ATHENS 2014 International Conference on Sustainable Solid Waste Management
Athens - Greece from 12th to 14th June 2014

Tianjin University

Hydrogen and methane production from waste activated sludge and food waste by two-stage fermentation process

Liu Xinyuan, Li Ruying, Ji Min

Tianjin University, Tianjin, China

Contents

Backgrounds

Characteristics of Waste Activated Sludge

- Hazardous organic and inorganic matters, such as pathogens, organic pollutants, heavy metals, et al.

Backgrounds

Anaerobic digestion process —Biomass resource

Two-stage fermentation process

- Tolerance to high loading rate
- Resistance to toxic shocks
- Increase of energy yield and organic removal efficiency
- **Collection of hydrogen—ideal clean fuels**

Backgrounds

Waste activated sludge

- Low C/N
- Flocculated structure

Is it possible to produce hydrogen from waste activated sludge?

Backgrounds

Is it possible to produce hydrogen from waste activated sludge?

Pretreatment

Break the flocculated structure;

Release the component;

Co-digestion process

Increase the C/N;

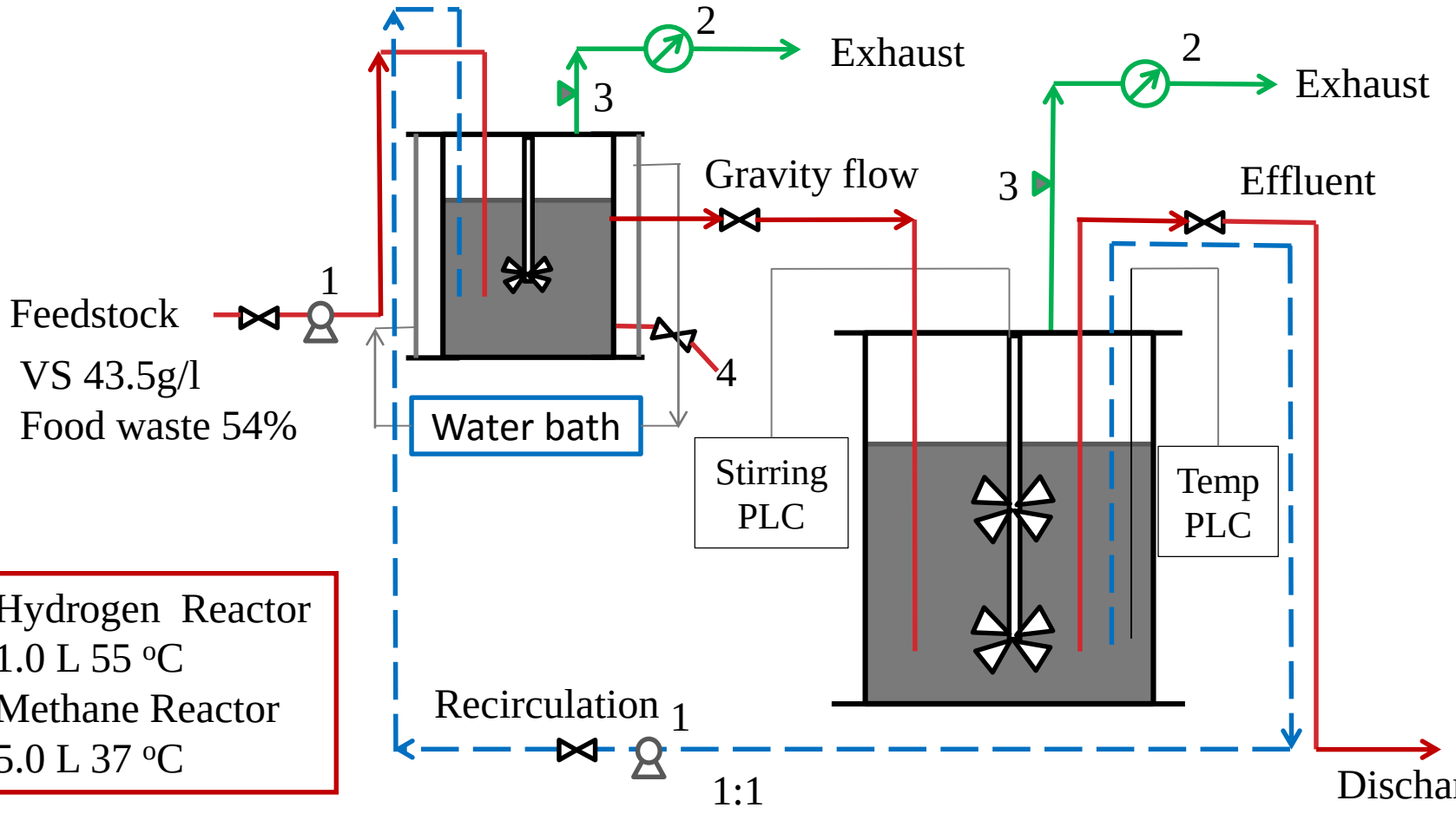
Adjust the nutrition balance;

