Effects of Sulfate and Ammonia Concentrations of The High Solid Food Waste on The Performance of The Anaerobic Digestion for Methane Generation

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Background

Food waste TS=20%~30%

Sustainable treatment method →

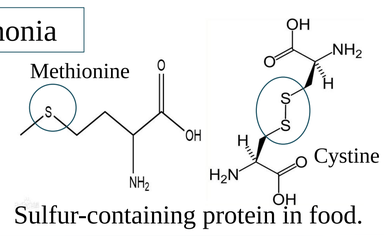
High solid anaerobic digestion (HS-AD)

Parameters affecting HS-AD performance →

- **Operating conditions**: pH、Temperature、Inhibitors
- **Feedstock characteristics**: Composition、C/N ratio…
- **Process control**: Inoculum、Percolate recirculation …

Fatty acids + Sulfate

Ammonia



Sulfur-containing protein in food.

Methods & Results

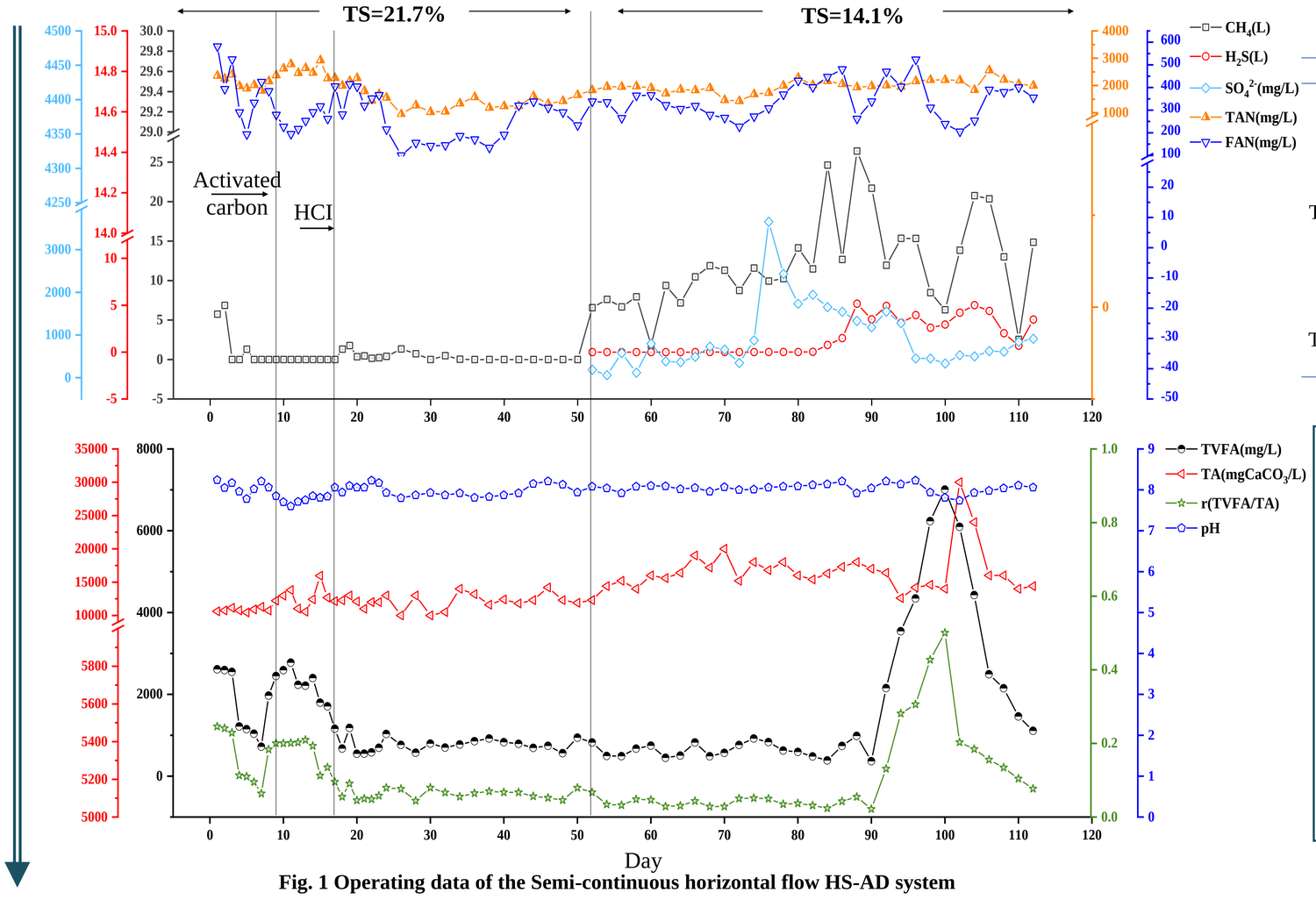


Fig. 1 Operating data of the Semi-continuous horizontal flow HS-AD system

Table 1 C and N distributions of the Semi-continuous horizontal flow HS-AD system

C%	15d	20d	40d	60d
TC in solid	25.61%	26.44%	26.86%	25.39%
TC in liquid	29.10%	29.97%	51.78%	38.30%
CH_4 in gas	7.72%	9.23%	0.58%	4.12%
CO_2 in gas	9.69%	11.58%	0.99%	5.28%
TC in discharged sludge	0.76%	0.78%	1.36%	1.00%
N%				
TN in solid	27.53%	28.36%	29.19%	27.95%
TN in liquid	48.50%	54.19%	64.21%	69.42%
TN in discharged sludge	0.76%	0.78%	1.36%	1.00%

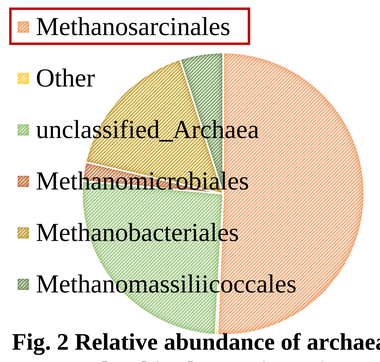


