolved reached 0.2% at the beginning of composting and it reached 4.4% after 20 days. The magnitude of CO_2 cycle was gradually decreased till the CO_2 reached 2.3% at 90 days. The CO_2 evolved trend was similar in static compost system to that of temperature. It means that there is a positive effect between the CO_2 evolved and the temperature of compost pile.

In the turned compost data revealed that the CO_2 evolved reached 9.8% after 20 days. After turning the piles, CO_2 decreased to 4.2% then sharply increased again to 7.4% after 40 days. The CO_2 was slowly decreased to reach 2.1% after 90 days. The previous data show the decline in CO_2 evolved to less than 2.3% in the final stage. These results are in accordance with those reported by Rynk (2000).

- Bulk density:

Results in Table 2 showed gradual increases in bulk density as the composting proceeds. The bulk density values increased from 0.314 to 0.569 g/cm^3 for turned and from 0.314 to 0.648 g/cm^3 for static compost. The increase of compost weight per unit of volume as the composting process proceeds reflects the high percentage of fine particle. This variations could be attributed to the physical characteristics and weights of the organic wastes used. Raviv *et al.* (1987) mentioned that bulk density was highly affected by the composting process lengths. This is most probably due to the breaking down of fiber structure of celullosic and legnocellulosic compounds.

- Hydrogen ion concentration (pH):

The pH changes during the composting process were presented in Table 2. Data indicated that no differences were noticed between static and turned composting methods.

In static piles, pH value was 7.03 at the beginning and decreased to 5.59 after 30days, then increased to reach 8.05 after 50days, followed by slightly decrease to be 7.89 after 70days. Meanwhile at 90 days the pH value was 8.06. while in the turned compost the values of pH were 7.03 at the beginning changed to 5.98, 7.78 and 7.94 after 30, 60 and 90 days of composting, respectively. Similar pH behaviour was observed by Gohar *et al.* (2006). The decrease in the pH value could be a consequence of degradation of easily decomposable polysaccharides and the production of organic acids during bio-oxidative phase. While the increase in pH value may be referred to the metabolic degradation of these organic acids (Faure and Deschamps, 1990).

Table (2): Changes of bulk density, pH, EC, CEC and moisture content during the composting processes of the static and turned piles.

Parameters / Period (days)	Bulk Density (g/cm^3)		PH (1:10)		EC dS/m (1:10)		CEC meq/ 100g compost		Moisture content (%)	
	Turned	Static	Turned	Static	Turned	Static	Turned	Static	Static	Turned
0	0.314	0.314	7.03	7.03	2.71	2.71	36.11	36.11	65	65
20	0.365	0.473	6.23	6.71	4.64	2.88	46.68	37.15	55	58
30	0.392	0.523	5.98	5.59	5.74	4.36	53.28	39.78	47	42
40	0.421	0.575	7.81	7.98	5.44	3.75	58.88	42.53	43	38
50	0.462	0.583	7.92	8.05	5.40	3.55	66.78	47.28	39	33
60	0.516	0.623	7.78	7.95	5.04	3.50	78.18	51.53	39	28
70	0.536	0.632	7.81	7.89	4.64	3.41	79.21	54.41	38	24
80	0.573	0.654	7.80	7.91	4.51	3.38	79.58	59.53	30	23
90	0.569	0.648	7.94	8.06	4.34	3.34	88.98	68.93	22	20

- Electrical conductivity (EC):

Data in Table 2 showed gradual increases of the EC during the first 30 days of composting period. The EC value was 2.71 dSm^{-1} at the beginning and increased to reach 4.36 and 5.74 dSm^{-1} for the static and turned piles, respectively. Thereafter, the EC of composting materials was slightly decreased with relatively low changes in their values till the end of the composting period. Increases in EC of composted materials could be attributed to the high concentration of ammonia and other nutrients released during the rapid mineralization of organic materials. Similar results were obtained by Raviv *et al.* (1987).

