

COMPOST PRODUCTION FROM SOME AGRICULTURAL WASTES

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ABSTRACT

The aim of this study is to investigate the prevailing physico-chemical changes and microbial structure during composting of agricultural wastes. Two kinds of crop residues (rice straw and cotton stalks) were selected with cattle dung to make nine mixtures. Some of these mixtures were mixed with natural amendments to investigate their influences on composting process and the end product. The composting process was allowed to continue up to 12 weeks. Results showed that all physical, chemical and biological properties of mixtures were strongly influenced by the type of raw wastes and natural additives. Where, pH and electrical conductivity (EC) values were increased with increasing composting period. High concentrations of NH₄-N were observed at the thermal phase and then decreased towards the end of composting, while the contents of NO₃-N showed an opposite trend. In this respect, a gradual increase in total nitrogen was observed, while organic matter, organic carbon and C/N ratio were significantly decreased as composting progressed. Decomposition rates of the organic matter increased and reached to its maximum values after the 4th week. Meanwhile, application of natural amendments induced relatively high values of decomposition rates. Availability of both phosphorus and potassium were significantly increased throughout the decomposition period. Further improvements in the examined parameters were gained by application of the natural amendments and still more pronounced with EM addition. *Salmonella* and *Shigella* counts dropped rapidly, being not detected at the end of composting. But a general increase in counts of phosphate dissolving bacteria throughout the composting process was observed especially in the amended treatments. Numbers of ammonifiers and nitrifying bacteria varied according to compost age, type of raw wastes as well as natural additives.

Keywords: Composting, Agricultural wastes, Rice straw, Cotton stalks, Natural amendments.

INTRODUCTION

It is well known that burning crop residues has harmful environmental effects and health costs through increasing the respiratory problems in the local population. It is currently estimated that over 30 million tons/year of agricultural wastes are generated in Egypt with rice straw exceeding 4 million tons and about 1.2 million tons annually from cotton stalks. In general, the major percent of these crop residues are not utilized (UNDP, 2005). In addition, the traditional methods of using crop residues and cattle dung are of low efficiency and deprive agricultural lands of needed organic matter and

plant nutrients. In addition, such methods are a constant hazard to human and animal health and represent a major source of environmental pollution (El-Shimi, 2005). However, the use of agricultural wastes as soil amendments on farmland instead of burning is an attractive alternative because it allows for some cost recovery, improves soil physical, chemical and biological properties and recycles the nutrients into the soil (Edwards, 2002).

Composting is an aerobic process by which organic wastes are decomposed through the activities of successive groups of microorganisms (Gajdos, 1992) and converted into organic manure rich in plant nutrients and humus (Sharma *et al.*, 1999). It is an environmentally sound way to reduce organic wastes and produce either organic fertilizers or soil conditioners. Besides, the use of compost for plant nutrition in organic farming systems, it is also considered the cornerstone of nutrient resources for conserving the soil fertility.

Enriched compost is attained through management of the composting process by addition of microorganisms capable of tolerating and/or decomposing inhibitory compounds, and/or mixing with other substances that stimulates biological decomposition. Some researchers have reported the effect of natural amendments on composting process. Allam (2005) found that application of natural minerals such as rock phosphate and feldspar to the composted organic materials enhanced the decomposition rate throughout the composting period. This may be due to the availability of essential nutrients for the increased biological activity as it was explained by Gautam *et al.*, (2009). Moreover, compost enrichment reduces nitrogen volatilization, increases the percentage of humic substances in the end product and releases some nutrients to be available for plants, especially phosphorus and potassium contents (Kaloosh, 1994; Estefanous, 2003; El-Haggar *et al.*, 2004 and Ebrahim, 2006).

The objectives of this work are to monitor composting process of some agricultural residues combined in different ratios and enriched with some natural additives. The effects of such natural additives on composting process and the end product, as well as the changes in the microbial community structure during composting were also taken into consideration.

