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Bulk density determination as a simple and complementary tool in composting process control

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ABSTRACT

Ten composting facilities (CF) treating source-sorted organic fraction of municipal solid waste (OF) were sampled to study the relationship between the bulk density and the composting process (CP) development. Hundred and fourteen samples from different stages of the CP were considered (organic fraction, initial mixture, final decomposition, final maturation and compost), including the reject materials coming from the densimetric table at postprocessing. Total organic matter (TOM), moisture content (MC), wet bulk density and dry basis (BDd) were determined. Significant differences were detected for MC, TOM and BDd between some stages of the CP. The BDd increased along the CP while TOM decreased. Correlation studies showed a significant negative relationship between TOM and bulk density, especially BDd, during the CP, as a result of the biological activity. Moreover, a clear relationship was also found between TOM and BDd in samples related to reject materials. The results indicate that bulk density could be a simple and useful tool to evaluate the CP, in addition to the others parameters commonly used. At the same time, BDd could be an easy way to infer TOM lost within rejects.

1. Introduction

In order to design efficient methods of compost production it is important to have information about the nature of the materials involved and a complete understanding of the process and the available tools to perform it.

Careful selection and blending of the constituent materials for compost provides a suitable environment for microorganisms but the material must still be placed and handled in an optimal way during and after processing.

The physical and chemical properties of organic wastes and the factors that affect their performance in composting require easily identifiable and reliable methods to control the process *in situ*, in order to make proper decisions about its performance.

In Spain recent applications of large-scale composting have encountered many problems because of: lack of understanding of the biological fundamentals, treatment of a lot of unsuitable waste materials, control failures and other short-comings. This behaviour has resulted in unacceptable environmental problems such as foul odours and leachates, at times resulting in local complaints.

Nowadays, the control of the composting facilities is focused on the quality of the compost obtained; mainly on its level of pollutants through the RD 824/2005 (Spanish Ministry of Presidency, 2005). But problems related to local complains are usually associated with the composting management. Thus, it is necessary to use specific tools to control the process and prevent these problems.

The most common method in the facilities is to follow the process with temperature and oxygen level monitoring and moisture content control. Temperature and oxygen level are clearly involved with the aerobic biological activity of the composting microorganisms and, therefore, they are good indicators of the process development. Moreover, both are easily and quickly determinable by using specialised probes. On the other hand, microorganism activity is also strongly influenced by the moisture content of the mass. Thus, to assess the process it is essential to monitor this parameter but, unlike temperature or oxygen level, moisture content needs a sample procedure and also a simple determination, taking 24 h to get a measurement. Unfortunately, because of this moisture content is not always monitored.

There are other physical parameters that can indicate what is going on with the composting process and how it could be developed, like bulk density and free air space (FAS). Above all FAS has been studied to assess the starting mixture and some studies have

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been developed to assess the best technique to determine it (Ruggieri et al., 2009; Su et al., 2006). It is an interesting tool to assess the balance between moisture and oxygen content of the composting matrix. In fact, as some authors have demonstrated that FAS is closely related to the bulk density (Agnew and Leonard, 2003; Ahn et al., 2008; Day and Shaw, 2001; Mohee and Mudhoo, 2005), in some cases establishing empirical equations about their relationship. Bulk density is a physical measurement also related to the moisture content (Madejon et al., 2002) and organic and mineral content of the compositing matrix. As aerobic composting proceeds, particle size of organic solid fraction decreases due to the breakdown of larger particles and microbial surface decomposition processes (Raviv et al., 1987; Tarre et al., 1987). The aerobic decomposition of organic materials increases ash content and decreases volatile solids – or total organic matter – and organic carbon content (Breitenbeck and Schellinger, 2004; Inbar et al., 1989; McCartney and Chen, 2000; Tarre et al., 1987; Van Ginkel et al., 1999; Witter and Lopez-Real, 1986). Ash and total organic matter changes imply an increase in particle density (Raviv et al., 1986). Subsequently, due to the decrease in particle size and the increase in particle density, dry bulk density of composting matrix increases with composting time (Larney et al., 2000; Mohee and Mudhoo, 2005; Raviv et al., 1986, 1987; Romeela et al., 2008). In turn, a porosity decrease is observed (Inbar et al., 1993; Raviv et al., 1986, 1987) associated with the settlement of smaller and heavier particles in the volume matrix.