Advantages for co-digestion process

- Treat two kinds of organic waste
- Low cost without extra investment on pretreatment

Food waste

Two-stage Fermentation Reactor



1-Peristaltic pump 2-Gas meter 3-Gas sampling 4-Liquid sampling


BIOTECH www.bxbio.com

Two-stage Fermentation Reactor

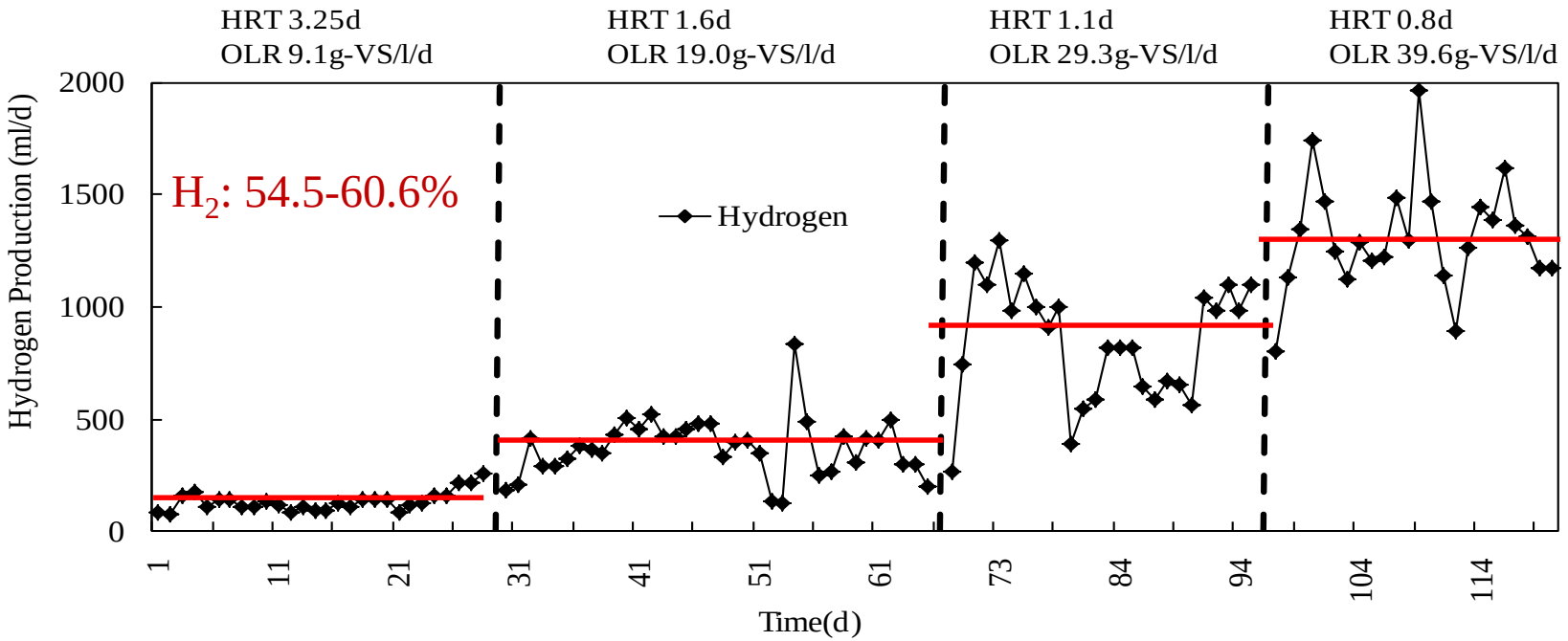
The operating conditions in the experiment

