Composting the solid fraction of cattle slurry with straw (*Lolium multiflorum* L) and gorse (*Ulex Europaes*)

L. M. Brito [1], A. L. Amaro [1], I. Mourão [1] & J. Coutinho [2]
[1]Escola Superior Agrária de Ponte de Lima, Refóios, 4990-706 Ponte de Lima
Tel: (+351) 258 909 740 – Fax: (+351) 258 909 779 – E-mail: miguelbrito@esapl.pt
[2]C Química, Dep Edafologia, Universidade de Trás-os-Montes e Alto Douro,
ap 1013, 5001-911 Vila Real

Abstract

Cattle slurry solid fraction (SF) was collected from a dairy farm and composted with increasing rates (0, 25, 33 and 50% v/v) of Italian ryegrass (*Lolium multiflorum* L) straw or gorse (*Ulex Europaes*), in static piles turned three times, 28, 56 and 112 days after composting was initiated. Temperatures increased to a maximum temperature of 65ºC after the first turn in the pile only with SF. In contrast, higher temperatures were registered much sooner in piles mixed with straw (68ºC at day 7), or with gorse (74ºC at day 3). Gorse or straw addition to SF increased temperatures and also the initial rates of organic matter mineralization. In contrast, potential organic matter mineralization and compost N concentration was decreased with the presence of gorse or straw.

The C/N ratio declined following a similar pattern for all compost treatments, from 32 - 38 at the beginning of the process, to a value of 12 - 16 towards the end of composting. Stabilized compost was obtained from raw SF feedstock as indicated by the low compost temperature, low C/N ratio and the small content of NH_4^+ combined with increased concentrations of NO_3^-. The high concentration of OM (784 - 838 g kg^{-1}) and total N (28 - 35 g kg^{-1}) in the final composts, together with a low electrical conductivity (between 72 and 116 mS m^{-1}) suggests that SF composts may be useful as soil amendments with agronomic and environmental advantages. The use of straw or gorse contributed to guarantee compost hygienization.

Key words: Compost, dairy cattle, mineralization, nitrogen, organic amendments

Introduction

Solid-liquid separation can be an effective slurry treatment method for producing nutrient-rich organic solids and potentially reducing the nutrient contents and organic matter in the liquid phase (Ford and Fleming, 2002). There is value in separating the solid fraction for use as a soil conditioning agent and this is particularly important in Southern European climates where soils are deficient in OM.

Separating the OM fraction from the soluble nutrients increases the value of the solids for soil conditioning purposes, by allowing larger rates of application without oversupplying nutrients. In addition, the solid fraction can be exported to other farms with a high demand for organic amendments, when there is need to remove nutrients and transport them from the farm. To make the offer of solid fractions more attractive to the farmers outside the surplus areas, composting can be a solution. Compost may also be transported further distances, since volume and mass are significantly reduced during the composting processes (Peigné and Girardin, 2004).

This work aims to find methods to improve the composting process of SF based on the effects of straw and gorse addition on the evolution of SF chemical and physicochemical characteristics such as temperature, pH, electrical conductivity, N content and on the rate of mineralization of OM during composting, in order to maximize final compost quality.

Methods

Cattle slurry solid fraction (SF) was collected from a dairy farm and dewatered using a screw press. The press was supplied with slurry at a rate of 3 $m^3 h^{-1}$ to produce SF with 25% DM. The SF was composted without additional material and with increasing rates (0, 25, 33 and 50% v/v) of Italian ryegrass (*Lolium multiflorum* L) straw or gorse (*Ulex Europaes*), in static piles turned three times, 28, 56 and 112 days after composting was initiated.

Composting piles were periodically sampled (four repetitions) for chemical analysis at the start of the process and at day 7, 14, 28, 56, 84, 112, 140 and 164 days after the beginning of composting. Compost temperature was monitored automatically with a thermistor positioned in the centre of each pile (Delta-T Devices). During composting, the average ambient air temperature was 15 ºC.