Moreover, bulk density is also required to evaluate the volume of the mass under composting and its reduction during the process (Breitenbeck and Schellinger, 2004; Larney et al., 2000), parameters related to the treatment capacity of the composting facilities.

In this paper, different samples from several facilities were considered to study bulk density changes in a co-composting process of source-sorted organic fraction of municipal solid waste and yard trimmings. Bulk density determination was carried out in a simple way to prove its adaptation in large-scale composting, using simple and available materials. The relationship between this determination with moisture and organic matter content was also studied. The results obtained could prove the viability of that determination and the usefulness of its monitoring during composting.

2. Methods

2.1. Source-sorted organic fraction of municipal solid waste characteristics

The study was focused on source-sorted organic fraction of municipal solid waste and yard trimmings co-composting facilities from Catalonia (NE Spain). The quality of this organic fraction treated by these composting facilities has been measured annually since 2004 by the Catalan Government (ARC, 2009) through the characterisation of the percentage of non-compostable materials and even, since 2006, the proportion of each type of them (plastic, glass, paper, etc.). This characterisation was done by external laboratories following methodology described previously in Alvarez et al. (2008), and data was compiled in a data base available in the official site of the Catalan Government (SDR, 2009). This site is an important tool to assess the evolution of the separate source collection of the municipal organic fraction in Catalonia. In 2008, this site compiled 1226 characterisations to assess the quality of the total biowaste treated in Catalonia by the composting facilities, and the results showed a mean of 10.80% of non-compostable materials (Giró, 2009), where a 0.65% corresponded to big bulky rejects that are removed before starting the composting process. Plastic and paper were the main non-compostable materials comprising 1.66% and 4.55%, respectively.

2.2. Composting facilities

Ten composting facilities provided with similar equipment and management were studied in 2008. These plants treated source-sorted organic fraction of municipal solid waste with low content in non-compostable materials (⩽10%). Fig. 1 shows the simplified composting development followed by the composting plants studied. The process started once a mixture of organic fraction (OF), yard trimmings and recovered yard trimming was completed. The whole composting process lasted around 90 days: 30 days for the decomposition phase (thermophilic) and 60 days for maturation or curing phase. Only three composting facilities presented different timings because of the use of forced air equipment in the decomposition phase. Because of this, the process lasted 75 days for these three composting facilities: 15 days for the decomposition phase and 60 days for maturation. The turning frequency varied from weekly to fortnightly for the decomposition phase and from fortnightly to monthly for the curing phase. For the three composting facilities with forced aeration equipment in the thermophilic phase, the frequency was dictated by the temperature of the treated mass. A treatment based in a trommel was applied at the end of the thermophilic phase to remove non-compostable materials, mainly plastic originated from household waste that was not properly selected and from non-compo-

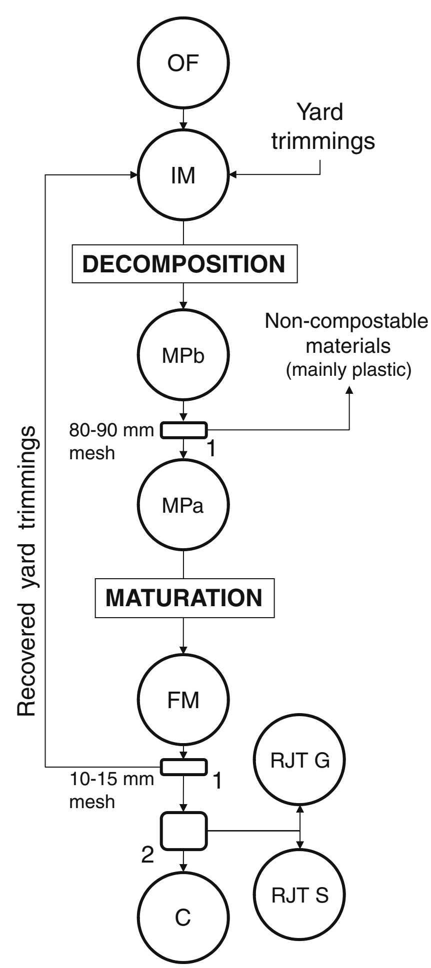

Fig. 1. Composting plants operational diagrams. (1) Trommel screening, (2) densimetric table. *Note:* OF, municipal solid waste organic fraction; IM, initial mixture; MPb, middle process before trommel; MPa, middle process after trommel; FM, final maturation; C, compost; RJTG, heavy grain reject; RJTS, heavy sand reject.