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PHYSICAL AND CHEMICAL CHANGES DURING COMPOSTING CYCLES OF RICE STRAW

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ABSTRACT

Physical, chemical and microbial colonization of rice straw compost heaps were investigated during composting cycles. The temperature of all compost heaps highly increased, reached its maximum values at 20 days (69°C at 50cm depth) and gradually decreased to the ordinary temperature at maturity (80 days). pH values turned to acidity in the first few days and increased to neutrality at compost maturity. EC, Bulk density and nitrogen content were increased whereas, total organic matter, organic carbon and C/N ratio drastically decreased with developing of composting heaps. The total numbers of mesophilic bacteria, fungi and actinomycetes highly increased in the initial and final cycles with all compost heaps. Whereas, they decreased in the heating cycles (20 and 40 days). On the other hand, thermophilic organisms highly increased in the heating cycles. Bacteria was the most dominant microbes in the cooling and heating cycles followed by actinomycets and fungi. The changes in the microbial populations in all compost heaps depend mainly on the changes in compost temperature as a result of microbial activity and subsequent changes in physical and chemical parameters.

Keywords: Composting, fungi, bacteria, actinomycetes, physical and chemical parameters.

INTRODUCTION

Nowadays Egypt has increased their agriculture land by adding newly reclaimed sand soils which are poor in its organic matter content. Maintaining and enhancing the fertility and productivity of agricultural soil have had a high priority in the last decades (Crecchio *et al*., 2004). The most important method to improve soil quality involve recycling of crop residues (Lalande *et al*., 2000). Composting is a microbial process that converts organic waste into a nutrient-rich end product used in horticultural and agricultural applications. Therefore, the recent trends in recycling of crop residues indicate the possibility of using certain efficient microflora particularly the best known cellulose and lignin degraders. If the microflora were added during composting the time of composting might be reduced (Buswell *et al*., 1994).

Mesophilic composting is more effective for mass reduction in rice straw cattle manure compost than thermophilic composting because of the higher decomposition activity of the microbial community characterized by the predominance of Protobacteria and fungi (Tang *et al*.,2007).

Physico-chemical and microbial properties in thermophilic composting processes of 3 different biological solid wastes: manure, garbage and sludge revealed that pH increased to above 8 and C/N ratio decreased during the process. Garbage composting shows highest composting activity, and the mass reduction rate is 47.2%-56.8% after 14 days. Quinone content, representative of microbial biomass, increased to 359.7-472.3 mol kg^{-1} at the late composting period (Tang *et al*.,2007).

During composting of different wastes or residues it is obvious that a high microbial activity with a succession of microbial populations depending on the temperature reached during the biodegradation processes (Tiquia 2005, Hachicha *et al*., 2009; Novinscak *et al*., 2009; Korniłłowicz-Kowalska and Bohacz, 2010).

MATERIALS AND METHODS

Preparation of compost heaps. Four compost heaps were prepared from plant residues of rice, wheat, faba bean, maize and clover straw with equal ratios. The heaps (1x1x0.7m) were set up as in the following:-

A- Rice, wheat, faba bean and maize straw

B- Rice, wheat, clover and maize straw

C- Rice, faba bean, clover and maize straw

D- Rice, wheat, clover, faba bean and maize straw

Each type of heap was inoculated with 1kg/ton with compost starter to initiate composting processes. The moisture of the heaps was adjusted to approximately 70%, the compost heaps were also turned up every 10 days.

MONITORING OF COMPOST PROCESS

Temperature of the heaps was recorded daily at depths of 15, 30 and 50cm from the heap surface using compost thermometer. Moisture content, bulk density, organic mater, organic carbon, total nitrogen, AC, pH and C/N ratio were also determined at different interval times (0, 3, 20, 40 and 80). The water content was determined by drying samples at 105^0C for 24h. For measurements of other parameters compost samples were diluted 1:10 with distilled water, shacked for 24h. and then filtered. pH and electrical conductivity(EC) were determined using a pH probe and EC probe. Total nitrogen and carbon were estimated according to the methods of Bremmer and Mulvaney (1982) and Sparks (1996).

MICROBIAL INVESTIGATION IN COMPOST HEAPS:

Three different compost samples were taken in sterile polyethylene bags from each heap at depth of approximately 30cm. The samples were collected at 0, 3, 20, 40, 80 days of composting periods. 5 gm from each compost sample was placed into a bottle containing 45 ml sterile distilled water, shaken well for 10 min and serial dilutions were prepared.

The total number of bacteria, fungi and actinomycetes were determined by inoculating 0.5 ml of suitable dilution onto agar plates with specific medium nutrient agar, potato dextrose agar and starch ammonium agar respectively. Six plates were prepared as a replicates for each compost sample, one set of plates were incubated at 30ºC, while other group was incubated at 55ºC. The total microbial number was counted.

