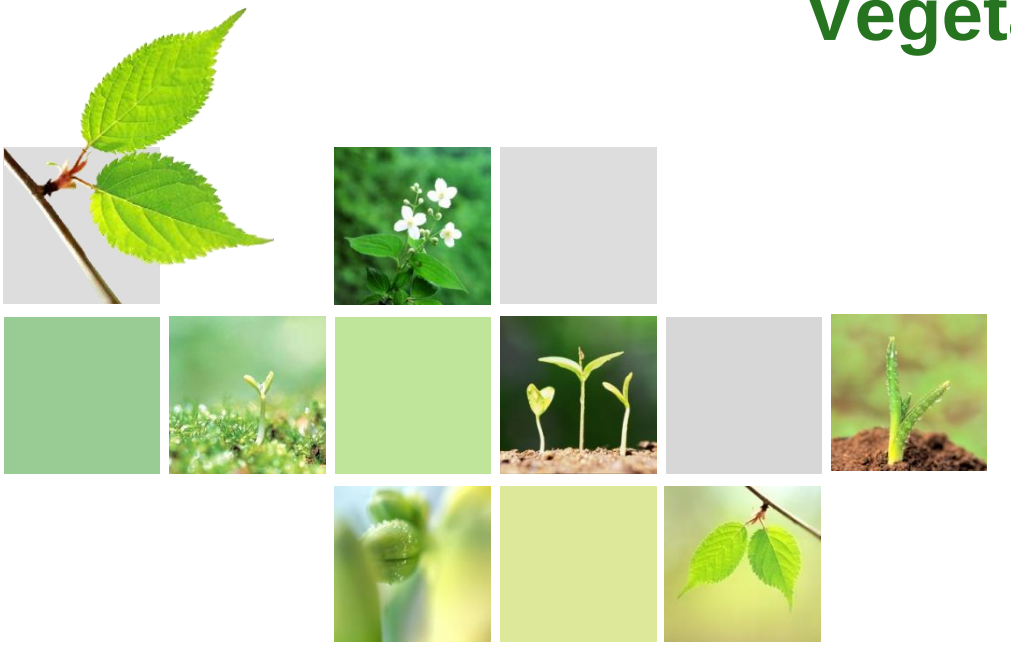
Beijing University of Chemical Technology
Section of Industrial Biogas

Optimization of the Operational Parameters of a Mesophilic Two-phase Anaerobic Digester for Vegetable Waste Degradation



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Contents

1.1 Waste Generation

Vegetable Waste

- Sources: farming, S&P, storage, etc…
- counts for 25% of harvested products
- Amount: average 80 tons per day per site

  120+ vegetable center in China

1.2 Potential Disposal Methods

Characteristics

- High Moisture Content: >85%
- High VS Contents: VS/TS＞0.8
- No hazardous contents
- Centralized production
- Seasonally change

Why anaerobic digestion?

- Incineration
- Landfill
- Livestock food
- Composting
- Anaerobic Digestion
  - ✓ Low energy requirements
  - ✓ Produce biogas energy 18,000 m^3/d/site and soil amendments
  - ✓ Stable production rate

1.3 Why Two Phase?

☺ To optimize the hydrolysis and biogasification phase separately

☺ Comparatively higher OLR, short digestion time, higher reduction rate

☺ Co-generate hydrogen and methane

○ Hydrolysis reactor is hard to start up, unstable；

○ Complicate process, high investment；

Design a process for vegetable waste?

Contents

2.1 Characteristics with seasons

Table1. Characteristics of raw vegetable wastes

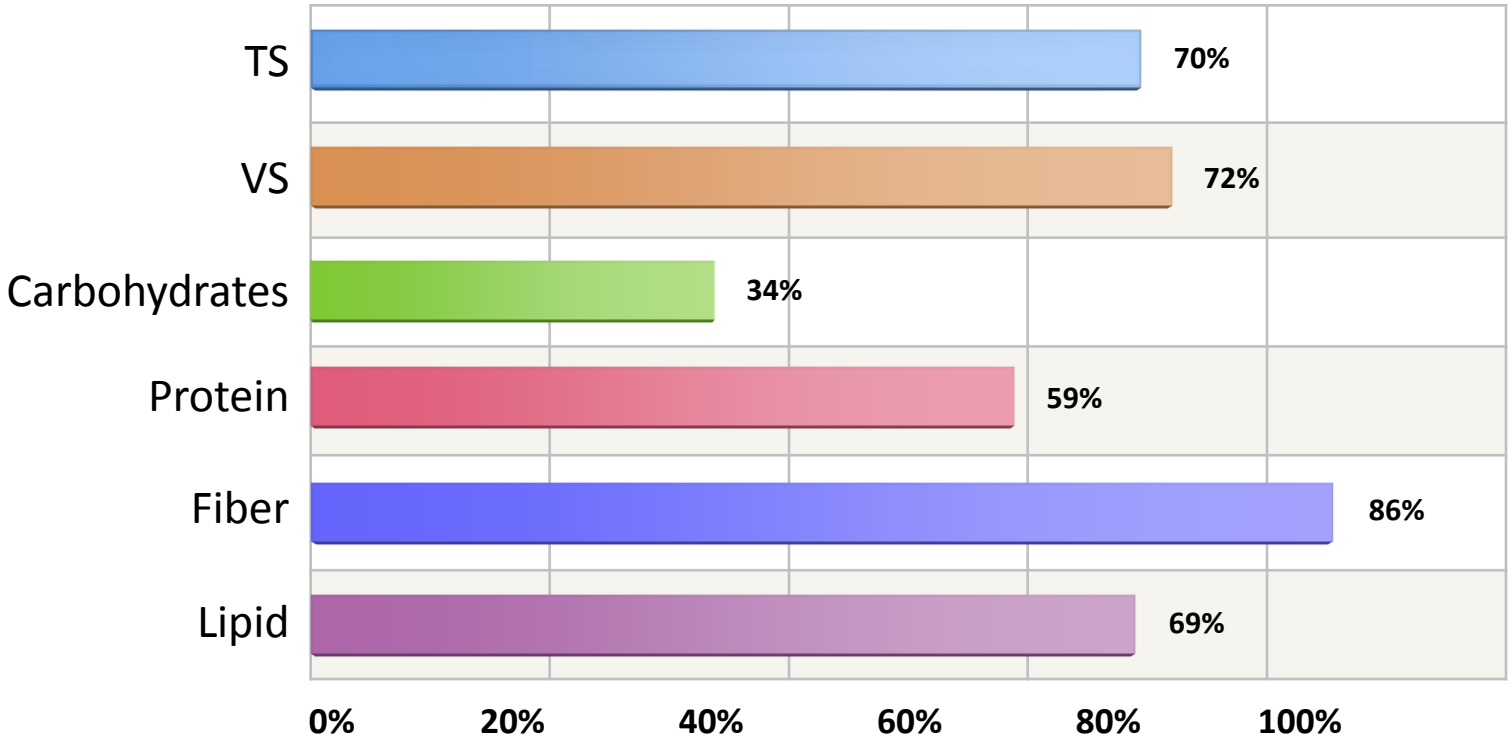
Sampling Time	TS/%	VS/%	MC/%	VS/TS
winter	11	10	89	0.89
spring	13	10	88	0.82
summer	7	6	93	0.86
autumn	8	6	92	0.84

Sampling Time	TKN/%	Carbohydrates /%	Protein/%	Fiber/%	Lipid/%
winter	2	12	14	25	4
spring	1	5	11	23	1
summer	3	1	18	32	7
autumn	2	2	16	33	6

