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Role of Yeast-Based Bioadditive on Controlling Lignin Inhibition in Anaerobic Digestion Process

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Abstract : Anaerobic digestion (AD) has been used since time in memorial to take care of organic wastes in the environment, especially for sewage and wastewater treatments. Recently, the rising demand/need to increase renewable energy from organic matter has caused the AD substrates spectrum to expand and include a wider variety of organic materials such as agricultural residues and farm manure which is annually generated at around 140 billion metric tons globally. The problem, however, is that agricultural wastes are composed of materials that are heterogeneous and too difficult to degrade -particularly lignin, that make up about 0–40% of the total lignocellulose content. This study aimed to evaluate the impact of varying concentrations of lignin on biogas yields and their subsequent response to a commercial yeast-based bioadditive in batch anaerobic digesters. The experiments were carried out in batches for a retention time of 56 days with different lignin concentrations (200 mg, 300 mg, 400 mg, 500 mg, and 600 mg) treated to different conditions to first determine the concentration of the bioadditive that was most optimal for overall process improvement and yields increase. The batch experiments were set up using 130 mL bottles with a working volume of 60mL, maintained at 38°C in an incubator shaker (150rpm). Digestate obtained from a local plant operating at mesophilic conditions was used as the starting inoculum, and commercial kraft lignin was used as feedstock. Biogas measurements were carried out using the displacement method and were corrected to standard temperature and pressure using standard gas equations. Furthermore, the modified Gompertz equation model was used to non-linearly regress the resulting data to estimate gas production potential, production rates, and the duration of lag phases as indicatives of degrees of lignin inhibition. The results showed that lignin had a strong inhibitory effect on the AD process, and the higher the lignin concentration, the more the inhibition. Also, the modelling showed that the rates of gas production were influenced by the concentrations of the lignin substrate added to the system – the higher the lignin concentrations in mg (0, 200, 300, 400, 500, and 600) the lower the respective rate of gas production in ml/gVS.day (3.3, 2.2, 2.3, 1.6, 1.3, and 1.1), although the 300 mg increased by 0.1 ml/gVS.day over that of the 200 mg. The impact of the yeast-based bioaddition on the rate of production was most significant in the 400 mg and 500 mg as the rate was improved by 0.1 ml/gVS.day and 0.2 ml/gVS.day respectively. This indicates that agricultural residues with higher lignin content may be more responsive to inhibition alleviation by yeast-based bioadditive; therefore, further study on its application to the AD of agricultural residues of high lignin content will be the next step in this research.

Keywords : anaerobic digestion, renewable energy, lignin valorisation, biogas
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