RESULTS

Temperature changes of compost piles: The temperature of the compost heaps at different depths (0, 30, 50cm) showed a slight increase at the initial time with various depths. Whereas, at 20 days of composting the temperature of the heaps showed a marked increase at a depth of 30 and 50cm reached to approximately 57 and 69^0C respectively, and exhibited the maximum recorded temperatures during the composting process. While, at 40 and 60 days of composting the temperatures of the heaps showed a marked decrease tell it reached to the original temperature at the beginning of the composting process (Fig.1).

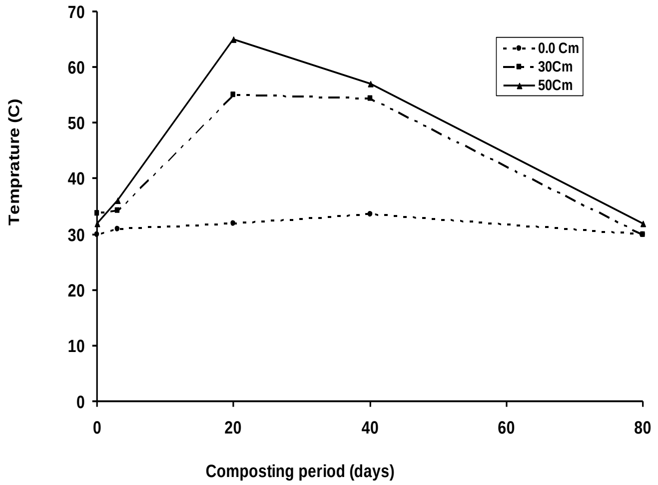


Fig. 1. Temperature changes of compost heaps at different time intervals during composting process.

pH changes of the heaps: The pH of the compost heaps at the beginning of composting process tend to be slightly alkaline (7.7) while, at the third day of composting it markedly decreased to the acidic values reached to approximately 6.5. Whereas, it increased to be near neutrality at maturity of the compost heaps (Fig.2a).

Changes in the electric conductivity (AC): The values of electric conductivity of the compost heaps markedly increased with increasing composting periods. At maturity it exhibited 2 fold higher than at the beginning of composting process (Fig.2b).

Changes of the bulk density: The bulk density of the heaps highly increased from the initial time of composting up to the maturity period (80 days), it increased to approximately 3.6 times at maturity higher than at the beginning of the composting process (Fig. 2c).

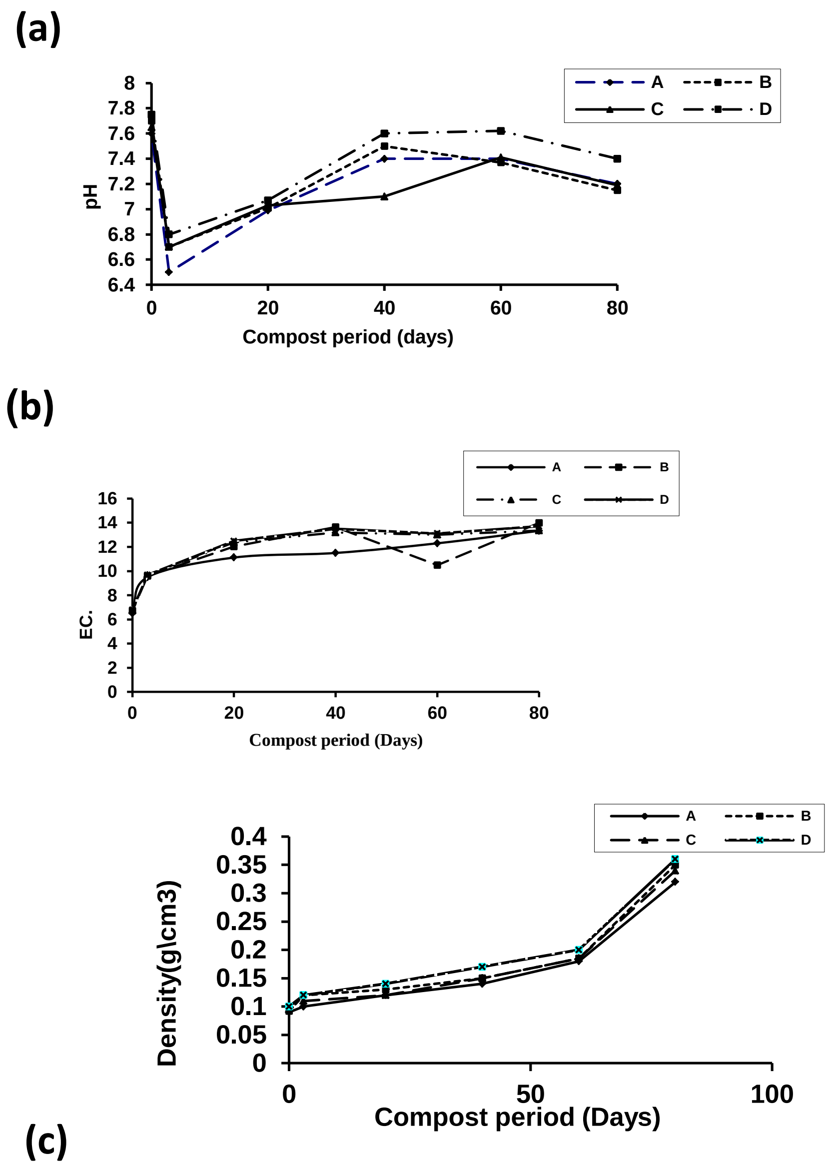
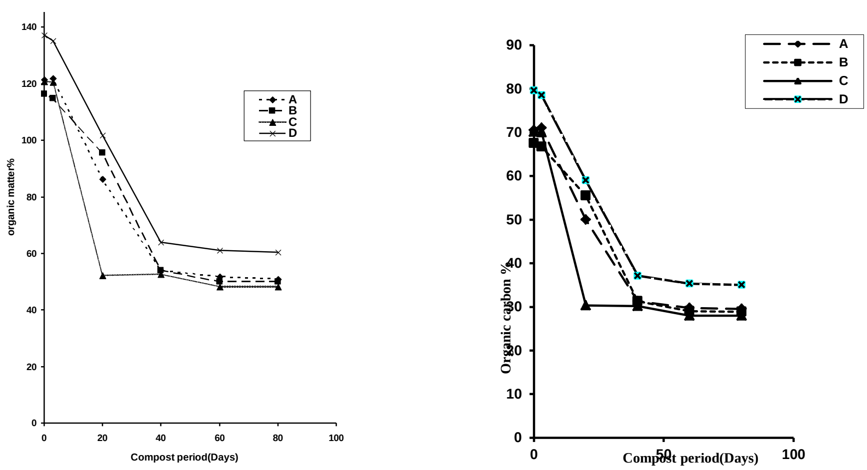


