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Application of Anaerobic Digestion Model No. 1 for describing anaerobic digestion of grass, maize, green weed silage, and industrial glycerine

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HIGHLIGHTS

- Four substrates were characterized by Weender/van Soest analysis.
- Anaerobic Digestion Model No. 1 was used to model biogas production.
- As an optimization method downhill simplex methods algorithm was applied.
- New kinetic constants indicated satisfactory correlation with experimental values.
- Applicability of the model for optimization of biogas power plants is confirmed.

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ABSTRACT

Anaerobic digestion of organic waste plays an important role for the development of sustainable energy supply based on renewable resources. For further process optimization of anaerobic digestion, biogas production with the commonly used substrates, grass, maize, and green weed silage, together with industrial glycerine, were analyzed by the Weender analysis/van Soest method, and a simulation study was performed, based on the International Water Association's (IWA) Anaerobic Digestion Model No. 1 (ADM1). The simplex algorithm was applied to optimize kinetic constants for disintegration and hydrolysis steps for all examined substrates. Consequently, new parameters were determined for each evaluated substrate, tested against experimental cumulative biogas production results, and assessed against ADM1 default values for disintegration and hydrolysis kinetic constants, where the ADM1 values for mesophilic high rate and ADM1 values for solids were used. Results of the optimization lead to a precise prediction of the kinetics of anaerobic degradation of complex substrates.

1. Introduction

1.1. Biogas modeling through optimization

As anaerobic digestion of organic waste is increasingly practiced to produce biogas as a renewable energy resource (Directive 2009/28/EC, 2009), it is necessary to carry out process optimization based on reliable simulation models.

In order to ensure that a model is useful also for plant operators, a widely accepted model should be the basis of model development. The primary goal is to improve a model already applied in practice with respect to the reliable calculation of digester dynamics for a wide range of substrates. Therefore it was decided to make use of a common model and to analyze the agreement between experimental and calculated data. This analysis shows capabilities and limitations of an established model and gives information about necessary improvements. In the current study, a reliable model for anaerobic digestion of different substrates and their mixtures was developed based on the Anaerobic Digestion Model No. 1 (ADM1). It was shown that ADM1 was capable of describing biogas production rate and composition without major changes to the model structure. Nevertheless, improvement of parameters was necessary since the initial biomass disintegration and hydrolysis phase was not reflected adequately for different substrates.

1.2. Anaerobic Digestion Model No. 1

The Anaerobic Digestion Model No. 1 (ADM1) was developed by the International Water Association's (IWA) Task Group (Batstone et al., 2002). The strength of this model is in its consideration of separate biomass fractions and their decay, apart from incorporating four main stages of anaerobic degradation, and dividing them into 31 processes and 33 groups of fractions. Moreover, the model includes a composite fraction (X_C), which represents a complex substrate. The composite fraction (X_C) is degraded into

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