Bioresource Technology 130 (2013) 559–569

Contents lists available at SciVerse ScienceDirect

Bioresource Technology

journal homepage: www.elsevier.com/locate/biortech

# Anaerobic co-digestion of solid waste: Effect of increasing organic loading rates and characterization of the solubilised organic matter

Rangaraj Ganesh [a], Michel Torrijos [a,*], Philippe Sousbie [a], Jean Philippe Steyer [a], Aurelien Lugardon [b], Jean Philippe Delgenes [a]

[a] INRA, UR50, Laboratoire de Biotechnologie de l'Environnement, Avenue des Etangs, Narbonne F-11100, France
[b] Naskeo Environnment, 52 rue Paul Vaillant Couturier, F-92240 Malakoff, France

## HIGHLIGHTS

- ▶ Co-digestion of waste studied at a low OLR of <2 kgVS/m$^3$ d yielded 0.33 l $CH_4$/gVS fed.
- ▶ OLR increase to a maximum of 7.5 kgVS/m$^3$ d resulted in 20% decrease in methane yield.
- ▶ COD solubilised at high loading was characterized for biodegradability and size-fractionation.
- ▶ Biodegradability of the solubilised organic matter ranged between 10% and 38%.
- ▶ Solubilised COD comprised mostly (82%) of colloidal and very fine particulate organics.

## ARTICLE INFO

*Article history:*
Received 19 September 2012
Received in revised form 14 December 2012
Accepted 15 December 2012
Available online 23 December 2012

*Keywords:*
Co-digestion
Liquid effluent
Size-fractionation
Filtration
Granulometry

## ABSTRACT

The impact of stepwise increase in OLR (up to 7.5 kgVS/m$^3$ d) on methane production, reactor performance and solubilised organic matter production in a high-loading reactor were investigated. A reference reactor operated at low OLR (<2.0 kgVS/m$^3$ d) was used solely to observe the methane potential of the feed substrate. Specific methane yield was 0.33 l $CH_4$/gVS at the lowest OLR and dropped by about 20% at the maximum OLR, while volumetric methane production increased from 0.35 to 1.38 m$^3$$CH_4$/m$^3$ d. At higher loadings, solids hydrolysis was affected, with consequent transfer of poorly-degraded organic material into the drain solids. Biodegradability and size-fractionation of the solubilised COD were characterized to evaluate the possibility of a second stage liquid reactor. Only 18% of the organics were truly soluble (<1 kD). The rest were in colloidal and very fine particulate form which originated from grass and cow manure and were non-biodegradable.



## 1. Introduction

Anaerobic co-digestion, where two or more types of waste are treated in the same digester, has aroused renewed interest due to its inherent advantages. Common benefits of co-digestion include easier handling of mixed waste (Li et al., 2009), adjustment of the carbon-to-nitrogen (C:N) ratio (Xie et al., 2011), dilution of potential toxic compounds, improved balance of nutrients, increased loads of biodegradable organic matter (Gannoun et al., 2007; Bouallagui et al., 2009) and increased gas yields (Fountoulakis et al., 2008; Macias-Corral et al., 2008). Thanks to the positive synergistic effects, the overall result was higher mass conversion and lower weight and volume of residual digested matter (Macias-Corral et al., 2008).

Large-scale biogas plants are often built merely on the basis of conventional plant design or even rule-of-thumb (Lindorfer et al., 2008; Appels et al., 2011) resulting in under or over design. Laboratory and pilot-scale testing on the optimum and maximum organic loading rate applied for the specific substrates involved in co-digestion is highly important for the design and upgrading of biogas plants. Such experiments make it also possible to gain details on system overloading (Angelidaki et al., 2004). Based on pilot-scale studies, Comino et al. (2010) have concluded that most agricultural biogas plants have potential for significant increase in capacity and technological improvements.

The optimization of the organic loading rate (OLR) and the influence of high-loading rates on the post-methane potential of reactor

* Corresponding author. Tel.: +33 468425185; fax: +33 468425160.
*E-mail addresses:* sairganesh@yahoo.com (R. Ganesh), torrijos@supagro.inra.fr (M. Torrijos), sousbie@supagro.inra.fr (P. Sousbie), steyer@supagro.inra.fr (J.P. Steyer), aurelien.lugardon@naskeo.com (A. Lugardon), delgenes@supagro.inra.fr (J.P. Delgenes).

0960-8524/$ - see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.biortech.2012.12.119