STUDY OF THE CO-COMPOSTING PROCESS OF MUNICIPAL SOLID WASTE AND SEWAGE SLUDGE: STABILITY AND MATURITY

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ABSTRACT

Assessment of compost maturity or stability is important for successful use of compost in agricultural and horticultural production. The aim of this study consisted basically on the evaluation of several methods to determine the degree of stability and maturity of compost. The applied methods are microbial respiration and the measurement of several enzymatic activities for stability determination and biogermination test for maturity determination. These procedures have been applied to the monitoring of evolution of the process of compost of different urban waste: Pile 1, organic fraction of municipal solid waste (OFMSW); Pile 2, relationship in weight OFMSW/sewage sludge (2:1); Pile 3, relationship weight OFMSW/ sewage sludge (1:2); Pile 4, sewage sludge. Piles were aerated by mechanical turning (windrow composting system).. There is a direct relationship between microbial respiration and several enzymatic activities, like dehydrogenase and phosphatase activities, and compost stability.
Keywords: *OFMSW, sewage sludge, stability, maturity.*

INTRODUCTION

The knowledge of stability and maturity degree of compost is of great importance for compost producers and its consumers. Maturity is a general term describing fitness of compost for a particular end use, while stability refers exclusively to the resistance of compost organic matter for further degradation. Mature compost are ready to use; they contain negligible or acceptable concentrations of phytotoxic compounds like NH_3 or short chain organic acids (Brewer and Sullivan, 2003). Compost maturity and stability has so far been evaluated using different methods. Maturity would be determined basically by a series of tests on plants (biogermination test), in which germinating power of seeds in watery extracts of compost is determined (Chansayak et al., 1983). Juste describes also a test (toxicological test), to determine potential toxic effects of samples of compost on the first stages of growing of plants (Juste, 1980). In other to asses the degree of compost stability many authors have proposed chemical methods (pH, relationship C/N, etc) and physical methods (temperature, moisture, etc.). However, respirometric tests have proved to be the most appropriate (Coorperband, et al., 2003, Chica et al., 2003). This report tries to develop methods to determine the degree of stability and maturity of compost from co-composting process of municipal solid waste and sewage sludge.

MATERIALS AND METHODS

Four compost windrows were constructed. Compost consisted of different fractions of municipal solid waste and sewage sludge. Parameters for stability or maturity were determined as follows:

Microbial Respiration.- A 20 g oven-dry compost sample was brought to 60% moisture

contend (by weight) and placed into 250 mL flask together a vial containing 15 mL of 0.5 M NaOH. The sealed flask were incubated at 28ºC for five days. Daily, vials are removed and the respiration rate was determined by titration of NaOH with HCl 0.2 M, previous precipitation of carbonates with 3 mL of $BaCl_2 \cdot 2H_2O$, 20%(w/v), by using timolftaleine like indicator.

Biogermination Test.- Test proposed by Zucconi et al (1981) has been used. This test consist on determining the germinating power of compost. It is carried out in Petri disk in adequate germination conditions, employing seeds of *Lepidiun sativum* L. for their rapid germination. Watery extracts of compost are placed on a filter-paper in Petri disk and incubated for six days at 28ºC. Subsequently, germination percentage, average length of roots (Lm) and germination index are calculated as G.I. = (% germination) x (Lm sample roots/Lm control roots).

Dehydrogenase activity.- it was measured following the method described by Skujins (1976) with a modification proposed by García et al (1993). This method is based on compost incubation with 2-p-iodophenyl-3-p-nitrophenyl-5-phenyltetrazolium chloride (INT) like electron acceptor and a colorimetric determination of iodo-nitrotetrazolium formazane (INTF) formed.

Urease activity.- Urease activity determination were measured according to Nannipieri et al. (1980). This method is based on the measure of ammonia generated using urea like substrate.

Hydrolysing protease-BAA activity.- The determination of the activity of N-α-benzoyl-L-arginamide (BAA) hydrolysing protease has been realized like the urease activity (Nannipieri et al, 1980).

