Composting Cotton Mill Waste

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ABSTRACT

Composting of cotton mill wastes may provide means for the production of a stable organic material, useful for soil improvement and as a substrate for plant growth. The aim of this work was to examine the composting process of cotton wastes and to evaluate the produced compost. Three composting piles were formed. In the first the ratio C/N was reduced to 28 with the addition of NH_4NO_3 , in the second cotton wastes were mixed with olive tree leaves at a ratio 2:1, respectively and in the third one a small amount of mature compost was added in order to trigger micro-organism activity. The results concerning the composting process, revealed that the reduction of the C/N ratio of the raw material is not a critical parameter for the composting of cotton mill wastes. The addition of olive tree leaves, as a bulking agent, enriched the final compost in nutrients and humic substances but delayed the overall process. The evolution of the composting process seems to be accelerated by the addition of a small amount of mature compost at the beginning. Decomposition of the materials lowered gradually the ratio C/N, due to carbon loss, reaching values between 9 and 10 while the nitrate content was increased significantly. The final produced composts were rich in nutrients and extractable humic substances. Tomato seedlings were superior in substrate with 30% (v/v) cotton mill wastes mature compost, compared to that in commercial substrates.

Introduction

Every year in Greece about one hundred thousands (100.000) tones of cotton wastes are generated in cotton mills and their great majority gathered in huge heaps outside them.

Composting is the preferred treatment for many types of organic wastes, to produce stable organic matter, useful for soil improvement and plant growth substrates (Raviv, 1998). Intensive farming and organic agriculture use increasing quantities of composts. Application of stabilized mature composts in crop soils is a preferred way to increase soil organic matter and nutritional levels (Chen and Anvimelech, 1986).

To the present knowledge research work concerning cotton mill wastes composting is inadequate world-wide. The possibility of decomposing the cotton wastes was examined in piles with different nitrogen supply in the raw material and the results were promising (Safwat, 1981).

The purpose of this work was to characterize the composting process of cotton mill wastes and to determine the physicochemical and biological properties of the final produced composts. The results revealed that cotton wastes composts are of good agronomic value.

Materials and Methods

The raw material was from Levadia area and had a ratio C/N: 45,5 and an organic content 90% on dry basis. Three composting piles were formed at the experimental farm of T.E.I. Heraklion. In the first pile NH4NO3 was added in order to lower the C/N ratio of the cotton waste (CW) to 28 (pile: +N). In the second pile CW were mixed with olive tree leaves (OTL) from local olive oil factories at a ratio 2:1 (v/v) respectively (pile: +OTL). The third pile was consisted only from CW and a small quantity (2 lit) of mature OTL compost was added as a micro-organism inoculum (pile: +COM). Each pile was about 2.7m3 (400 Kg of wastes).

The piles were turned at 20, 52 and 109 days. Water was added to the piles during the remixing of the pile material in order to increase moisture levels. Samples taken from the composting piles were kept at -40°C or air dried for analysis. The temperature was recorded at the centre of the piles during the composting process. Electrical conductivity (E.C.) and pH were measured potentiometrically in 1:1.5 (v/v) water extracts of fresh samples. Volatile solids and ash were measured after the treatment of the samples at 400°C for 24h. Carbon, nitrogen and sulphur percentage total content was measured with elementar analysis (Perkin Elmer elementar analyzer, Series II, model 2400). Ammonium and nitrate forms of nitrogen were determined using the Kjeldahl procedure in dry samples (Page *et al.*, 1982). Humic substances were determined according to the method developed by Govi *et al.* (1993).

The final composts were analyzed for nutrient elements and also humic substances content. The samples were taken from the composts 170 days from the beginning of the composting. Phosphorus in

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solution was determined by the visible spectrophotometric method of the phosphovanadomolubdic complex. For mineral element determinations, dry samples were ashed in 480°C for 2h and ashes treated with conc. HCl on a hot plate. Potassium in compost material extracts were determined by flame emission spectrophotometry, and Ca, Mg, Fe, Mn and Zn by atomic absorption spectrophotometry (instrument: GBC, model 902). Growth assays with mature compost of the 1st pile were conducted with tomato (Lycopersicon esculentum L.) seedlings.

Results and Discussion

Composting

Analysis of the raw materials revealed that CW and OTL had the same content in organic matter and organic C, but different total N content (Tab. I). The C/N ratio in the raw materials was 45.5 for CW and 30.2 for OTL.

In order to obtain a preliminary evaluation of the effects of nitrogen supply to composting process the C/N ratio was reduced to 28 (1st pile).

