Set-up of CSTR and effects of operation conditions on biodegradability performance of kitchen waste

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Introduction

Kitchen waste : Approximately 60milion tones kitchen waste was produced in China every year and 1200 tons was produced in big city(Beijing) every day.

Characteristic： High content of moisture, organics, fat and salt, highly perishable, mosquito breeding

Technology

Landfill	Less reduction, higher area occupation, water and soil pollution
Incineration	Low heat value because of high moisture content， production of harmful gas
Compost	Not suitable for compost, and also lower fertilizer effect because of high salt content
Anaerobic Digestion	Waste minimization and production of clean energy(biogas)

Harmless, reduction, and resource utilization

Research Objective

Technology

Investigate the performance of one-phase continuously feed anaerobic digestion of kitchen waste

Improvement

Compare the impact the HRT on biogas production and system stability

Materials and Methods

	Kitchen Waste	Sludge
TS（%）	23.4	4.7
VS（%）	18.3	2.0
TC（%）	29.3	--
TN（%）	2.3	--
Fibre（%）	4.0	--
Fat（%）	24.1	--
Protein（%）	14.6	--
Total sugar（%）	35.8	--
Total salt（%）	22.3	--
Na^+（g/kg）	17.6	--
Cl^-（g/kg）	21.3	--
Ca^{2+}（g/kg）	1.5	--
NO_3^--N（mg/kg）	454	--

Materials and Methods

Fig.1 CSTR anaerobic digester

Research Set-up

R1				R2			
VS loading ($g/L.d^{-1}$)	HRT (d)	Feed concentration (gVS/L)	Feed volume (mL)	VS loading ($g/L.d^{-1}$)	HRT (d)	Feed concentration (gVS/L)	Feed volume (mL)
1	30	30	100	1	40	40	75
1.5	30	45	100	1.5	27	40	112.5
1.75	30	52.5	100	1.75	23	40	131.3
2	30	60	100	2	20	40	150
2.25	30	67.5	100	2.25	18	40	168.8
2.5	30	75	100	2.5	16	40	187.5
2.75	30	82.5	100	2.75	14	40	206.3

