7TH INTERNATIONAL CONFERENCE ON SUSTAINABLE SOLID WASTE MANAGEMENT

Acetic acid by-product from various fermentations of fermented biogas excess sludge and acidic sludge substrate

Asst. Prof. Nittaya BOONTIAN Ph.D.

n.boontian@sut.ac.th

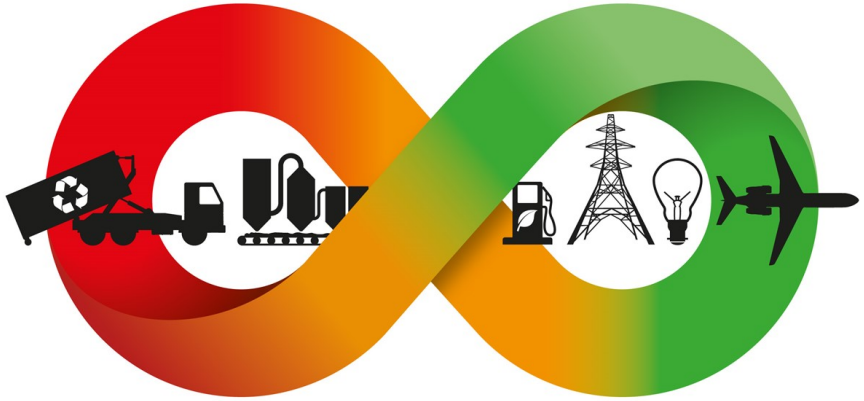
School of Environmental Engineering

Institute of Engineering

Suranaree University of Technology

THAILAND

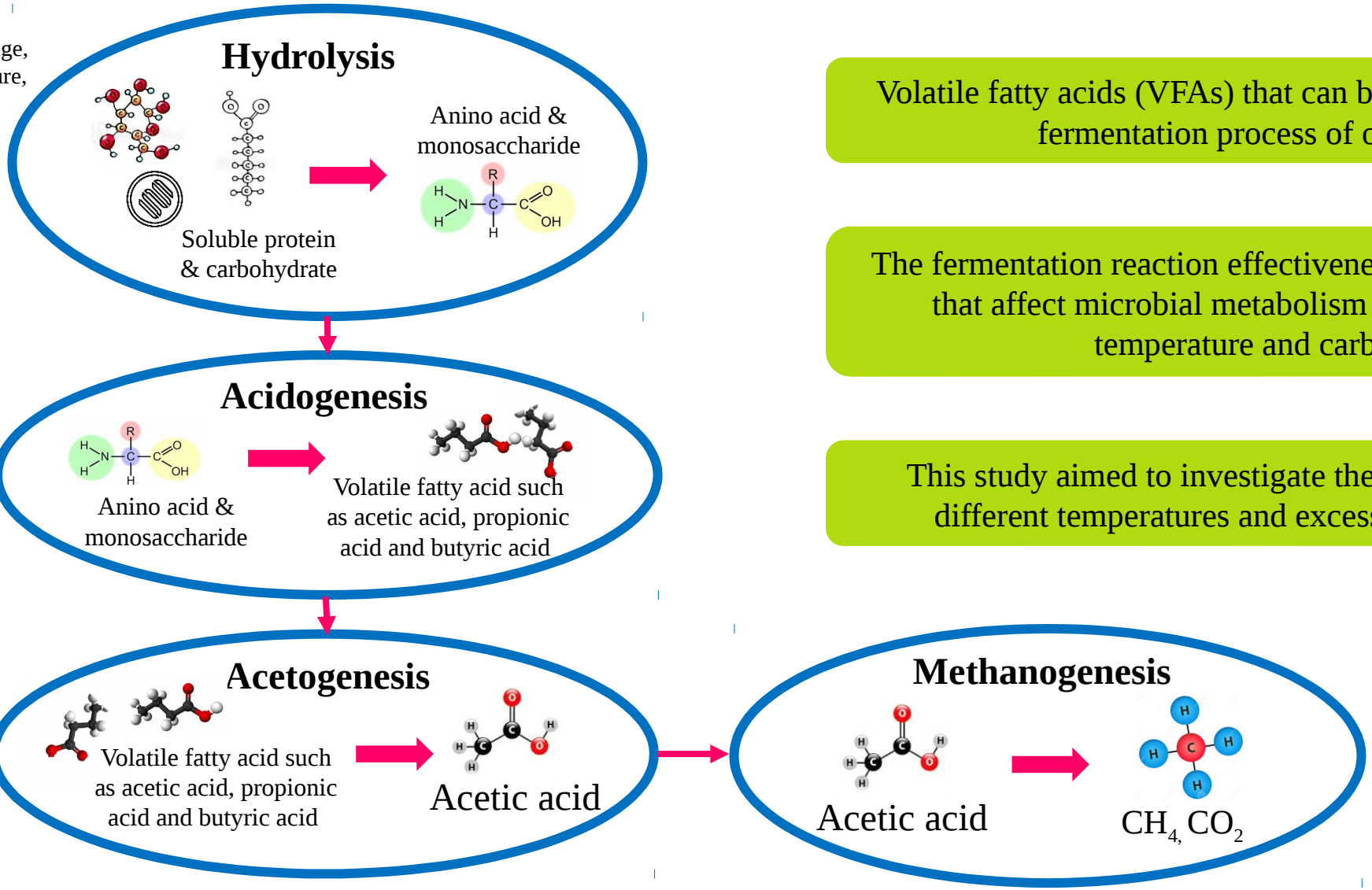
Content



Introduction

Waste

Excess sludge, swine manure, food waste



Volatile fatty acids (VFAs) that can be obtained from anaerobic fermentation process of organic waste.

The fermentation reaction effectiveness relies on the parameters that affect microbial metabolism processes such as pH, temperature and carbon source

This study aimed to investigate the acetic acid produced in different temperatures and excess sludge source ratios.

Methods

1

CAS in set 1 and 2 control with 35 and 55 °C

The samples collected every 4 hrs for analyze the volatile fatty acids (VFAs).

2

Excess sludge from EBPR in set 3 and 4 control with 35 and 55 °C

The samples collected every 4 hrs for analyze acetic acid, butyric acid or propionic acid concentrations.

3

Excess sludge from EBPR in set 5

Value of pH was varied to be 1 2 3 6 9 10 11 12 13 and 14 using 2N H_2SO_4 and 2N NaOH at 35 °C.

The samples collected every 4 hrs for analyze the VFAs.

4

5-liter 5-liter 5-liter

Excess sludge from EBPR and SM in set 6 and 7 control with 35 °C

The samples collected every 4 hrs for analyze the VFAs.

5

5-liter 5-liter 5-liter

FS:AF (1:1), RS:AF (4:1) and RS:AF (1:4) in set 8, 9 and 10 control with 35 °C.

The samples collected every 4 hrs for analyze acetic acid, butyric acid or propionic acid concentrations.

