Co-digestion of source segregated domestic food waste to improve process stability

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Cattle slurry and card packaging were used to improve the operational stability of food waste digestion, with the aim of reducing digestate total ammoniacal nitrogen concentrations compared to food waste only. Use of cattle slurry could have major environmental benefits through reducing greenhouse gas emissions associated with current management practices; whilst card packaging is closely linked to food waste and could be co-collected as a source segregated material. Both options increase the renewable energy potential whilst retaining organic matter and nutrients for soil replenishment. Co-digestion allowed higher organic loadings and gave a more stable process. A high ammonia inoculum acclimated more readily to cattle slurry than card packaging, probably through supplementation by trace elements and micro-organisms. Long-term operation at a 75-litre scale showed a characteristic pattern of volatile fatty acid accumulation in mono-digestion of food waste, and allowed performance parameters to be determined for the co-digestion substrates.

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1. Introduction

Anaerobic digestion of organic material in municipal solid waste provides renewable energy in the form of biogas (Mata-Alvarez, 2003) and can also offer a means of recycling valuable plant nutrients back to agricultural land (Lukehurst et al., 2010). To achieve the latter requires source segregation of targeted organics, as the material arising from mechanical pre-treatment has a high level of contamination, with heavy metal concentrations exceeding the accepted values for agricultural land used in food production (BioAbV, 1998; PAS 110, 2010). Food waste from both domestic and commercial sources has been targeted for biogas production because of its high biochemical methane potential (Zhang et al., 2011; Banks and Zhang, 2010), whilst its high water content makes energy recovery through thermal treatment unattractive (Ahring, 2003). It can, however, be difficult to digest as a mono-substrate (Zhang et al., 2011), leading to digester instability and in some cases failure (Neiva Correia et al., 2008; Resch et al., 2011; Palatsi et al., 2011). Recent work by Banks et al. (2012) has shown that stable digestion is possible at the high ammonia concentrations associated with food waste by selective trace element addition. An alternative approach is to co-digest food waste with other waste materials so as to increase the carbon to nitrogen ratio as a means of overcoming process limitations due to ammonia inhibition (Zhang et al., 2011). There are also strong environmental reasons for adopting co-digestion: treating animal manures in a controlled process reduces the fugitive emissions associated with manure management and could lead to greenhouse gas savings (Clemens et al., 2006; Banks et al., 2007; Marañón et al., 2011). The mixing of a high energy potential substrate such as food waste with low energy potential animal slurries can make the overall process economic (Angelidaki and Ellegaard, 2003; El-Mashad and Zhang, 2010; Zhang et al., 2011). A number of studies have explored this option and shown improved performance or increased process stability (Callaghan et al., 2002; Hartmann and Ahring, 2005; Capela et al., 2007; Alvarez and Lidén, 2008). The concept has also been successfully applied to achieve better nutrient management by cooperative schemes in Denmark (Holm-Nielsen et al., 2009), mainly using commercial or industrial sources of biodegradable wastes from animal slaughter and food processing (Raven and Gregersen, 2007). These schemes are often regarded as a model of best practice (Braun and Wellinger, 2003); not all of the Danish co-digestion plants have worked without problems, however, probably due to unwise selection of co-substrates (Nielsen and Angelidaki, 2008).

Banks et al. (2011a) suggested that on-farm co-digestion of source segregated domestic food waste was the most effective means of making cattle slurry digestion economically viable, with associated benefits in greenhouse gas reduction and nutrient management. In dense urban areas where centralised digestion may be more appropriate, card packaging material becomes an attractive co-substrate as it is generated and can be co-collected in close association with food waste, and is generally available in tonnage quantities as a low or negative value stream from materials recovery facilities. The aim of the current work was to investigate the co-digestion of source segregated domestic food waste with cattle slurry and also with card packaging: in both cases it was...