Results: R1-Fixed HRT

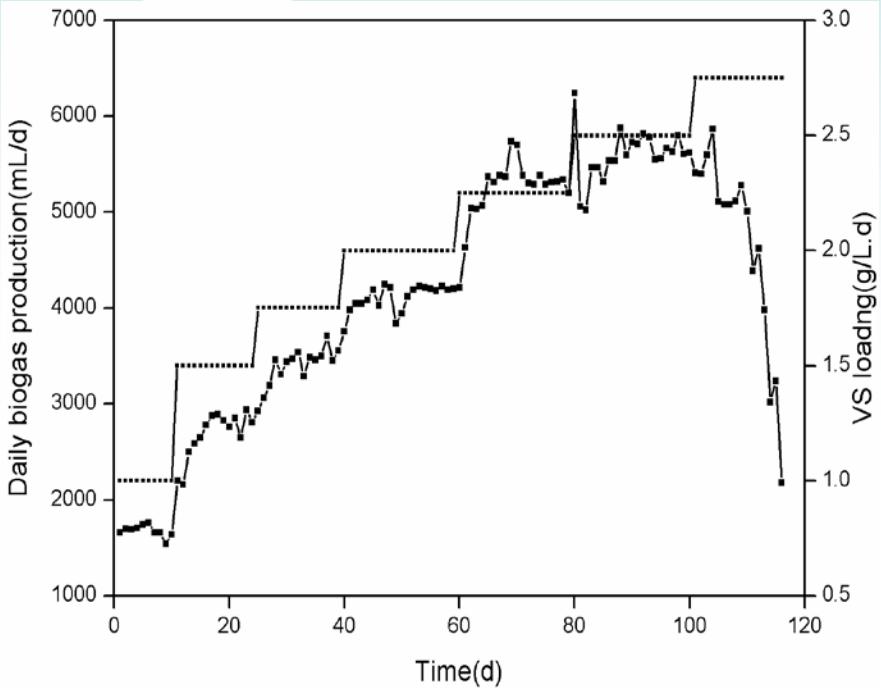


Fig.2 Daily biogas production of R1

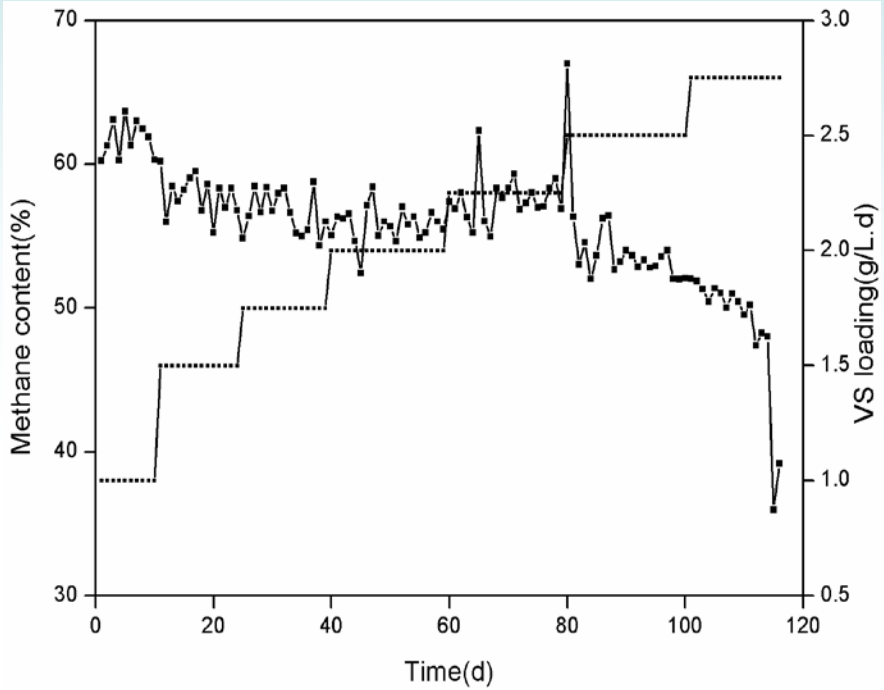


Fig.3 Methane content

The ultimate biogas production increased from 1g·L^{-1}·d^{-1} to 2.5 g·L^{-1}·d^{-1} and then decreased obviously with decreasing methane content from over 60% to below 40%.

