Available online at www.sciencedirect.com
ScienceDirect
Waste Management 28 (2008) 2735–2742
wasteWmanagement
www.elsevier.com/locate/wasman

Comparison of aerobic and anaerobic stability indices through a MSW biological treatment process

Sergio Ponsá [a], Teresa Gea [a], Llorenç Alerm [b], Javier Cerezo [c], Antoni Sánchez [a,*]

[a] *Composting Research Group, Department of Chemical Engineering, Escola Tècnica Superior d'Enginyeria, Universitat Autònoma de Barcelona, 08913 Bellaterra, Barcelona, Spain*
[b] *Entitat Metropolitana de Serveis Hidràulics i Tractament de Residus, Carrer 62 núm 16-18 Edifici B. Zona Franca, 08040 Barcelona, Spain*
[c] *Ecoparc del Besòs SA, Polígon Industrial Can Salvatella, Zona de Can Cabanyes, 08110-Montcada i Reixach, Barcelona, Spain*

Accepted 1 December 2007
Available online 8 February 2008

Abstract

A complex mechanical–biological waste treatment plant designed for the processing of mixed municipal solid wastes (MSW) and source-selected organic fraction of municipal solid wastes (OFMSW) has been studied by using stability indices related to aerobic (respiration index, RI) and anaerobic conditions (biochemical methane potential, BMP). Several selected stages of the plant have been characterized: waste inputs, mechanically treated wastes, anaerobically digested materials and composted wastes, according to the treatment sequence used in the plant. Results obtained showed that the main stages responsible for waste stabilization were the two first stages: mechanical separation and anaerobic digestion with a diminution of both RI and BMP around 40% and 60%, respectively, whereas the third stage, composting of digested materials, produced lesser biological degradation (20–30%). The results related to waste stabilization were similar in both lines (MSW and OFMSW), although the indices obtained for MSW were significantly lower than those obtained for OFMSW, which demonstrated a high biodegradability of OFMSW. The methodology proposed can be used for the characterization of organic wastes and the determination of the efficiency of operation units used in mechanical–biological waste treatment plants.

1. Introduction

The bulk municipal solid waste stream (MSW, which can contain a range of 35–50% of organic materials) and the source-selected organic fraction of municipal solid waste (OFMSW, with an organic content over 80%) have received special attention from the European authorities. As a result, at present there is an increasing number of facilities such as composting, anaerobic digestion and mechanical–biological treatment plants whose main goal is to reduce the biodegradable organic matter content of these organic wastes and stabilize them by means of biological processes.

The analysis of waste treatment efficiency in these plants requires a reliable measure of the biodegradable organic matter content of organic wastes and thus, their stability defined as the extent to which readily biodegradable organic matter has decomposed (Lasaridi and Stentiford, 1998). This measure would permit the evaluation of current working plants, the improvement of the biological treatment process, the design of optimized facilities and the potential environmental impact of the final products.

Some biochemical parameters such as volatile solids (VS), total and dissolved organic carbon (TOC, DOC) and chemical oxygen demand (COD) have been used to monitor the evolution of biological processes (Fontanive et al., 2004; Komilis and Ham, 2003; Papadimitriou and

* Corresponding author. Tel.: +34 93 5811019; fax: +34 93 5812013.
E-mail address: antoni.sanchez@uab.cat (A. Sánchez).

0956-053X/$ - see front matter © 2008 Elsevier Ltd. All rights reserved.
doi:10.1016/j.wasman.2007.12.002

Balis, 1996; Ros et al., 2006). These parameters lack precision when determined on heterogeneous materials such as MSW or OFMSW because of the presence of non-biodegradable volatile or oxidizable materials.