Results and Discussion

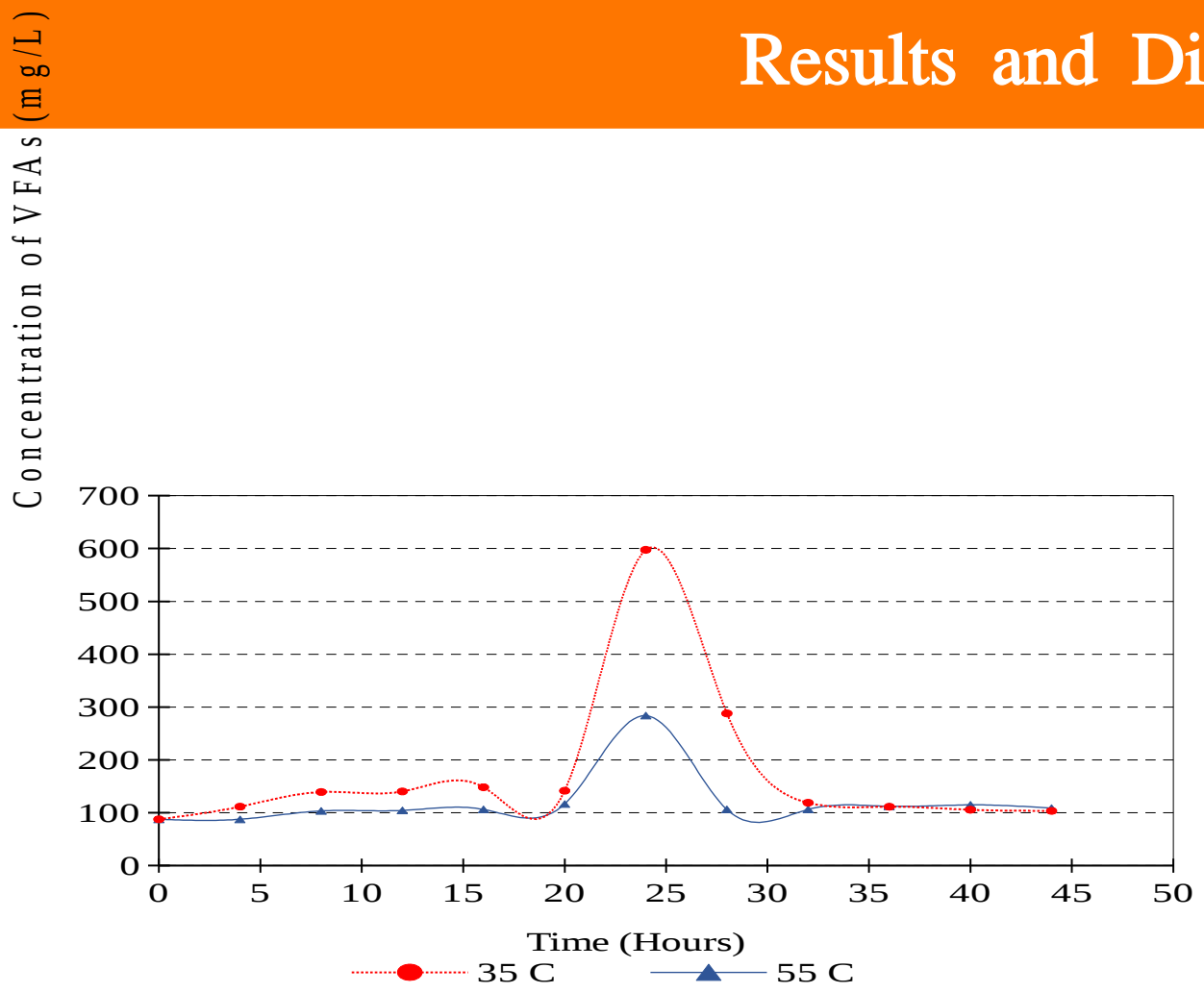


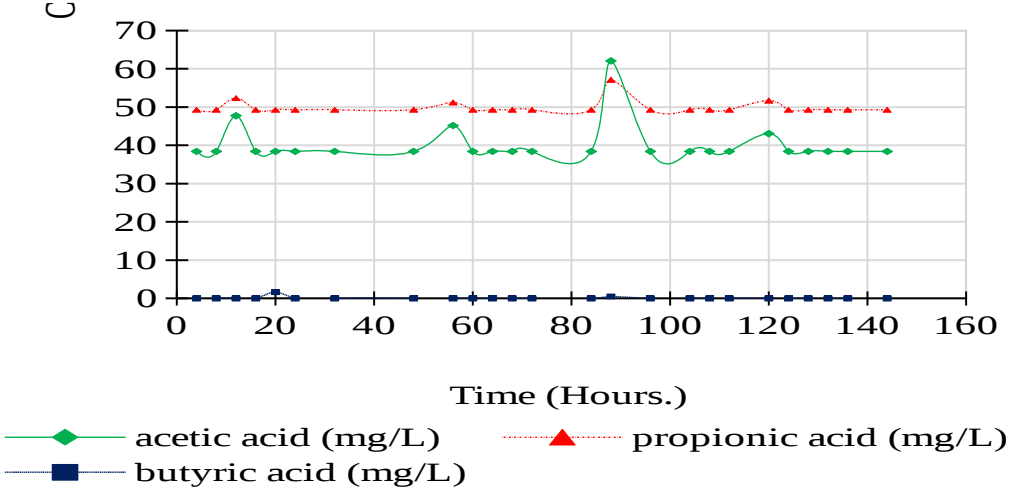
Fig 1 Concentration of VFAs from fermented excess sludge from activated sludge system (set 1-2) at temperature 35 °C and 55 °C

The concentration of VFAs was 597 and 283 mg.COD/L at a temperature of 35 °C and 55 °C, respectively for 24 Hr.

The concentration of VFAs that occurred at 35 ° C was not significantly different with the temperature of 55 °C (sig. = 0.10> 0.05).

Both temperatures did not affect the degradation rate of the CAS system at the ratio of TVS / TS equal to 0.27.