MATERIALS AND METHODS

Compost preparation

For compost preparation, two plant residues (rice straw and cotton stalks) and cattle dung were selected to make nine mixtures. Plant residues were air dried and chopped into small pieces (3 – 5 cm length) while, the animal waste was used fresh. Some characteristics of these raw materials are presented in table (1). The materials of each pile were made homogenous by mixing them to give total weight about 200 kilograms for each pile and having C/N ratio about 30:1. For decomposition, the mixtures were tilled in plastic containers having (100×100×150) cm (W×L×H), respectively.

Preparation of the composting mixtures in different proportions was as follow:

1. Rice straw (RS) + cattle dung (CD) (1:1) dry weight basis.
2. Cotton stalks (CS) + cattle dung (CD) (1:1) d.w. basis.
3. (RS) + (CS) + (CD) ($\frac{1}{2}$: $\frac{1}{2}$: 1) d.w. basis.
4. Mixture (1) + natural additives.
5. Mix. (2) + natural additives.
6. Mix. (3) + natural additives.
7. Mix. (4) + EM.
8. Mix. (5) + EM.
9. Mix. (6) + EM.

Natural additives such as natural rocks (rock phosphate and feldspar) as well as vermiculite were mixed with the previous materials of about 2.5% of total pile's weight; sulfur was also added with a percentage 1% of total pile's weight. Finally, one liter of effective microorganisms (EM) solution was added. (EM) has been described as a multi-culture of coexisting aerobic and anaerobic beneficial microorganisms. The main species involved in EM include: (Lactic acid bacteria, Photosynthetic bacteria, Yeasts, Actinomycetes and Fermenting fungi) (Higa and Parr, 1994).

In all previous compost piles the moisture content was adjusted to about 60% of water holding capacity (WHC). The composting process was allowed to continue for 12 weeks, including maturation period. The piles were turned manually for aeration at 2, 4, 8 weeks of composting time.

2. Chemical and physical analyses

Compost samples were collected for analyses after 2, 4, 8 and 12 weeks. The moisture content was determined according to the method described by Black *et al.*(1965). pH and EC were determined in the compost water extract (1:10) using a glass electrode pH meter (Orion Expandable ion analyzer EA920) for pH (Jodice *et al.*, 1982) and using EC meter, ICM model 71150 for EC according to (Richards, 1954). Soluble nitrogen forms (NH_4^+ -N and NO_3^- -N) were measured by the method outlined by (Page *et al.*, 1982). Organic matter (OM) content was determined by glowing the dried compost samples at 550°C up to a constant weight as described by Black *et al.*(1965) and organic carbon (OC) was calculated by multiplying (OM) by 58%. Kjeldahl digestion method described by Jackson (1973) was used for determination of the total nitrogen (TN) in compost samples. Available phosphorus and potassium in compost samples were extracted by ammonium-bicarbonate-DTPA solution according to (Soltanpour and Schwab, 1977) and measured using spectrophotometer as described by Troug and Mayer (1949). All the data obtained were statistically analyzed according to the procedures outlined by Gomez and Gomez (1984). And the mean values were compared at the 5% level of significance by using the least significant difference (L.S.D) test.

Table (1): Main characteristics of the used agricultural wastes and natural rocks

Physico-chemical characteristics	Waste type			Natural rocks	
	Rice straw	Cotton stalk	Cattle dung	Rock phosphate	Feldspar
Bulk density (Kg/m ³)	77	125	500	--	--
PH (1 : 10)	6.73	6.78	8.70	7.15	8.33
EC (1 : 10) dS/m	6.00	4.16	2.09	4.10	6.15
Moisture content %	11.3	10.8	66.7	2.05	1.12
NH ₄ ⁺ (ppm)	197.8	20.3	557.5	--	--
NO ₃ (ppm)	364.5	25.4	0.0	--	--
TN %	0.9	1.2	1.8	--	--
OM %	82.68	92.05	78.63	--	--
OC %	47.95	53.39	45.60	--	--
C/N ratio	53:1	45:1	25:1	--	--
Ash %	17.32	7.95	21.37	--	--
T.P %	0.05	0.20	0.27	17.1	0.05
T.K %	0.33	0.53	1.78	0.35	11.0

