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Effects of different types of biochar on the anaerobic digestion of chicken manure

Junting Pan[a], Junyi Ma[a], Xiaoxia Liu[b], Limei Zhai[a], Xihui Ouyang[b], Hongbin Liu[a,*]

[a] Key Laboratory of Non-point Source Pollution of Ministry of Agricultural and Rural Affairs, Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, 100081 Beijing, PR China

[b] Environmental Factors Risk Assessment Laboratory of Agricultural Products Quality and Safety of Ministry of Agriculture and Rural Affairs, Beijing Station of Agro-Environmental Monitoring, 100029 Beijing, PR China

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ABSTRACT

This study investigated the impact of different types of biochar on the anaerobic digestion (AD) of chicken manure. Wheat straw, discarded fruitwood, and air-dried chicken manure were pyrolysed at 350, 450, and 550 °C to generate biochar. A lab-scale batch anaerobic digestion experiment was conducted at 35 ± 1 °C. Substantial improvements in methane production were observed for all nine types of biochar. With the production of 294 mL CH_4/g VS_{added}, fruitwood char pyrolysed at 550 °C increased the methane yield by 69% from the control. Characteristic analysis indicated that fruitwood char pyrolysed at 550 °C exhibited the largest specific surface area and highest total ammonia nitrogen reduction capacity. The buffering capacity of the AD system was improved by the biochar through accelerating the transformation of macromolecular substances to dissolved substrates and reducing the contents of soluble salts, total ammonia nitrogen, and free ammonia.

1. Introduction

Biochar is a stable, carbon-rich by-product synthesised by pyrolysis, which is a cost-effective technology for treating biomass with the flexibility to obtain a combination of solid, liquid, and gaseous products (Song et al., 2018a). Biochar has several properties, such as its high specific surface area, porosity, and cation exchange capacity (CEC) (Sun et al., 2018), which make it an efficient material for removing contaminants. The distinctive characteristics of biochar are closely related to its formation process. The composition of C and N will decrease with increasing pyrolysis temperatures due to combustion and volatilisation, while the P, Ca, and Mg contents will increase as the temperature increased (Cao and Harris, 2010). The composition of hydrogen and oxygen also decrease with increasing temperature, resulting in a decrease in biochar polarity (Godlewska et al., 2017). A variety of biomass types can be used as feedstock for pyrolysis, and the type of feedstock selected affects the biochar's properties. For example, biochar produced from animal manure exhibits a smaller specific surface area than that derived from crop residue and wood biomass (Ahmad et al., 2014). Owing to its favourable properties, substantial attention has been paid to using biochar for numerous environmental applications, such as soil remediation, pollutants removal, and carbon sequestration (Sohi et al., 2010).

Anaerobic digestion (AD) is a sustainable technology used for organic waste disposal, which can reduce sludge and generate renewable energy in the form of biogas (Song et al., 2018b). Other benefits associated with AD include the reduction in greenhouse gas emissions, procuring additional income for farmers, recycling of nutrients, and the decrease in pollution (Bareha et al., 2018). It is difficult to maintain the stability of AD reactors due to the accumulation of toxic inhibitors, unsteady pH, or other key factors (Chen et al., 2008b). To take better advantage of AD technology, extensive efforts have been dedicated to preventing disturbance and increasing energy efficiency through mechanical, physical, chemical, or biological methods (Gil et al., 2018; Montalvo et al., 2018). As increasing amounts of animal products are required to meet the demands of the increasing global population, the environmental impacts of animal manure generation and disposal are becoming increasingly severe (He et al., 2016). AD is a favourable and sustainable method for treating animal manure with their high protein and organics content (Molinuevo-Salces et al., 2013). Chicken manure, which is an organic waste with a high ammonium content, has been investigated as a representative of N-rich feedstock (Wu et al., 2016). The co-digestion of different substrates, technical stripping, and biological enzymes or trace elements treatments were applied in previous studies (Molaey et al., 2018; Nie et al., 2015). These approaches could effectively dissolve chicken manure and mitigate the accumulation of ammonia, while increasing the complexity and cost of the operation.

* Corresponding author.
E-mail address: liuhongbin@caas.cn (H. Liu).

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