A CONTRIBUTION TO THE STUDY OF CO-COMPOSTING OF POULTRY AND FOREST WASTES

M.E. Silva[1], L.T. Lemos[1], O.C. Nunes[2]

[1]Departamento de Ambiente, ESTV, Campus Politécnico, 3504-510 Viseu, Portugal.
beta@amb.estv.ipv.pt
[2]LEPAE, Dep. Eng. Química, Fac. Engenharia da Universidade do Porto, Rua Roberto Frias, 4200-465 Porto, Portugal

ABSTRACT

The major aim of the present study was to control and optimise the co-composting of poultry manure with forest wastes. The co-composting of these wastes was performed in piles, at a pilot scale. As controls, composting of poultry manure and poultry manure and straw was performed. The main operating conditions (temperature, aeration and humidity) were controlled by a procedure of manual turning. The process was monitored along time by evaluating standard physical, chemical and microbiological parameters.

The comparison of the quality of the final composts showed that co-composting of poultry manure with forest wastes might represent a good alternative to treat these solid wastes.

INTRODUCTION

Composting is an aerobic biological treatment system able to stabilise organic wastes that can be further used as fertilizers. In this way, composting allows the recycling of organic compounds. Composting has been used as a treatment system for diverse types of solid organic wastes, such as sewage sludges, and garden and manure wastes (Santos, 1995). Co-composting is usually necessary since the mixture of different compounds allows to achieve a C/N ratio of about 25:1-30:1, considered the most adequate to obtain a high quality final compost (Vallini, 1995, cit. in Queda, 2001).

In the Portuguese region of Viseu, the poultry breeding activity is very important. However, its wastes can contaminate the surrounding environment. An important forest area also characterises this region. The accumulation of the settled forest waste increases the risk of forest fires, which originate, every year, serious damages with dramatic environmental consequences. In this way, it is important to implement treatment systems for these types of solid organic wastes.

Several authors reported that manure, usually rich in nitrogen, is efficiently composted when mixed with straw (Queda, 1999). However, straw is considered a high value compound, while forest wastes constitute an environmental problem. This study intended to evaluate if straw could be replaced by forest wastes in the co-composting of poultry manure, in terms of the quality of the final compost. During this study, poultry manure was composted alone, mixed with straw and mixed with forest wastes. The processes were monitored along time and the quality of the final composts was evaluated.

MATERIALS AND METHODS

Composting system. The raw materials (poultry manure, forest wastes of *Pinus pinaster* and straw) and wood chips as bulking agent were used to build three conic piles: 1.5 m high and 2 m diameter base (cfr. also Russo et al., 1999). Pile 1 only contained poultry manure, Pile 2 contained both poultry manure and straw and Pile 3 contained both poultry manure and forest wastes. The piles were turned manually every day and slopped with water, in order to prevent excessive high temperatures, anaerobic conditions and dryness.

The monitoring process involved the evaluation, through time, of several physical, chemical and microbiological conventional parameters. The analysed physical-chemical parameters included: pH (EN 13039, 1999), electric conductivity (EN 13038, 1999), moisture, organic, and ash matter content (EN 13040, 1999), total carbon and total nitrogen content (prEN 13654-1, 2001), carbon/nitrogen ratio (C/N) and content in mineral elements (prEN 13650, 1999). The quality of the compost in microbiological terms was performed according to APHA (1995), using total and faecal coliforms and *Enterococcus faecalis* as indicative microorganisms. The presence of *Salmonella spp.* was also evaluated. The evaluation of the degree of maturity/stability of the compost was obtained through: the humics acids/fulvics acids ratio**,** the self-heating test (RALGZ, 1992, cit. in Gonçalves et al., 2001) and the germination index according to Brito (1997) (cit. in Costa, 2001).

RESULTS AND DISCUSSION

Poultry manure had a high moisture content (74%, w/w) when compared with forest wastes (51%, w/w) and straw (27%, w/w). Inversely, the C/N ratio of poultry manure was low (5.8) when compared with forest wastes (400.0) and straw (200.0). In this way, the mixture of poultry manure with those materials was advantageous because they could act as conditioning agents, permitting to obtain an adequate C/N ratio, and also favouring the aeration of the pile. As expected, the initial C/N ratio in pile of poultry manure (Pile 1) was 8:1, while piles of poultry manure and straw (Pile 2) and of poultry manure and forest wastes (Pile 3) presented values of 19.4:1 and 11.2:1, respectively.

