Bioresource Technology 343 (2022) 126086

Contents lists available at ScienceDirect

Bioresource Technology

journal homepage: www.elsevier.com/locate/biortech

Influence of augmentation of biochar during anaerobic co-digestion of *Chlorella vulgaris* and cellulose

Jessica Quintana-Najera [a], A. John Blacker [a,b], Louise A. Fletcher [c], Andrew B. Ross [a,*]

[a] *School of Chemical and Process Engineering, University of Leeds, LS2 9JT Leeds, UK*
[b] *Institute of Process Research and Development, School of Chemistry, University of Leeds, LS2 9JT Leeds, UK*
[c] *School of Civil Engineering, University of Leeds, LS2 9JT Leeds, UK*

HIGHLIGHTS

- Biochar addition improved biomethane yield particularly at less favourable ISR 0.5–0.9.
- Biochar provided a buffering effect at lower ISR and C/N ratio.
- Factorial regression model provided optimal anaerobic co-digestion conditions.
- Biochar effect is highly dependent on the digestion conditions.

ARTICLE INFO

Keywords:
Anaerobic co-digestion
Biochar
Pyrolysis
Biomethane optimization
Microalgae

ABSTRACT

The anaerobic co-digestion (AcoD) of microalgae is a prospective option for generating biomethane from renewable sources. This study investigates the effects of inoculum-to-substrate ratio (ISR), C/N ratio and biochar (BC) load on the AcoD of *Chlorella vulgaris* and cellulose. An initial augmentation of BC at ISR 0.5–0.9 and C/N ratio 10–30 offered a pH buffering effect and resulted in biomethane yields of 233–241 mL CH_4/g VS, corresponding to 1.8–4.6 times the controls. BC addition ameliorated significantly AcoD, supporting the digestate stability at less favourable conditions. The effect of the process variables was further studied with a 2^3 factorial design and response optimisation. Under the design conditions, the variables had less influence over methane production. Higher ISRs and C/N ratios favoured AcoD, whereas increasing amounts of BC reduced biomethane yield but enhanced production rate. The factorial design highlighted the importance of BC-load on AcoD, establishing an optimum of 0.58 % (w/v).

1. Introduction

Biomethane is a valuable option towards a sustainable and low-emissions future due to its compatibility with gas infrastructure. Currently, biomethane represents only 0.1% of natural gas demand, however, recent policy changes towards decarbonising transport are supporting its injection into natural gas grids. Many countries like Germany, Netherlands, United Kingdom, Brazil and the USA are supporting the introduction of biomethane into the transport sector. Since 2010, the installed biogas power generation capacity has been growing 4 % annually, however, this future development is highly dependent on feedstock availability (IEA, 2020).

Microalgae is an attractive feedstock for biofuel production due to their highly productive growth, and photosynthetic solar efficiency that doubles the terrestrial plants. Among the advantages of microalgae is the utilisation of land areas unsuitable for food production, utilise carbon dioxide emissions, resulting in lower land-use footprint and providing carbon–neutral biofuels. There are different types of microalgae, including the ‘weed’ green species *Chlorella vulgaris,* which is considered a rich biomass source, with a low content of toxic compounds, rapid growth rate and high protein content (Chronakis and Madsen, 2011). However, the demanding nutrient requirements and recalcitrant cell wall of *C. vulgaris* hinders its biodegradability (BD) (Ward et al., 2014). Increasing the BD of microalgae can be achieved by physical–chemical pre-treatments, however, this is often uneconomically or energetically unjustified.

Coupling microalgae cultivation with anaerobic digestion (AD) is suggested to overcome some of the inherent limitations (Ward et al.,

* Corresponding author.
E-mail address: a.b.ross@leeds.ac.uk (A.B. Ross).

https://doi.org/10.1016/j.biortech.2021.126086
Received 4 August 2021; Received in revised form 30 September 2021; Accepted 1 October 2021
Available online 6 October 2021