	Hydrogen production		Methane production		Running day (d)
	HRT (d)	OLR (g-VS/l/d)	HRT (d)	OLR (g-VS/l/d)	
Operation 1	3.25	9.1	18	1.2	1~30
Operation 2	1.6	19.0	9	2.7	31~66
Operation 3	1.1	29.3	6	4.4	67~96
Operation 4	0.8	39.6	4.5	6.1	97~120

pH: hydrogen 5.0-5.3, methane 6.9-7.4

Biogas Production

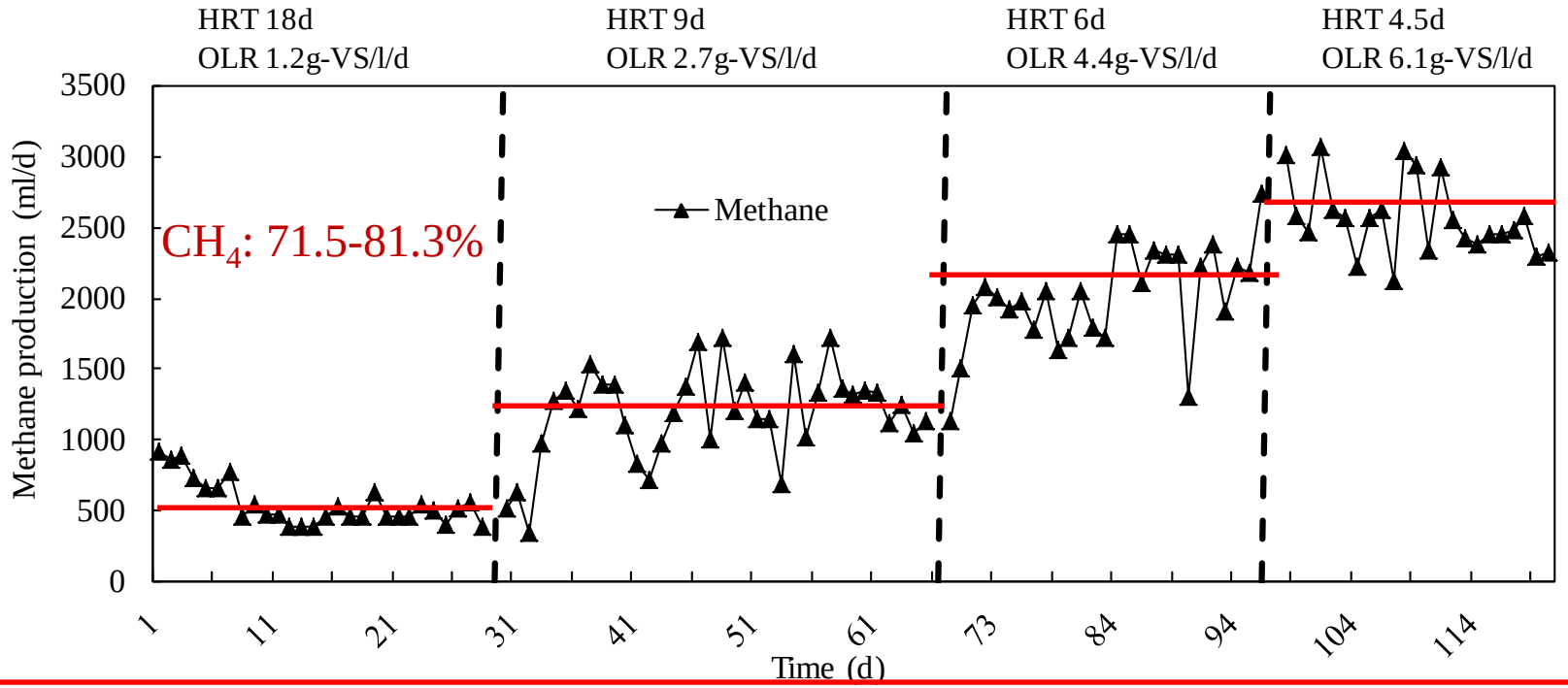
Hydrogen production in the first stage



The hydrogen production was stable in each operation condition.
The hydrogen production in the first stage increased with OLR.
The highest hydrogen production was 2057.1 ml/l/d.

Biogas Production

Methane production in the second stage



The methane production was also stable in each operation condition and increased with OLR, and the highest value was 713.6 ml/l/d.