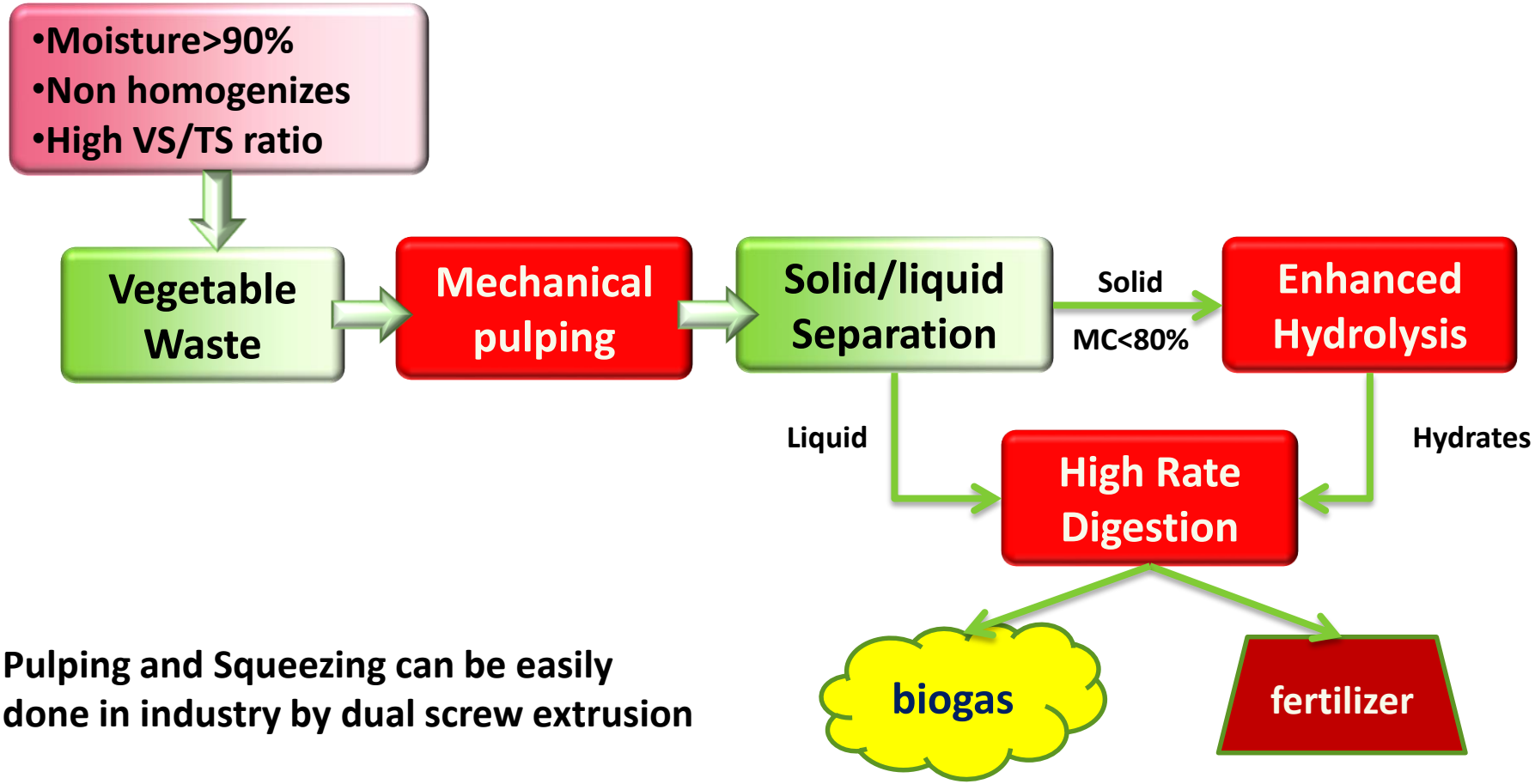
* TC, TKN, carbohydrates, Protein, Fiber and Lipid contents are based on dry solids

2.1 Characteristics of Vegetable Waste

figure 1. Characteristics: Solids vs. Total

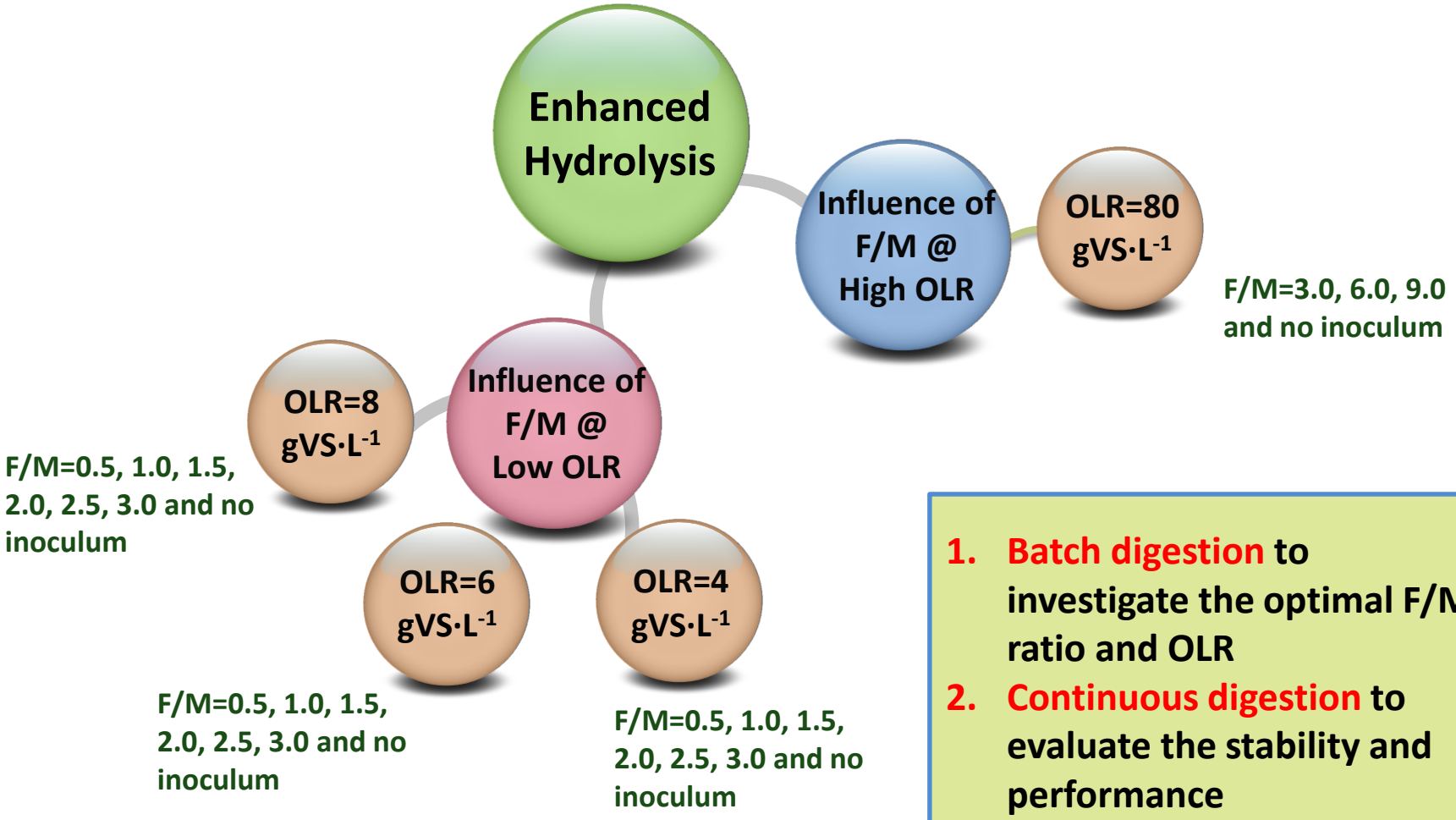


2.2 Methods——overview



Pulping and Squeezing can be easily done in industry by dual screw extrusion

2.2 Methods——hydrolysis



1. **Batch digestion** to investigate the optimal F/M ratio and OLR
2. **Continuous digestion** to evaluate the stability and performance