Results: R1-Fixed HRT

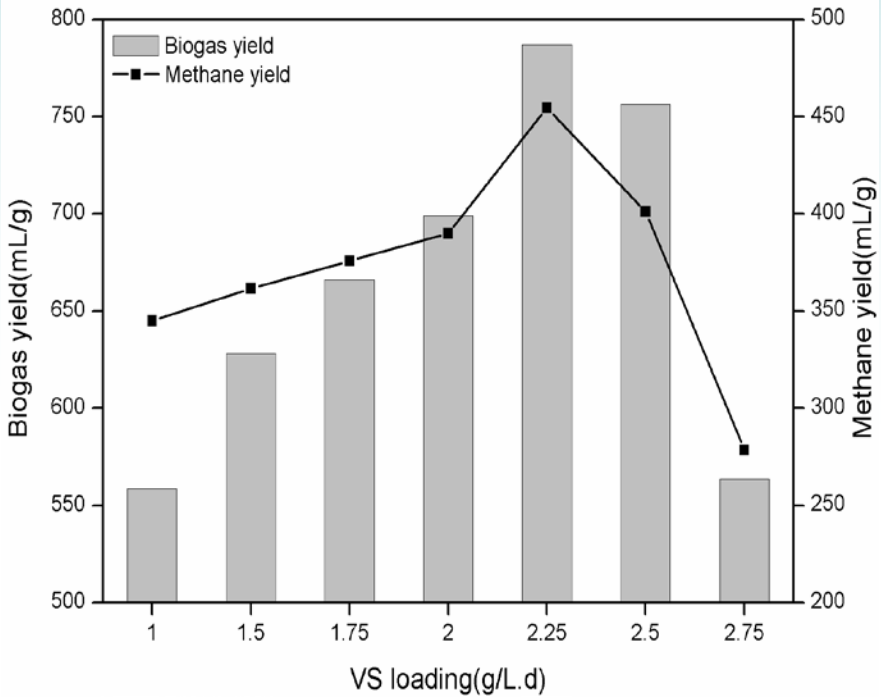


Fig.4 Biogas and methane yield of R1

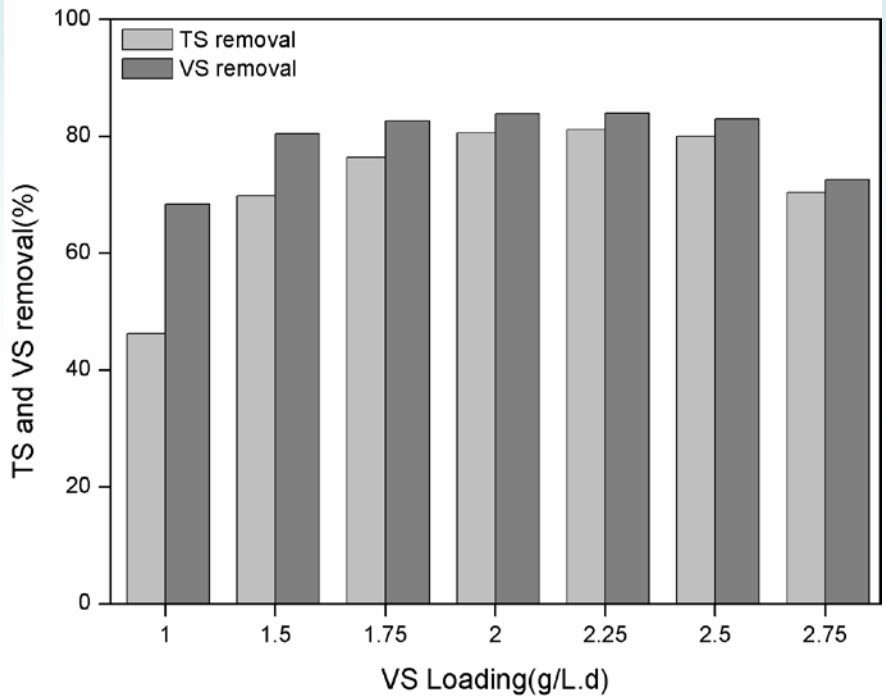
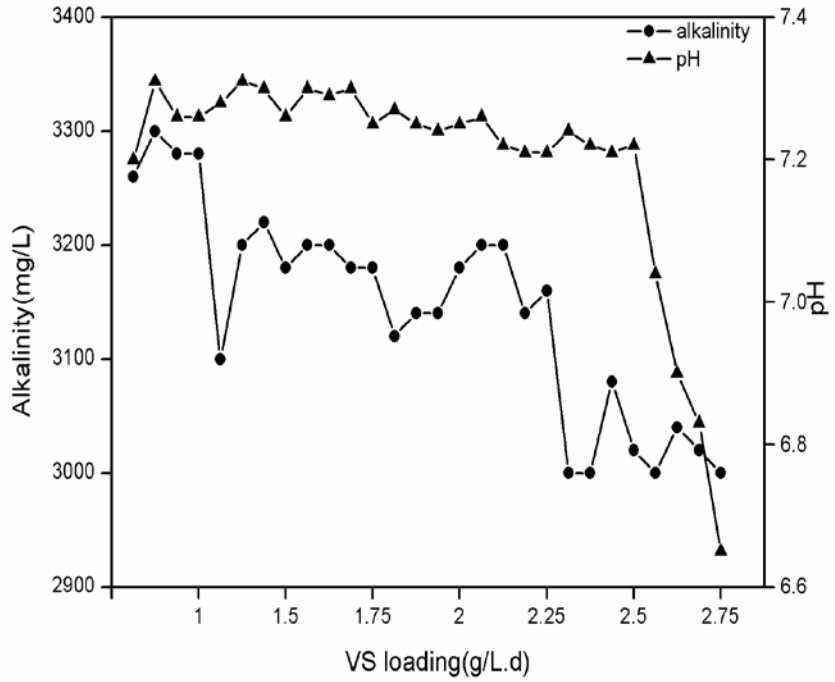