Biological activity measurements have been widely suggested in the literature as a measure of biodegradable organic matter content or stability. In this sense, aerobic respirometric techniques and methanogenic activity assays have been proposed (Adani et al., 2004; Barrena et al., 2006; Hansen et al., 2004; Ianotti et al., 1993; Ligthart and Nieman, 2002; Scaglia et al., 2000; Tremier et al., 2005). The suggested methodologies differ in key assay parameters, such as temperature, which is directly related to the biological activity rate. Indeed, changes in the optimum temperature value have been reported for maximum biological activity determination through the composting process evolution (Barrena et al., 2005; Lasaridi et al., 1996). Some comparisons between a few of the proposed aerobic methods have been made (Adani et al., 2003, 2006; Gea et al., 2004), concluding that respirometric indices are suitable for biological process monitoring. On the other hand, only one recent reference (Cossu and Raga, 2008) has presented a good correlation between an accumulative aerobic respiration method and the biogas potential for landfill excavated waste. Furthermore, a number of standards have been already proposed (ASTM, 1996; Cooper, 2005; US Department of Agriculture and US Composting Council, 2001). Notwithstanding the amount and quality of the work referred to, there is no consensus for stability measurements within the research community in the solid waste treatment field (Barrena et al., 2006).

Some of the above-mentioned methods have been considered in the European legislation drafts (European Commission, 2001) and adopted in national regulations by some European countries such as Germany (Federal Government of Germany, 2001), Italy (Favoino, 2006) and England and Wales (Godley et al., 2005). Table 1 shows the test conditions for some of the national standards defined for biological stability determination under aerobic and anaerobic conditions and the proposed stability limits. As can be observed, the methodologies proposed differ in many key aspects such as the use of an inoculum, the amount of sample to be used and its preparation, the assay temperature (mesophilic or thermophilic) and the test duration. Even the expression of the results (oxygen uptake rate or cumulative consumption) and the units (dry or volatile solids basis) are different among the tests published.

The objectives of this research are therefore: (i) to study the suitability of the aerobic respiration index and the methane potential for the determination of the biodegradable organic matter content and biological stability in samples from a selected MBT plant (Ecoparc de Montcada, Barcelona, Spain), which were obtained at different stages of their biodegradation process; (ii) to compare the two indices proposed (aerobic and anaerobic); (iii) to determine the correlations among the methods studied; and (iv) to determine the efficiency of the treatment of biodegradable organic matter in the evaluated MBT plant, based on the selected indices.

2. Materials and methods

2.1. Materials

Samples were obtained from a mechanical–biological treatment (MBT) plant (Ecoparc de Montcada, Montcada i Reixach, Barcelona) that treats mixed MSW ($63 \pm 11\%$ dry matter content, $63 \pm 12\%$ volatile solids content) and OFMSW ($39 \pm 5\%$ dry matter content, $67 \pm 11\%$ volatile solids content). Samples were collected during April–May 2006. Analytical methods were carried out on a representative sample (approximately 20 kg) obtained by mixing four

Table 1
Stability indices proposed in some European regulations

Reference[a]	Inoculation	Water content	Temperature	Test duration	Results expression[b]	Stability limit
European Commission (2001), Italia (Lombardia), Favoino (2006)			Biological treatment of biowaste, second draft			
DRI	No	10–13 kg, 75% water holding capacity	Self-heated	<4 days	mg O_2 kg VS^{-1} h^{-1}	1000
AT_4	Yes	500 g, 50% moisture	58 °C	4 days expandable	mg O_2 g VS^{-1}	10
Federal Government of Germany (2001)			Abfallablagerungsverordnung – AbfAblV			
AT_4	No	40 g, saturation + empty filtration	20 °C	4 days + lag phase	mg O_2 g DM^{-1}	5
GB_{21}	Yes	50 g DM + 50 mL inoculum + 300 mL water	35 °C	21 days + lag phase	L kg DM^{-1}	20
Godley et al. (2005)			United Kingdom Environment Agency			
DR_4	Yes	400 g, 50% MC	35 °C	4 days	mg O_2 g DM^{-1} or mg O_2 g VS^{-1}	No limit proposed
BM_{100}	Yes	20 g VS + 50 mL inoculum + 200 mL solution	35 °C	100 days	L kg VS^{-1}	No limit proposed

[a] DRI, AT_4 and DR_4 are respiration indices (oxygen consumption), whereas GB_{21} and BM_{100} are anaerobic indices (biogas production).
[b] DM: dry matter; VS: volatile solids.