- Cation exchange capacity (CEC):

Data of CEC for static and turned piles are presented in Table 2. The CEC of all piles showed a gradual increase throughout the composting process. In static compost, the CEC values increased from 36.11 meq/100g dry weight at the initial time to 68.93 meq/100g after 90 days of the composting process. In the turned piles, the CEC values increased from 36.11meq/100g at the initial time to 88.98 meq/100g after 90 days.

Similar trend of results were obtained by Jimenez and Garcia (1989). The greater increase in values of CEC occurred in turned compost than the static compost may be attributed to the turning frequency.

The increase in CEC during composting might be explained not only to the accumulation of materials bearing a negative charge such as legnin derived product, but also may be due to an increase of carboxyl and/or phenolic hydroxyl groups (Lax *et al.*, 1987).

- Organic carbon, total nitrogen and C/N ratio:

The changes in organic carbon during the composting process are presented in Table 3. Results show a decrease from 43.54 at the start to 27.72% after 90 days in the static piles. While it was 43.54% at zero time reduced to 23.09% after 90 days in the turned compost. The organic carbon content was evidently decreased when the compost materials were unturned than in mechanically stirred treatment. The decrease in organic carbon could be attributed to the loss of carbon as CO_2 via microbial oxidation during the composting process. These results are in agreement with those obtained by Wong *et al.* (2001) the total losses in organic carbon percentage were 13.9, 28.4 and 36.3% after 30, 60 and 90 days for the static piles and to 31.6, 47.0 and 49.6% for the turned piles, respectively. It is noticed that the losses in organic carbon were higher in the turned piles than that in the static one after 30 days of composting.

Table (3): Changes of organic carbon, total nitrogen and C/N ratio of static and turned piles during composting processes

Parameters Period (days)	Organic Carbon%		Total Nitrogen%		Carbon/ Nitrogen Ratio	
	Static	**Turned**	**Static**	**Turned**	**Static**	**Turned**
0	43.54	43.54	1.45	1.45	29.9	29.9
20	38.45	34.37	1.46	1.31	26.2	23.0
30	37.48	29.77	1.52	1.25	24.6	19.5
40	33.96	25.67	1.56	1.53	21.7	16.7
50	32.64	23.77	1.61	1.61	20.2	14.8
60	31.19	21.92	1.65	1.62	18.9	13.5
70	30.09	22.17	1.72	1.69	17.4	13.1
80	28.52	22.76	1.79	1.73	15.5	13.1
90	27.72	23.09	1.91	1.71	14.5	13.4
L.S.D$_{0.05}$	2.33		0.10		2.11	

Data in Table 3 indicated that total nitrogen increased from 1.45% at zero time to 1.91% after 90 days during static composting process. On the other hand, in the turned compost, the total nitrogen increased from 1.45% at the beginning to 1.71% after 90 days. The percentage of total nitrogen in composted materials increased by time till the end of the experiment. However, the amount of total nitrogen contents decreased by time. The nitrogen changes may be attributed to losses of organic carbon and/or losses of ammonia through volatilization or some denitrification happened. These findings are similar to those obtained by Wong *et al.* (2001) and Gohar *et al.* (2006).

As a result of decreasing organic carbon and increasing total nitrogen during the composting process, data in Table 3show a decrease in C/N ratio from 29.9 at the start of composting to 24.6, 18.9 and 14.5 after 30, 60 and 90 days for the static piles and to 19.5, 13.5 and 13.4 for the turned piles, respectively. Similar findings were obtained by Mondini *et al.* (1996) and Abdel Wahab (1999) who indicated that C/N ratio tended to be narrow with time in compost heaps due to gaseous loss of carbon as CO_2 while the nitrogen remained more tightly bounded in organic combination. It is noticed that value of C/N ratio showed a gradual narrowing during the composting process and reached to lowering 20:1 after 30 days for the turned pile while it reached after 60 days in case of the static one. It means that the beneficial effect of the turning parameter on the compost maturation.

