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Research article

Simulation of the behavior of a refuse landfill on a laboratory scale

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The characteristics and properties of waste in a landfill, and its evolution over time, are difficult to estimate because of the heterogeneity of materials, biomass degradation, density, cover material, and infiltration of water. In this work, a lysimeter was used to simulate how refuse from mechanical-biological treatment (MBT) plants evolved in a landfill over a 45-day period. Water was added as a way to imitate the effects produced during rainy seasons. Field capacity and changes in the physical and chemical properties (volatile solids, biomass, and heating value) were analyzed. The results of this research show that the percentage of biomass lowers, and the heating value increases, after bringing about infiltration and percolation of water in the waste mass. Therefore in order to stabilize waste in a landfill, employing irrigation or leachate recirculation could be advisable. As the heating value increases after percolation, it could also be a good idea to recover the fuel material after stabilization.

1. Introduction

In recent years, the waste-related goals of developed countries have focused on reducing the volume of waste and exploiting the resources contained in different waste types as much as possible. As a result of such policies, the amount of municipal solid waste (MSW) sent to landfills can be minimized. By means of Directive 2008/98/EC, the European Union fosters a waste hierarchy, defined as a priority order in waste prevention management legislations and policies, where the most preferred option should be prevention, followed by preparing for reuse, recycling, other recovery choices, with disposal being the least preferred option. Accordingly, as well as the policies that promote prevention and reuse, the other rules and regulations on waste currently in force foster a better exploitation of generated MSW; first by separating the collection systems of different materials (glass, paper, cardboard, used oils, packaging, biowaste, etc.) to recycle them; second, applying mixed waste treatment prior to landfill.

Ultimately, MSW management strategies and challenges in adaptation are also rendered necessary for solid waste management, which are related mainly to waste treatment technologies (Pires et al., 2011). In recent years, the treatment trend for mixed waste in some EU countries like Spain is a mechanical-biological treatment (MBT), which stabilizes organic matter by a composting process. Applying this treatment allows recyclable materials to be recovered. However, a large portion of mixed waste ends up becoming refuse, and is therefore taken to landfills (de Araújo-Morais et al., 2008; Gug et al., 2015). This portion of mixed and non recyclable waste is called refuse. Refuse from MBT plants has different characteristics from those of MSW because biodegradable, inert and recyclable fractions (plastics, paper-cardboard, metals, glass, etc.) have been removed.

There are many types of MBT plants. Some separate biomass from the rest which is then biostabilized. Others perform a biological treatment and the bulk waste is then separated into biostabilized material, recyclable materials and different sources of refuse. EU legislation has expected the MBT of MSW for several years. Pre-treatment benefits include reducing the pollutant load of the produced leachate, reducing the generated amount of landfill gas, less clogging of leachate drainage systems, improving waste settlement times, as well as a shorter timescale to waste stabilization (Robinson et al., 2005). Nevertheless, a high proportion of waste cannot be recovered (refuse). Such refuse from MBT plants represents about 65–75% of the volume of the initial MSW and is usually incinerated as a solid, which is recovered fuel or landfilled (Edo-Alcón et al., 2016; Gallardo et al., 2014; Montejo et al., 2011). In many countries, refuse is dumped in sanitary landfills.

Furthermore, the MBT process includes several refuse flows: refuse from the recovery stage (A), refuse from the biological stage (B), and refuse from refining pre-matured biowaste (C) (Fig. 1). Thus

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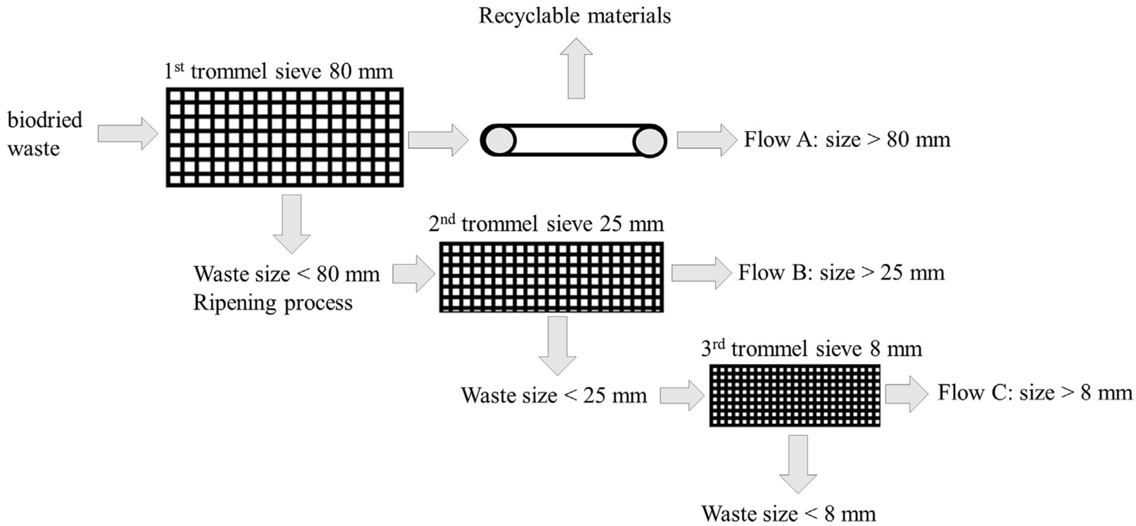