Contents

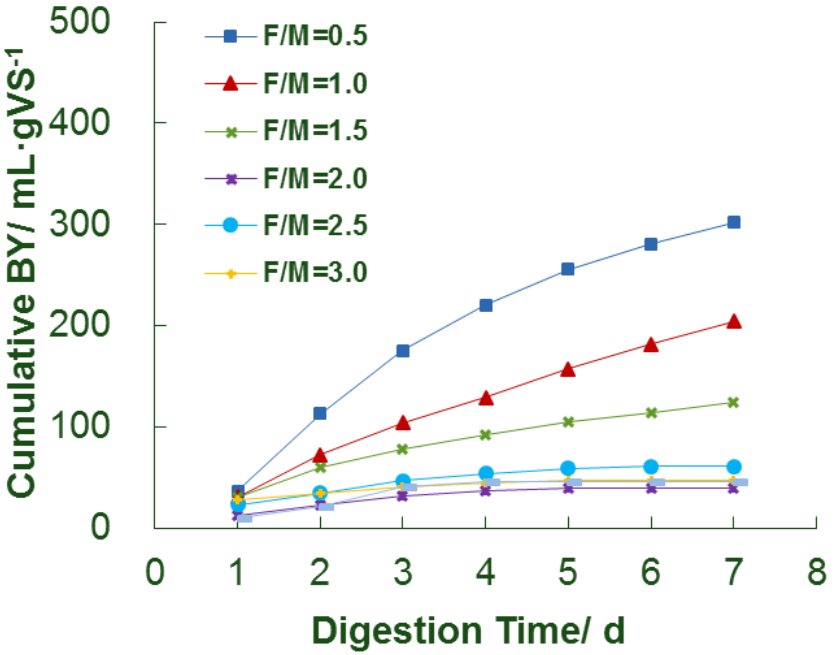


3.1 Batch digestion

investigate the optimal F/M ratio and OLR

Results——Enhanced Hydrolysis

OLR=4 gVS·L^{-1}——biogas yields and compositions



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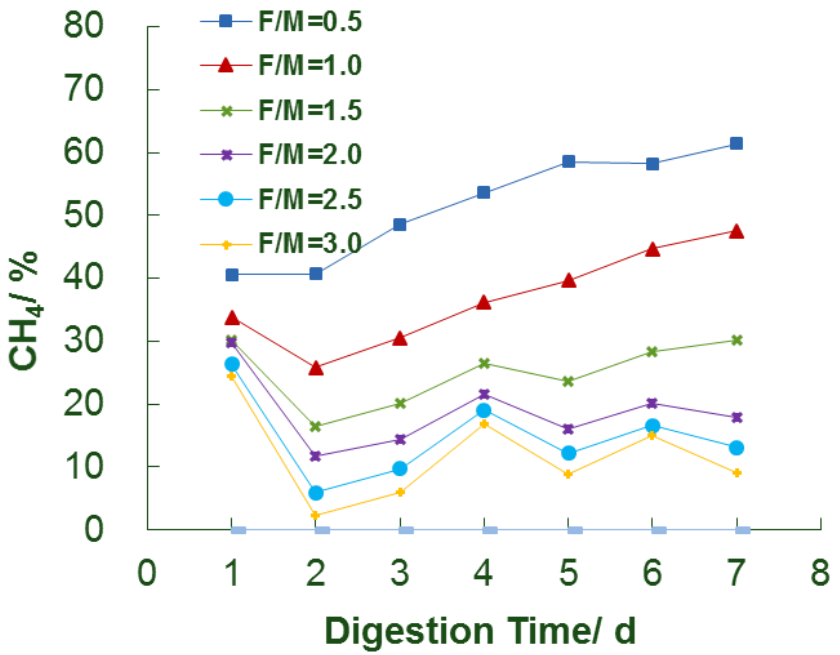


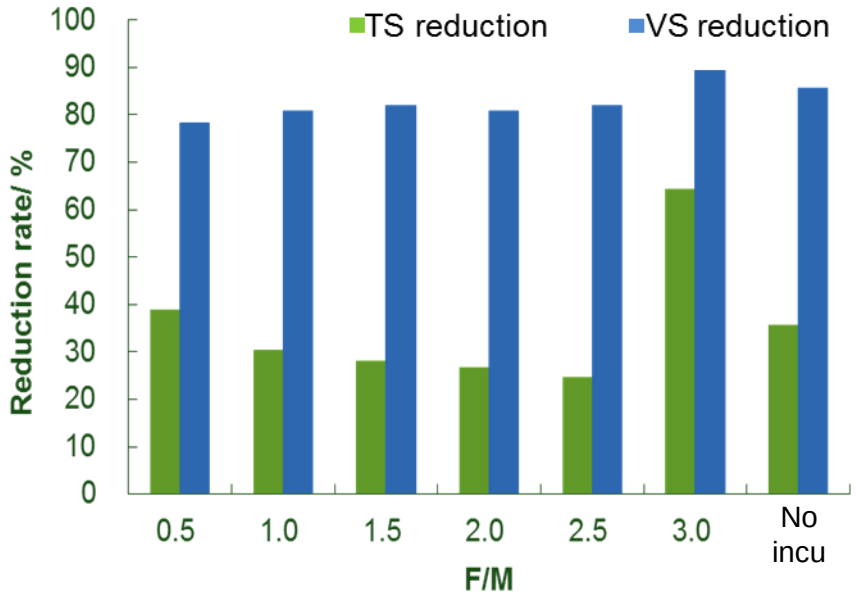
(b)

Fig1(a). Daily biogas yield at various F/M

Fig1(b). Methane contents at various F/M

Results——Enhanced Hydrolysis

OLR=4 gVS·L^{-1}——solid reduction and intermediates



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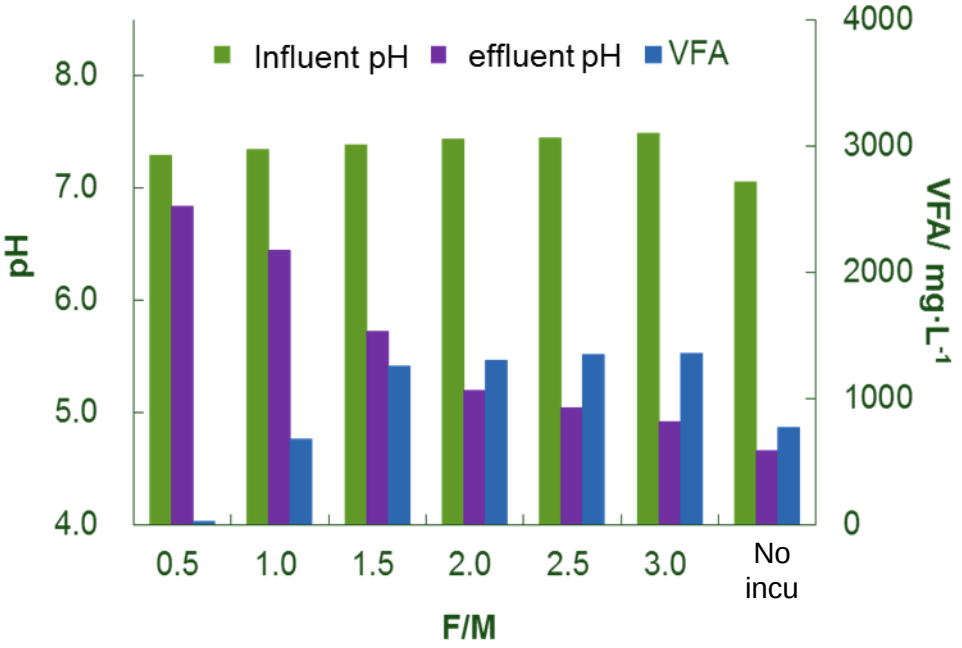


