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Review

Achievements of biochar application for enhanced anaerobic digestion: A review

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ABSTRACT

Anaerobic digestion (AD) and pyrolysis are two promising technologies used worldwide for waste biomass treatment. Interests on intensification techniques of AD has been increasing to obtain sufficient and sustainable methane production with stable digester performance. For instance, considerable attention has been devoted to the coupling of AD with biochar, which is produced by biomass thermochemical conversion. This manuscript presents a comprehensive review about recent achievements in enhancing AD efficiency with the utilization of biochar. The key roles of biochar include enhancing and equilibrating hydrolysis, acidogenesis-acetogenesis, and methanogenesis, as well as alleviating inhibitor stress were summarized. Biochar can promote biomethane process mainly by serving as a provision for bioelectrical connections between fermentative bacteria and methanogens, a support for microbial colonies, and a reinforcer for buffer capacity. Through an overview of the early applications, this paper aims to pinpoint the potential mechanism and future explorative directions of biochar enhancing AD performance.

1. Introduction

Biochar as a precursor of activated carbon, is a carbonaceous solid material obtained from the thermochemical conversion of biomass in an oxygen depleted environment (Tan et al., 2017). Various types of wastes such as agricultural wastes (Ahmad et al., 2012), animal manure (Liang et al., 2014), wood (Dugdug et al., 2018) and sewage sludge (Hossain et al., 2011) can be treated as feedstock for biochar formation. The origin of biochar application is serving as soil amendment, which can upgrade the soil quality by increasing carbon sequestration, soil nutrient status, aggregate stability and cation exchange capacity (CEC), adjusting soil pH and reducing the negative effects of toxicants (Butnan et al., 2015; Ghosh et al., 2012; Xu et al., 2014). Due to the eco-friendly features and excellent functions of biochar, its promising application in other aspects of environmental management has captured extensive interests. Biochar can improve the composting process and the compost quality by accelerating the organic matters decomposition, increasing the carbon content of the compost and reducing the compost toxicity (Malinowski et al., 2019; Vandecasteele et al., 2016; Waqas et al., 2018). Moreover, biochar can be used to remove contaminants such as heavy metals (Ding et al., 2016; Ho et al., 2017) and toxic chemicals like organic dyes (Zhang et al., 2019a), toluene (Bhandari et al., 2014), nitrobenzene (Zhao et al., 2018), etc. The major mechanisms supposed for the effective functions of biochar is its favorable physicochemical properties, such as high CEC, large porosity and surface area (Sanchez-Monedero et al., 2018), which enable surface complexation for interaction with nutrient cycles, mineral precipitation for immobilization or adsorption and modified symbiotic relationships between microbial communities (Liu and Fan, 2018; Sohi et al., 2010).

Anaerobic digestion (AD) is an acceptably principal method of organic wastes management (Pfluger et al., 2019), which can allow concomitant energy and resource recover from various types of organic wastes, like crop straw (Yu et al., 2019), wastewater (Shen et al., 2015a), animal manure (Caruana, 2019), food waste (Li et al., 2018b), etc. The AD process is a biological approach performed by consortia of bacteria and archaea under anoxic conditions (Narihiro and Sekiguchi, 2007). To convert organic matters into biogas (mainly composed of methane and carbon dioxide), the anaerobic digester is supposed to go through four sequential stages. The stages involve the decomposition of macromolecular organics into easily dissolved monomers during the hydrolysis step. In the acidogenesis step, the soluble monomers degrade into micromolecular volatile fatty acids (VFAs), lactic acid, alcohol, etc.

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