EFFECT OF A SULPHURIC ACID - FERRIC SULPHATE MIX ADDITION ON THE COMPOSTING OF DOMESTIC SEWAGE SLUDGE AND OLIVE MILL SOLID WASTES

L. Rodríguez, J. Villaseñor, V. Sánchez
Chemical Engineering Department, University of Castilla-La Mancha, Faculty of Chemistry,Avda. Camilo José Cela, s/n, 13071-Ciudad Real, Spain. Jose.villasenor@uclm.es.

ABSTRACT

Composting is one of the several biowaste management options that allows an important waste volume reduction and also produces a valuable product such as agriculture fertilizer. The aim of this work is to study the effect of a chemical reagent (*Sulfafer*) addition on the co-composting of two kinds of biowaste: domestic sewage sludge and olive mill solid wastes. *Sulfafer* is an industrial by-product of Tioxide-Europe S.A., and is mainly composed of ferric sulphate with a low amount of sulphuric acid. Batch pilot scale composting experiments were done using eventually turned static piles (3 m^3 each) at the University of Castilla-La Mancha experimental farm. Each pile was composed by a mixing of the above mentioned wastes and a certain amount of *Sulfafer*. During the process, waste characterization was made by measuring C, N and P, content and several metals according to Spanish compost regulations.

The results obtained showed that the *Sulfafer* addition inhibited the biological process due to the acid pH (2) reached. In these conditions, the C degradation process changed from biological oxidation to chemical one. For this reason, the typical composting temperature profile was not observed when *Sulfafer* was used. Temperature did not overcome 35ºC. Finally, it was observed that the C mineralization rate increased when higher amounts of *Sulfafer* were added.

INTRODUCTION

As a promising alternative for biosolids disposal, land application of composted biosolids has increased in the past decade (Goldstein and Steuteville, 1996). Composting is one of the several biowaste management options that allows an important waste volume reduction and also produces a valuable product such as agriculture fertilizer. During composting the most biodegradable organic compounds are broken down and part of the remaining organic material is converted into humic-like substances (Sánchez-Monedero et al., 1999; Wu and Ma, 2002). However, application on soil of nonstabilized organic materials could affect both crops and environment because of the presence of phytotoxic compounds (Butler et al., 2001). Due to these concerns, extensive research has been conducted to study the composting processes and to develop methods to evaluate the stability/maturity of compost prior to its agricultural use (Hue and Liu, 1995, Wu et al., 2000). Oxidant materials, such as metallic oxides, have been used to increase the stabilization rate. The results obtained depends upon the amount and kind of the original OM.

The aim of this work is to study the effect of a chemical reagent (*Sulfafer*) addition on the co-composting of two kinds of biowaste: domestic sewage sludge and olive mill solid wastes. *Sulfafer* is an industrial by-product from Tioxide-Europe S.A., and is mainly composed of ferric sulphate with a low amount of sulphuric acid.

MATERIALS AND METHODS

Batch pilot scale composting experiments were done using eventually turned static piles (3

m^3 each) at the University of Castilla-La Mancha experimental farm "Dehesa Galiana", near Ciudad Real. Each pile was composed by a mixture of the above related two wastes and a certain amount of *Sulfafer*. Periodically turnings were applied to maintain humidity and oxygen concentration at the adequate level for microbial development. Soil pollution was avoided by using non-permeable plastic material at the bottom of the piles in order to recover leachate. Temperatures were measured diary. Oxygen concentrations, humidity and production of CO_2 and CH_4 were weekly measured by a field gas analyser. Organic Carbon content of samples was measured using a TOC equipment. To measure soluble nitrogen and phosphorous, solid samples were pre-treated according to the APHA Standard Methods. Total Nitrogen was analysed according to Kjeldahl method. Heavy and alkaline metals were analysed before composting and several time during the process with ICP-Mass Spectrometry. The characterization of the all samples and the final compost was developed according to Spanish compost regulations.

RESULTS AND DISCUSSION

In the present work, two variables were studied: the effect of *Sulfafer* addition, and the mixture composted. Figure 1 (a, b and c) shows the effect of *Sulfafer* over a mixture of different olive mill solid wastes. As it can be seen, the addition of *Sulfafer* lead to a change in the waste transformation from a biological process to a chemical one. Pile number one show the typical parameters (temperature and pH) of a composting process. However, after the *Sulfafer* addition, the pH decreased from about 7 to about 2 and the microbial activity stopped. Being the degradation of the wastes associated to a chemical oxidation. The rate of carbon mineralization increases after *Sulfafer* addition. That lead to a decrease in the time needed to achieve the stability of the wastes.