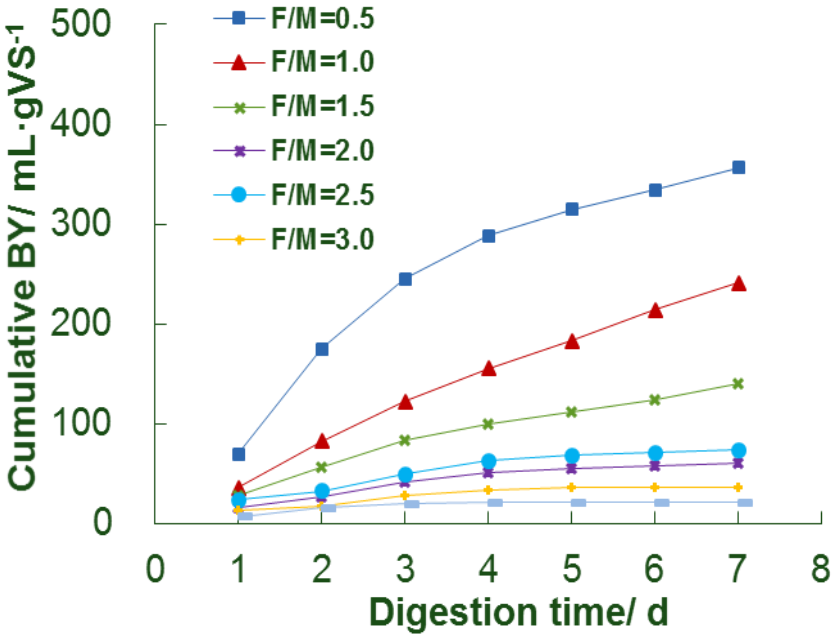
(b)

Fig2(a). TS reduction and VS reduction at various F/M

Fig2(b). The pH of the influent and effluent and the VFA concentration of effluent

Results——Enhanced Hydrolysis

OLR=6 gVS·L^{-1}——biogas yields and compositions



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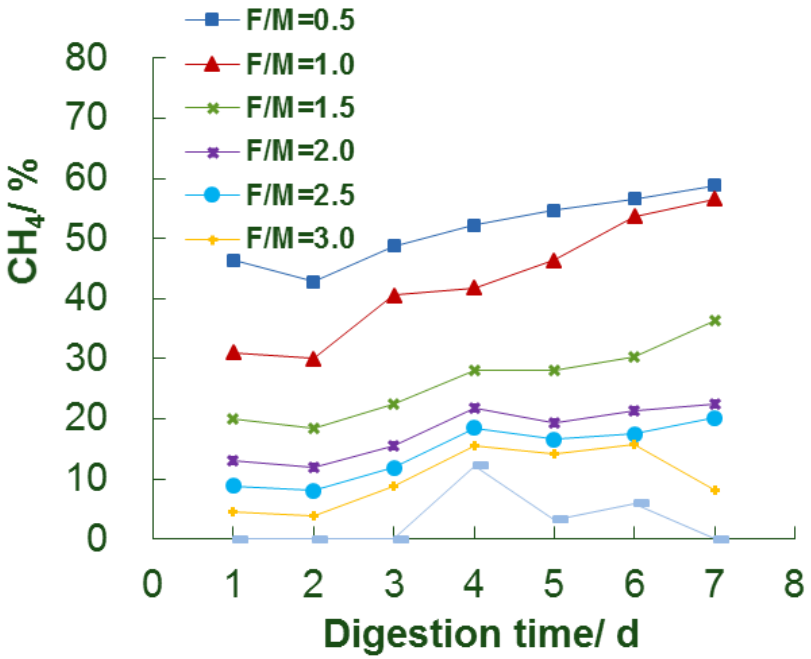


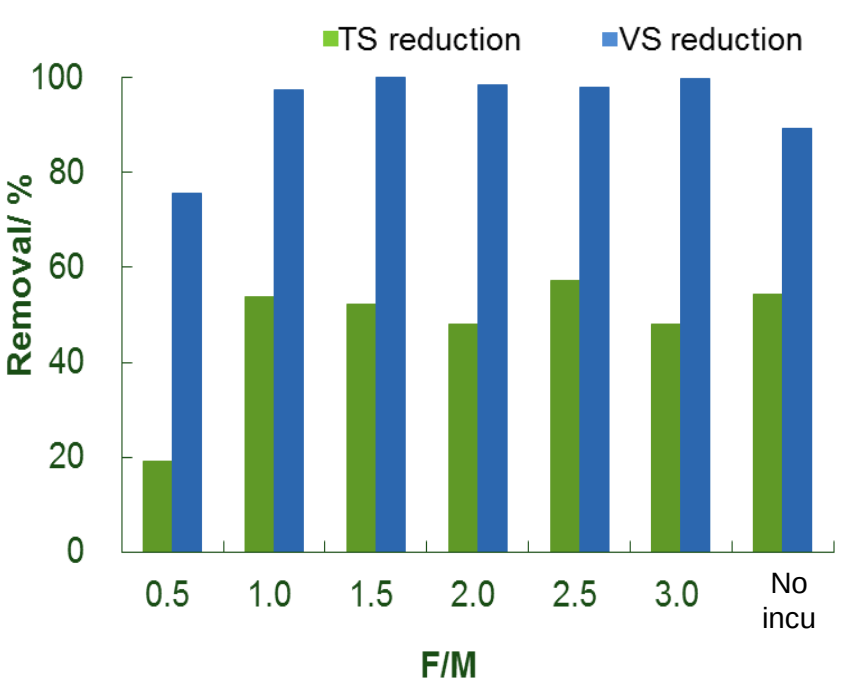
(b)

Fig3(a). Daily biogas yield at various F/M

Fig3(b). Methane contents at various F/M

Results——Enhanced Hydrolysis

OLR=6 gVS·L^{-1}——solid reduction and intermediates



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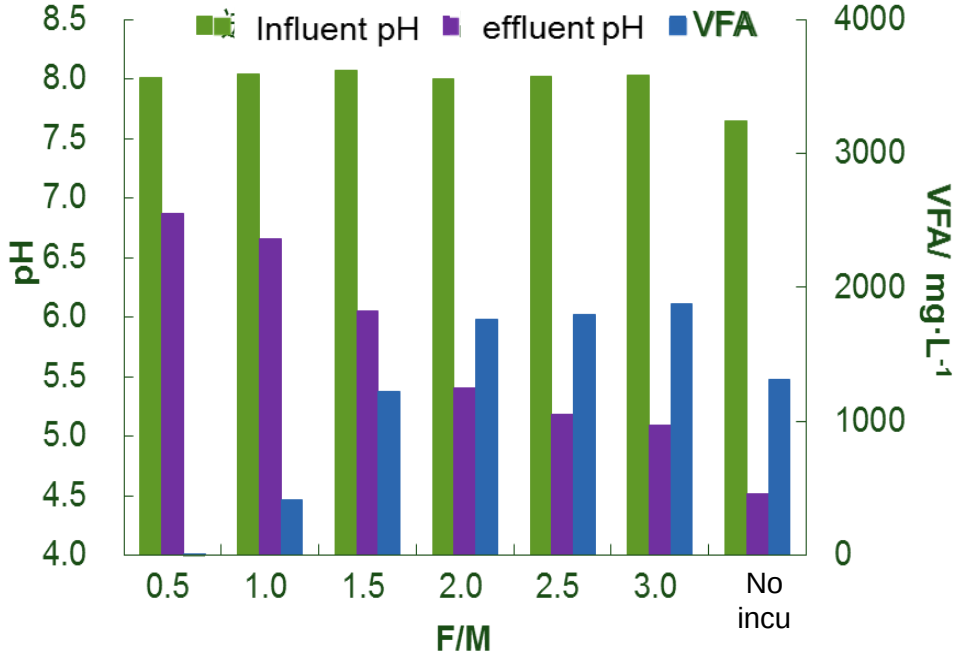