Fig. 2 Relative abundance of archaea at genus level in the Semi-continuous horizontal flow HS-AD system.

- More than **20%** solid content, more than **2000** mg/L ammonia nitrogen concentration, and **3500** mg/L sulfate will have different degrees of **negative** effects on methane production.
- The effect of sulfate on the methane production of the system has a **lag period.**
- Most **C** and **N** remained in **liquid** form.
- The main flora in the system was **methanosarcinales.**

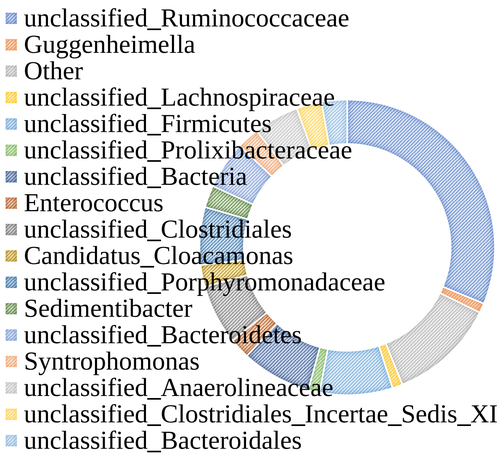


Fig. 3 Relative abundance of bacteria at genus level in the Semi-continuous horizontal flow HS-AD system.

HS-AD reactors reactor volume of 500 mL

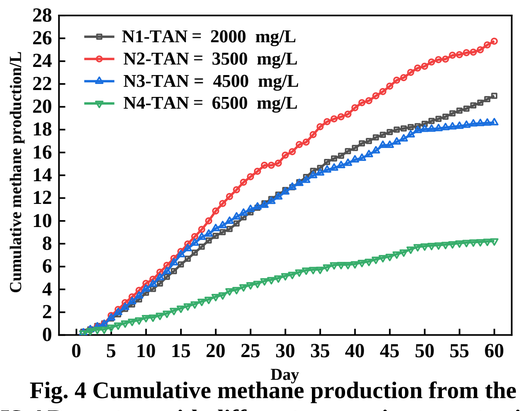


Fig. 4 Cumulative methane production from the HS-AD reactors with different ammonia concentrations

- The reactor with ammonia nitrogen concentration of **3500** mg/L had the **highest** cumulative methane production(25.74L).
- There was no significant difference in the amount of COD（acetate） and COD（CH_4）in the reactor with ammonia nitrogen concentration of **6500.**
- The accumulation of **acetate** in the reactor is the main cause of the reduction of methane production.