Results and Discussion



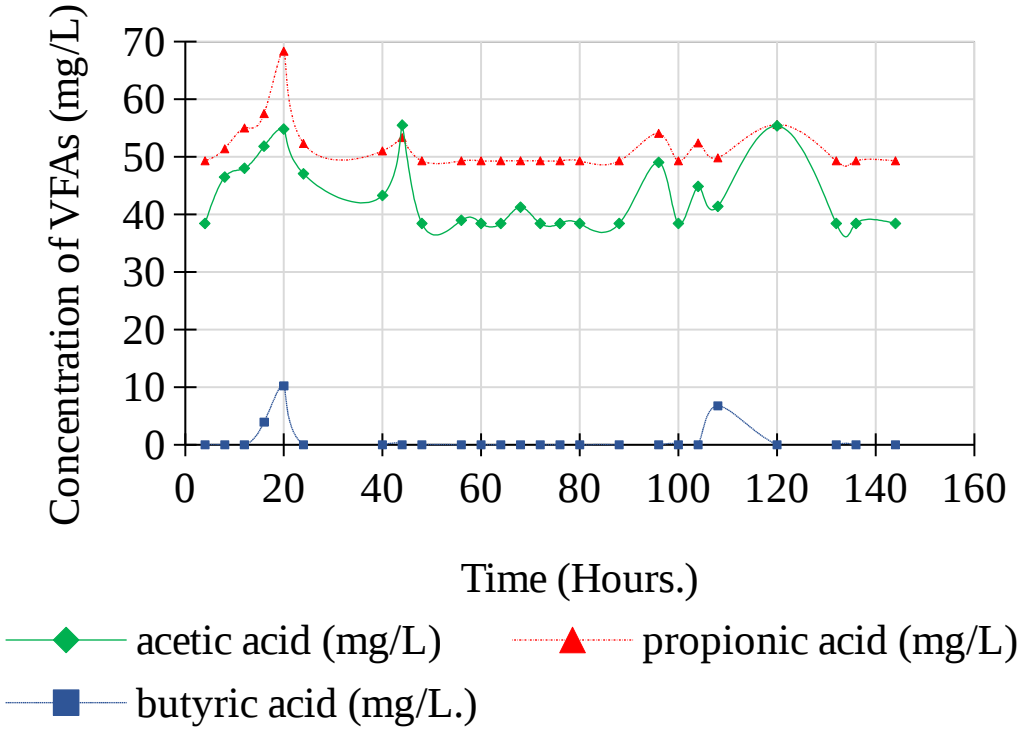


Fig 2 Concentration of acetic acid, propionic acid and butyric acid from excess sludge from EBPR. 35 °C (A) 55 °C (B)

Set 3 and 4 showed the highest CH_3COOH of 62 and 55 mg/L at 88 and 44 hours, respectively.

Set 3 and 4 were not significantly different (sig. = 0.09> 0.05) indicating that the temperature had no effect on WAS fermentation to produce CH_3COOH.

Results and Discussion

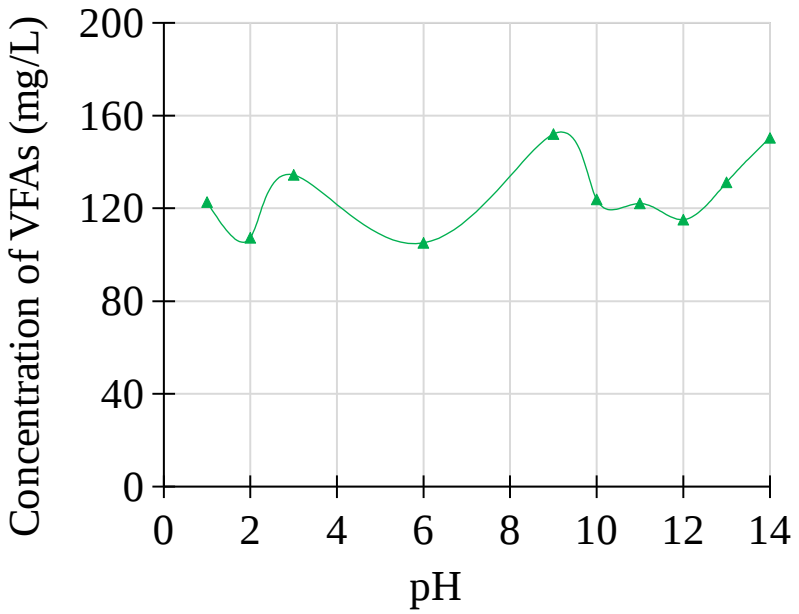


Fig 3 Concentration of VFAs in pretreatment of excess sludge from EBPR (set 5) with different pH.