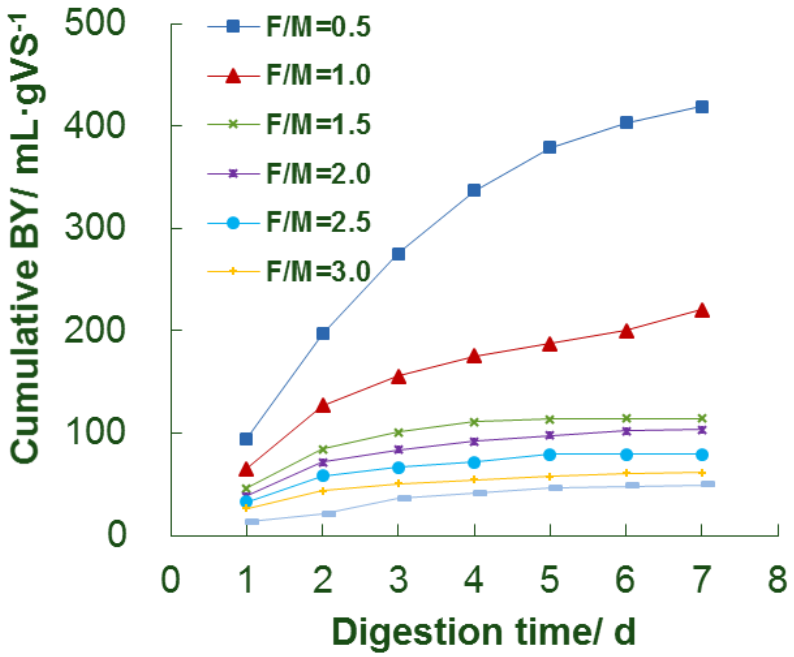
(b)

Fig4(a). TS reduction and VS reduction at various F/M

Fig4(b). The pH of the influent and effluent and the VFA concentration of effluent

Results——Enhanced Hydrolysis

OLR=8 gVS·L^{-1}——biogas yields and compositions



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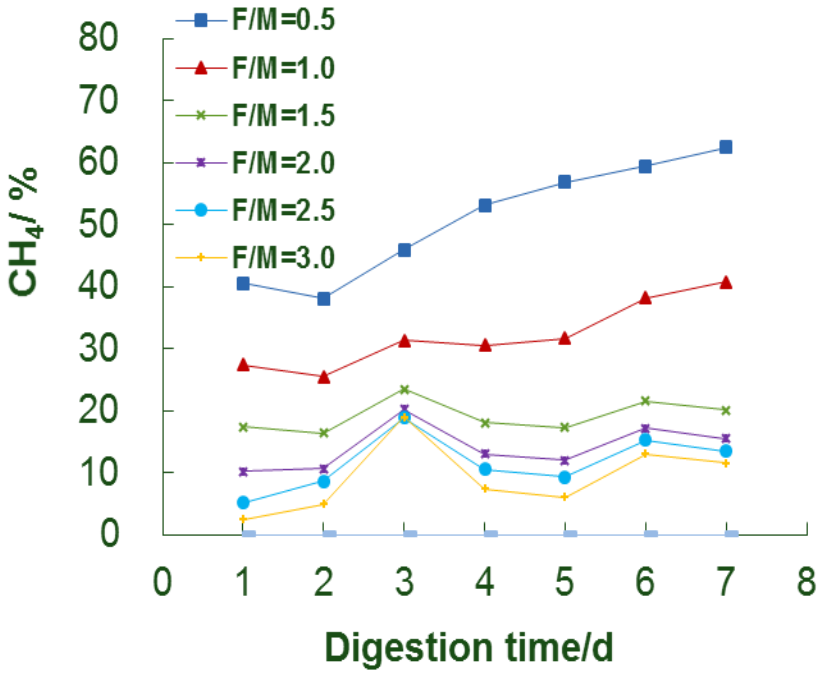


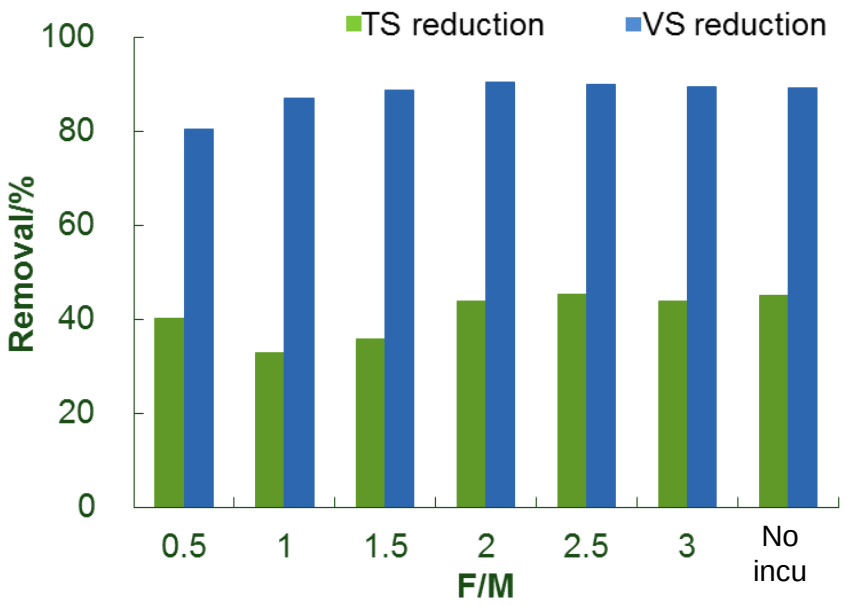
(b)

Fig5(a). Daily biogas yield at various F/M

Fig5(b). Methane contents at various F/M

Results——Enhanced Hydrolysis

OLR=8 gVS·L^{-1}——solid reduction and intermediates



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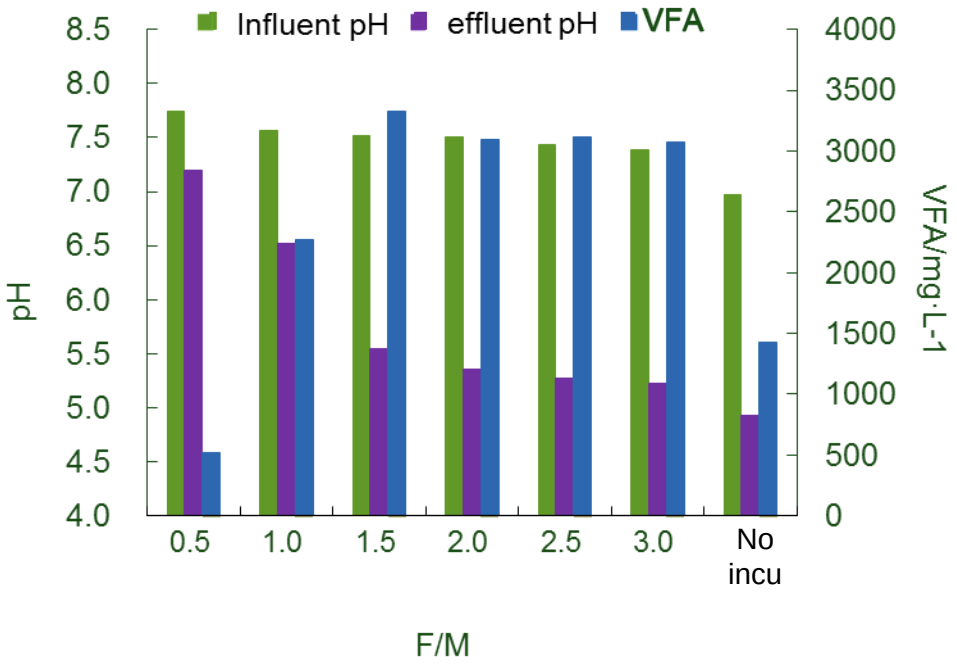


