INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title:
DEVELOPMENT OF A NOVEL STRATEGY FOR CLEAN BIOGAS GENERATION FROM ORGANIC WASTES THROUGH ANAEROBIC DIGESTION PROCESS

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SHORT ABSTRACT

Organic wastes such as cattle dung (CD) or food waste (FW) are the most abundant waste resources and contain high moisture and volatile organic solids. The landfill of such organic waste creates adverse environmental impacts due to the formation of leachates, contamination of soil and groundwater, and the emission of harmful gases. Among the various strategies for reducing emissions, anaerobic digestion (AD) is a highly appropriate and adaptable technology for managing biodegradable waste materials, which converts organic waste into biogas. However, various operating parameters like substrate mixing ratio, pH value and temperature affect the AD process. This study achieved the ideal substrate-water (S/W) ratio at 50:50 for cattle dung (CD) and cooked kitchen waste (CKW), whereas it was 60:40 for vegetable waste (VW). Further, controlled digesters (35±2°C) exhibited higher biogas generation rates than ambient temperature. Anaerobic co-digestions (AcoD) of VW and CKW with CD under controlled and uncontrolled temperatures were also studied by varying the co-substrate mixing ratios (SMR) without and adding biochar (BC) derived from biomass wastes, considering the ideal S/W ratio 50:50. Considerably, the BC-added and mesophilic digesters achieved a higher cumulative methane yield (CMY) than the respective digesters without BC. This improvement can be attributed to BC's porous structure, functional groups, and alkali and alkaline earth elements within it. In the case of AcoD of CD and VW, the maximum CMY was detected for the SMR of 60%CD:40%VW, whereas the maximum CMY was achieved at SMR of 40%CD:60%CKW for AcoD of CD and CKW. Additionally, the addition of 15 g/L BC achieved the highest CMY, recommending it as the optimal amount of BC addition for the AcoD of CD and FW. This study discloses that BC addition is a significant approach to increasing CH_4 yield. Furthermore, in order to check the feasibility of the optimum S/W 50:50 ratio obtained from a batch study on a lab scale, a field-scale experiment was performed in a 1 m^3 capacity AD plant using CD as a substrate. The integration of the solar energy-assisted heating (SAH) system during the winter season improved the cumulative biogas yield by an average of 9.93% over the digester without the SAH system.

This study confirms that adopting a passive SAH system for a field-scale AD plant is a novel approach towards enhancing the biogas yield. The present studies also confirmed that biogas production depends on the substrates used, climatic conditions, and technology adapted for production, which affect the composition of generated biogas. CO_2 and other trace gases, such as H_2S, water vapour, etc., must be removed to enhance biogas's energy content and calorific value for various applications like electricity generation and direct heat production. In this regard, a cost-effective fixed-bed adsorbent column purification system was developed to study the biogas upgradation using BC derived at different pyrolysis temperatures of 550°C, 450°C, and 350°C from coconut husk (CH), sugar cane bagasse (SB) and water hyacinth (WH) biomasses. Results indicated that BC prepared at higher pyrolysis temperatures demonstrated higher adsorption capacities for CO_2 and H_2S, with a CO_2 removal efficiency of 55.02%, 49.65% and 45.22% for CH, SB and WH-based BC, respectively. Amongst several factors affecting CO_2 and H_2S adsorption, the surface area played an important role in adsorption along with the associated factors like pyrolysis temperature, surface functional groups, and alkaline and alkaline earth elements in the BCs. This study highlights the potential of using biochar derived from various waste biomasses as an effective adsorbent for biogas upgrading.