The temperature profile obtained throughout the composting process of the different piles is shown in Fig. 1. The Pile 2 showed the highest values, with temperatures higher than 55ºC However, it was Pile 3 that showed the longest period of thermophilic period (25 days).

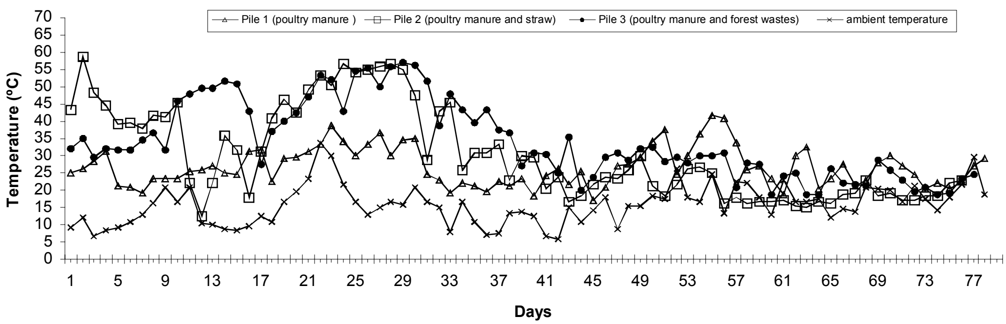

Figure 1*. Average temperature of the piles and of the ambient temperature during composting.*

The content of carbon and of total nitrogen has decreased along the process in all the piles, being obtained values of C/N ratio of 9.1, 14.7, and 13.8, for Piles 1, 2, and 3, respectively. The decrease of the nitrogen content was lower in Piles 2 and 3, showing the effect of the conditioning agent in the nitrogen conservation. However, it was observed that such decrease was lower in the case of Pile 2, comparatively to Pile 3, fact that evidences the effect of the C/N ratio, which means that the conservation of the nitrogen was greater for the pile with the higher initial C/N ratio.

Table 1 shows the compost characteristics after 140 days of composting.

Table 1. *Results of the compost characterization.*

Parameters	Pile 1	Pile 2	Pile 3
pH	8.3	8.7	8.4
Electric conductivity ($mS.cm^{-1}$)	5.2	3.9	4.5
Moisture (%)	18.5	52.6	22.1
Organic Matter (% d.m.)	17.0	24.9	19.9
Total Carbon (% d.m.)	8.5	12.5	9.9
Total Nitrogen (% d.m.)	0.9	0.9	0.7
C/N ratio	9.1	14.7	13.8
CaO ($g.Kg^{-1}$ d.m.)	108.1	114.2	93.5
MgO ($g.Kg^{-1}$ d.m.)	13. 2	17.1	13.7
P_2O_5 ($g.Kg^{-1}$ d.m.)	0.2	0.5	0.2
K_2O ($g.Kg^{-1}$ d.m.)	36. 2	41.5	28.1
Na ($g.Kg^{-1}$ d.m.)	12 .9	15.2	11. 4
Zn ($g.Kg^{-1}$ d.m.)	0.2	0.2	0.4
Cu ($mg.Kg^{-1}$ d.m.)	62.8	72.1	55.1
Ni ($mg.Kg^{-1}$ d.m.)	16.2	16.6	10.5
Cr ($mg.Kg^{-1}$ d.m.)	n.d.	n.d.	n.d.
Cd ($mg.Kg^{-1}$ d.m.)	n.d.	n.d.	n.d.
Pb ($mg.Kg^{-1}$ d.m.)	n.d.	n.d.	n.d.
Total coliforms (CFU/g d.m.)	n.d.	3.5×10^5	n.d.
Faecal coliforms (CFU/g d.m.)	n.d.	n.d.	n.d.
Enterococcus faecalis (CFU/g d.m.)	n.d.	8.5×10^6	4.0×10^3
Salmonella spp.	n.d.	n.d.	n.d.

d.m.- dry mass; n.d. -not detected; CFU - colony forming unit

The obtained composts possess important amounts of organic matter and of several nutrients, namely calcium, potassium and magnesium, thus constituting a good organic corrective for agricultural soils. The heavy metals levels found for the different composts are lower than the values in the Portuguese (EU base) regulation proposal (Gonçalves et al., 2001). However, the high salinity observed values restrain the composts use as fertilizers (2 mS/cm at 25ºC – maximum allowed value), imposing important care, concerning the tolerance of the cultures to salinity.