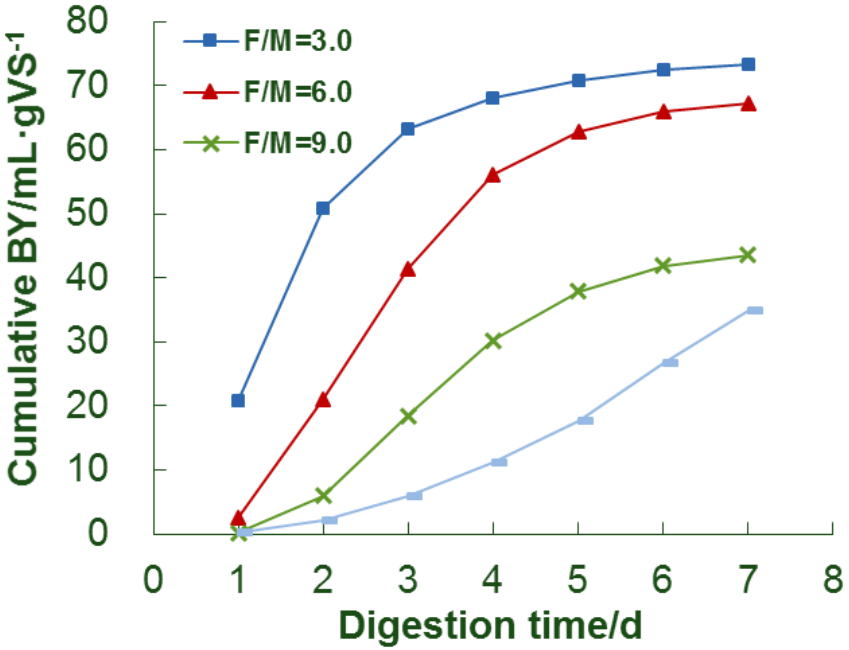
(b)

Fig6(a). TS reduction and VS reduction at various F/M

Fig6(b). The pH of the influent and effluent and the VFA concentration of effluent

Results——Enhanced Hydrolysis

OLR=80 gVS·L^{-1}——biogas yields and compositions



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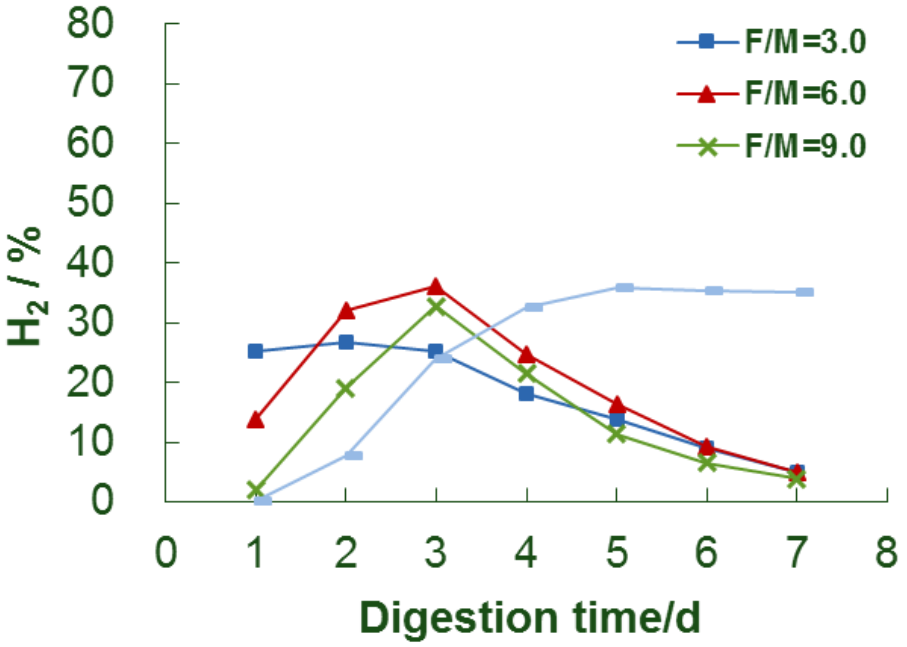


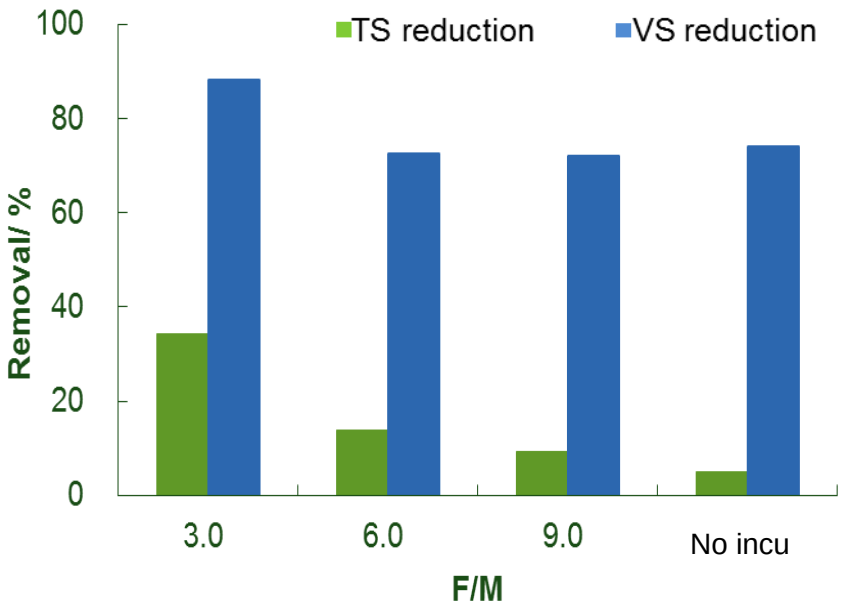
(b)

Fig7(a). Daily biogas yield at various F/M

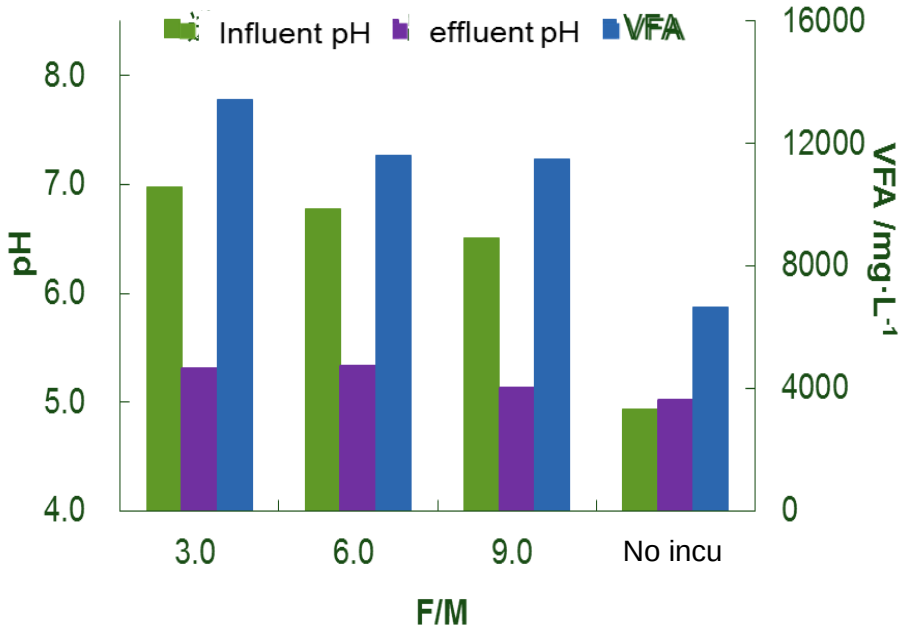
Fig7(b). Methane contents at various F/M