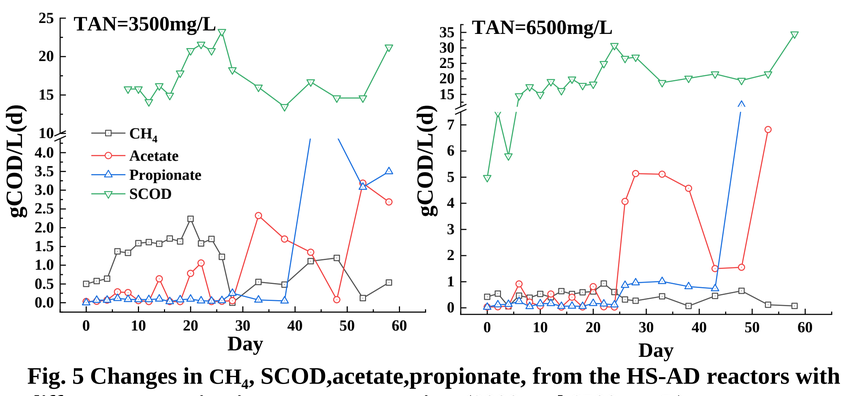


Fig. 5 Changes in CH_4, SCOD,acetate,propionate, from the HS-AD reactors with different ammonia nitrogen concentrations(2000 and 6500 mg/L).

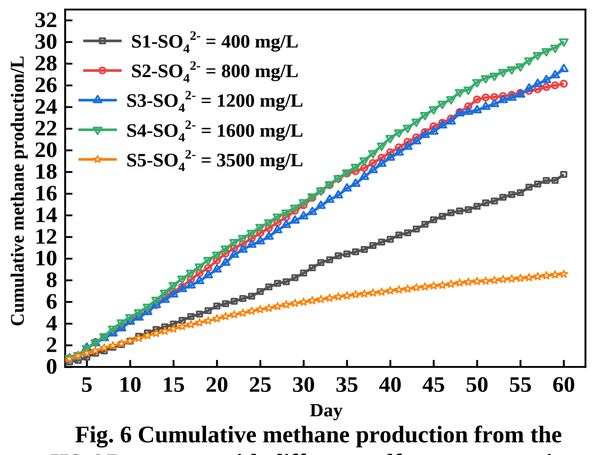


Fig. 6 Cumulative methane production from the HS-AD reactors with different sulfate concentrations

- The concentration of **1600** mg/L sulfate would significant enhance the methane production (30.05L).
- In the reactor with sulfate concentration of **3500** mg/L , **acetate** and **propionate** continued to accumulate.

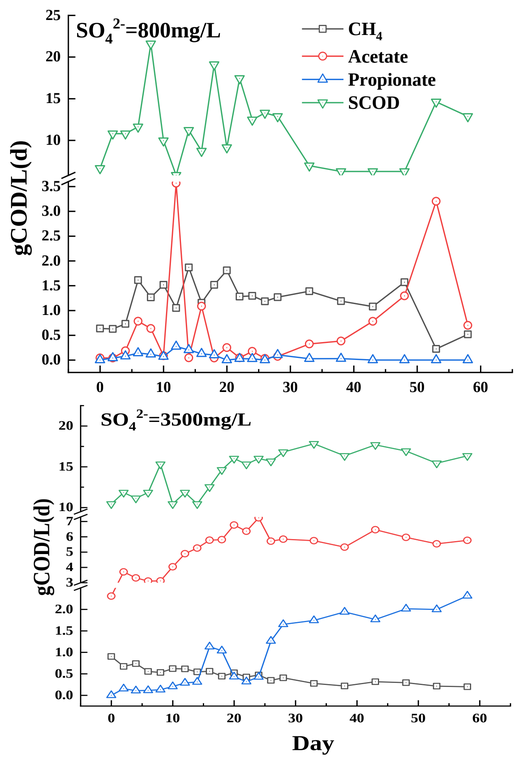


Fig. 7 Changes in CH_4, SCOD,acetate,propionate, from the HS-AD reactors with different sulfate concentrations(800 and 3500 mg/L).