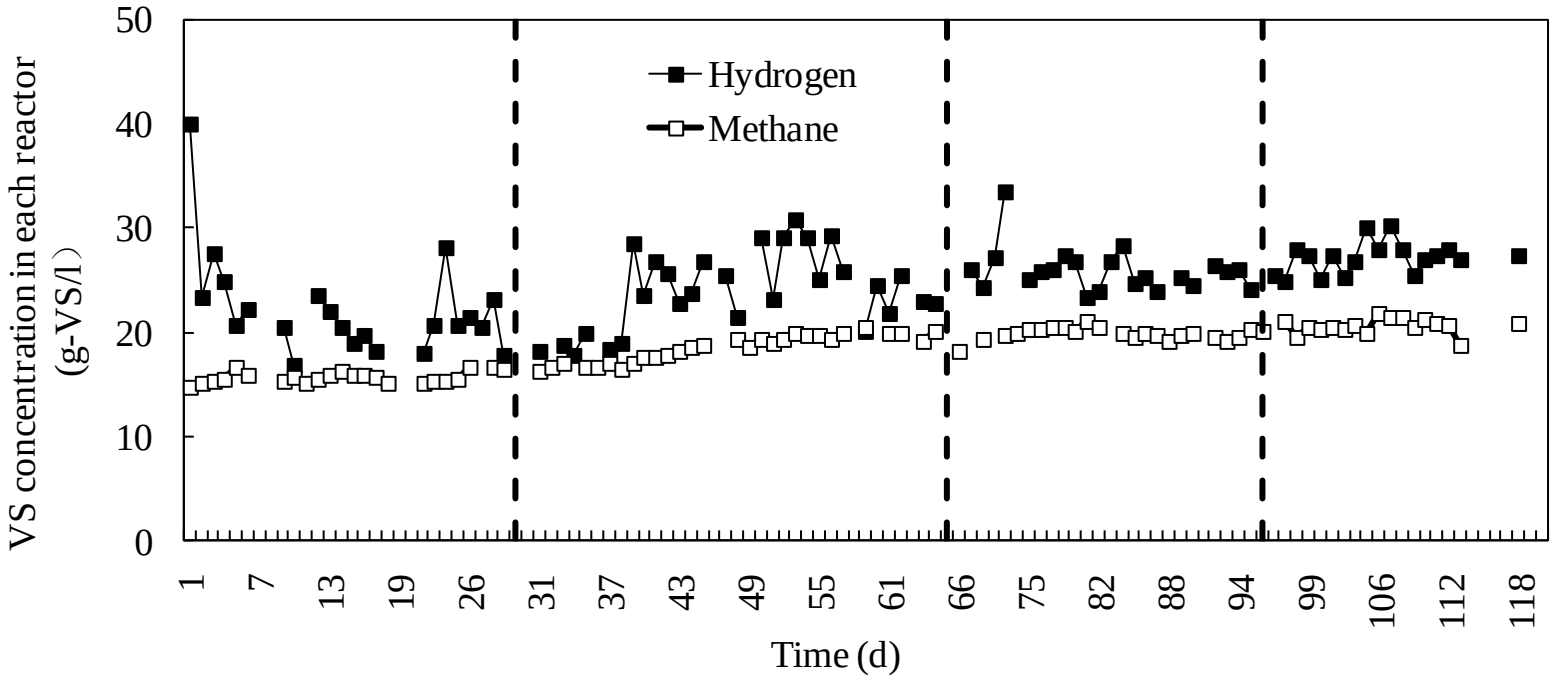
Biogas Production

The performance of biogas and energy yield of each operation stage

OLR for Hydrogen (g-VS/l/d)	Operation 1 9.1	Operation 2 19.0	Operation 3 29.3	Operation 39.6
Hydrogen production rate (ml/l/d)	211.6 ± 66.5	574.8 ± 198.8	1294.8 ± 396.8	2057.1 ± 349.8
Hydrogen yield (ml/g-$VS_{removed}$)	62.3 ± 19.6	95.8 ± 33.1	159.8 ± 49.0	207.5 ± 35.3
OLR for Methane (g-VS/l/d)	**Operation 1 1.2**	**Operation 2 2.7**	**Operation 3 4.4**	**Operation 6.1**
Methane production rate (ml/l/d)	149.3 ± 38.6	332.4 ± 84.7	558.5 ± 100.9	713.6 ± 73.9
Methane yield (ml/g-$VS_{removed}$)	437.4 ± 122.4	541.5 ± 138.0	554.3 ± 100.2	475.2 ± 49.2