Fig. 1. Refuse classification according to size.

the behavior of refuse landfills usually differs from that of MSW landfills. Nevertheless, refuse usually contains large amounts of combustible material, such as plastic film, paper-cardboard, and textile, which could be a future source of fuel. The technique used to recover these materials is known as landfill mining (Krook el al., 2012).

It is also very important to control pollution from landfills since incorrect management can result in hazards for both the environment and human health. This control involves conducting extensive technical and scientific studies that enable the properties of the refuse in landfills to be known (field capacity), and the amount and the physical and chemical properties of leachates to be forecast according to climatic conditions.

Moisture strongly influences degradation times in sanitary landfills (Barlaz et al., 1990). Field capacity (FC) can vary depending on the density, age and composition of waste. FC determinations allow the volume of water retained in the waste mass to be estimated. Therefore, if the initial moisture of refuse is known and climatic conditions are simulated in a lysimeter, FC can be calculated after measuring the amount of generated leachate.

Very little research on refuse landfills has been conducted, although existing studies have been conducted with MSW (Orta de Velasquez et al., 2003; Uguccioni and Zeiss, 1997). The main goal of this paper is to, therefore, supply information from a laboratory-scale simulation of refuse in landfills, the results of which can be useful for landfills located in other countries. In this work, the behavior of the refuse from an MBT plant was studied on a laboratory scale by determining the FC and evolution of the biomass content under known conditions. Moreover, the lower heating value (LHV) of refuse and its variation over time provide information about the possibility of recovering refuse as a future fuel (landfill mining).

2. Methodology

Refuse was obtained from an MBT plant in east Spain. This plant produces 65,000 t/year of refuse, which represents 73.27% of the MSW generated in the study area (Gallardo et al., 2014). The MSW is submitted to a biodrying process when it reaches the MBT plant.

As shown in Fig. 1, the general flow of refuse is divided into three smaller flows with the following percentages: 44% from the refuse from the recyclable materials recovery process (Flow A: size > 80 mm); 42% from the refuse before the biostabilized material refining process (Flow B: size > 25 mm); 14% from the biostabilized material refining process (Flow C: size > 8 mm).

Fig. 2 lists the methodology steps followed. The steps are further explained below.

2.1. Sample collection

The methodology for characterizing and sizing the sample by quartering applied in this work is described by the European Commission (2004). Following these indications, 1000 kg of refuse were collected *in situ* and a 25-kg sample was selected from this total amount. This procedure was applied in flows A, B and C, and samples were taken to the solid waste laboratory. Refuse (A, B and C) has to be milled to ensure that each piece is smaller than 70 mm (Stoltz et al., 2010).

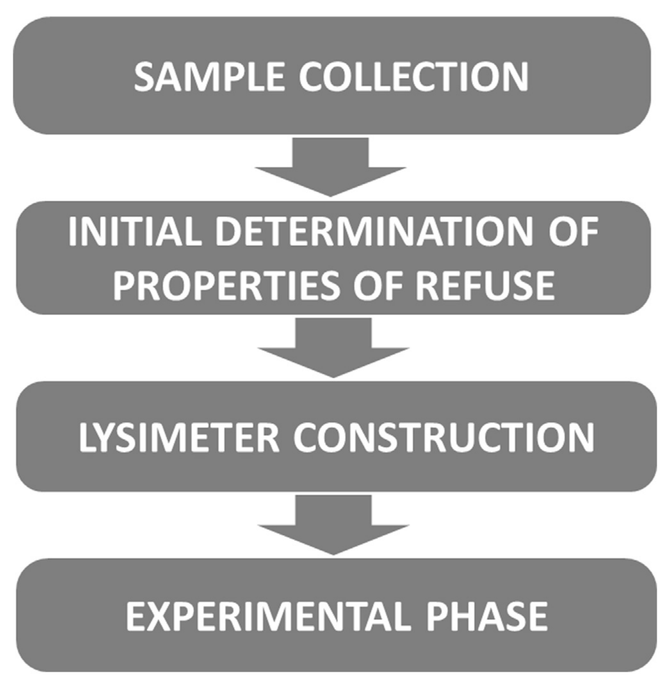

Fig. 2. Summary of the steps followed in this work.