The pH 14 had the highest concentration of CH_3COOH equal to 93.14 mg/L and Propionic acid was 59.1 mg/L at pH 9.

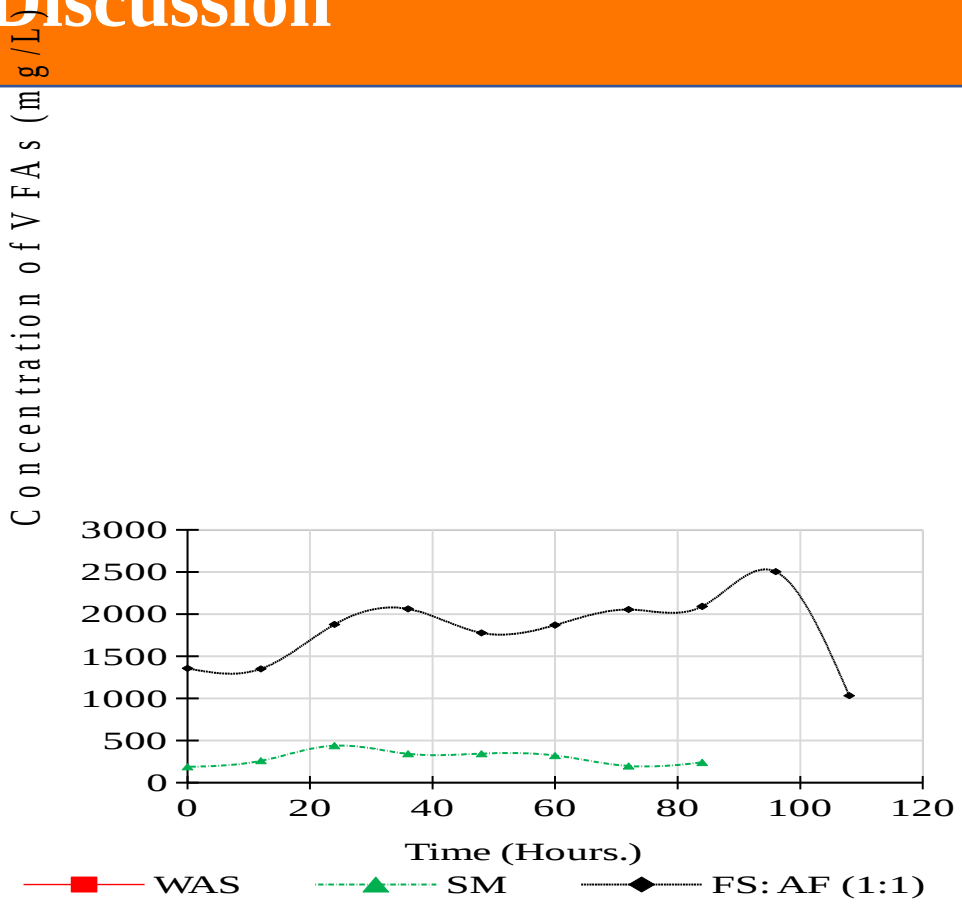


Fig 4 Concentration of VFAs from EBPR (set 6), pig manure (set 7) and FS:AF (1:1) (set 8) in temperature 35 °C.

The comparison of VFAs from 3 carbon sources revealed that VFAs in set 6 and 7 were 650 and 439 mg/L, respectively.