Organic Matters Removal

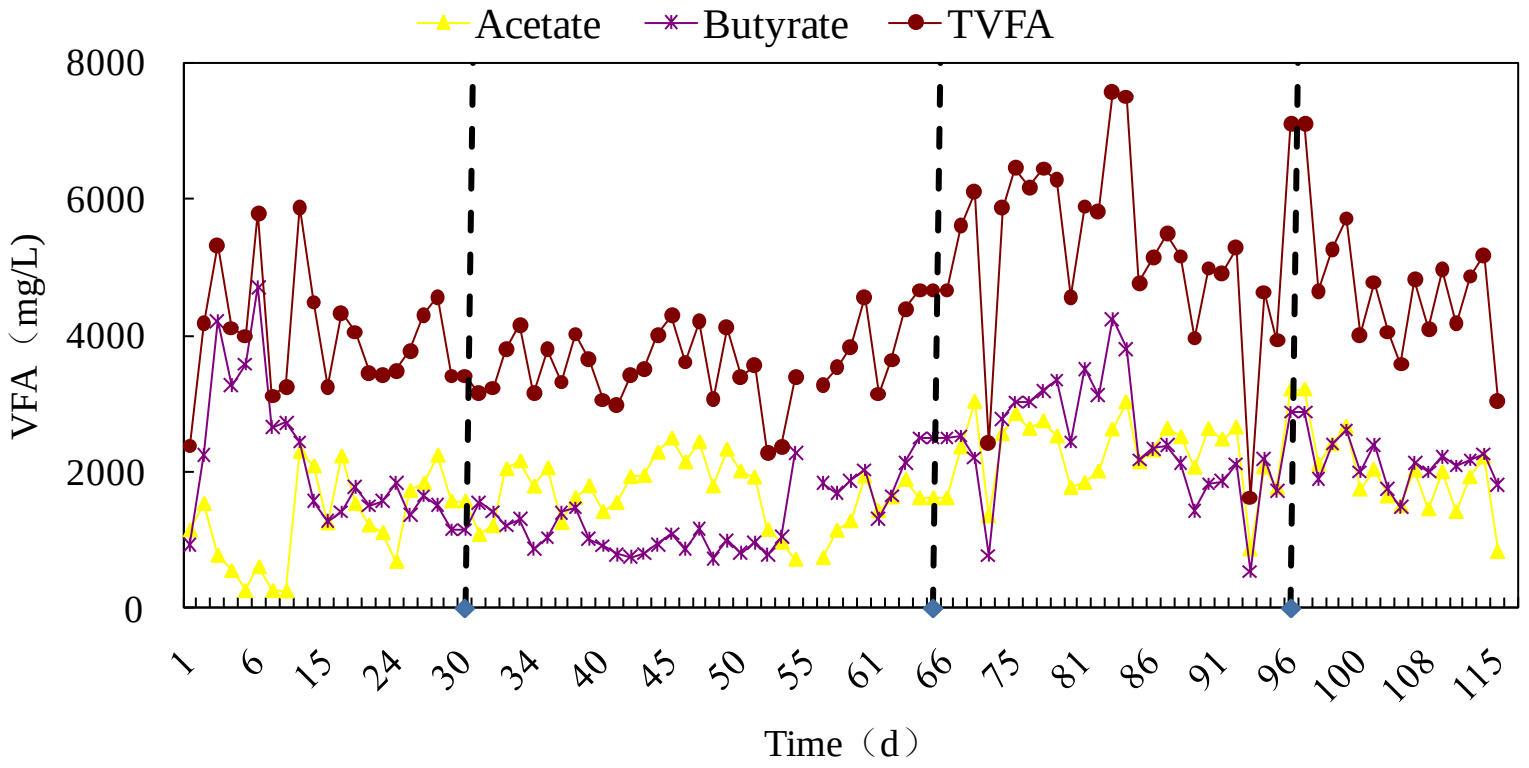
VS concentration in each reactor



VS in feedstock is 43.5 g-VS/l

VS removal efficiency : 53.1-63.8%