The evaluation of the higienisation efficacy of composting of the raw materials used was very important due to the fact that poultry manure can be a vehicle of pathogens dissipation in the environment. It was verified that after 131 days, Pile 1 attained complete higienisation, while in Piles 2 and 3 total coliforms and/or *Enterococcus faecalis* were still present (Table 1). The microorganisms of the last group were the most resistant and in Pile 2 their value is higher than the maximum admitted value specified by Zucconi et al. (1987) (5.0×10^3 CFU/g d.m.) (cit in Queda, 2001).

Values of humics acids/fulvics acids ratio higher than 1 are indicative that the compost is matured (Roletto et al., 1985, cit. in. Costa et al., 2001). As can be seen in table 2, only Piles 2 and 3 reached values higher than 1 suggesting that these composts were matured.

Compost is considered stable when its temperature is lower than 40ºC, once submitted to the self-heating test, which corresponds to maturation degrees IV and V (Gonçalves et al., 2001). A maturation degree of IV was obtained for Pile 1 and a maturation degree of V for the other piles. That means that the 140 days were enough for the process of composting.

In agreement with the evaluation of the germination index, the compost obtained from Pile 1 possessed some phytotoxic characteristics since 20% (v/v) of this compost only allowed the germination of 10% of seeds, thus being susceptible of affecting the development of plants. The compost quality of the other piles was similar, however, 40% (v/v) of compost of Pile 2 was less inhibitory in terms of germination of seeds (20%) then the same concentration of compost of Pile 3 (10%).

Table 2. *Results of the evaluation of the maturation degree of the different composts.*

Parameters	Pile 1	Pile 2	Pile 3
Humics Acids (HA) (%, w/w)	0.28	1.52	3.85
Fulvics Acids (FA) (%,w/w)	1.49	0.87	0.65
HA/FA ratio	0.2	1.7	5.9
Self-heating test	IV	V	V

IV e V - Maturation Degrees

CONCLUSIONS

The obtained results show that composting, being a way of treatment of the poultry manure, becomes more efficient when it is performed by co-composting with other materials that can serve as carbon source, as it is the case of the straw and of the forest wastes. The mixture of the poultry manure with the straw, comparatively to its mixture with forest wastes, did not present more benefits in terms of speed of the process, nor in the quality of the final compost. The composting technique seems to be a good alternative for the valorisation of both the poultry manures and the forest wastes, as biodegradable wastes, thus contributing to the resolution of their environmental problems.

REFERENCES

American Public Health Association (APHA). 1995. Standard Methods for Examination of Water and Wastewater. 19th edition, Glesceri et al., USA.

Costa, M.M., Fernandes, A. 2001. Valorização Agronómica de Resíduos da Indústria Têxtil: Lamas e Fibras de Algodão. In: *Jornadas Técnicas Internacionais de Resíduos*, Viana do Castelo.

Gonçalves, M.S., Silva, M. 2001. Qualidade do Composto para Utilização na Agricultura (Proposta de Regulamentação). In: *Conferência Europeia sobre C*ompostagem, Lisboa.

Queda, A.C. 1999. Dinâmica do Azoto Durante a Compostagem de Materiais Biológicos Putrescíveis. Dissertação de Doutoramento em Engenharia Agro-Industrial, Instituto Superior de Agronomia da Universidade Técnica de Lisboa.

Queda, A.C., 2001. " A importância da Selecção das Biomassas na Compostagem numa perspectiva da Valorização de Resíduos versus Qualidade dos Compostos Obtidos. In: *Conferência Europeia sobre Compostagem*, Lisboa.

Russo, M.A.T., Carvalho, A. 1999. The Relevance of Moisture Control in Organic Municipal Solid Waste Windrow Composting Process. In: *Internacional Conference ORBIT 99 on Biological Treatment of Wastes and the Environmental*, Rhombos Verlag, Berlin, pp. 69-75.

Santos, J.Q. 1995. Fertilização e Poluição – Reciclagem Agro-florestal de Resíduos Orgânicos. Edição do autor, Lisboa.