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Removal of ammonia from rubber wastewater using rubber-sludge-based biochar to enhance biogas production

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A B S T R A C T

Anaerobic digestion of rubber wastewater (ADRW) is an option for methane derivation for biogas production. However, the ammonia content in rubber wastewater, known as ammonia inhibition, has made the practical implementation of ADRW not yet feasible due to anaerobic digestion (AD) instability and low substrate degradation. Numerous studies have mentioned the use of biochar to overcome its inhibitory effect in AD. However, there are no report on the performance of rubber-sludge-based biochar (RSB) for removing ammonia from rubber wastewater to enhance biogas production. Therefore, this study investigates the potential of RSB to remove ammonia from wastewater to enhance biogas production. Initially, the RSB adsorbent was prepared by facile carbonization method and characterized with scanning electron microscopy (SEM), N_2 physisorption, Fourier transform infrared (FTIR) spectroscopy, and elemental analysis. The performance of the RSB adsorbent for ammonia removal from wastewater was examined using the one -factor -at -one -time (OFAT) adsorption method. The AD process was then conducted using the treated wastewater. The results show that RSB possessed significant porous structure with high carbon content and a surface area of 20.3218 m^2/g. The highest ammonia removal was 7.5 mg/l at an initial adsorbent loading dosage of 1.5 g of RSB for 30 min of mixing. Further, during the AD process, the highest biogas yield of 19.061 ml/g was achieved after 28 days at pH 8. Approximately 83 % of the methane composition was obtained from the biogas yield, indicating that the RSB contributes to the enhancement of biogas production by removing ammonia from rubber wastewater.

1. Introduction

The increasing production of rubber wastewater is very concerning, especially when Malaysia has a large rubber industry that grows each year with the increase in demand (Ali et al., 2021; Ho et al., 2023; Lim et al., 2022). Therefore, the direct discharged to nearby streams or rivers and on land will lead to environmental pollution. Besides, rubber wastewater contains a large number of organic substances that can be harmful to the ecosystem. High level of hazardous pollutants in this wastewater can result in eutrophication and oxygen depletion in receiving waters, which kill aquatic life (Akindele and Sartaj, 2018). One of the approaches to solving this issue is by converting wastewater into alternative energy sources, such as producing biogas (Zarghami Qaretapeh et al., 2024).

Biogas is a mixture of gases formed by the biological degradation of organic matter in the absence of oxygen (Kaur et al., 2024; Qu et al., 2023). It is a colourless combustible gas that can be used as automotive fuel and for electricity generation utilization (Farrukh et al., 2024; He et al., 2024). Primarily, biogas comprise of methane (CH_4), carbon dioxide (CO_2), and other gases such as hydrogen (H_2), nitrogen (N_2) and hydrogen sulphide (H_2S)(Li et al., 2023; Paranjpe et al., 2023). Generally, the production of biogas involves anaerobic digestion (AD) from three primary categories of biomass; namely, energy crops (sugar beet, maize), organic waste (wastewater, municipal solid waste), and aquatic biomass (microalgae) (Atelge et al., 2021). However, numerous studies have mentioned various types of wastewater as feedstock for biogas production (Chen et al., 2023; Domrongpokkaphan et al., 2021; Karray et al., 2017; Raketh et al., 2021).

However, ammonia content in wastewater significantly contributes to instability, low degradation, and even failure of AD system, known as ammonia inhibition (Ambaye et al., 2021; Gao et al., 2021; Qu et al.,

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