



Comparison of compostable bags and aerated bins with conventional storage systems to collect the organic fraction of municipal solid waste from homes. A Catalonia case study

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ARTICLE INFO

Article history:

Received 18 May 2012

Accepted 13 February 2013

Available online 11 March 2013

Keywords:

Aerated bin

Compostable bag

Waste collection systems

Composting

Organic fraction of municipal solid waste

ABSTRACT

The separation of biowaste at home is key to improving, facilitating and reducing the operational costs of the treatment of organic municipal waste. The conventional method of collecting such waste and separating it at home is usually done by using a sealed bin with a plastic bag. The use of modern compostable bags is starting to be implemented in some European countries. These compostable bags are made of biodegradable polymers, often from renewable sources. In addition to compostable bags, a new model of bin is also promoted that has a perforated surface that, together with the compostable bag, makes the so-called “aerated system”. In this study, different combinations of home collection systems have been systematically studied in the laboratory and at home. The results obtained quantitatively demonstrate that the aerated bin and compostable bag system combination is effective at improving the collection of biowaste without significant gaseous emissions and preparing the organic waste for further composting as concluded from the respiration indices. In terms of weight loss, temperature, gas emissions, respiration index and organic matter reduction, the best results were achieved with the aerated system. At the same time, a qualitative study of bin and bag combinations was carried in 100 homes in which more than 80% of the families participating preferred the aerated system.

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1. Introduction

The organic fraction of municipal solid waste (OFMSW), or biowaste, is mainly composed of food rejects of vegetable or animal origin and green waste, in an amount that depends on the region considered (Eurostat, 2013). According to European recommendations and environmental considerations, these wastes need to be separately collected at home to be biologically treated through composting or anaerobic digestion to ensure the production of high quality compost, in accordance to new European regulations (European Union, 2008).

Catalonia, a well-developed region in the northeast of Spain is implementing an integrated system to collect source-separated OFMSW all over the territory. The last study about the municipal waste composition in Catalonia was carried out in 2004–2005 and showed that OFMSW, together with several other types of green waste, formed 36% (32% of kitchen waste and home green wastes and 4% of green wastes from municipalities, respectively) of the total weight of collected municipal wastes (Agència de Residus de Catalunya, 2006). In Spain, around 23 million tonnes of mu-

nicipal solid waste (MSW) were collected in 2004. 2.3 million tonnes of this overall MSW stream were collected separately of which 262,221 tonnes were composted and 323,896 were anaerobically digested (Spanish Ministry of Environment, 2008). In Catalonia it is estimated that about 40% of MSW is collected by using a system that requires separation at home, mainly street bin or door-to-door systems. These values are steadily increasing in last years (Agència de Residus de Catalunya, 2006). Other waste streams are being incinerated and landfilled, options for waste treatment that have considerably decreased in last years. Specifically, 318,354 inhabitants (about 4% of the total population) have access to a door-to-door collection system, which means that 55,770 tonnes of biowaste could be collected through this system (Giró, 2006), being the rest of wastes collected by street bin systems. In recent years, the percentage of people participating in source separation systems has considerably increased, which is due to the tax incentives from the local government to improve the quality of the OFMSW, as explained later.

The management of OFMSW, including collection and processing, should be carried out as soon as possible and under conditions that minimise leachate and odours arising from the OFMSW owing to its high density, moisture and putrescibility. In 1993, Catalonia first started the separate collection of OFMSW, which has been

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gradually implemented all over the Catalan territory. Since then, the collection system has been continuously analysed and improved with specific actions such as the implementation of source-separate collection systems in all the municipalities of Catalonia, with information campaigns and delivering bags and bins for population to facilitate the separation jointly with a continuous monitoring of the OFMSW quality (Agència de Residus de Catalunya, 2012). Currently, different systems are used to collect biowaste: door-to-door and street containers being the most extended. In Europe, several collection systems have been implemented with different configurations, collection frequencies or source-separation schemes. The experience during these years has shown that the best collection systems in terms of valorisation and recycling of organic wastes imply the source-separation of the OFMSW. Among the systems proposed for source OFMSW separation, door-to-door systems have always shown better results in terms of recovery and quality of the material, which is typically collected for a biological treatment such as composting or anaerobic digestion (Giró, 2006; European Union, 2008; Huerta-Pujol et al., 2010). In any case, the collection systems start from the same point; the first step is separation at home, in which a bag in a bin with a total capacity of 10 L is commonly used. Normally, low-density polyethylene plastic bags have been used to collect OFMSW. Most of the plastics that arrive at composting plants as non-biodegradable materials and, consequently, impurities of the OFMSW, are the bags used to collect and dispose of OFMSW (Huerta-Pujol et al., 2010). Because polyethylene is not biodegradable, the presence of plastic bags results in a problem during the composting process and makes the pre- and post-treatment more difficult (Körner et al., 2005). To avoid this problem, local administrations are now recommending the use of compostable bags (CBs) made from corn or potato starch. The physical deterioration and biodegradation of these bags can be complete in just 6 days, under conditions similar to that of the composting process (Mohee and Unmar, 2006).