Compost DM, pH, electrical conductivity, organic matter (OM), and Kjeldahl N were determined by standard procedures (CEN, 1999). Losses of OM were calculated according to the following formula:

$$\text{OM loss (g kg}^{-1}\text{)} = 1000 - 1000[x_1(1000 - x_2)]/[x_2(1000 - x_1)]$$

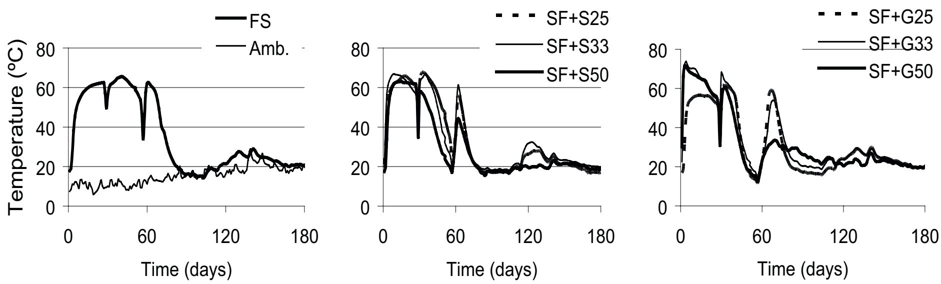
where x_1 and x_2 are the initial and final ash contents (g kg^{-1}), respectively (Paredes, et al., 2000). Mineral N of fresh compost samples was extracted with 2M KCl 1:5. Contents of NH_4^+-N and NO_3^--N in the extracts were determined by molecular absorption spectroscopy in a segmented flow analyser system equipped with dialysers to prevent interferences from colour or suspended solid particles of the extracts.

Non-linear regression using the Levenberg-Marquardt method and the Duncan's multiple range to test for significant differences of means were both carried out using SPSS 15.0 for windows (SPSS Inc.).

Results and discussion

Temperature conditions during SF composting (fig. 1) followed expected trends (Ross et al., 2006). Initially the temperature of composting piles rose as a consequence of the rapid breakdown of the readily available organic matter and nitrogenous compounds by micro-organisms (thermophilic phase). As the organic matter became more stabilised, the microbial activity and the organic matter decomposition rate declined and the temperature decreased to ambient levels, approximately 3 months after composting was initiated.

Figure 1 – Evolution of the ambient temperature and of the temperature of composting piles of dairy cattle slurry solid fraction (SF) with increasing rates (0%, 25%, 33% and 50% v/v) of straw (S) or gorse (G)



The highest temperature (74 ºC) was recorded four days after composting was initiated in the pile with 33% (v/v) of gorse, whereas the maximum daily temperature found in the pile with SF alone was 65 ºC. These temperatures are able to guarantee a satisfying compost hygienization, according to Tchobanoglous et al. (1993).

Composting proceeded in piles far above the moisture content (MC) of 60% suggested as the maximum for composting (Tchobanoglous et al., 1993). MC of SF decreased from 75% to 52% during the composting period whereas MC for piles with maximum rates of straw or gorse addition decreased, respectively, from 55% to 28% and from 70% to 30%.

The pH of SF was alkaline during the thermophilic phase of composting process with variations in the range of 8 - 9, increasing the potential for NH_3 volatilization. Final compost pH ranged from 7.6 to 8.1, indicating that the concentration of bicarbonates had not been sufficiently reduced (Cáceres et al., 2006). The electrical conductivity (EC) of SF increased from an initial value of 72 mS m^{-1} to a final value of 116 mS m^{-1}.

Organic matter content of SF decreased from a maximum of 909 g kg^{-1} at the beginning of composting to a minimum of 784 g kg^{-1} of the remaining composted material after 168 days. Maximum final compost OM (838 g kg^{-1}) was found in the pile with 50% (v/v) of gorse.

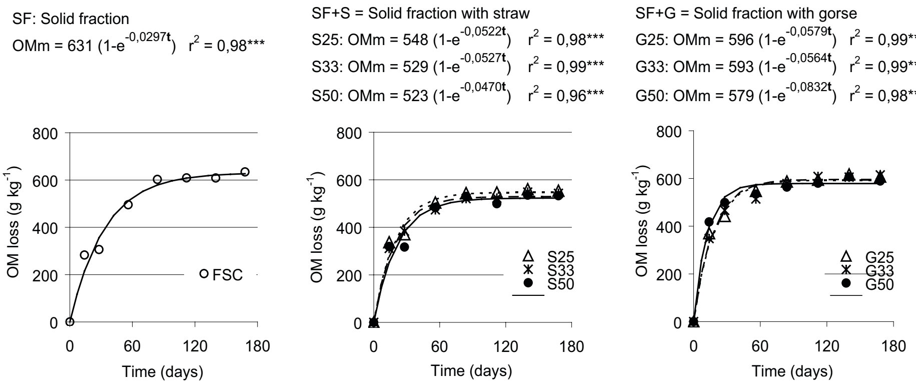
Mineralization of OM, based on OM losses formula, followed a first order kinetic equation:

$$OM_m = OM_0\,(1-e^{-kt})$$

where OM_m indicates the mineralized OM (g kg^{-1}) at the time t (days), OM_0 the maximum mineralisable OM (g kg^{-1}) and k the rate of mineralization (day^{-1}).