Microbial determinations

Numbers of some microbial groups were determined; *Salmonella* & *Shigella* microorganisms were counted on (SS) agar medium (Difco, 1977) and were recognized with black centered colonies. (Bunt and Rovira, 1955) modified by Abdel-Hafez (1966) was used for counting the phosphate dissolving bacteria which were readily detected by clear zones around the colonies after incubation at 30°C for 48 hours. (Subba Rao, 1982) and nitrifying bacteria medium (Black *et al.*, 1965) were used for counting both ammonifiers and nitrifiers, respectively.

RESULTS AND DISCUSSION

Physical and chemical changes during composting process:

Changes in the different parameters during composting of agricultural wastes are presented in table (2). It is seen that initial pH values of the composted materials were in the alkaline range (around 8). By the time, general decrease in pH values was observed as organic acids released at the first stages of composting; then, they gradually increased towards the last week of the composting time. This was true for mixtures 1, 2 and 3. While pH values in the amended mixtures (4, 5, 6, 7, 8 and 9) extended in neutral or slightly acidic till the end of composting. The rate of decrease in pH values in the amended piles was higher than in the unamended ones. The subsequent increase in pH may be attributed to the metabolic degradation of the organic acids and/or due to the intensive proteolysis liberating ammonia compound (Faure and Deschamps, 1991). The composting materials showed a gradual increase in EC values until the end of composting to reach values between 4.25 and 5.17 dS/m. These results are in line with those of Allam (2005) and Sohsah (2008).

Total nitrogen (TN) of different organic wastes increased gradually throughout the composting period. This increase seems to be in the range 1.23% and 1.50% after 12 weeks of composting. These increases may be due

to the concentration effect caused by the decomposition of organic carbon compounds which reduced the weight of the composting mass (Viel *et al.*, 1987). In this respect, ammonium concentrations of the compost piles at the beginning ranged between 370 and 760 ppm in all treatments, and then it increased to maximum levels during the thermophilic phase and decreased to low levels at the end of composting. Meanwhile, the $\text{NO}_3\text{-N}$ concentrations were very low at the beginning, but by proceeding of composting, $\text{NO}_3\text{-N}$ increased due to nitrification process indicating that the decrease of $\text{NH}_4\text{-N}$ was associated with significant increase in $\text{NO}_3\text{-N}$, where the increase in the rate of nitrification led to a high concentration of $\text{NO}_3\text{-N}$. Morisaki *et al.* (1989) reported that little nitrification occurred under thermophilic conditions, since high temperature and excessive amount of ammonia reduced the activity and growth of nitrifying bacteria. Maximal level of nitrate was recorded at the last week of composting; amended piles have recorded levels of nitrate greater than unamended ones and compost mix. (9) showed the maximum value (350 ppm). These results are in harmony with those obtained by Wong *et al.* (2001) and Allam (2005).

Data also showed that compost contained high concentrations of organic matter at the initial stage of composting. As composting progressed, these concentrations decreased significantly which occurred mainly during the active phase (thermophilic), causing by mineralization and humification (Bustamante *et al.*, 2008 and Auldry *et al.*, 2009). Decomposition rate of the organic matter was strongly influenced by the mixture compositions as well as additives used (Table 2). While the presence of natural rocks induced relatively high values of decomposition rates in organic matter 19.54, 16.43 and 17.32 g/kg/day after one month, these values increased to 20.27, 18.70 and 20.44 g/kg/day with EM addition. These results agreed with the observation of Gautam *et al.* (2009) who reported that the enrichment of compost with natural additives increased the decomposition rate, which may be due to the high available content of nutrients essential to increase the biological activity.