Fig.5 TS and VS removal at different loadings of R1

The maximum biogas yield **of 787.0mL·g^{-1}·d^{-1}** and methane yield of **454.61mL·g^{-1}·d^{-1}** were achieved at 2.25g·L^{-1}·d^{-1} with highest TS removal of 81.22% and VS removal of 83.96%.

Results: R1-Fixed HRT



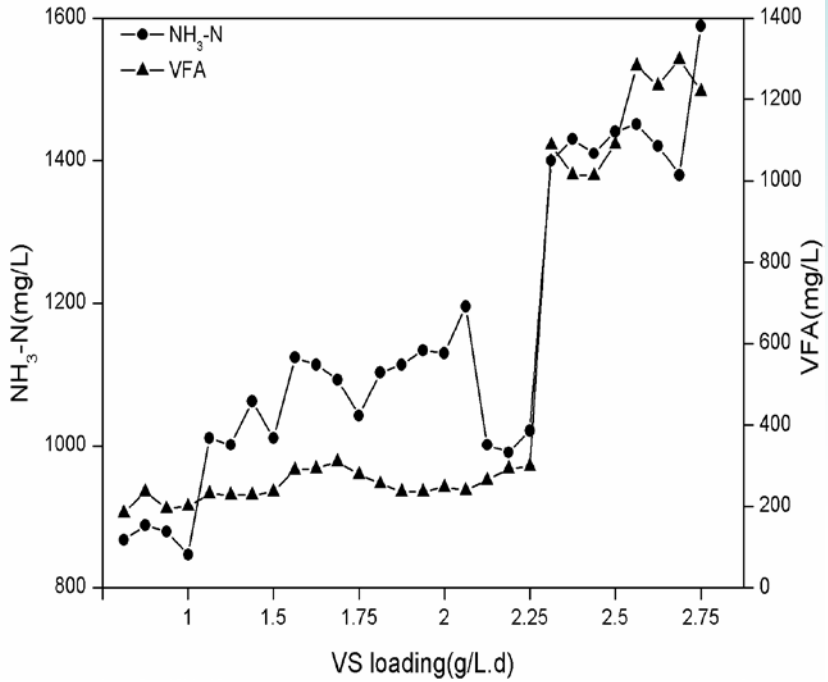


Fig.6 pH and alkalinity of effluent at different loadings **Fig.7** NH^3-N and VFA of effluent at different loadings

The pH remained between 7.2-7.31 at below 2.5g·L^{-1}·$d^{-1}$and then dropped .

The alkalinity was between **3000-3280mg·L^{-1}** for the whole period.

Ammonia nitrogen concentration maintained **800mg·L^{-1}-1500mg·L^{-1}** and no inhibition.

VFA concentration remained 180 mg·L^{-1}-300 mg·L^{-1} at below 2.5 g·L^{-1}·$d^{-1}$and achieved a high level at 2.5 g·L^{-1}·d^{-1}.