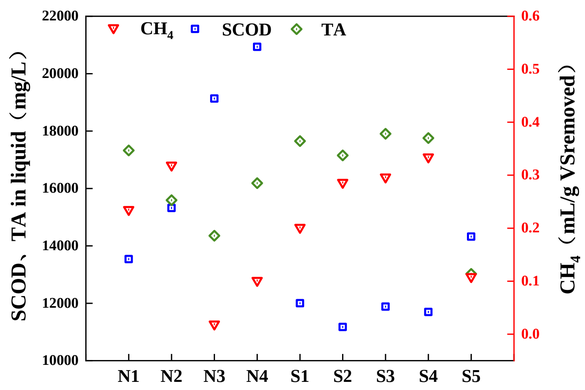


Fig. 8 Changes in CH_4, SCOD and TA from the HS-AD reactors with different ammonia and sulfate concentrations

Table 2 C and N distributions of eight HS-AD reactors

C%	N1	N2	N3	N4	S1	S2	S3	S4	S5
TC in solid	17.39%	16.40%	16.69%	16.11%	16.85%	15.46%	16.37%	17.28%	17.77%
TC in liquid	45.90%	45.03%	47.53%	48.34%	34.91%	32.93%	36.68%	34.42%	58.06%
CH_4 in gas	7.73%	8.64%	5.84%	3.28%	7.72%	9.35%	7.07%	8.96%	2.11%
CO_2 in gas	9.09%	10.10%	8.30%	5.00%	8.94%	8.63%	11.36%	11.13%	3.72%
TC in discharged sludge	0.52%	1.78%	1.88%	1.91%	1.38%	1.30%	1.45%	1.36%	2.29%
N%									
TN in solid	14.92%	14.64%	17.32%	16.02%	14.04%	12.42%	13.35%	13.39%	13.58%
TN in liquid	82.93%	76.26%	79.34%	73.21%	83.53%	71.41%	74.71%	80.22%	62.48%
TN in discharged sludge	2.41%	2.14%	3.14%	2.89%	3.30%	2.82%	2.92%	3.17%	2.47%

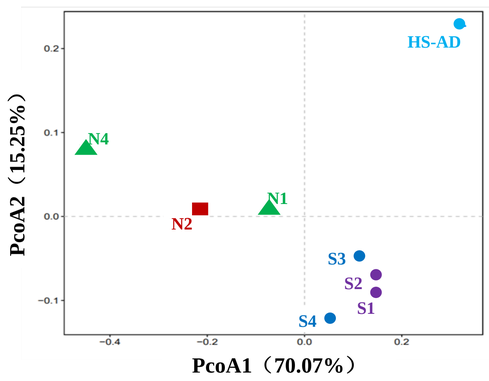


Fig. 9 Principal co-ordinates analysis of the HS-AD reactors (N1、N2、N4、S1、S2、S3、S4 and Semi-continuous horizontal flow HS-AD system).

- HS-AD reactors can maintain alkalinity above 10,000 mgCaCO3 mg/L.
- In the reactor with different sulfate concentration within 1600 mg/L, the utilization rate of **C** is higher than that with different ammonia nitrogen concentration.
- The microbial species in the reactor with different ammonia nitrogen concentration are different greatly.

Conclusions

- The solid-liquid distribution of **C** and **N** in the HS-AD has no significant correlation with the concentration of ammonia nitrogen and sulfate.
- The HS-AS system can even tolerate as high as **3500-4500** mg/L ammonia nitrogen concentration.
- The presence of sulfate can accelerate the methane production by improving the methanation rate of organic carbon, at sulfate concentrations of **800–1200** mg SO_4^{2-} /L.