The C/N ratio is one of the main characteristics that limit the suitability of the composting process. Here, C/N ratios for the composted materials narrowed from around 30:1 at the beginning to the values between 15: 1 and 22: 1 after 12 weeks. This narrowing mainly may be due to the losses of organic-C as carbon dioxide CO_2 and increase of total-N (Goyal, 2005 and Kamolmanit and Reungsang, 2006). The statistical analysis emphasized that there is a significant difference between treatments. the ratio reached to around 20:1 after 12 weeks for composts 1,2 and 3 and after 8 weeks when natural additives were added to mixtures 4, 5 and 6. Moreover, addition of EM and natural additives together maximized the narrowing of C/N ratio to 19.51:1, 21.24:1 and 18.70:1 in composts 7, 8 and 9, respectively at the 8th week comparing with its negative at the same interval (20.10:1, 21.87:1 and 18.52:1) for composts 4, 5 and 6.

Table (2): Chemical analyses of the organic wastes mixtures at different composting periods

Periods (weeks)	Organic carbon %	Soluble nitrogen (ppm)		Total N %	C/N ratio	pH (1:10)	EC(1:10) (dS/m)	Decomposition rate (g/kg/day)	Available-P (ppm)	Available-K (ppm)
		NH ₄ ⁺	NO ₃ ⁻							
Mixture 1 (Rice straw + cattle dung)										
0	36.06	406	22	1.04	34.67	8.21	2.43	---	89	78
2	35.18	813	18	1.09	32.28	7.57	2.98	7.32	119	100
4	32.10	573	12	1.15	27.91	7.75	3.19	16.02	197	125
8	29.70	230	79	1.24	23.95	8.07	4.71	8.75	215	165
12	27.91	78	196	1.30	21.47	8.11	4.90	4.61	213	180
Mix. 2 (Cotton stalk + cattle dung)										
0	39.71	491	30	1.21	32.82	8.12	1.43	---	93	83
2	38.77	922	21	1.28	30.29	7.60	1.86	6.77	127	109
4	34.92	391	10	1.35	25.87	7.79	3.25	16.62	181	133
8	31.59	189	166	1.40	22.56	7.96	3.98	8.94	210	174
12	29.16	80	212	1.44	20.25	8.07	4.25	6.30	225	195
Mix. 3 (Rice straw + cotton stalk + cattle dung)										
0	36.41	450	35	1.08	33.71	8.09	1.52	---	98	91
2	35.01	835	14	1.11	31.54	7.72	2.10	8.75	135	115
4	32.37	313	20	1.20	26.98	7.80	3.44	16.53	150	157
8	29.41	211	150	1.30	22.62	7.99	3.87	8.52	294	200
12	27.81	63	202	1.36	20.45	8.02	4.31	4.79	310	210
Mix. 4 (Mix. 1 + natural additives)										
0	35.99	760	45	1.04	34.61	8.09	2.50	---	101	85
2	35.35	729	34	1.08	32.73	7.86	2.92	7.94	215	101
4	29.35	315	13	1.19	24.66	7.42	3.15	19.54	397	218
8	25.33	280	183	1.26	20.10	7.20	4.00	11.23	543	300
12	20.96	88	315	1.30	16.12	6.98	4.66	8.30	630	398
Mix. 5 (Mix. 2 + natural additives)										
0	39.53	405	36	1.20	32.94	8.03	1.22	---	99	93
2	38.74	841	14	1.25	30.99	7.78	1.83	7.72	225	115
4	35.18	450	10	1.30	27.06	7.35	2.90	16.43	410	224
8	31.05	228	177	1.42	21.87	7.30	3.76	9.95	550	315
12	26.12	57	295	1.50	17.41	7.05	4.50	7.59	685	400
Mix. 6 (Mix. 3 + natural additives)										
0	35.03	506	30	1.03	34.01	8.11	1.35	---	110	98
2	33.34	690	18	1.11	30.04	7.79	2.06	10.39	230	121
4	29.71	318	13	1.20	24.76	7.61	3.05	17.32	390	230
8	25.00	125	200	1.35	18.52	7.21	4.06	11.19	568	325
12	20.78	61	320	1.37	15.17	7.03	4.37	8.09	710	417
Mix. 7 (Mix. 4 +EM)										
0	35.60	370	25	1.04	34.27	8.25	2.05	---	102	97
2	33.52	715	19	1.12	29.93	7.56	2.97	12.15	300	120
4	28.50	466	24	1.18	24.15	7.40	3.43	20.27	493	295
8	23.41	215	210	1.20	19.51	7.05	4.25	11.53	678	467
12	20.73	74	330	1.23	16.85	6.90	4.91	6.60	865	513
Mix. 8 (Mix. 5 + EM)										
0	38.35	471	42	1.19	32.28	8.18	1.19	---	112	98
2	37.36	821	30	1.23	30.37	7.58	1.77	9.11	315	124
4	33.01	391	11	1.29	25.59	7.31	3.27	18.70	519	300
8	27.82	220	115	1.31	21.24	7.09	4.90	10.93	760	480
12	23.07	57	288	1.35	17.09	6.83	5.17	7.57	901	521
Mix. 9 (Mix. 6+EM)										
0	34.81	386	40	1.04	33.47	8.06	1.38	---	119	100
2	32.97	928	23	1.17	28.18	7.43	2.05	11.99	325	135
4	28.32	429	15	1.21	23.40	7.32	3.41	20.44	544	314
8	24.12	228	203	1.29	18.70	7.00	4.88	10.68	782	471
12	19.73	66	350	1.33	14.83	6.80	5.00	8.94	920	530