Results and Discussion

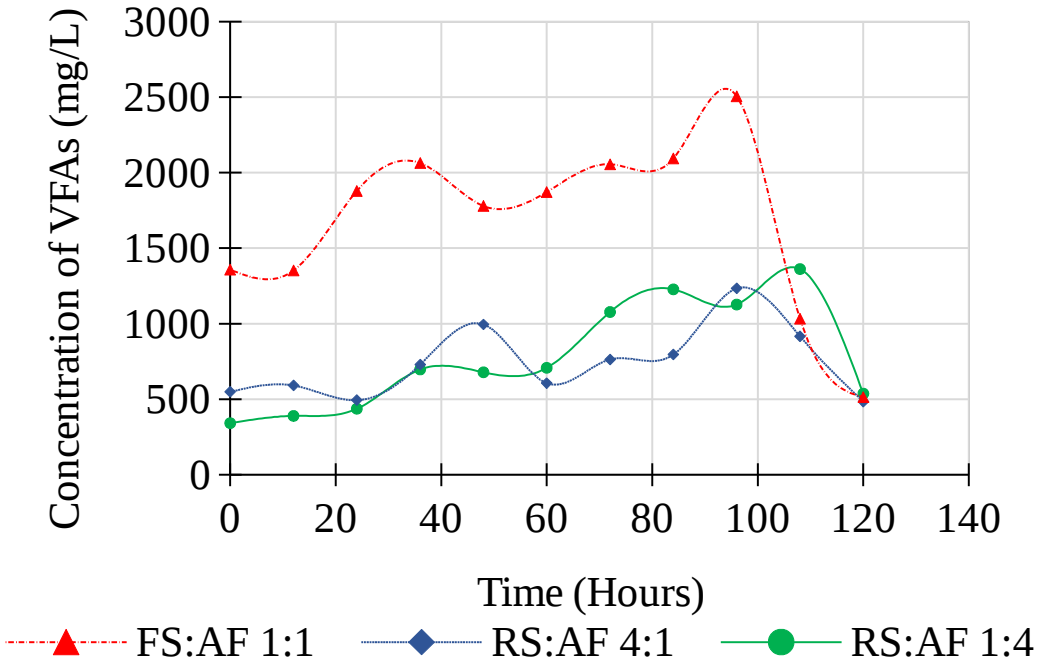


Fig 5 VFAs in batch tests operated at different substrates ratios FS: AF (1:1), RS: AF (4:1) and RS: AF (1:4).

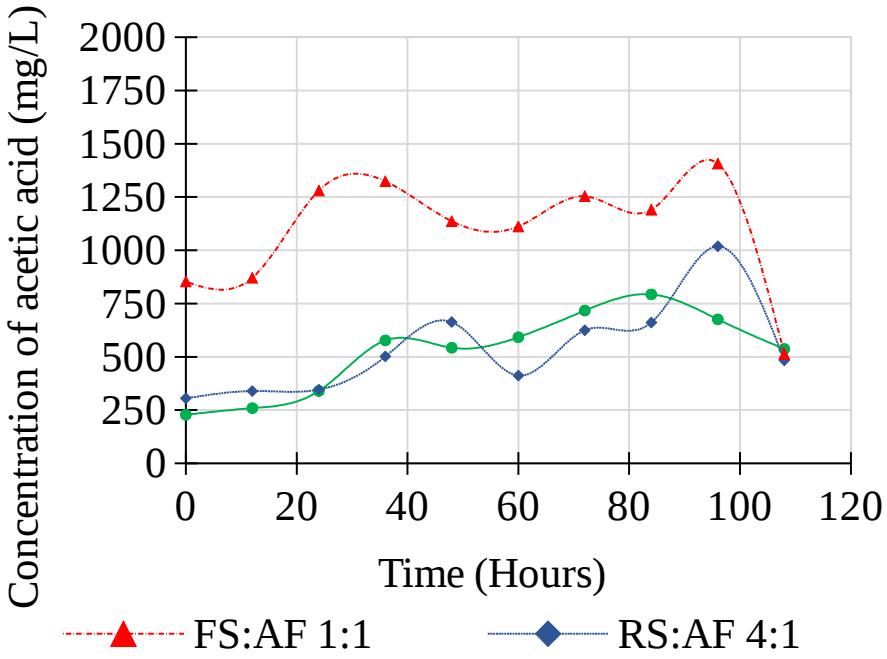


Fig 6 Acetic acid in batch tests operated at different substrates ratios FS: AF (1:1), RS: AF (4:1) and RS: AF (1:4).

VFAs that produced using the carbon source FS: AF 1: 1 equal to 2,500 mg / L slowly increased from 12 to 96 hours.

using RS: AF (4: 1) and RS: AF (1: 4) had Similar VFAs in experiments, which approximately 341-1,362 mg / L at 96 and 108 hours, respectively.

FS: AF 1: 1 (Series 8) at 96 hours, found that the highest amount of CH_3COOH was 1.4 g.COD / L

The highest proportion of CH_3COOH was more than 80%. Production of CH_3COOH in Series 8 is able to be used as a carbon source for biological phosphorus removal.