The initial temperature rise was rapid in all piles. Temperature reached a maximum of 72°C in the 1st pile and 67°C in the 2nd and 3rd pile during the first days (Fig.1). Moisture content was 50% (w/w) in all cases (Fig.2a). It seems that the N supplement caused a more rapid increase of the temperature in the 1st pile. The next days temperature fluctuated between 70°C and 55°C (Fig.1) and moisture content decreased slightly (Fig.2a).

After 20 days of composting piles were turned and water was added. The moisture content was increased to 60% in all piles. These treatments triggered temperature rise in all cases. The second turning was done after 52 days of composting since the moisture content was reduced to 50% again and the temperature was 40°C (Figs. 1 and 2a). The second treatment gave rise to temperatures once again. After 80 days of composting the temperature in the 3rd pile was 40°C, while in the other piles the temperature was at 40°C after 90 days. The third turning and addition of water was done after 109 days of composting and had little effect on temperature rise in all piles. We suggest that the moisture content in the piles must be above 60% and a frequent addition of water in the piles may lead to an optimal composting process of CW.

A small change in pH occurred in all piles during composting, reaching a final value near 7.75 (Fig. 2b). Fluctuations during the composting were possibly due to the formation of organic acids (Manios *et al.*, 1989).

The observed increase of E.C. during the composting process (Fig. 2b) was probably due to the high nitrate formation rates (Fig. 2d) and generally the decomposition of organic materials. Similar results for OTL composts have also been reported previously (Manios *et al.*, 1989).

Volatile solids were reduced during composting of CW (Fig. 2c). The greater reduction was observed in the 3rd pile (+COM). Changes in volatile solids in the same range were reported previously for other composts (Lasaridi and Stendiford, 1998).

The decrease of the C/N ratio due to carbon loss during CW composting (Figs. 2e, 2g) was typical of the organic residues composting. The delay of the reduction of carbon content and C/N ratio in the 2nd pile with OTL is probably due to lower decomposition rate of OTL compared to that of CW.

CW composts

All produced composts were found rich in humic substances content which was increased significantly during the maturation period (Table 2). The nitrogen, calcium, magnesium and iron content was found in satisfaction levels in the final CW composts (Table 3). Future research is needed in order to estimate the nutrient elements availability to plants and also their percentage which is linked to organic matter (e.g. humic substances).

Humic substances and almost all the determined nutrient elements content were found elevated in the compost from the 2nd pile (CW + OTL). Only K and Mg levels were found in lower amounts in the 2nd pile (Tables 2, 3). These differences between the 2nd pile with OTL and the other piles consisted only from CW probably reflect the different composition of the raw materials CW and OTL.

The final compost from the 1st pile was used in mixture with peat as a substrate for tomato seedling growth. The dry matter of tomato seedlings grown in substrates with CW compost was larger compared to that grown in a commercial substrate (Table 4).

In conclusion, composting of CW took about 120 days in this experimental design and the process was similar to that of other organic residues composting. Of particular interest is the rapid and high rise of temperature in all cases. Co-composting of CW with other organic residues may provide means for a more efficient and rapid decomposition of hard to compost organic materials. This is a topic for further research. The produced composts were of good quality and agronomic value. Further research is needed to optimize the composting process and reduce the period from the raw material to a stable compost and to evaluate further the agronomic value of the CW composts.

References

Chen, Y. and Y. Anvimelech. (1986): The Role of Organic Matter in Modern Agriculture. Martinus Nirhoff Publishers, Dordrecht.

Govi, M., C. Ciavatta and C. Gessa. (1993): Evolution of organic matter in sewage sludge: a study based on the use of humification parameters and analytical electrofocusing. Biores. Tech. 44:175 - 180.

Lasaridi, K.E. and E.I. Stendiford. (1998): Biological parameters for compost stability assessment and process evaluation. Acta Horticulturae 469:119 - 128.

Manios, V.I., P.E. Tsikalas, C.I. Siminis and O. Verdonck. (1989): Phytotoxicity of olive tree leaf compost in relation to the organic acid concentration. Biological Wastes 27:307 - 317.

Page, L.A., R.H. Miller and D.R. Keeney (eds.), (1982): Methods of Soil Analysis, Part 2, Chemical and Microbiological Properties. Publishers: A.S.A. Inc., S.S.S.A. Inc., Madison, Wisconsin USA.

Raviv, M. (1998): Horticultural uses of composted material. Acta Horticulturae 469:225 - 234.

Safwat, M.S.A. (1981): Composting cottonseed wastes. In: Composting, Theory and TPpractice for City, Industry and Farm. J.G. Press, Emmaus PA.

Table 1. Physicochemical characteristics of raw materials (r.m.) at the beginning of the experiment.

