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Anaerobic treatment of lignocellulosic material to co-produce methane and digested fiber for ethanol biorefining

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HIGHLIGHTS

- Co-digestion of corn stover and swine manure benefited methane/ethanol production.
- The optimal stover-to-manure ratio was 40:60 for maximizing energy output.
- 18% increase on overall net energy output was obtained from the optimal mixing ratio.

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ABSTRACT

Five different ratios of corn stover to swine manure were investigated to evaluate the performance of anaerobic digestion and the quality of anaerobically digested fiber (AD fiber) as a feedstock for bioethanol production. The stover-to-manure ratio of 40:60 generated 364 L biogas and 797 g AD fiber per kg of dry raw feedstock daily. The AD fibers after digestion were pretreated and hydrolyzed to release sugars for ethanol fermentation. The stover-to-manure ratio of 40:60 was able to produce 152 g methane and 50 g ethanol per kg of dry raw feedstock. The net energy generated from the ratio 40:60 was 5.5 MJ kg^{-1} dry raw feed, which was an 18% increase on net energy output compared to the other ratios and proved to be most beneficial for a biorefinery.

1. Introduction

Fuels such as crude oil, natural gas, and coal have played an important part in the advancement of human society. With the intent to reduce foreign oil dependence, create new jobs, and limit pollution emissions, society is looking for new and effective ways to generate energy (Vispute and Huber, 2008). Anaerobic digestion (AD) as an effective method to convert organic material into biogas represents such a promising approach. European countries like Germany and Denmark have long utilized this conversion of waste to energy. The waste treatment capabilities and corresponding energy recovery makes it very attractive to provide a win–win solution for both waste management and bioenergy production (Chen et al., 2008; Vispute and Huber, 2008). Other benefits of anaerobic digestion include the reduction of odor, pathogens, organic matter, and the preservation of plants nutrients (Cantrell et al., 2008; Lansing et al., 2010; Zhu, 2000).

Recently, co-digestion of crop residues and animal manures has attracted much attention due to its capability of largely increasing biogas and methane yields (Wu et al., 2010). There have been recent studies on the co-digestion of swine manure with crop residues. Wu et al. studied the impact on co-digestion of swine manure with corn stocks, oat straw and wheat straw, and it showed a positive effect on biogas production (Wu et al., 2010). This was largely attributed to increasing the carbon to nitrogen ratio within the digesting reactors. Research was also performed with swine manure and cooking grease showing increased energy production as much as 124% (Lansing et al., 2010). Both studies were able to achieve methane concentrations at approximately 68%.

An area of study that has been overlooked is the utilization of the remaining residual solids after digestion for energy production. This is owing to the recalcitrant property and low nutrient value of the solid digestate (Tambone et al., 2009). Recent investigations, though, have concluded that anaerobically treated agricultural wastes, such as digested dairy manure, still contain important components of remaining carbohydrates and lignin that can be used as feedstock in a biorefinery concept (Chen et al., 2005; Yue et al., 2010).

The focus of this study was to apply co-digestion technology on corn stover and swine manure to investigate digestion performance

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