Results and Discussion

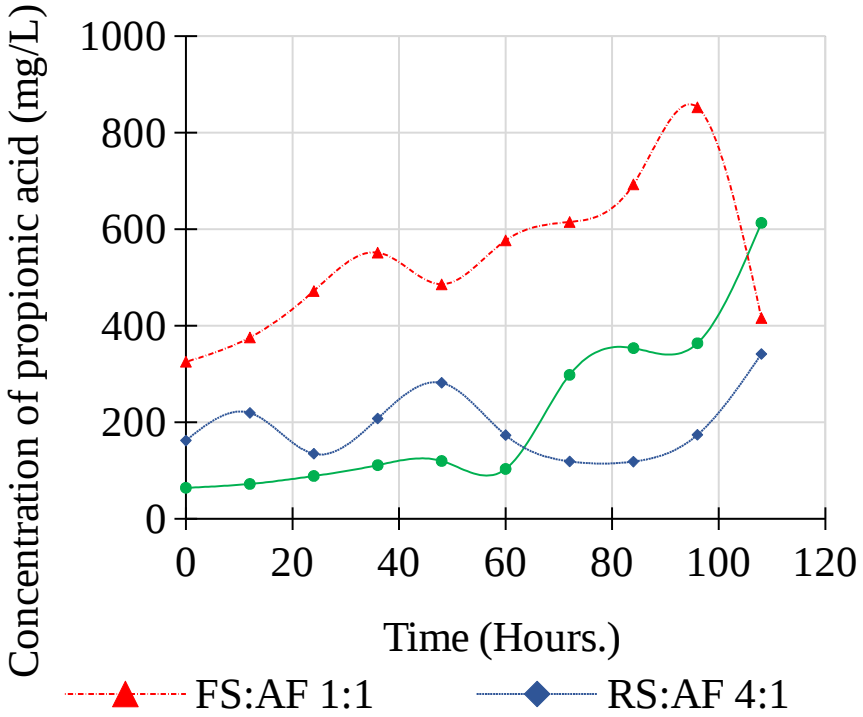


Fig 7 Propionic acid in batch tests operated at different substrates FS: AF (1:1), RS: AF (4:1) and RS: AF (1:4).

Set 8 (FS: AF (1: 1)) had the highest propionic acid which equal to 853 mg/L at HRT of 96 hours.

At 108 hours, set 9 and 10 produced propionic acid as much as 341 mg/L and 612 mg/L, respectively.

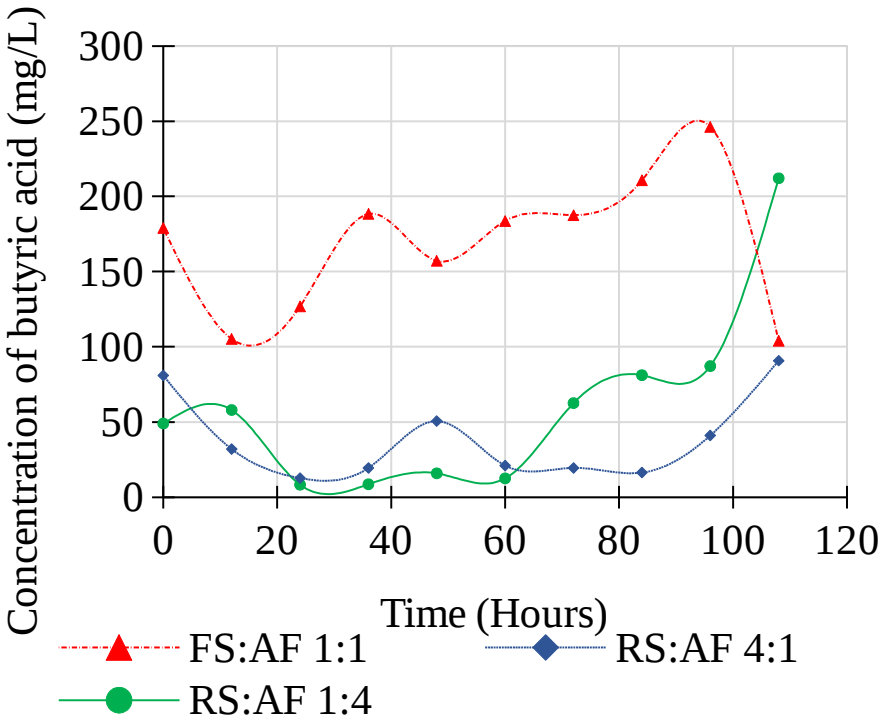


Fig 8 Butyric acid in batch tests operated using different substrates FS: AF (1:1), RS: AF (4:1) and RS: AF (1:4).