Losses of OM showed two different kinetic phases of mineralization. The first phase had a steeper slope, indicative of the rapid decomposition of the most easily biodegradable substrates and a high rate of microbial activity. The second phase showed a slower rate of OM loss because only the more resistant compounds remained, lowering the mineralization rate (fig. 2). The OM mineralization rate increased for piles with straw or gorse in comparison to the pile only with SF, but maximum mineralisable OM decreased.

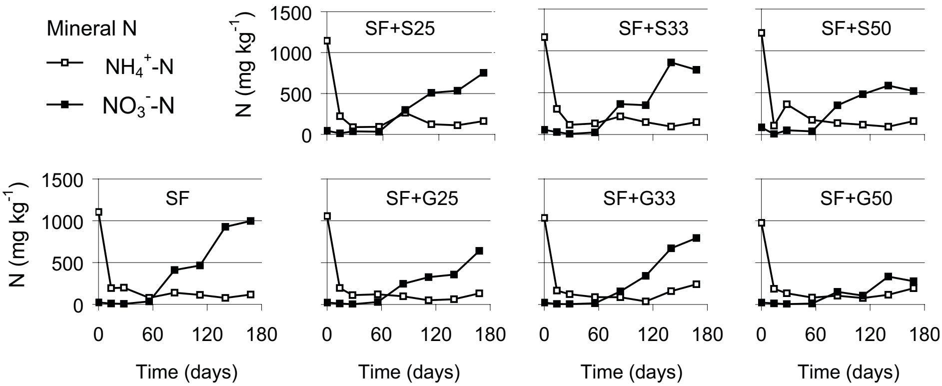
Figure 2 – Organic matter (OM) losses of dairy cattle slurry solid fraction (SF) with increasing rates (0%, 25%, 33% and 50% v/v) of straw (S) or gorse (G)



Total N increased from 13 - 17 g kg^{-1} to 28 - 35 g kg^{-1} in the final composts whereas the C/N ratio declined following a similar pattern for all compost treatments, from 32 - 38 at the beginning of the process, to a value of 12 - 16 towards the end of composting, indicating a high degree of stabilization.

Mineral N was characterized by an initial high NH_4^+ and low NO_3^- content, followed by a sharp decrease of $NH_4^+$and a steady increase of NO_3^- content (fig. 3). The low amounts of NH_4^+ combined with the increase in NO_3^- towards the end of composting confirm that the SF composts was mature 168 days after composting was initiated.

Figure 3 – Ammonium and nitrate N contents during composting of cattle slurry solid fraction (SF) with increasing rates (0%, 25%, 33% and 50% v/v) of straw (S) or gorse (G)



Conclusions

Thermophilic temperatures were attained soon after separation of SF and were above 60ºC for a period long enough to guarantee satisfying compost hygienization. Straw and gorse addition to the SF increased initial compost OM mineralization rates and pile temperatures, and decreased final compost moisture content. However, compost potential mineralization decreased with straw or gorse addition because of the high C/N ratio of these materials. Mature compost can be obtained with raw SF, as indicated here by the low compost temperature, the low C/N ratio and the low amounts of NH_4^+, combined with the increase in NO_3^- in final composts.

Acknowledgements
This study was supported by project AGRO 794, funded by EU and the Portuguese Institute for Biological Resources (INRB).

References

Cáceres, R., Flotats, X., Marfà, O., 2006. Changes in the chemical and physicochemical properties of the solid fraction of cattle slurry during composting using different aeration strategies. Waste Manage. 26, 1081–1091.

CEN, 1999. European Standards - Soil Improvers and Growing Media. European Committee for Standardization.

Ford, M., Fleming, R., 2002. Mechanical solid-liquid separation of livestock manure. Literature review, in: Report to Ontario Pork, Case Study 7 – Screw Press. Ridgetown College, University of Guelph.

Peigné, J., Girardin, P., 2004. Environmental impacts on farm scale composting practices. Water, Air and Soil Pollut. 153 (1), 45–68.

Paredes, C., Roig, A., Bernal, M.P., Sánchez-Monedero, M. A., Cegarra, J., 2000. Evolution of organic matter and nitrogen during co-composting of olive mill wastewater with solid organic wastes. Biol. Fertil. Soils 20, 226–236.

Ross, M., Garcia, C., Hernández, T., 2006. A full-scale study of treatment of pig slurry by composting: Kinetic changes in chemical and microbial properties. Waste Manage. 26, 1108–1118.

Tchobanoglous, G., Theisen, H., Vigil, S.A., 1993. Integrated solid waste management, Engineering principles and management issues. McGraw-Hill, series in Water Resources and Environmental Engineering.