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Optimizing feeding composition and carbon–nitrogen ratios for improved methane yield during anaerobic co-digestion of dairy, chicken manure and wheat straw

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HIGHLIGHTS

- ▶ Co-digestion of multi-substrates, dairy, chicken manure and wheat straw was conducted.
- ▶ Anaerobic co-digestion was optimized by feeding composition (DM/CM) and C/N ratio.
- ▶ Higher synergetic effect showed in mixed DM, CM and WS than single manure with WS.
- ▶ C/N ratios of 25:1 to 30:1 resulted in stable pH, low ammonium nitrogen and free NH_3.
- ▶ Maximize methane potential realized with DM/CM of 40.3:59.7 and C/N of 27.2:1.

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ABSTRACT

This study investigated the possibilities of improving methane yield from anaerobic digestion of multi-component substrates, using a mixture of dairy manure (DM), chicken manure (CM) and wheat straw (WS), based on optimized feeding composition and the C/N ratio. Co-digestion of DM, CM and WS performed better in methane potential than individual digestion. A larger synergetic effect in co-digestion of DM, CM and WS was found than in mixtures of single manures with WS. As the C/N ratio increased, methane potential initially increased and then declined. C/N ratios of 25:1 and 30:1 had better digestion performance with stable pH and low concentrations of total ammonium nitrogen and free NH_3. Maximum methane potential was achieved with DM/CM of 40.3:59.7 and a C/N ratio of 27.2:1 after optimization using response surface methodology. The results suggested that better performance of anaerobic co-digestion can be fulfilled by optimizing feeding composition and the C/N ratio.

1. Introduction

Anaerobic digestion converts plant biomass, crop residues, animal manures, and other organic wastes into methane-rich biogas, which is widely used as a source of renewable energy. As a result of global warming, increases in waste disposal and energy costs and the need for environmentally sustainable waste management, this technology has received great attention, especially in rural areas of developing countries. China produces about 600 million tons of crop straw (of which rice, corn and wheat straw account for 79.5%) and 3.9 billion tons of livestock and poultry manure every year (Zhang et al., 2009). Historically, rural households have used straw and manure as their prime sources of energy, animal feed and fertilizer (Hu et al., 2008). However, with gradual changes in the structure of rural energy consumption in China, commercial energy consumption is increasingly important (Pachauri and Jiang, 2008). The utilization of crop straw and manure as fuel has therefore decreased significantly, which has produced serious environmental pollution. Biogas production from anaerobic digestion of biomass is a technology that can produce sustainable energy and also reduce the environmental risks associated with manure and agricultural waste. By 2010, over 40 million household-scale small digesters and 30,000 large-scale digesters had been built in China.

Co-digestion of various biosolid wastes, which can use the nutrients and bacterial diversity in those wastes to optimize the digestion process, is an attractive approach for improving the efficiency of biotransformation (Wang et al., 2012). Many successful co-fermentation processes using different substrates have shown large increases in methane potential, compared with separate digestion of the substrates. Research by Xie et al. (2011) recommended applying pig manure to grass silage in a ratio of 1:1 in practice due to a high specific methane yield and a short lag phase. Umetsu et al. (2006) showed that the average yield of methane was

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