- Available forms of some macronutrients: Ammonical and nitrate nitrogen

Changes in NH_4-N and NO_3-N as affected by composting time are presented in Table 4. Data showed a gradual increase of NH_4-N in all composted piles and to reach its maximum values during the 1st 20 days of composting period. Thereafter, the concentration of ammoniacal N rapidly decreased towards the end of the composting period to reach its minimum values. This decrease could be attributed to oxidation of ammonia to nitrate (Morisaki *et al.*, 1989 and Mori *et al.*, 1981). Data also showed a decrease in NH_4-N from 481 mgKg^{-1} at zero time to 48 and 31mgKg^{-1} after 90 days in case of static and turned piles.

Table (4): Available forms of some macronutrients during the composting process of static and turned piles.

Parameters	NH_4- N (mg/kg)		NO_3- N (mg/kg)		P (mg/kg)		K (mg/kg)	
Period (days)	Static	Turned	Static	Turned	Static	Turned	Static	Turned
0	481	481	62	62	312	312	106	106
20	735	684	118	125	204	276	177	157
30	671	598	157	152	295	301	265	179
40	485	471	151	189	466	515	285	222
50	377	345	173	246	481	522	348	389
60	251	217	286	316	516	598	419	553
70	173	136	358	423	524	617	524	597
80	67	57	403	472	549	563	545	612
90	48	31	473	531	563	642	564	642
L.S.D$_{0.05}$	72.3		78.9		29.2		31.7	

On contrary, nitrate N showed a gradual increase as a result of converting ammonia to nitrate by nitrifying bacteria to reach values greater than those at initial time of composting. Data also indicated that the increases of NO_3-N in turned windrow were more obvious rend than that of the static pile. This variations of oxidized form NO_3 may be attributed to the increase of the activity of nitrifying bacteria.

- Available P:

Values of available P decreased from 312 mgkg^{-1} to 204 and 276 mgkg^{-1} for the static pile and turned windrow during the first stage of composting (20 days) then sharply increased to reach maximum values at the end of composting periods as shown in Table 4.

The decreases of available P could be due to the microbial immobilization while the increases could be attributed to the microbial mineralization of organic phosphorus. These results are in agreement with those of Singh and Sharma (2002).

It is noticed that at maturation stage, the values of available P remain increasing in the turned compost more than that in static piles.

- Available K:

Data in Table 4 showed gradual increases of available K. In the static pile available K increased from 106 to 564 mgkg^{-1} at 90 days. While it was increased from 106 to 642mg/kg after 90 days in the turned one. This increase may be due to the high activity of microorganisms which led to the increase of the mineralization rate. These results are in harmony with those of Singh and Sharma (2002). The increases of available K in the turned windrow was more obvious than that in the static piles

- Available micronutrients:

Data presented in Table 5 show an increase in Fe, Mn, Zn and Cu during the composting process in both static and turned heaps. The magnitude of this increase in case of turned piles was higher than that of static one.

Table (5): Changes in available micronutrients during the composting process of static and turned piles.

Parameters / Period days	Fe (mg/kg)		Mn (mg/kg)		Zn (mg/kg)		Cu (mg/kg)	
	Static	Turned	Static	Turned	Static	Turned	Static	Turned
0	128.5	128.5	68.5	68.5	48.5	48.5	28.0	28.0
20	110.1	115.2	95.6	112.0	58.3	75.5	22.7	31.0
30	171.1	213.5	114.7	125.0	63.4	91.2	45.0	38.0
40	185.6	232.3	162.6	171.2	74.8	107.0	54.0	59.0
50	214.0	245.2	178.1	182.3	79.9	122.1	59.0	76.0
60	282.0	259.0	183.9	208.0	89.6	159.0	61.0	84.0
70	235.0	268.0	178.5	215.0	128.0	166.1	62.0	85.0
80	243.0	282.1	192.3	223.0	138.0	175.0	65.0	85.0
90	276.1	324.0	196.0	227.4	181.0	193.0	68.0	85.0
L.S.D$_{0.05}$	21.9		17.4		14.1		10.3	

These results are in agreement with those obtained by Allam (2005). Trace elements are not directly a part of the organic chemicals but they have a very strong tendency to be adsorbed on the organic matter. They are further not transformed during the aerobic composting process and they will therefore not be lost to the surrounding environment in any significant manner. This means that the metals found in the incoming material will also be found in the finished compost. The mass of the compost is reduced during composting and the concentrations of the heavy metals (mg metal/Kg dry matter compost) will therefore increase and reach their highest levels in the final product (Tjalfe, 2003).