Physicochemical characteristics	Cotton Mills Wastes [1] (CW)	Olive Tree Leaves [1] (OTL)
Humidity % r.m.	15.0	30.5
Organic Matter % d.w.	90.0	90.8
Ash % d.w.	10.0	9.2
Org. C % d.w.	50.0	50.5
Total N % d.w.	1.10	1.67
C / N	45.5	30.2
pH	6.73	5.82
E. C.	4.44	1.54

[1] Values are expressed as percentage of dry weight (d.w.) and r.m.

Table 2. Extractable humic substances content[1] in cotton mill wastes composts after 50 and 170 days.

Days	1st pile: +N	2nd pile: +OTL	3rd pile: +COM
50	9.3	8.7	10.0
170	12.7	14.8	13.3

[1] Values are expressed as percentage of dry weight

Table 3. Composition of the final composts in nutrient elements[1].

	N %	P %	K %	S %	Ca %	Mg %	Fe %	Zn ìg/g	Mn ìg/g
1st pile: +N	3.95	0.22	0.16	1.37	2.24	0.70	0.50	64	189
2nd pile: +OTL	4.31	0.29	0.12	1.74	2.74	0.64	0.64	97	209
3rd pile: +COM	4.12	0.25	0.13	1.17	2.22	0.72	0.42	79	192

[1] Values are expressed as percentage and ìg/g of dry weight.

Table 4. Dry matter of tomato seedlings grown for three weeks in substrates containing cotton wastes compost from the 1st pile (+N)[1].

Substrate	Root (g)	Shoot (g)
Control (commercial substrate)	0.19 ± 0.02	1.01 ± 0.10
30% compost + 70% peat + sand 70 l/m^3	0.23 ± 0.01	1.32 ± 0.12
70% compost + 30% peat + sand 70 l/m^3	0.28 ± 0.01	1.15 ± 0.15

[1]Values represent mean of 40 plants ± SE.

Figure 1. **Changes of temperature during the composting process at the centre of the piles. 1st pile: +N, with addition of NH_4NO_3, 2nd pile: +OTL, with addition of olive tree leaves, 3rd pile: +COM, with addition of mature compost from OTL (Arrows indicate turning and watering).**