Results: R2-Fixed Feed concentration

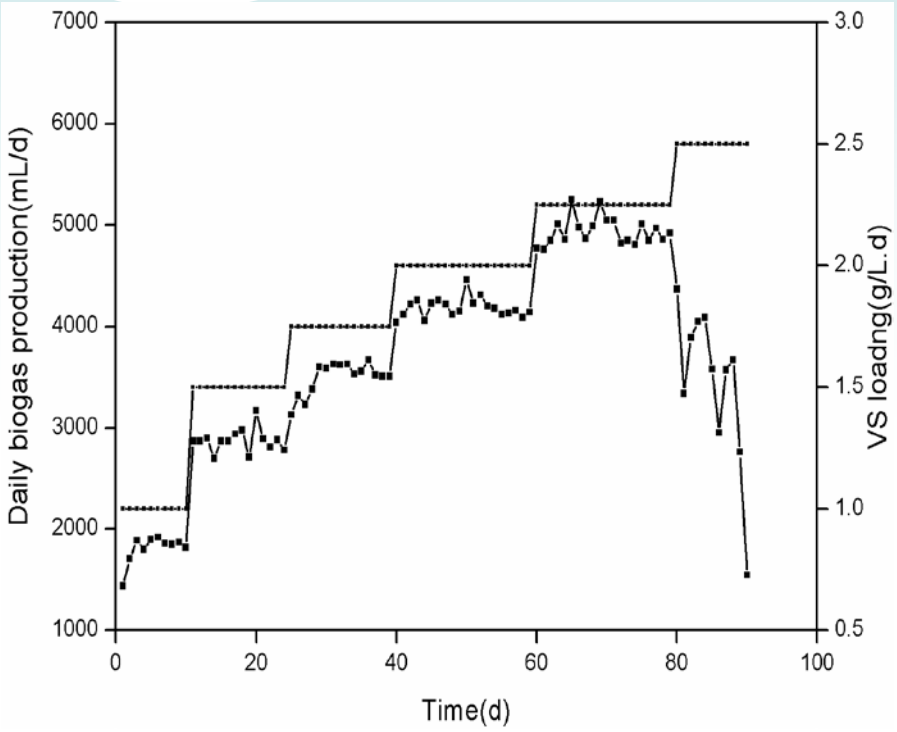


Fig.8 Daily biogas production of R2

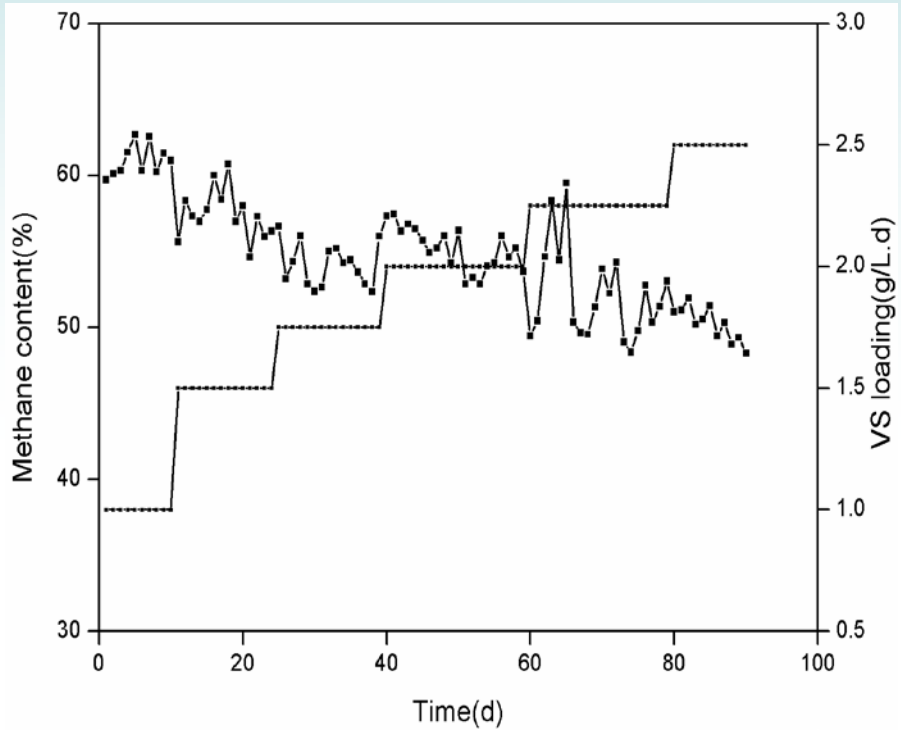


Fig.9 Methane content

The ultimate biogas production increased from 1g·L^{-1}·d^{-1} to 2.25 g·L^{-1}·d^{-1} with maximum daily biogas production of 4886mL/d，and then dropped obviously. Methane content showed slowly decreasing trend.