Phosphatase activity.- For this determination p-nitrophenil phosphate (PNP) is used as artificial substrate, later it can be measure by using a colorimetric method of p-nitrophenol generated (Tabatabai, 1994).

RESULTS AND DISCUSSION

Microbial Respiration.- There is a dependence between microbial respiration and the presence of biodegradable organic mater. Microbial respiration decreases the percentage of organic substrate assimilated by the microbiota. Final value of this parameter, independently of the initial composition of compost windrows, are similar, ranges between 0.47 and 0.58 mg CO_2/g.DW/day. These results are similar to the proposal of other authors for compost obtained from different organic residues (Foster et al., 1993; García-Gómez et al., 2003), as can be observed on Table 1.

***Table 1**. Microbial respiration of compost from different organic residues (mg CO_2/g.DW/day).*

Present work	Foster et al. (1993)	García-Gómez, et al. (2003)
0.47-0.58	0.25-0.62	0.50-0.60

Dehydrogenase activity.- Compost process evolution implied a decrease on dehydrogenase activity. Its value could considered stable after five month of assay, ranges between 0.056 and 0.070 mg INTF/g.DW. Pile 1, mainly composed of organic fraction of municipal solid waste, present the highest value. Temporal evolution of these enzymes are similar to the microbial respiration. They are related with the oxidative phosphorylation and, therefore, associated to the respiratory process of microorganisms. For this reason, the activity of dehydrogenase enzymes can be considered as a measure of biomass oxidative activity, very correlate with the compost basal respiration. It could be considered like a good index of the biological activity of compost.

Biogermination Test.- When the process progress, there is an increase on G.I. due to the

degradation of fitotoxic organic compounds. Results shown that there is not a direct relationship between the Pile composition and the final value of germination index. However, these results of all assays are higher to 80%. For this reason, according with the criteria of Zucconi et al (1981), the final compost obtained have not any phytotoxic problems. Moreover, the value higher to 100 %, implies, according with the criteria of Tiquia et al (2001), that the aqueous extract has an stimulant effect for plant growth.

Hydrolysing protease-BAA and urease activities.- These enzymes are relate with the presence on organic matter easily biodegradable, that is an inductor of enzymatic synthesis. At the end of the study, both activities are negligible, and they remain inactive when the compost is mature. The hydrolytic enzymes urease and hydrolysing protease-BAA can be used like an objective stability criteria for the compost. Both activities disappear when the composts are stable.

Phosphatase activity.- This activity, as the dehydrogenase, is related to the biological state of the compost. When the composting process finish there is a residual phosphatase activity. The behaviour of these enzymes are different to the hydrolytic enzymes, urease and protease, that are negligible when the process finish.

In Table 2 there is a resume of the main results obtained in the different Piles at the end of the composting process.

Table 2*. Main results of the stability and maturity parameters.*

Parameter	Pile 1	Pile 2	Pile 3	Pile 4
Germination Index (%)	116	118	108	105
Basal Respiration (mg CO_2/gDW/d)	0.56	0.47	0.54	0.58
Dehydrogenase activity (mg INTF/gDW)	0.070	0.059	0.057	0.056
Protease activity (mg NH_3/g DW)	n.d.	n.d.	n.d.	n.d.
Phosphatase activity (M PNP/g DW) * 10^{-5}	1.4	1.3	1.6	1.8
Urease activity (mg NH_3/g DW)	n.d.	n.d.	n.d.	n.d.

CONCLUSIONS

There is a dependence between basal respiration and the presence of organic biodegradable matter. The microbial respiration decreased with the percentage of organic substrates that could be assimilated by compost microbiota.

Hydrolysing protease-BAA and urease activities can be used like an objective stability criteria for the compost., because both activities disappear when the compost is stable. However, phosphatase and dehydrogenase activities maintain a residual biological activity in the range of 1.4-1.7·10^{-5}M PNP/gDW and 0.05-0.07 mg INTF/gDW, respectively. This residual activity is very interesting for the agronomic application of compost to the cultivation soils. The soil enzyme activities can stimulate by the addition of the organic amendments.

There is no phytotoxic problems with all the compost obtained, and a stimulant effect for plant growth was found.

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