Set 8 (FS: AF (1: 1)) had the highest butyric acid equal to 246 mg COD/L at 96 hours.

Results and Discussion

Table 3 Concentration VFAs from different condition and concentration of acetic acid.

Carbon source	Acetic acid	Concentration of VFAs	Conditions	Reference
Set 1 (WAS from AS)	-	597 mg/L at 24 hours.	pH not controlled at35 °C	This study
Set 2 (WAS from AS)	-	283 mg/L at 24 hours.	pH not controlled at 55 °C	
Set 3 (WAS from EBPR)	62 mg/L	120 mg/L	pH not controlled at 35 °C	
Set 4 (WAS from EBPR)	56 mg/L	133 mg/L at 20 hours.	pH not controlled at 55 °C	
Set 5 (WAS from EBPR)	93.14 mg/L	152 mg/L	pH 14	
Set 6 (WAS from EBPR)	-	574 mg/L	pH not controlled at 35 °C	
Set 7 Pig Manure	109 mg/L.	439 mg/L		
Set 8 FS:AF (1:1)	1,406 mg/L	2,505 mg/L at 96 hours.		
Set 9 RS:AF (4:1)	1,018 mg/L	1,233 mg/L at 96 hours.		
Set 10 RS:AF (1:4)	792 mg/L	1,227 mg/L at 108 hours.		
Excess sludge from sedimentation tank and secondary sedimentation tank	-	423.22±25.49 mg. COD/g.VSS	Ratio of excess sludge from sedimentation tank and secondary sedimentation tank (w/w: 1:1) at pH 8.9	Yun et al. (2017) [23]
Animal dung and wheat straw	1,394 mg/L	-	Anaerobic condition for 10 days	Maie et al. (2017) [27]
Cow manure and corn silage	6,444 mg/L	14,651 mg/L	Controlled 55 °C for 4 days	Cristina et al. (2017) [28]
secondary sedimentation tank and anaerobic fermentation tank	615 mg/L	666.5 mg/L	Controlled 55 °C for 6 days	Huibin และSheng (2017) [26]
Sludge from trickling filter system	-	1,327 mg/L at 120 °C	Heating at 75 °C for 10 minutes	Jiabing et al. (2016) [29]
Pig manure	-	12.6 mg. COD/g.VSS	Controlled at 35 °C	Weiwei et al. (2016) [30]
Waste activated sludge	191 mg/L	574.4 mg/L at 35 °C	Mixing 165 rpm, pH 6.6 - 7.1 for 48 hours.	Jiuxiao and Hui (2015) [11]
Excess sludge from SBR (Sequencing Batch Reactor)	2,862 mg/L. At pH 4	pH 4; 3,914 mg/L pH 6; 2,607 mg/L	Controlled 26 °C and mixing 60 rpm	Infantes et al. (2011) [31]

Conclusions

- The optimum conditions for excess sludge fermentation to produce acetic acid was FS: AF (1: 1) in set 8 which resulted 1,406 mg/L acetic acid as final concentration in condition of 120 rpm mixing rate for 96 hours at 35 ^{o}C.

- The highest acetic acid was also detected in RS: AF (4: 1) (set 9) and RS: AF (1: 4) (set 10) where the acetic acid concentrations were equal to 1,018 and 792 mg/L, respectively.

- The comparison of acetic acid production of set 8 to set 9 and set 8 to 10 using Paired t-test at 95% confidence level showed that there were significant differences ($p = 0.00 < 0.05$) in both pairs.

- Set 8 experiment condition with its carbon source is very potential for the biological phosphorus removal system as it had the highest acetic acid which suitable for the growth of PAOs in biological phosphorus removal systems.

Research Group Members

Asst. Prof. Nittaya Boontian Ph.D.

Suranaree University of Technology
n.boontian@sut.ac.th

Chatlada Piasai

Suranaree University of Technology
chatlada_jan@hotmail.com

Thunchanok Phorndon

Suranaree University of Technology
thun-bb@hotmail.com

Mohamad Padri

Suranaree University of Technology
biologiunm10@gmail.com