Results: R2-Fixed Feed concentration

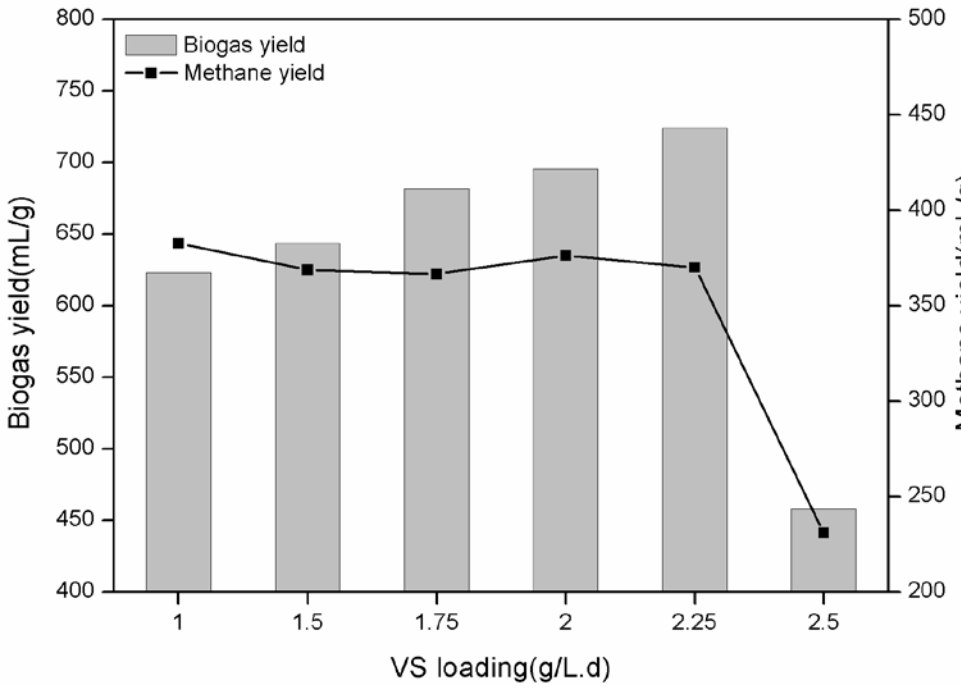


Fig.10 Biogas and methane yield of R2