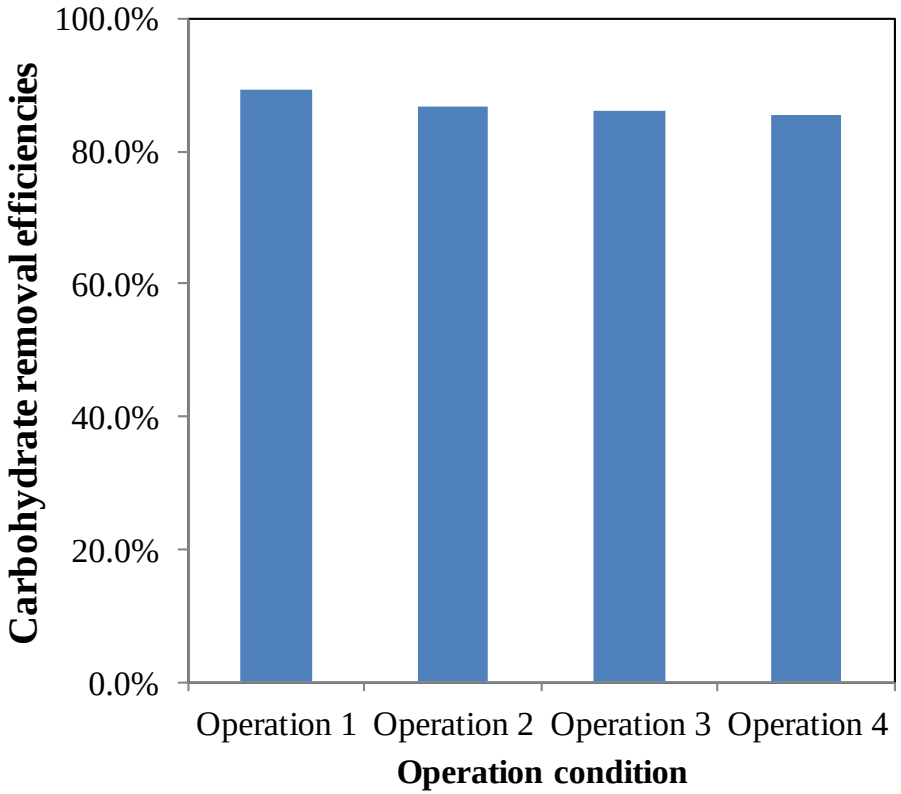
Organic Matters Removal



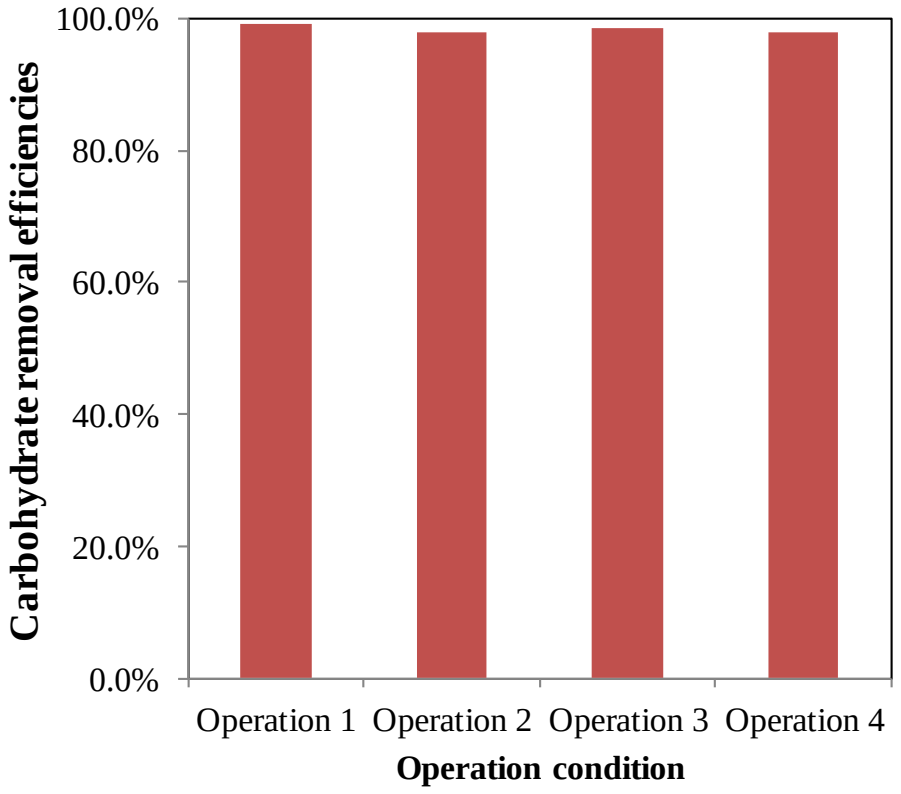
- VFA produced in hydrogen reactor: Sum of acetate and butyrate was 83.0-90.0%, and the concentration of acetate and butyrate was similar.
- The VFA removal efficiency reached 92.9-98.5% in methane production stage.