L.S.D. at (0.05)

For organic carbon

Treatments = 0.76

Periods = 0.56

Interaction = 1.69

C/N ratio

0.73

0.54

1.63

NH₄⁺

11.28

8.41

25.23

NO₃⁻

2.29

1.71

5.13

available-P

0.73

0.55

1.64

available-K

6.28

4.68

14.05

This could be explained by the positive action of rocks and EM addition in stimulating decomposition that leads to further decreases in C/N ratio, and hence, shortening of composting time. Moreover, mixtures of rice straw showed reduction in C/N ratio more than those contained cotton stalk in separate, however mixing them in ratio (1:1) maximized the reduction in C/N ratio. Similar findings were noted by Estefanous (2003); El-Haggar *et al.* (2004) and Lela (2005). Ali (2001) explained the slow rate of decomposition in cotton stalks compost compared to those of rice straw by the presence of high relatively amount of lignin.

In respect of available phosphorus and potassium changes during composting process, Data in table (2) showed that nutrients availability was strongly influenced by the decomposition period, type of raw materials and additives used. Concentrations of available-P and K gave a gradual increase during the 12 weeks to reach their maximum at the end of composting; this increase was in the range 213 - 920 ppm for available-P and 180 - 530 ppm for potassium. It was noticed that increasing of P and K availability was maximized in cases of combining rice straw with cotton stalk at ratio of 1:1 (w/w) as compared to composting each of them separately. Among all different treatments, the conjugation of natural additives and effective microorganisms (EM) gave the highest concentrations of phosphorus (920 ppm) and potassium (530 ppm). These results suggest the beneficial effect of such amendments on nutrients releasing and on increasing content of soluble ions which becomes more available to plants. Many investigators have confirmed the nutrients dissolution during composting process (Zayed and Abdel-Motaal, 2005 and Ebrahim, 2006).

Changes in microbial populations during composting process:

Many factors determine the microbial community during composting. Under aerobic conditions, temperature is the major factor that determines the types of microorganisms, species diversity, and the rate of metabolic activities (Hassen *et al.*, 2001).