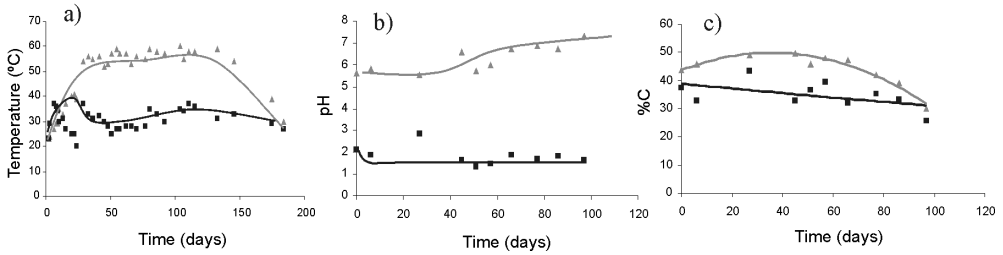

Figure 1. *Effect of Sulfafer addition over the composting process. a) Temperature; b) pH; c) Carbon concentration.* ▲*pile 1: olive mill solid wastes;* ■ *pile 2: olive mill solid wastes + 20% Sulfafer.*

Figure 2 (a, b and c) shows the results achieved when the experiments were developed using a mixture of olive mill solid wastes and domestic sewage sludge. It can be observed how the addition of domestic sewage sludge to the initial mixture (Figure 1) favoured the composting process, increasing the composting rate and, then, decreasing the time needed to achieve the stability of wastes. This can be explained taking into account that the second mixture composted had a C/N ratio of about 24, near to that considered as optimum for composting (30). However, the mixture without domestic sewage sludge had a C/N ratio of 42.

Table 1 shows the macronutrients content of the final compost obtained in the four piles studied. The most important difference observed between piles with and without *Sulfafer,* is the Fe content. This is associated to the high Fe content of *Sulfafer.* The Fe content is an important advantage because allows the addition of this component essentially to alkaline sols.

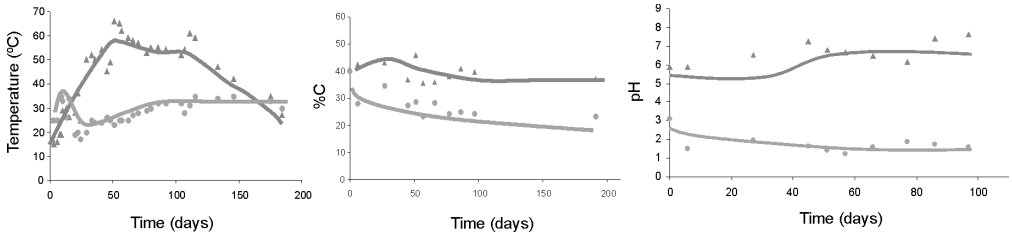

Figure 2. Effect of changes in the wastes mixture over the composting process. a) Temperature; b) pH; c) Carbon concentration. ▲ pile 3: olive mill solid wastes (65%) + domestic sewage sludge (35%); ♦ pile 4: olive mill solid wastes (65%) + domestic sewage sludge (35%) + 20% Sulfafer

Heavy metals content in the final compost obtained from the four piles was tested for its. All the compost obtained fullfil the limits established by the Spanish compost regulations. The higher levels were achieved by Cr and Zn due to the concentration of these heavy metals on *Sulfafer* and domestic sewage sludge. The concentration of these two heavy metals can limit the amount of *sulfafer* and domestic sewage sludge used in the composting process.

Table 1. *Macronutrients content in the final compost*

Nutrient	Minimum value (Spanish law)	Pile 1	Pile 2	Pile 3	Pile 4
Nitrogen (%)	0.60	0.98	1.93	4.27	5.4
Phosphorous (%)	-	0.17	0.21	0.09	0.22
P_2O_5 (%)	0.50	0.20	0.40	0.2	0.5
K_2O (%)	0.30	2.18	2.62	1.30	1.23
CaO (%)	2.00	4.91	0.63	2.83	2.86
$CaCO_3$ (%)	3.00	5.77	5.12	5.05	5.11
MgO (%)	0.30	0.30	0.25	0.30	0.25
Fe (%)	-	0.14	4.55	-	4.62

CONCLUSIONS

From the experimental results obtained, the following conclusions can be derived:

- *Sulfafer* addition inhibited the biological process. The pH dropped to 2 causing death of microbiological population but also sterilization. So, the C degradation process changed from biological oxidation to chemical one.
- Since the acid reagent was added, aeration, and thus turning, was not needed.
- The typical composting temperature profile was not observed when *Sulfafer* was used. Temperature did not overcome 35ºC.
- The C mineralization rate increased when *Sulfafer* was added.
- *Sulfafer* addition caused that the final compost contained higher amounts of Fe, valuable

nutrient for olive agriculture. Heavy metals levels were maintained under the maximum concentrations indicated by Spanish regulations.

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