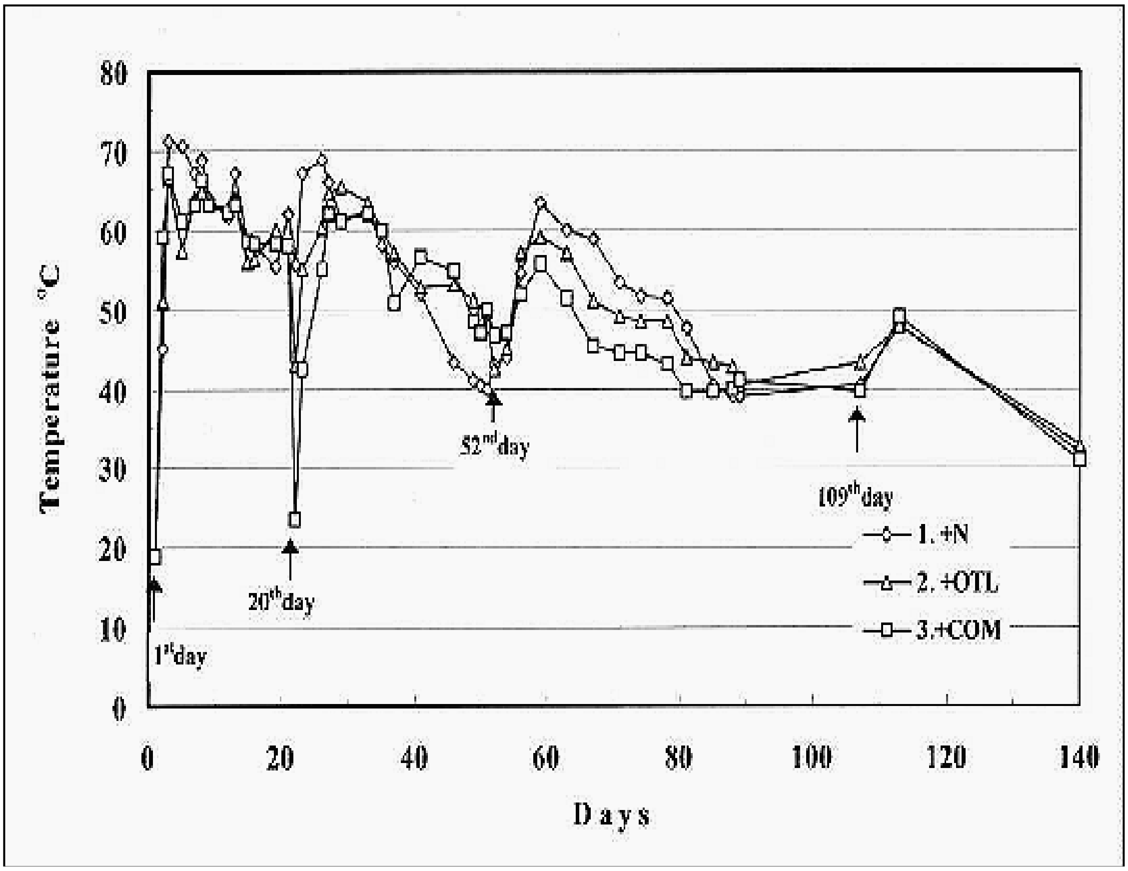

Figure 2 . Variation of physical and chemical parameters with age in the piles. ***1st pile: +N*, with addition of NH_4NO_3 , *2nd pile: +OTL*, with addition of OTL, *3rd pile: +COM*, with addition of mature compost from OTL.**

Figure 2a. Moisture

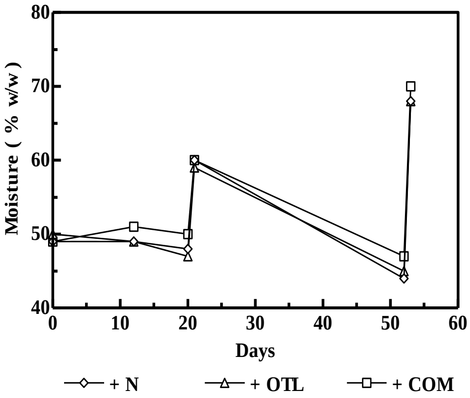

Figure 2b. pH and electric conductivity.

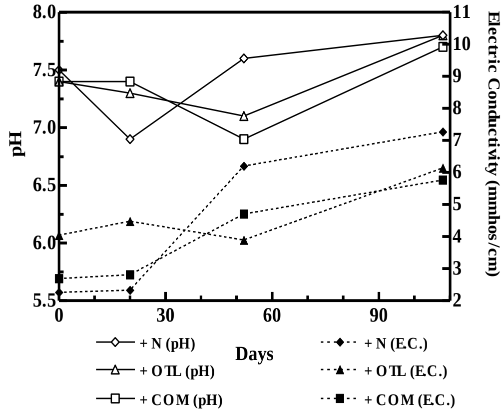

Figure 2c. Volatile solids and ash.

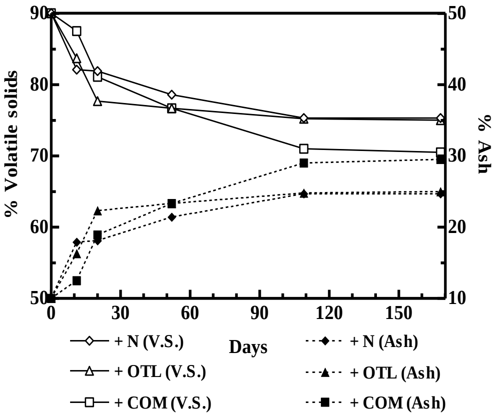

Figure 2d. NO3-N and NH4-N.

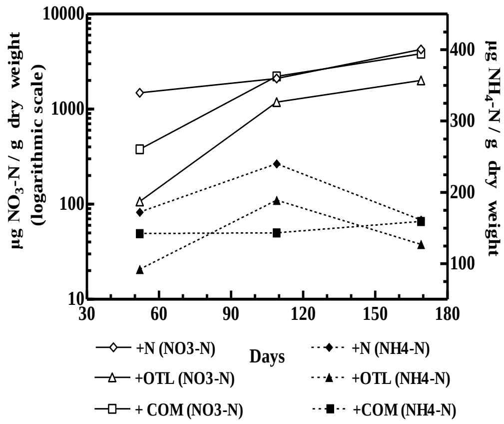

Figure 2e. Carbon, Nitrogen, and Sulfur.

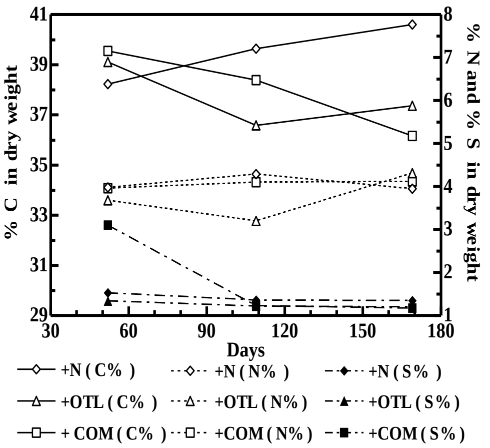

Figure 2g. C / N.