Survival of pathogenic microorganisms (*Salmonella* and *Shigella*):

One of the main purposes of composting was to eliminate the pathogenic microorganisms and to avoid a later recontamination of wastes (Venglovsky *et al.*, 2005). Effects of composting on the survival of *Salmonella* & *Shigella* microorganisms are presented in table (3). *Salmonella* and *Shigella* were not detected in most of the mixtures after 8 weeks and completely disappeared from compost after 12 weeks suggesting the highest degree of sanitation. Many workers confirmed the decrease in pathogenic microorganisms by the time of composting (Hassen *et al.*, 2001; Pourcher *et al.*, 2005 and Saidi *et al.*, 2008). In fact, auto-sterilization induced by relatively high temperatures during composting caused a significant change in bacterial communities (Hassen *et al.*, 2001). Moreover, the antagonistic effect of other microorganisms is involved in the inactivation of pathogens as found by Nell *et al.* (1983) and Stentiford *et al.* (1984).

Phosphate dissolving bacteria:

Data illustrated in Table (3) showed a general increase in counts of phosphate dissolving bacteria throughout the composting process. However, reduction in their population accompanied the thermophilic phase (4 weeks),

followed by increase in mesophilic phase till the end of composting period (12 weeks). Application of natural amendments and effective microorganisms (EM) seems to be accelerator for the multiplication of phosphate dissolving bacteria in compost, where the highest counts in the amended mixtures were in the range of 58×10^5 to 132×10^5 cfu/g of d.w. These results were in accordance with the findings of Abdel-Motaal (2004) and Ebrahim (2006).

Table (3): Changes in some microbial groups during composting process

Composts	Initial	2 weeks	4 weeks	8 weeks	12 weeks
Salmonella & Shigella × 10¹ cfu/g					
1. Rice straw + cattle dung	500	65	40	6	nd
2. Cotton stalk + cattle dung	620	50	35	7	nd
3. Rice straw + cotton stalk + cattle dung	490	44	25	nd	nd
4. Compost (1) + natural additives	530	55	25	nd	nd
5. Comp. (2) + natural additives	580	46	20	3	nd
6. Comp. (3) + natural additives	600	45	18	nd	nd
7. Comp. (4) +EM	450	34	10	nd	nd
8. Comp. (5) +EM	420	37	15	nd	nd
9. Comp. (6) +EM	530	20	9	nd	nd
Ammonifying bacteria × 10³ cfu/g					
1. Rice straw + cattle dung	89	320	192	41	9
2. Cotton stalk + cattle dung	100	383	160	55	25
3. Rice straw + cotton stalk + cattle dung	90	235	96	44	12
4. Comp. (1) + natural additives	95	220	92	60	26
5. Comp. (2) + natural additives	80	330	125	45	14
6. Comp. (3) + natural additives	120	245	96	22	11
7. Comp. (4) +EM	92	254	172	50	21
8. Comp. (5) +EM	110	345	98	33	16
9. Comp. (6) +EM	82	390	115	60	35
Nitrifying bacteria × 10³ cfu/g					
1. Rice straw + cattle dung	1.9	0.9	0.2	13.1	17.0
2. Cotton stalk + cattle dung	3.3	2.0	0.5	11.0	25.2
3. Rice straw + cotton stalk + cattle dung	2.4	1.1	0.2	12.7	21.0
4. Comp. (1) + natural additives	2.5	1.0	0.1	12.0	26.0
5. Comp. (2) + natural additives	2.4	1.0	0.3	16.2	24.5
6. Comp. (3) + natural additives	3.0	1.2	0.2	14.0	28.3
7. Comp. (4) +EM	3.2	0.9	0.2	15.6	25.0
8. Comp. (5) +EM	2.6	1.3	0.3	16.8	27.5
9. Comp. (6) +EM	1.8	0.8	0.1	17.3	30.3
Phosphate dissolving bacteria × 10⁵ cfu/g					
1. Rice straw + cattle dung	12	10	9	55	80
2. Cotton stalk + cattle dung	19	15	13	46	58
3. Rice straw + cotton stalk + cattle dung	21	9	10	38	78
4. Comp. (1) + natural additives	17	12	7	31	73
5. Comp. (2) + natural additives	25	15	16	56	92
6. Comp. (3) + natural additives	13	6	6	52	98
7. Comp. (4) +EM	24	21	18	95	125
8. Comp. (5) +EM	33	12	10	92	110
9. Comp. (6) +EM	39	27	12	105	132

nd : not detected.

cfu : colony forming unit.