In recent years, a new system to separate organic waste at home has been introduced. This system, known as the “aerated system”, comes from northern Europe. This system is based on the use of a perforated bin combined with CBs. By using this system the aeration of OFMSW is improved and the weight reduction of the waste through water evaporation is promoted. The continuous air exchange between the waste and the environment reduces unpleasant odours, which is one of the most common complaints about OFMSW separation at home (Agència de Residus de Catalunya, 2006). Moreover, the aerated system increases the mechanical resistance of the CB through drying of the bag surface.

The improvement of OFMSW quality through the general use of CBs could have a notable influence on municipal waste management, because treatment costs often depend on the percentage of impurities of the source-separated fractions. In general, taxes levied for waste treatment are used to optimise the municipal solid waste management system and improve the biological treatment of OFMSW to obtain biogas and/or high quality compost. For instance, in Catalonia, a specific tax is levied for any municipal waste that is finally disposed of in landfill or burned in an incineration plant (10 € t^{-1} and 5 € t^{-1} , respectively) (Agència de Residus de Catalunya, 2006). The tax revenue raised is returned to compensate the municipalities for the cost of source-separated collections and for the maintenance of existing biowaste treatment plants and construction of new ones (by using biological processes such as composting, anaerobic digestion or a combination of both). The tax might cover all these costs but, obviously, this strongly depends on the level of implementation and participation in source separation, the public information campaigns and the perceptible benefits of the use of this tax in each municipality. Moreover, in Catalonia, part of this tax is returned to the municipalities and

the amount is calculated according to the quality and quantity of the separated collection of OFMSW, so its value depends on each municipality characteristics and implication. Obviously, the final value of returned tax is dependent on positive participation by residents with the source-separated collection system, which could presumably increase with the use of the aerated system because results are more satisfactory for residents. In any case, the economic results of implementing this aerated system for a municipality depend on all the above-mentioned factors and require analysis.

Although LCA is not the main objective of this study, there is a number of literature reports on LCA of solid waste management and/or treatment processes (Blengini, 2008; Banar et al., 2009). In this framework all the data obtained on the storage of OFMSW at home allows a more complete LCA on the overall process of waste management.

The main goals of this work are: (i) to determine the efficiency of the different combinations to separate OFMSW at home (aerated or non-aerated bin and compostable or non-compostable bag) by using quantitative data on the characteristics of organic matter found in each system; (ii) to study the use of CBs in society and the effect on the impurities content of OFMSW by implementing all the storage systems available for the collection of OFMSW at home and (iii) to estimate the economic viability of the aerated system for municipalities.

2. Materials and methods

2.1. Bins

Two different types of bins have been used in this study. The first one is a closed bin. In most cases, these bins are rectangular with a 10 L capacity and close tightly. Fig. 1 shows an image of a closed non-aerated bin (nAB) used at home together with the aerated bin (AB). Both bins are a similar shape and have the same total capacity.

2.2. Bags

Bags made from low-density polyethylene (hereon referred to as plastic), compostable biopolymers (Mater-Bi[®] product) and paper have been used in this study to collect OFMSW. Table 1 shows the main properties and general characteristics of these different bags. Currently, plastic or non-compostable bags (nCBs) are still the most widely used in Catalonia. CBs are made from synthetic biopolymers obtained from natural sources. The CBs used in this study were made from corn-starch. Paper bags (PBs) are also fully biodegradable but they have resistance problems when wet wastes are collected. Unlike plastic bags, which are made of fossil fuels, the raw materials of both CBs and PBs are obtained from crops. The images of the three types of bags are shown in Fig. 2.



Fig. 1. Image of the bins used in this study. Non-aerated bin (nAB; left); Aerated bin (AB; right).

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