Generally, in both static and turned piles it was noticed that estimated available nutrients as NH_4-N, NO_3-N, available P, available K and extractable Fe and Mn initially decreased during thermophilic stage or the breakdown of composed materials, followed by gradual increases during the mesophilic stage or build up stage then, remain constant during the maturity stage. In other words, during composting time, different available nutrients were subjected to immobilization in the initial stage followed by significant mobilization or mineralization and finally, remain constant at maturation stage.

- Microbiological population:

Data presented in Table 6 show the changes of beneficial and pathogenic microorganisms throughout the composting process. Results revealed that the numbers of beneficial microorganisms decreased during the 1st 30days of composting process thereafter, their numbers increased to be maximum values till the end of composting in both of static and turned piles. As the temperature decreased during the decline and maturation phase, the mesophilic total microorganisms count proliferated rapidly and their numbers increased. After 30 days of composting in which the temperature degree was higher than 45°C, the thermophilic microorganisms proliferated rapidly and showed maximum numbers for all piles under study. These results agree well with those obtained by Allam (2005). Data in Table 6 showed also that the numbers of pathogenic microorganisms were rapidly decreased during the composting periods and were not detected for all static and turned piles at the maturation stage. The disappearance of pathogens could be explained on the basis that when a beneficial microbe fills an ecological niche that would otherwise be exploites by a pathogen. For example, a beneficial organism may out complete a pathogen for energy, nutrients, or "living space", thereby decreasing the survival of the pathogen (Brinton *et al.*, 2001). Time and temperature are the most important parameters responsible for pathogen die-off during composting. It should be noted that a complete inactivation of pathogens in compost pile.

Table (6): Numbers of beneficial and pathogenic microorganisms (CFU/ g dw) during different periods in both static and turned piles.

Microrganisms	**Numbers of microorganisms (CFU/ g dw)**					
	Static Compost					
Beneficial	**Period days**					
	0	**10**	**30**	**50**	**70**	**90**
Azotobacter spp.	$2.5x10^2$	$2.4x10^2$	$1.4x10^2$	$2.1x10^3$	$2.9x10^6$	$5.9x10^5$
Azospirillum spp.	$1.8x10^2$	$1.7x10^2$	$1.6x10^2$	$2.7x10^2$	$3.4x10^5$	$4.1x10^5$
Klebsiella spp.	$1.1x10^2$	$0.9x10^2$	$0.8 x10^2$	$1.6x10^2$	$2.2x10^3$	$2.9x10^3$
Clostridium	$1.5 x10^2$	$1.4x10^2$	$0.6x10^2$	$0.9x10^3$	$1.4x10^3$	$1.4x10^3$
Bacillus spp	$2.2 x10^2$	$2.1x10^2$	$1.8x10^2$	$2.7x10^3$	$1.1x10^4$	$3.9x10^4$
Nitrosomonas	$0.9 x10^2$	$0.8x10^2$	$05 x10^2$	$0.9x10^3$	$2.4x10^3$	$2.5x10^3$
Nitrobacter	$0.8 x10^2$	$0.7x10^2$	$0.6x10^2$	$3.2x10^4$	$4.2x10^4$	$3.8x10^3$
Pathogenic						
Escherichia coli	$0.6 x10^2$	$0.4x10^2$	$0.2x10^2$	nd	nd	nd
Salmonella	$0.7 x10^2$	$0.5x10^2$	$0.1x10^2$	nd	nd	nd
Shigella	$0.4 x10^2$	$0.2x10^2$	$0.1x10^2$	nd	nd	nd
	Turned compost					
Azotobacter spp.	$2 x10^2$	$1.9x10^2$	$0.5x10^2$	$2.4x10^4$	$1.7x10^9$	$1.2x10^9$
Azospirillum spp.	$1.4 x10^2$	$1.2x10^2$	$1.1 x10^2$	$1.5x10^4$	$1.1x10^7$	$0.9x10^7$
Klebsiella spp.	$0.8 x10^2$	$0.6x10^2$	$0.5 x10^2$	$0.5x10^2$	$0.6x10^4$	$1.4x10^3$
Clostridium	$0.9 x10^2$	$0.7x10^2$	$0.6 x10^2$	$1.3x10^2$	$0.7x10^4$	$1.8x10^3$
Bacillus spp	$2.4 x10^2$	$2.2x10^2$	$1.9x10^2$	$4.1x10^5$	$1.1x10^6$	$6.2x10^5$
Nitrosomonas	$0.7 x10^2$	$0.5x10^2$	$0.4 x10^2$	$1.4x10^3$	$5.9x10^4$	$4.1x10^4$
Nitrobacter	$0.9 x10^2$	$0.6x10^2$	$0.5 x10^2$	$5.7x10^4$	$2.3x10^6$	$7.6x10^5$
Pathogenic						
Escherichia coli	$0.8 x10^2$	$0.5x10^2$	nd	nd	nd	nd
Salmonella	$0.6 x10^2$	$0.3x10^2$	nd	nd	nd	nd
Shigella	$0.5 x10^2$	$0.4x10^2$	nd	nd	nd	nd