Organic Matters Removal

Total carbohydrate



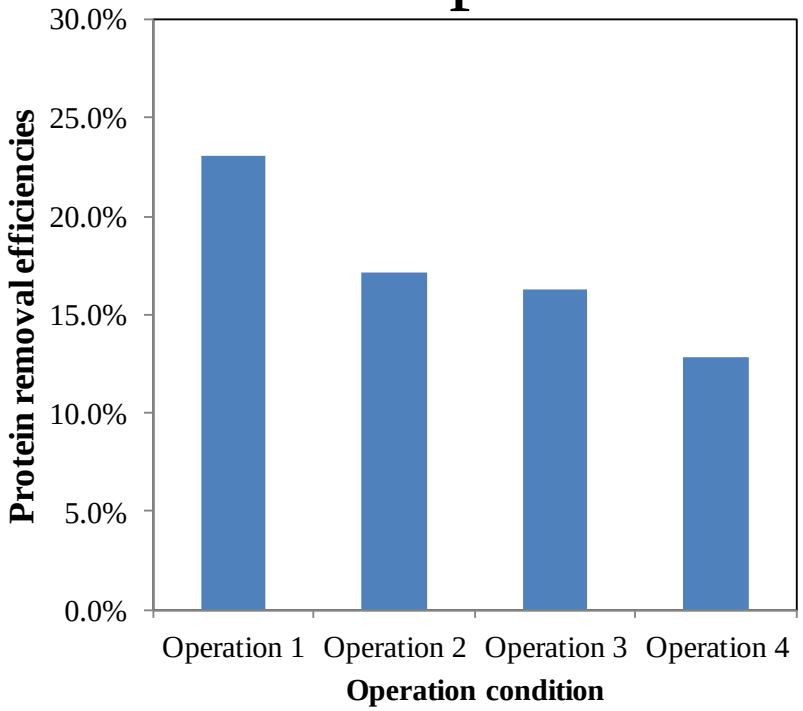
Soluble carbohydrate



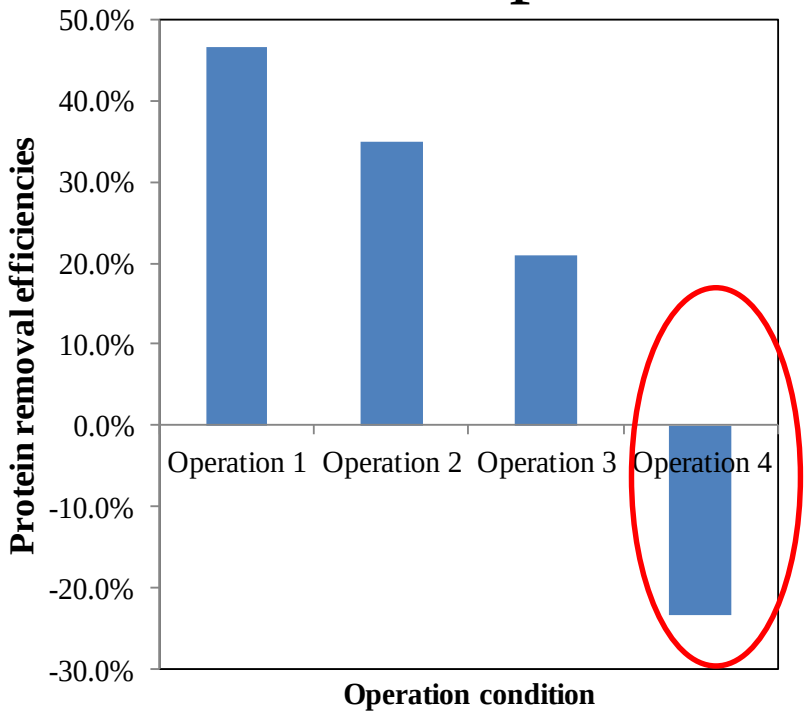
- The total carbohydrate and soluble carbohydrate removal efficiencies were 85.6-89.4% and 97.9-99.1%.

Organic Matters Removal

Total protein



Soluble protein



- The total protein and soluble protein removal efficiencies were gradually decreased with the OLR.

Solid protein-- dissolution--**Soluble protein**--hydrolysis--**Amino acid**

Conclusions

- Hydrogen and methane was proved to be produced steadily and efficiently by co-digestion of waste activated sludge and food waste in a two-stage fermentation process.
- The hydrogen yield increased with OLR and the highest value was 207.5 ml/g-$VS_{removed}$, however, the highest methane yield of 554.3 ml/g-$VS_{removed}$ was obtained at 4.4 g-VS/l/d other than the highest OLR.
- The dominant VFA produced in hydrogen reactor were acetate and butyrate.
- The VS removal efficiency of 53.1-63.8% was achieved.

Thank you!

Name:Liu Xinyuan

Address: Tianjin University, Tianjin, China

Email: liuxinyuan11@163.com