Fig. 2. Physical and chemical changes in compost heaps during composting process (a) pH values, (b) EC (dS\M), (c) Bulk density (g\cm^3).

Changes in organic carbon:

It is obvious that the percentages of the organic carbon highly decreased with increasing the composting periods tell maturity. The results indicated that in the early days of composting up to 20 days there is a slight decrease in organic carbon content while, a sharp decrease occurred at 40 days. It was also observed that the same pattern occurred with all compost heaps (Fig. 3 a, b).

(a) **(b)**



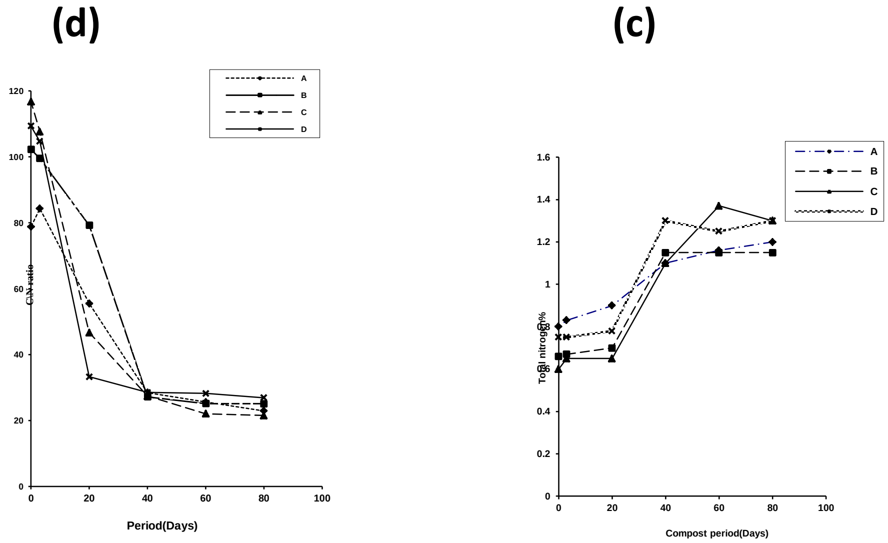


Fig. 3. Chemical changes in compost heaps during composting process (a) Organic carbon %. (b) Organic matter. (c)Total nitrogen %. (d) C\N ratio.

Changes in total nitrogen: Nitrogen content in all compost heaps exhibited a slight increase in total nitrogen content of all compost heaps in the early days of composting up to 20 days whereas, it highly increased after 40 days. At maturity nitrogen content was 1.3% compared with 0.75% at the beginning of composting process (Fig. 3c). Moreover, the C/N ratio exhibited a highly decrease with increasing composting periods of all tested heaps (Fig. 3d).