Results——Enhanced Hydrolysis

OLR=80 gVS·L^{-1}——solid reduction and intermediates



(a)



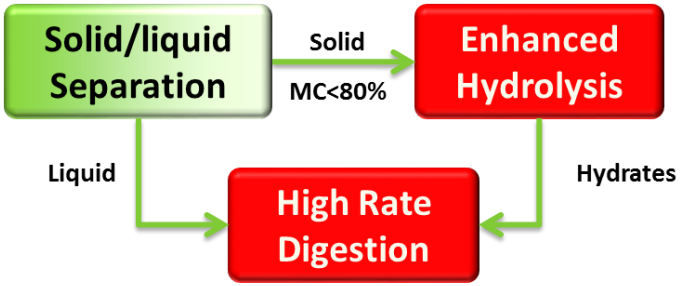
(b)

Fig8(a). TS reduction and VS reduction at various F/M

Fig8(b). The pH of the influent and effluent and the VFA concentration of effluent

3.2 Integrated Two Phase Digestion

evaluate the OLR and stability and performance



Experiment Setup

Reactor Design

- Two Phase CSTR+ASBR
- Working Volume：16L/16m³
- Water Jacket heating
- CSTR started at optimal F/M
- Mechanical stirring

Results——Two Phase Digestion

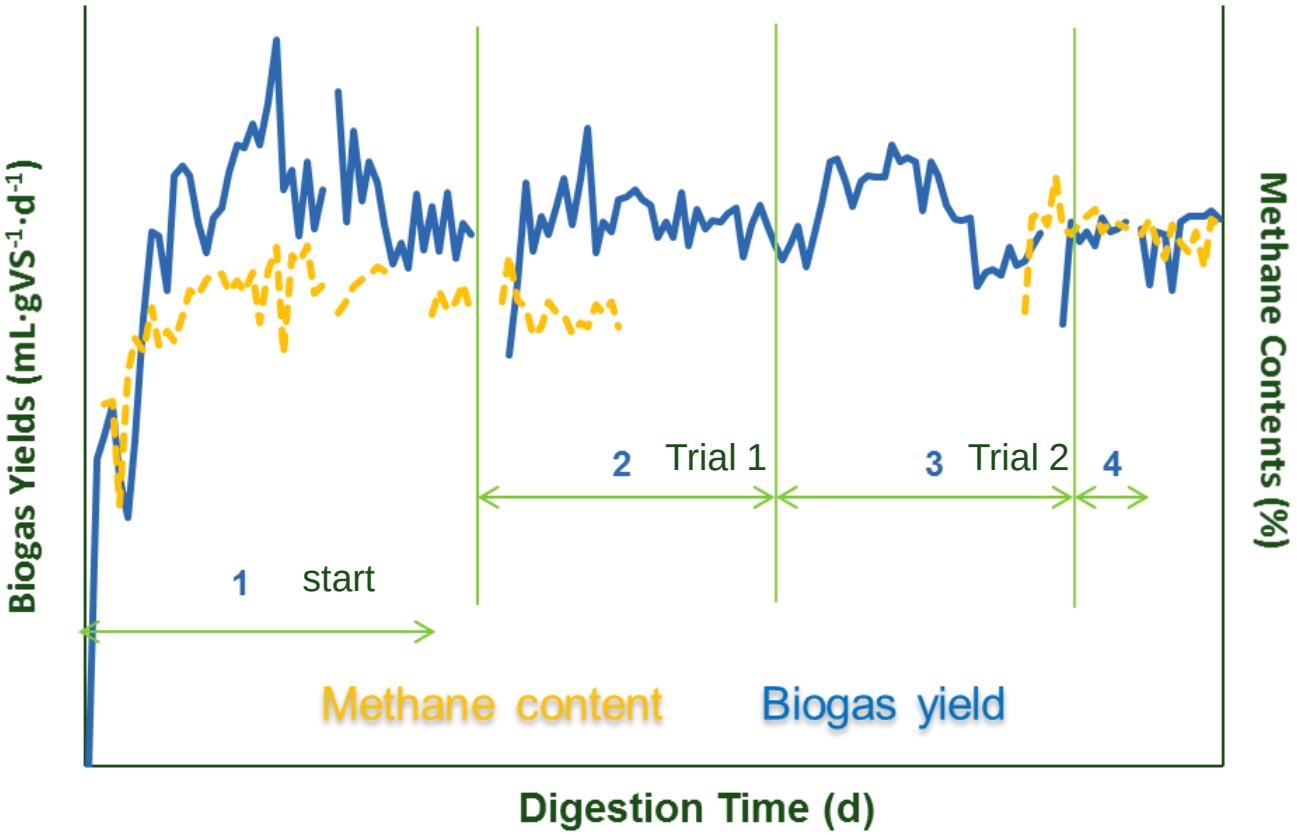


Fig 9. Daily biogas yield and methane content in biogas

Results——Two Phase Digestion

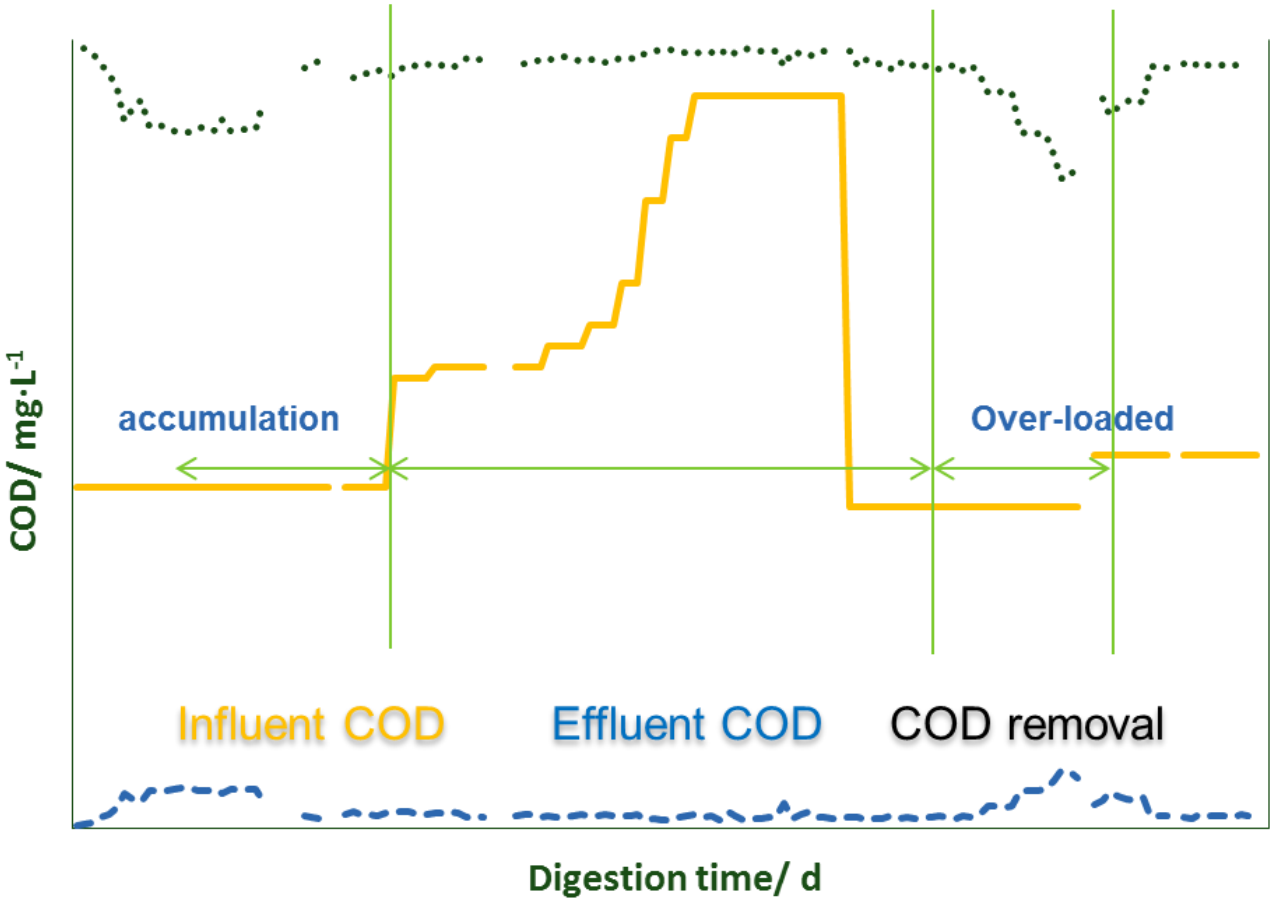


Fig.10 COD concentration and the removal efficiency

