

Process Stability and Organic Matter Conversion Performance of a Semi-dry Anaerobic Digestion of Pig Manure

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1 Introduction

Anaerobic digestion (AD) was ideal for treating pig manure. Conventional AD typically handled total solids (TS) ranging from 2% to 6%, with concentrations above 8% considered high (Liu *et al.*, 2016). High-concentration AD mitigated these issues but faced hurdles with high volatile solids (VS) content (over 60%) (Wu *et al.*, 2017). Besides, high TS conditions posed challenges in methane production and process stability compared to wet process. However, research on achieving continuous and stable AD with exclusively high solid concentration pig manure was limited, as was understanding the flow distribution of chemical oxygen demand (COD) and mass conversion in high-solid pig manure AD. In this study, a continuous stirred-tank reactor with high solid concentration of pig manure was run for a long time to investigate the conversion performance and process stability.

2 Material and methods

The CSTR operated at 37°C. The working volume was 3 L with a Hydraulic Retention Time (HRT) of 60 days, leading to an operational duration of approximately 140 days. Then the HRT changed to 30 days, the working volume was 4 L, and the reactor continued its operation for about 170 days. The characteristics of pig manure was TS=15.0%, VS=10.8%, pH=6.7 and TCOD, soluble chemical oxygen demand (SCOD), total ammonia nitrogen (TAN) was 170.4 g/L, 19.2 g/L, 1.3 g/L, respectively.

3 results and discussion

3.1 Biogas and biomethane production performance in the long term operation

Fig.1 reflected the gas production of the system. When the HRT was 60 days, the stability of gas production was stronger compared to HRT 30 days. The volumetric biogas production rate ranged from 0.75 to 1 L/(L·d) at HRT 60 days. The extension of the HRT from 30 days to 60 days resulted in significant improvements in both average biogas and methane yields. The biogas yield increased from 0.34 to 0.49 L/g-VS, and the methane yield rose by 0.09 L/g-VS, reaching 0.30 L/g-VS. The methane concentration remained relatively stable within the range of 60%-65% without notable variations. It was similar to other research of pig manure AD, which methane content was also around 65% (Lin *et al.*, 2022).

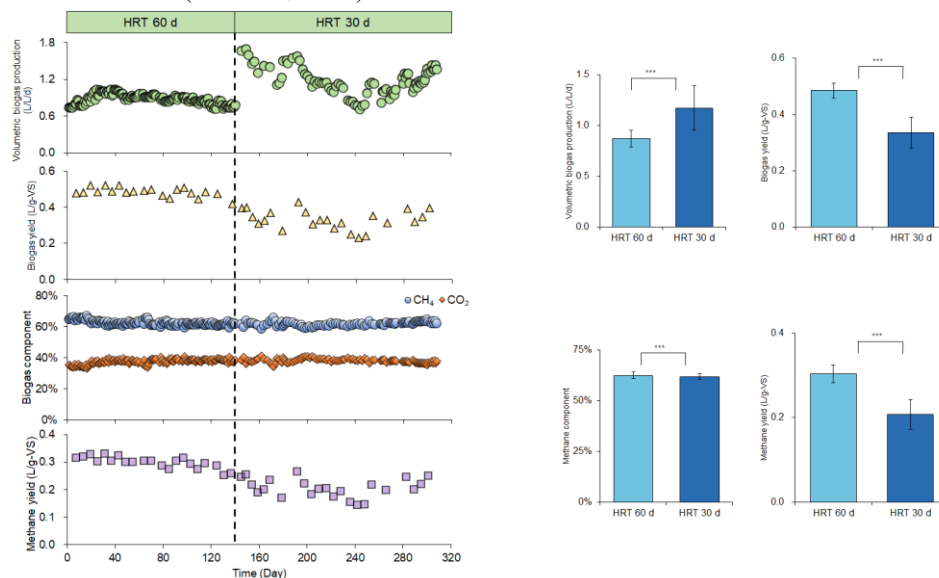


Fig.1 The gas production during the operation.

