



Optimizing anaerobic digestion by selection of the immobilizing surface for enhanced methane production

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HIGHLIGHTS

- ▶ The type of immobilizing support contributed over 60% variation in methane yield.
- ▶ Loading rate and inoculum each had an 18% contribution to methane yield.
- ▶ C:N ratio, mixing and trace nutrients had significant interactive effects.
- ▶ Optimization improved methane production by over 150%.

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ABSTRACT

Maximizing methane production while maintaining an appreciable level of process stability is a crucial challenge in the anaerobic digestion industry. In this study, the role of six parameters: the type of immobilizing supports, loading rate, inoculum levels, C:N ratio, trace nutrients concentrations and mixing rate, on methane production were investigated under thermophilic conditions ($55 \pm 1^\circ\text{C}$) with synthetic substrate medium. The immobilizing supports were Silica gel, Sand, Molecular Sieve and Dowex Marathon beads. A Taguchi Design of Experiment (DOE) methodology was employed to determine the effects of different parameters using an L_{16} orthogonal array. Overall, immobilizing supports influenced methane production substantially (contributing 61.3% of the observed variation in methane yield) followed by loading rate and inoculum which had comparable influence (17.9% and 17.7% respectively). Optimization improved methane production by 153% (from 183 to 463 $\text{ml CH}_4 \text{ l}^{-1} \text{ d}^{-1}$).

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1. Introduction

One of the significant environmental challenges facing the world today is global warming which can be mainly attributed to the accumulation of greenhouse gases in the earth's atmosphere (IPCC, 2011). Energy consumption and the agricultural industry are some of the major sources of greenhouse gases; and therefore any attempts to combat the challenges of global warming should have agricultural and energy sustainability as key components of the solution package. Accordingly, in the energy sector, biogas from anaerobic digestion has been identified as an important source of clean energy as it provides an excellent opportunity for reducing greenhouse gases by displacing fossil fuels in domestic

and industrial applications (Yadvika et al., 2004; Sørensen, 2004). Moreover, the digestate produced by anaerobic digestion is increasingly being utilized as a rich source of biofertilizer for the nutrient-hungry agricultural sector due to its peculiar rheology and elemental composition (Shanmugam and Horan, 2009).

Methane fermentation is a complex process which takes place in four inter-connected stages namely hydrolysis, acidogenesis, acetogenesis, and methanation (methanogenesis) (Deublein and Steinhauser, 2008). The stages are linked because the different microbial communities involved in each stage work in sequence, with the products of one stage serving as substrate for the next (Gerardi, 2003). To ensure an efficient process, there is the need to balance the degradation rates of the hydrolytic–acidogenic stage on one hand, and the acetogenic–methanogenic stage on the other hand. Imbalance in these processes has been observed to cause accumulation of organic acids and a reduction in the buffering capacity of the system resulting in reduced methane yield

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