Bioresource Technology 130 (2013) 689–695

Contents lists available at SciVerse ScienceDirect

Bioresource Technology

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

Mesophilic anaerobic co-digestion of cow manure and biogas crops in full scale German biogas plants: A model for calculating the effect of hydraulic retention time and VS crop proportion in the mixture on methane yield from digester and from digestate storage at different temperatures

Bernd Linke[a,*], Ivo Muha[b], Gabriel Wittum[b], Vincent Plogsties[a]

[a] Leibniz-Institut für Agrartechnik, Potsdam-Bornim e.V. Max-Eyth-Allee 100, 14469 Potsdam, Germany
[b] Johann Wolfgang Goethe-Universität Frankfurt am Main, Goethe-Center for Scientific Computing (G-CSC), Kettenhofweg 139, 60325 Frankfurt am Main, Germany

HIGHLIGHTS

- New comprehensive model for co-digestion of biogas crops and cow manure.
- Coupling of *HRT* with VS-proportion of biogas crops in the mixture.
- Calculatin of methane yield from digester and storage tank.
- Methane yield in storage tank as function of temperature and storage time.

ARTICLE INFO

Article history:
Received 13 September 2012
Received in revised form 27 November 2012
Accepted 28 November 2012
Available online 8 December 2012

Keywords:
Biogas
Model
Co-digestion
Methane yield
Digestate storage

ABSTRACT

Data from 24 full scale biogas plants in Germany digesting cow manure and crops were evaluated. Special emphasis was given to the effect of hydraulic retention time *HRT* and proportion of crops in the mixture (VS basis) $p^{\mathrm{Inp}}_{\mathrm{VS,Crops}}$ on the methane yield from the digester $y^{\mathrm{D,VS_{Inp}}}_{\mathrm{CH_4}}$ and the storage tank $y^{\mathrm{S,VS_{Inp}}}_{\mathrm{CH_4},T}$ at 37 and 22 °C. The evaluation has shown model parameters for maximal methane yield of manure and crops $y^{\mathrm{eff,VS_{Inp}}}_{\mathrm{max\,CH_4}}$ at 270 and 420 L kg^{-1}, respectively. For example, at *HRT* of 60 days, maximum methane yield result to 249 and 388 L kg^{-1} for a crop proportion in the input of 0.0 and 1.0, respectively. The calculation of $y^{\mathrm{S,VS_{Inp}}}_{\mathrm{CH_4},T}$ considers first order reaction rates and a temperature term f_T. Hence, at any arbitrary temperature in the range of 12 °C < T < 37 °C the values of $y^{\mathrm{S,VS_{Inp}}}_{\mathrm{CH_4},T}$ in the course of time can be calculated, which correspond to methane emissions for uncovered storage tanks.

1. Introduction

Demand for energy and associated services, to meet social and economic development and improve human welfare and health, is increasing. On the other hand recent data confirm that consumption of fossil fuels accounts for the majority of global anthropogenic greenhouse gases (GHG) (EU Directive, 2009). With a 10.2% share of energy sources in total global primary energy supply in 2008, tendency rising, biomass will play a vital role for sustainable energy supply (IPCC, 2012). Among other renewable energy sources, biogas production has shown significant GHG savings compared to the utilization of fossil fuels (Tilche and Galatola, 2008; Holm-Nielsen et al., 2009; Arthurson, 2009; Panwar et al., 2011; Zaks et al., 2011; Maranon et al., 2011; Masse et al., 2011; Meyer-Aurich et al., 2012). Biogas can be produced from a variety of biomass feedstock, including agricultural and livestock residues. Biogas is a versatile renewable energy source, which can be used for replacement of fossil fuels for power and heat production, and as vehicle fuel (Weiland, 2010).

The concept of co-digestion whereby energy rich organic waste material or biogas crops are added to animal manure was realized in large scale biogas plants about two decades ago (Ahring et al., 1992; Tafdrup, 1994; Mata-Alvarez et al., 2011; Gübitz et al., 2010) have shown the state of the art of co-digestion on sewage sludge, the organic fraction of municipal solid waste (OFMSW) and energy crops with recent progress in research on anaerobic digestion. Some papers have dealt with

* Corresponding author. Tel.: +49 3315699110; fax: +49 3315699849.
E-mail address: blinke@atb-potsdam.de (B. Linke).

0960-8524/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.biortech.2012.11.137