3.2 process stability performance

Fig.2 shown the process stability. At HRT 60 days, the concentration of VFAs relatively remained at a lower level, fluctuating between 300-500 mg/L. For HRT 30 days, the minimum concentration of VFAs occurred around 60 days, primarily composed of acetic acid and propionic acid at concentrations of approximately 120 mg/L and 100 mg/L, respectively. Fig.3 illustrated the change of VFAs and pH during a 24-hour feeding cycle. Under a 30-day HRT, the overall patterns for total VFAs, acetic acid, and propionic acid are similar.

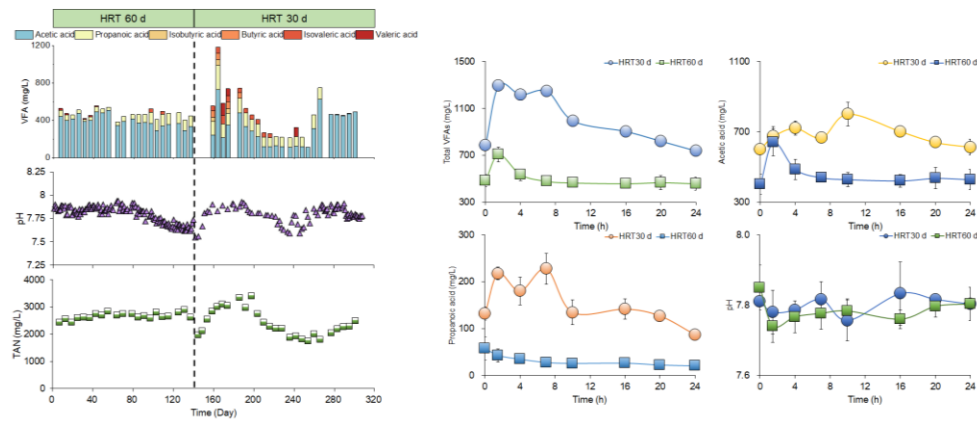


Fig.2 The system stability during the operation.

Fig.3 The change of VFAs and pH in 24 h.

3.3 removal efficiency and mass balance

At HRT 60 days, the removal efficiencies for TS, VS, and COD were 39.3%, 53.4%, and 47.6%, respectively. And the removal efficiencies for TS, VS, and COD were 26.1%, 34.3%, and 37.4%, respectively at HRT 30 days. According to the material balance, at HRT 60 days, 40%-50% of the organic matter was converted into methane, whereas only 30% of the organic matter was transformed into methane at HRT 30 days. The extension of HRT was more conducive to the degradation of organic matter within the system.

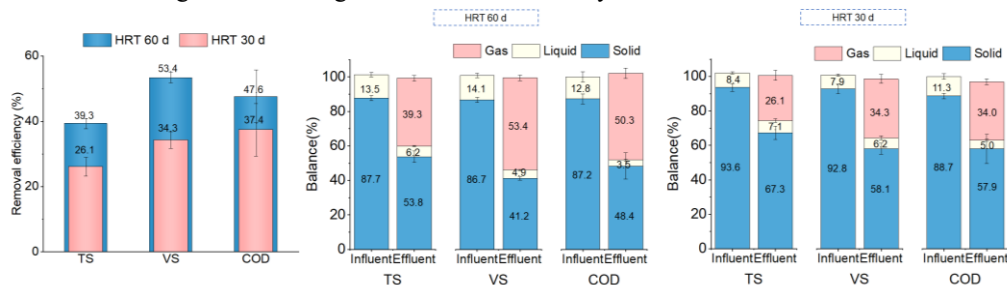


Fig.4 Organic matter removal and mass balance within the system.

4 conclusions

A semi-dry AD system with pig manure at 37°C could achieve long-term stability, with the system being more stable at HRT 60 days. Extending the HRT from 30 days to 60 days could improve the conversion efficiency of organic matter from 30%-40% to 40%-50%. It's advisable to consider extending the HRT appropriately to enhance system stability and material conversion efficiency in high solid pig manure AD.

Reference

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