nd: not detected

- Sifting evaluation

- Bulk density

Data presented in Table 7 show the physical and chemical properties of static and turned piles as affected by size of waste granules. Bulk density of compost granules for less than 15mm and less than 10 mm decreased from 0.648 g/cm^3 to 0.581 and 0.514 g/cm^3. while the coarse for 15mm and 10mm decreased to 0.627 and 0.594 g/cm^3, respectively. On the other hand, the corresponding figures for the turned compost were 0.569 g/cm^3 decreased to 0.434 and 0.419 g/cm^3 for the compost granules less than 10 and 15 mm. While, it decreased to 0.512 and 0.547 g/cm^3 for the coarse less than 10 and 15 mm, respectively.

Table (7): Physical and chemical properties of static and turned compost.

Sample		Weight kg	Bulk Density g/cm^3	CEC meq/100g compost	O.M %	O.C %	T.N %	C/N ratio
Composting method (C)								
Static pile								
Sifting process (S)	**Product(P)**	100	0.648	68.93	47.78	27.7	1.91	14.51
15 mm	**Fine**	80.32	0.581	67.12	45.95	26.7	1.68	15.88
	Coarse	19.68	0.627	68.13	46.02	26.7	1.41	18.93
10 mm	**Fine**	23.04	0.514	63.15	45.23	26.2	1.53	17.1
	Coarse	76.96	0.594	67.77	46.12	26.8	1.76	15.20
Turned pile								
	Product	100	0.569	88.98	39.40	23.1	1.72	13.44
15 mm	**Fine**	75.19	0.434	85.17	38.98	22.6	1.42	15.92
	Coarse	24.81	0.547	88.16	39.27	22.8	1.32	17.21
10 mm	**Fine**	22.88	0.419	81.27	38.46	22.3	1.25	18.6
	Coarse	77.12	0.512	86.04	39.55	22.9	1.49	15.39
L.S.D$_{0.05}$		C	0.51	1.57	2.75	1.32	0.08	1.43
		S	0.034	1.14	1.58	0.85	0.037	1.02
		P	0.012	0.42	1.02	0.36	0.009	0.30

- C/N ratio:

Data of the changes in organic carbon during sifting process presented in Table 7 showed a decrease from 27.7% for the final static compost to 26.7, 26.2, 26.7 and 26.8% for fine granules less than 15mm, fine granules less than 10mm, coarse product at 15mm and coarse product at 10 mm, respectively. In the turned compost, the organic carbon content was 23.1% for the final compost decreased to 22.6, 22.3, 22.8 and 22.9% for the abovementioned stated, respectively.

Regarding the changes in total nitrogen during sifting process, data showed a decrease from 1.91% for the final static compost to 1.68, 1.0, 1.41 and 1.76% at granules less than 15mm, granules less than 10mm, compost over size at 15mm and compost reject at 10mm, respectively.