Ammonifying and nitrifying bacteria:

Counts of ammonifiers and nitrifiers throughout composting period are presented in table (3). It is seen that the counts of ammonifying bacteria increased and reached to its maximum numbers after two weeks, then declined till the end of composting period. This trend showed a reasonable explanation of ammonical-N behaviour throughout composting process. The detected numbers of nitrifiers were lower than those of ammonifiers. A decrease in counts of nitrifying bacteria accompanied thermophilic phase, then it gradually increased till the end of composting. The high densities of ammonifying bacteria, especially in the amended treatments, which reached to maximum levels after two weeks of composting, might indicate a high ammonification activity and release of ammonia which subsequently enhance the multiplication of nitrifiers that extended to the end of composting. The decrease in ammonifiers after two weeks numbers might also indicate less ammonification activity. Therefore, nitrifiers showed higher numbers at the end of composting process. These results are in agreement with the fact that fresh materials inhibit nitrification. These results are in harmony with those of Gazi *et al.* (2007) who found that through composting of green wastes nitrifying bacteria only appeared when the temperature declined, as these organisms are not thermotolerant.

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إنتاج الكومبوست من بعض المخلفات الزراعية

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قش الأرز وحطب القطن اثنان من المخلفات الزراعية المنتشرة في مصر والتي يتم التخلص منها في كثير من الأحيان عن طريق الحرق، مما ينتج عنه خسائر اقتصادية و ضررا كبيرا بالبيئة وصحة الإنسان.تناول هذه الدراسة إنتاج الكومبوست من تلك المخلفات عبر تدعيمه ببعض المركبات الطبيعية والحيوية مثل صخر الفوسفات ، الفلسبار ، الكبريت الزراعي ، الفيرمكوليت، مركب الEM الحيوي . وتتبع بعض التغيرات الطبيعية والكيميائية والميكروبيولوجية خلال عملية الكمر .

وقد أشارت النتائج إلى حدوث فقد في المادة العضوية نتيجة للنشاط الميكروبي خلال مراحل التخمير حيث تحقق أعلى معدل تحلل للمادة العضوية عند استخدام الإضافات الطبيعية والميكروبية معاً بعد الأسبوع الرابع من الكمر (20.44 جم/كجم مادة جافة/يوم)، كما ضاقت نسبة الكربون: النيتروجين بتقدم عملية التخمير من القيم المبدئية حول 30 : 1 إلى قيم تتراوح بين 14.83 ، 21.47 : 1 بعد 12 أسبوع

من جهة أخرى سجلت تركيزات الفوسفور والبوتاسيوم الذائب زيادة مضطردة بزيادة فترة التخمير ، وكان ذلك متأثراً بنوع المخلفات و نوعية الإضافات المستخدمة، وقد أدى خلط قش الأرز مع حطب القطن بنسبة 1 : 1 إلى نتائج أفضل من حيث نسبة الكربون إلى النيتروجين ، وكميات الفوسفور والبوتاسيوم الذائب مقارنة بتخمير كل منهما منفصلاً. كما كان للإضافات الطبيعية المستخدمة تأثيراً على أعداد كل من بكتريا الأمونيا وبكتريا النتريته والبكتريا المذبذبة للفوسفات حيث أظهرت الكميات المعاملة بتلك الإضافات زيادة أعلى في أعدادها مقارنة بغير المعاملة أما أعداد ميكروبات السالمونيلا والشيجلا فقد أوضحت تناقصاً ملحوظاً بزيادة فترة التخمير حتى اختفت تماماً بعد 12 أسبوع من الكمر.

قام بتحكيم البحث

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