Results——Two Phase Digestion

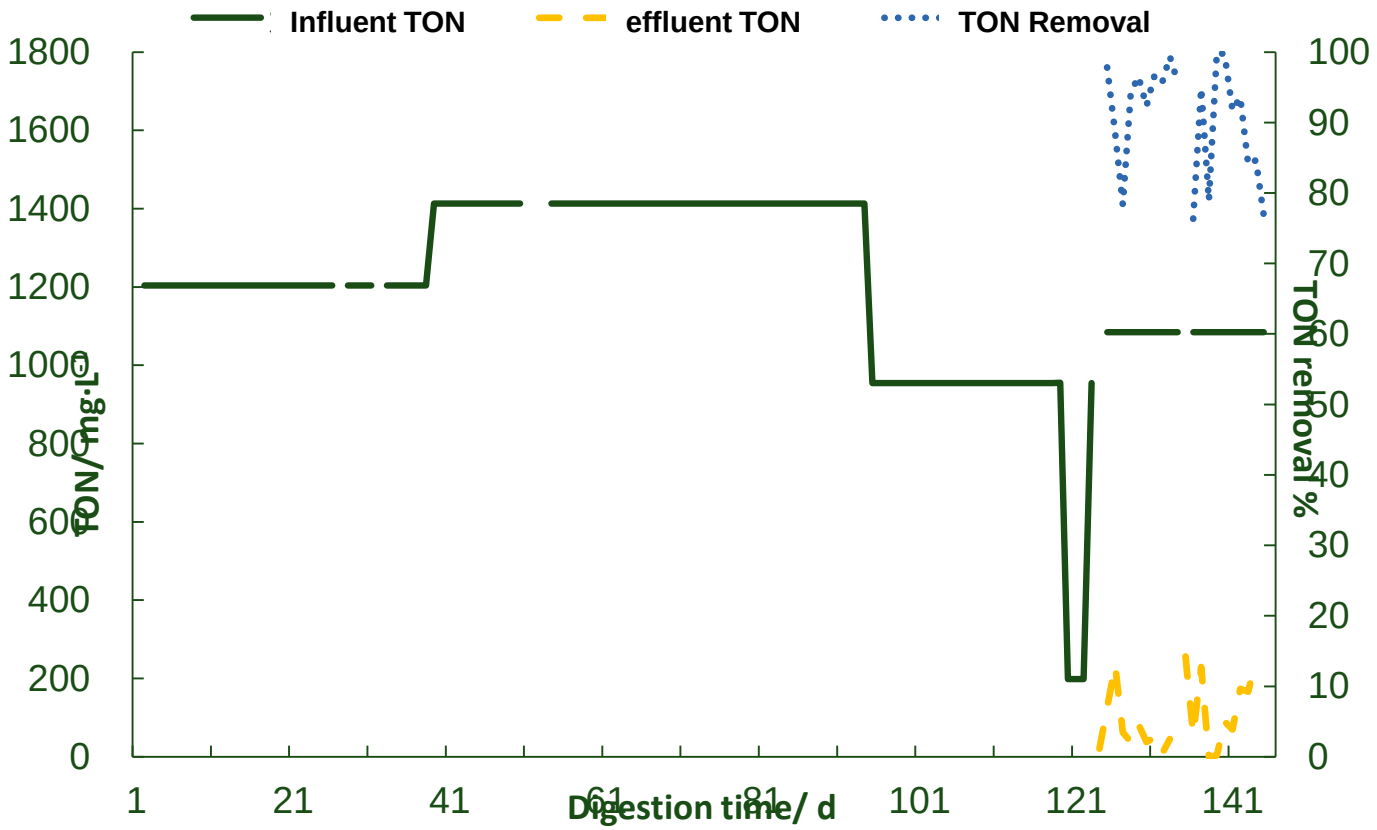


Fig11. Organic nitrogen concentration and the removal efficiency

Contents

Summary——Two Phase Digestion

Indicator

- Biogas yields based on VS loading rate can indicate feedstock's biogas potential

Selected OLR

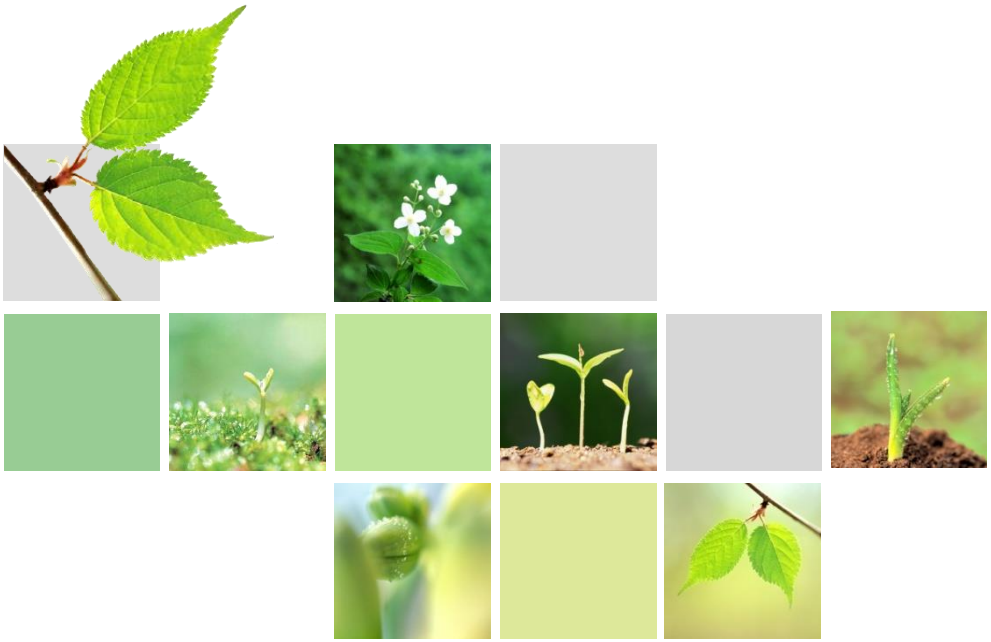
- Best biogas performance at OLR 8.0 $gVS \cdot L^{-1} \cdot d^{-1}$
- Can be steadily started at 80 $gVS \cdot L^{-1} \cdot d^{-1}$

Biogas Performance

- Biogas yield up to 860 $mL \cdot gVS^{-1}$
- Methane content 65%
- Compared to single phase digestion, same level biogas potential at 80 times OLR at hydrolysis

Inhibition

- NH_4 concentration up to 2383 $mg \cdot L^{-1}$
- No inhibition found



Thank you!

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