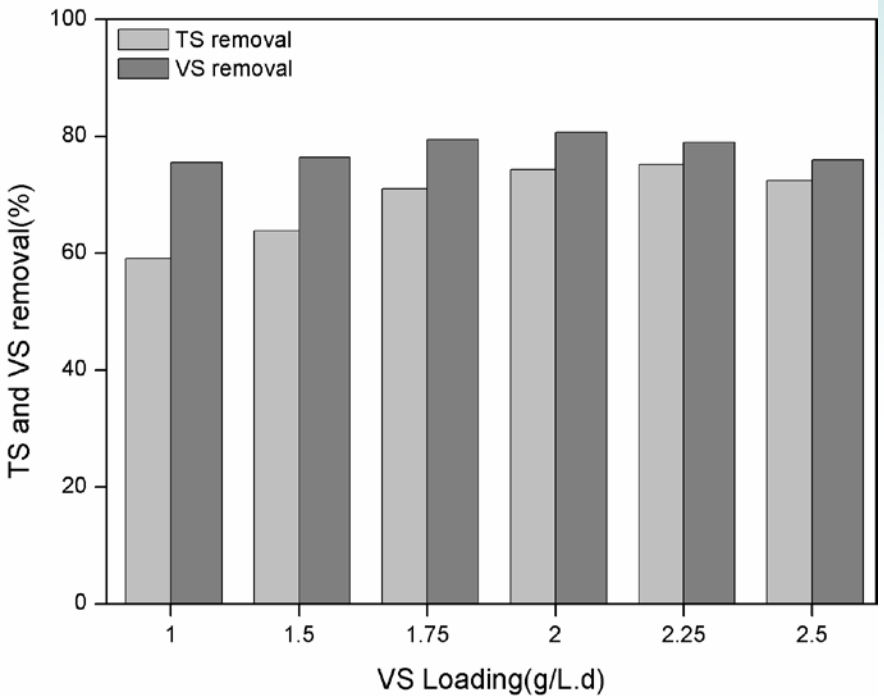
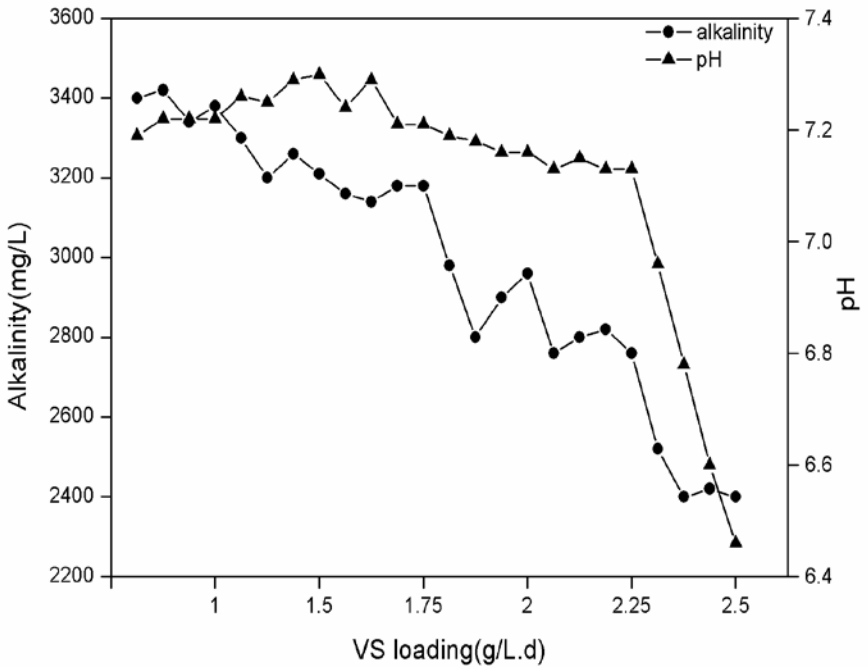
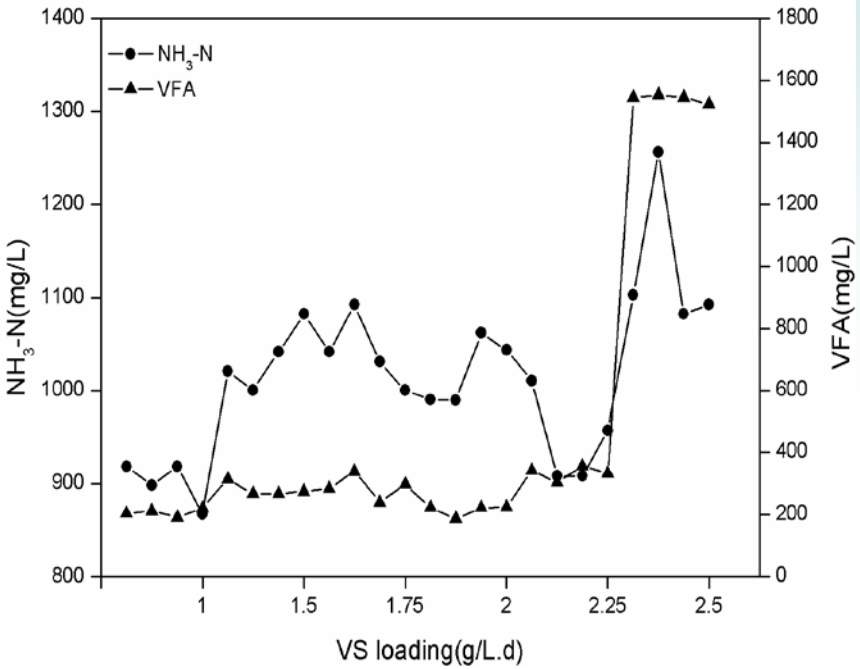


