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Performance of thermophilic anaerobic digestion of slaughterhouse waste for methane production

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Introduction :

The growing concern over environmental pollution and the need for sustainable waste management have renewed attention to the valorization of organic waste streams [1, 2]. Among these, slaughterhouse animal fat (SHAF) is a highly energy-rich yet underutilized by-product. However, its high lipid content poses operational challenges during anaerobic digestion (AD), such as the inhibition of methanogenic bacteria by long-chain fatty acids (LCFAs) [3, 4]. This study investigates the feasibility and efficiency of thermophilic anaerobic digestion of SHAF in a pilot-scale reactor. The primary objective are to evaluate methane production potential, substrate degradation performance, and overall process stability. The results contribute to improving waste-to-energy conversion and promoting circular economy strategies in slaughterhouse waste management.

Materials and substrate characterization

The SHAF used in this study consisted mainly of animal fats and entrails, collected from a slaughterhouse and homogenized prior to digestion. Cow dung, pre-incubated under anaerobic conditions, served as the inoculum. A 30 L stainless steel digester was loaded with 1 kg of SHAF and 25.21 kg of inoculum and operated at 55°C for 40 days. Initial characterization showed that SHAF had a total solids (TS) content of 35.83% and a high volatile solids (VS) fraction of 96.38%, indicating a high organic content suitable for biogas production. The initial chemical oxygen demand (COD) was 56.72 g O_2/L, and the initial pH of the inoculum was 8.29.

Results :

Process Monitoring and Stability

The pH remained within the optimal range (7.15–8.25), stabilized by the buffering capacity of the cow dung. A temporary accumulation of volatile fatty acids (VFA) was observed early in the digestion, reaching 2.9 g/L by day 6, but this was later reduced as methanogenesis advanced. The VFA/TA ratio, a key indicator of digester stability, remained below the inhibition threshold, confirming the process stability.

Substrate degradation and biogas production

During the 40-day digestion period, TS and VS were reduced by 24.88% and 29.53%, respectively. COD removal reached 56.14%, indicating effective organic matter biodegradation.

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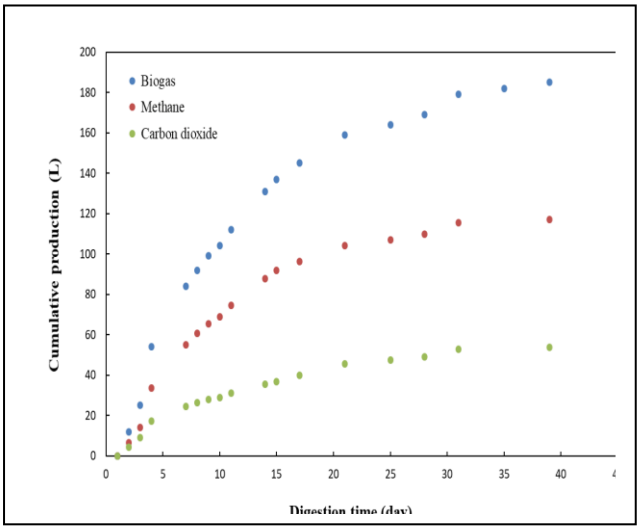
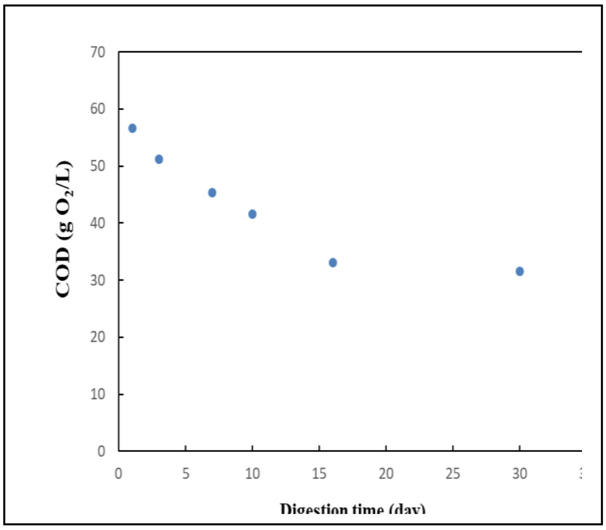
Biogas production followed typical AD kinetics, with an initial exponential phase from day 0 to 22, followed by a plateau. CH_4 production peaked early and stabilized for several days, reflecting efficient methanogen activity. Daily CH_4 concentrations remained between 67% and 71% for most of the fermentation. CO_2 levels decreased from 44% to 24% by day 4, suggesting active conversion of CO_2 to CH_4 via hydrogenotrophic methanogens. Methane production stopped around day 31 due to substrate depletion.





Conclusion :

This study confirms that thermophilic mono-digestion of SHAF is viable, stable and high-yield process for methane production. The use of untreated substrate in a pilot-scale digester demonstrated high methane yields without the need for co-substrates or chemical pretreatments. These results show the potential of SHAF as a valuable feedstock for bioenergy production and support its integration into circular economy strategies for organic waste valorization. Future research should investigate microbial community dynamics, kinetic modelling, and co-digestion processes to enhance methane productivity and operational stability under full-scale industrial conditions.

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