Total microbial count during composting cycles:

At the beginning of the composting cycles the total number of mesophilic bacteria, fungi and actinomycetes was high while, it sharply decreased in the heating phase at 20, 40 days and represented approximately 93, 35 and 96% respectively decrease comparing with the first cooling cycle. Whereas, they markedly increased again in the second cooling phase at 80 days and exhibited 1.6, 1.5 and 1.8 times respectively higher than at the first cycle.

In contrast to the above results, thermophilic bactreria, fungi and actinomycetes exhibited very low number in the first and second cooling cycle of composting while, they showed a sharp increase in their numbers at 20 days of composting. These results were also observed with all tested compost heaps. The highest number of these microorganisms was found in compost D comparing with other compost types (Table 1).

Table 1: Microbial count in different compost heaps at different composting periods.

Compost types	**Composting periods**	**Incubation temperature (^{0}C)**					
		30			55		
		Bacteria	Fungi	Actinomycetes	Bacteria	Fungi	Actinomycetes
A	0.0	150	20	50	0.085	0.05	0.08
	3	180	17	60	1.2	0.12	0.01
	20	10	13	2.2	1.9	20	50
	40	13	18	6.5	15	1.0	4.0
	80	250	30	90	0.006	0.001	0.002
B	0.0	150	25	52	0.09	0.06	0.01
	3	200	20	70	1.4	0.15	0.12
	20	10.7	1.5	3.0	200	23	52
	40	13.5	2.2	6.5	14	1.1	4.2
	80	260	33	100	0.007	0.001	0.002
C	0.0	165	25	55	0.087	0.07	0.13
	3	200	21	70	1.47	0.15	0.13
	20	10	1.7	3.2	210	25	55
	40	15	2.0	7.0	15	1.0	4.0
	80	300	33	100	0.003	0.003	0.002
D	0.0	170	25	58	0.008	0.09	0.12
	3	210	20	85	1.5	0.15	0.15
	20	11	1.5	3.3	230	27	55
	40	16	2.0	7.5	15	1.2	4.2
	80	300	32	110	0.003	0.004	0.002

Data are expressed as CFU X 10^3/g dry weight of compost.

Discussion

Composting is one of the most promising avenues for recycling plant residues and used it as organic manures to improve its quality and fertility. During composting processes, the temperature evaluation reflect the microbial activity and determine the composting efficiency (Miller,1992; Namkoony and Hwang, 1997). In this study the temperature of all tested compost heaps was highly elevated after the third day of composting and exhibited the maximum level (55 and 68^{0}C) at 20 days at a depth of 30 and 50 cm of the heap respectively. The results refer to high microbial activity at this time of composting which is more suitable to kill most pathogenic microbes. The obtained results are similar to that obtained by (Venglovsky *et al*., 2005 and Saidi *et al*., 2008) they also mentioned that rising the compost temperature up to 65^0 C was desirable to kill most pathogens.
In the early stage of composting the pH of the tested compost heaps slightly shifted toward acidity, this may a result of microbial action that produce some organic acids and CO_2 . This observation was in agreement with that found by (Venglovsky *et al*., 2005). The electric conductivity of all tested compost heaps showed a marked increase during composting process, this may be due to mobilization of some minerals and charged molecules. Similar results were also found during composting a mixture of municipal refuse, rotted vegetables and fruits (El-Nadi *et al*., 1995). Whereas, it was reported that the increase in electric conductivity of compost heaps could be related to release of high concentrations of ammonia (Abdel Wahab, 1999 and Benito *et al*., 2005).
The bulk density of the studied compost piles exhibited an increase due to breakdown of composted materials. This is similar to that obtained by (Rynk *et al*,. 1992), they stated that composting process lead to a volume reduction to more than one-half of the initial volume. In this study the organic carbon was gradually decreased during composting, this is mostly due to loss of carbon as CO_2. Same observation was also reported by (Kaloosh,1994) they attributed carbon loss due to the action of cellulolytic fungi.
Nitrogen content in compost heaps was increased comparing with bulk density which exhibited a decrease during composting and also may due to

nitrogen fixation by some bacteria. These results agree with that obtained by (Kaloosh ,1994) who mentioned that the increase in nitrogen content during composting may be due to stimulation of some nitrogen fixer.

In the present study, the number of mesophilic bacteria, fungi and actinomycetes was high in the early and final phase of composting in all compost heaps especially in compost D, this was also observed with thermophilic ones in the heating cycles. In conclusion, the changes in microbial populations during composting were a result of its activity and subsequent changes in compost temperature, pH, Carbon and nitrogen content, electron conductivity and bulk density of the compost heaps.

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