Fig .11 TS and VS removal at different loadings of R2

The maximum biogas yield of **723.89mL/g** and methane yield of **370.10mL/g** were achieved at 2.25 g/L with highest TS removal of 75.17% and VS removal of 79.02% 。

Results: R2-Fixed Feed concentration





The pH remained over 7.1 at below **2.25g·L^{-1}·d^{-1}**and then dropped .

The alkalinity showed decreasing from **3300mg/L to 2500mg/L**.

Ammonia nitrogen maintained **900mg·L^{-1}-1256mg·L^{-1}** and no inhibition.

VFA concentration remained below **200 mg·L^{-1}** and increased to 1500mg/L obviously at 2.5 g·L^{-1}·d^{-1}.

Performance Comparation of R1 & R2

	VS loading ($g \cdot L^{-1} \cdot d^{-1}$)	Feeding Concentration ($g \cdot L^{-1}$)	HRT (d)	Volume biogas yield ($mL \cdot L^{-1}$)	Loading biogas yield ($mL \cdot g^{-1}$)	TS removal (%)	VS removal (%)	pH	Alkalinity ($mg \cdot L^{-1}$)	NH_3-N ($mg \cdot L^{-1}$)	VFA ($mg \cdot L^{-1}$)
R1	1	30	30	558.67	558.67	46.31	68.39	7.26	3280	870.30	204.08
	1.5	45	30	942.08	628.06	69.91	80.43	7.29	3175	1020.99	231.42
	1.75	52.5	30	1165.56	666.03	76.46	82.60	7.29	3190	1092.68	292.62
	2	60	30	1398.15	699.07	80.60	83.91	7.25	3145	1119.82	244.47
	2.25	67.5	30	1770.74	787.00	81.22	83.96	7.23	3175	1051.72	274.01
	2.5	75	30	1891.08	756.43	80.02	83.04	7.22	3025	1420.38	1051.80
R2	1	40	40	623.33	623.33	59.10	75.51	7.21	3385	900.67	207.21
	1.5	40	27	965.00	643.33	63.84	76.41	7.28	3242.5	1036.35	281.12
	1.75	40	23	1193.03	681.73	71.09	79.44	7.24	3165	1041.47	290.53
	2	40	20	1391.11	695.56	74.33	80.68	7.17	2910	1021.45	214.36
	2.25	40	18	1628.75	723.89	75.17	79.02	7.14	2785	996.11	333.92
	2.5	40	16	1146.06	458.42	72.45	75.99	6.70	2435	1133.64	1541.50

Conclusions

1. Kitchen waste was anaerobic digested with CSTR and the maximum biogas yield of 787mL·g^{-1}.d^{-1} and methane yield of 454.6mL·g^{-1}.d^{-1}were achieved at 2.25g·L^{-1}·d^{-1} with fixed HRT of 30d.

2. With fixed HRT, the organic loading could reach 2.5g·L^{-1}·d^{-1} and gradually lost its stability at 2.75g·L^{-1}·d^{-1}, and the maximum loading could only reach 2.25g·L^{-1}·d^{-1} when the feed concentration is fixed.

3. The longer HRT should be choose at the start-up stage and enough HRT was needed at later stage of anaerobic digestion

Any questions?

Thanks your attention !