In the turned compost, the total nitrogen was 1.72% for the final compost decreased to 1.42, 1.25, 1.32 and 1.49% for the abovementioned stated, respectively. It is clear that the C/N ratio reduced as a result of the sifting process.

- Cation exchange capacity (CEC):

Data presented in Table 7 show that the CEC values were gradually decreased throughout the sifting process of the static or turned compost methods. The CEC value was 68.9 meq/100g for the final static compost decreased to 37.1, 63.1, 68.1 and 67.7 for fine granules less than 15mm, fine granules less than 10mm, coarse product at 15mm and coarse product at 10mm, respectively. Similar trend was observed in the turned compost during sifting process.

It is clear from the abovementioned results that the sifting process removed the granules greater than 10 mm which contain an important part degradable or humus and the main reason to reduce the organic matter content and nutrients of the final product.

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دراسة مقارنة بين طريقتي الكومات الساكنة والمقلبة لإنتاج الكمبوست

محمد عبد المؤمن الغزولي*، سمير أحمد علي، جمال عبد الحكيم محمد السيد***

*معهد بحوث الأراضي والمياه والبيئة- مركز البحوث الزراعية - الجيزة - مصر

** قسم الهندسة الزراعية - كلية الزراعة بمشتهر - جامعة بنها

أجري هذا البحث للمقارنة بين إنتاج السماد العضوي الصناعى (كمبوست) باستخدام معدات التقليب اوإنتاجه في كومات ثابته عن طريق وضع نظام للتهوية للتقليل بقدر الإمكان من استخدام تلك الآلات. بالإضافة إلي بحث تأثير عمليات النخل للسماد العضوي علي جودته ومحتواه من العناصر وتم النخل باشهر الأقطار الموجودة بالسوق المصري وهي ١٠مم و ١٥مم وكانت أهم النتائج المتحصل عليها كالآتي:

- سجلت درجات الحرارة معدلات أعلي وذلك خلال الطور الثرموفيللي الذي بدأ بعد يومين من عمل الكمبوست واستمر حوالي ٥٠ يوم للكمبوست الساكن وحوالي ٣٠-٣٥ يوم في الكمبوست المقلب وارتفعت خلالها درجات الحرارة ووصلت أقصاها (٦٠-٧٠°م) خلال العشرون يوما الأولي من بداية عمل الكمبوست.
- لم يستمر الطور الميزوفيللي أكثر من يوم واحد من بدء التجربة ثم ظهر مرة اخري بعد إنتهاء الطور الثرموفيللي واستمر حوالي ٤٠-٤٥ يوم في الكمبوست الساكن وحوالي ٢٨ يوم في الكمبوست المقلب.

- انخفض تركيز الامونيا بزيادة عمر الكمبوست من ٤٨١ ملليجرام/كجم الى ٤٨ و ٣١ ملليجرام/كجم فى نهاية كل من الكمبوست الساكن والمقلب وعلى العكس ازداد تركيز النترات وكانت الزيادة اوضح فى الكمبوست المقلب عنة فى الكمبوست الساكن.
- انخفضت قيم الكربون: النيتروجين ووصلت لاقل من ٢٠: ١ بعد ٣٠ يوم فى الكمبوست المقلب و ٦٠ يوم فى الكمبوست الساكن.
- ازدادت السعة التبادلية الكاتيونية من ٣٦,١ ملليمكافئ /١٠٠جم عند بداية التجربة إلي ٨٩ و ٦٨,٩ملليمكافئ /١٠٠جم لكل من الكمبوست المقلب والساكن عند مرحلة النضج. وكانت الزيادة اوضح فى الكمبوست المقلب عنة فى الكمبوست الساكن.
- ازداد تركيز كل من الفوسفور والحديد والمنجنيز والزنك والنحاس الميسرفي كلا نوعي الكمبوست وكانت الزيادة أوضح في الكمبوست المقلب عنه في الكمبوست الساكن.
- كان لعملية النخل الأثر السلبي علي كلا النوعين الساكن والمقلب من حيث محتواه من المادة العضوية والعناصر في المنتج النهائي.