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Performance of a commercial-scale DiCOM™ demonstration facility treating mixed municipal solid waste in comparison with laboratory-scale data

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ABSTRACT

The current paper describes the performance of a commercial-scale (20,000 tpa) demonstration facility of the DiCOM™ process, a biological treatment for the organic fraction of municipal solid waste (OFMSW). The 21-d process combines aerobic composting and high-solids (30% DM), thermophilic (55 °C) anaerobic digestion (AD), within a single vessel. Mechanically sorted OFMSW, derived from mixed household MSW (324 t), was exposed to sequential aerobic/anaerobic/aerobic treatment. The AD, initiated by adding anaerobic inoculum from a previous trial, was stable (without pH intervention) and the onset of methanogenesis, rapid (<3 h). Volatile fatty acids formed during AD (including propionate) were exhausted prior to reuse of the inoculum. As measured by an electron flux from solids to gaseous end-products, AD accounted for the greatest portion of solids degradation (86% = 160 m^3 CH_4/dry t OFMSW). However, unlike laboratory trials, limited degradation occurred during initial aerobic treatment. The discharged solids were classified as a composted soil conditioner.

1. Introduction

Increases in world population density and associated waste production, coupled with dwindling available land, increased fuel/transport costs and the need for environmentally sustainable waste treatment, has highlighted the need for close-to-source waste treatment facilities having a small footprint. Both, aerobic composting (Castaldi et al., 2005; Gajalakshmi and Abbasi, 2008; Golueke and Diaz, 1996; Rosen et al., 1993; Veeken and Hamelers, 2002) and anaerobic digestion (Braber, 1995; Fricke et al., 2005; Mata-Alvarez et al., 2000; Ostrem et al., 2004) have been described as biological alternatives for the treatment of this waste. The combination of thermophilic anaerobic digestion with in-vessel composting in a single vessel is one approach that aims at profiting from the benefits of anaerobic digestion (energy recovery) and composting (low odour compost as end-product). One such process has been tested and optimised at laboratory-scale (Walker et al., 2006a,b). This process, termed DiCOM™ has now been constructed as a commercial-scale (20,000 tpa) process for the treatment of high solids (20–40% DM), thermophilic (55 °C) anaerobic digestion (AD) combined with in-vessel composting of OFMSW within a single vessel.

The purpose of this paper is to test whether the performance of gas production and composting efficiency described from laboratory experiments (Walker et al., 2006a,b) and tested at pilot scale (8 m^3, unpublished) could be reproduced at full-scale; and investigate the effect of higher solids to liquid content on process performance, which is caused by the higher compaction occurring at the larger scale.

In particular the second point is of scientific and applied interest. Due to the vessel height of 22 m, a gradient of compaction over the height of the vessel would be expected, resulting in up to an estimated 1100 kg/m^3 of solids (at 50% moisture) at the point of highest compression within the vessel. Materials consolidation has been reported to decrease the pore space within a solid matrix by reducing, or ultimately eliminating, air channels between the solid particles (McCartney and Chen, 2001; Richard et al., 2004). Consequently, during the anaerobic digestion phase of DiCOM™ operation, greater consolidation will decrease the volume of water that can penetrate into these pores.

Preliminary data has suggested that the maximum anticipated consolidation in a fully loaded DiCOM™ reactor could result in an approximate 40% decrease in pore space. Thus, the solid to liquid ratio would increase from approximately 750 kg/m^3 with no compaction, as is the case at the top of the vessel (and as previously recorded in laboratory-scale experiments), to 2750 kg/m^3 at the point of greatest compaction. The increased compaction can be equated directly to 4 times less water available for the anaerobic digestion process within the regions of material exposed to maximum consolidation. With less water available, the release of fermentation products, such as volatile fatty acids, will more readily result in undesirable elevated concentrations and increased risk

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