REFERENCES

Abbasi, S.A., Nipaney, P.C., and Panholzer, M.B. (1991). Biogas production from the aquatic weed pistia (Pistia stratiotes). Bioresource Technology, 37(3), 211-214.

Abbasi, S.A., Nipaney, P.C., and Ramasamy, E.V. (1992). Studies on multiphase anaerobic digestion of salvinia. Indian Journal of Technology, 30(10), 483-490.

Abbasi, T., Tauseef, S.M., and Abbasi, S.A. (2012). Anaerobic digestion for global warming control and energy generation-an overview. Renewable and Sustainable Energy, 16, 3228-3242.

Balat, M. (2011). Production of bioethanol from lignocellulosic materials via the biochemical pathway: a review. Energy Conversion and Management, 52, 858-875.

Botheju, D., Lie, B., and Bakke, R. (2009). Oxygen effects in anaerobic digestion. Modeling, Identification and Control, 30(4), 191-201.

Botheju, D., Samarakoon, G., Chen, C., and Bakke, R. "An Experimental Study on the Effects of Oxygen in Bio-gasification - Part 1." European Association for the Development of Renewable Energies;Environment and Power Quality (EA4EPQ). March 2010a. Accessed on October 7, 2013 <http://www.icrepq.com/icrepq'10/690-Botheju.pdf>.

Botheju, D., Samarakoon, G., Chen, C., and Bakke, R. "An Experimental Study on the Effects of Oxygen in Bio-gasification - Part 2." European Association for the Development of Renewable Energies;Environment and Power Quality (EA4EPQ). March 2010b. Accessed on October 7, 2013 <http://www.icrepq.com/icrepq'10/732-Botheju.pdf>.

Botheju, D. and Bakke, R. (2011). Oxygen effects in anaerobic digestion-a review. The Open Waste Management Journal, 4, 1-19.

Chandra, R., Takeuchi, H., and Hasegawa, T. (2012). Methane production from lignocellulosic agricultural crop waste: a review in context to second generation of biofuel production. Renewable and Sustainable Energy Reviews, 16, 1462-1476.

Chen, Y., Cheng, J.J., and Creamer, K.S. (2008). Inhibition of anaerobic digestion process: a review. Bioresource Technology, 99(10), 4044-4064.

Daisy, A. and Kamaraj, S. (2011). The impact and treatment of night soil in anaerobic digester: a review. Microbial and Biochemical Technology, 3, 43-50.

Denise, C., Charles, J.B., Sonia, H., and Kimon-Andreas, G.K. (2012). The effect of pH control and 'hydraulic flush' on hydrolysis and volatile fatty acids (VFA) production and profile in anaerobic leach bed reactors digesting a high solids content substrate. Bioresource Technology, 123, 263-271.

Diaz, I., Lopes, A.C., Perez, S.I., and Polanco, M.F. (2010). Performance evaluation of oxygen, air and nitrate for the microaerobic removal of hydrogen sulphide in biogas from sludge digestion. Bioresource Technology, 101, 7724-7730.

Diaz, I., Bravo, A.D., and Polanco, M.F. (2011). Effect of microaerobic conditions on the degradation kinetics of cellulose. Bioresource Technology, 102, 10129-10142.

Fricke, K., Santen, H., Wallmann, R., Huttner, A., and Dichtl, N. (2007). Operating problems in anaerobic digestion plants resulting from nitrogen in MSW. Waste Management, 27(1), 30-43.

Hill, N., Walker, H., Beevor, J., and James, K. "2011 Guidelines to Defra/DECC's GHG Conversion Factors for Company Reporting: Methodology Paper for Emission Factors." Department for Environment, Food and Rural Affairs. August 2011. Accessed on October 4, 2013 < http://www.defra.gov.uk/ publications/files/pb13625-emission -factor-methodology-paper-110905. pdf>.

Jenicek, P. "Benefits and Drawbacks of Microaerobic Condition in Anaerobic Digestion." Department of Water Technology. 2011. Accessed on November 8, 2013 < http://mbr.eng.usf.edu/biowet/Jenicek1.pdf>.

Jenicek, P., Keclik, F., Maca, J., and Bindzar, J. (2008). Use of microaerobic conditions for the improvement of anaerobic digestion of solid wastes. Water Science and Technology, 58(7), 1491-1496.

Jenicek, P., Koubova, J., Bindzar, J., and Zabranska, J. (2010). Advantages of anaerobic digestion of sludge in micreaerobic conditions. Water Science and Technology, 62.2, 427-434.

Johansen, J.E. and Bakke, R. (2006). Enhancing hydrolysis with microaeration. Water Science and Technology, 53, 43-50.

Kato, M.T., Field, J.A., and Lettinga, G. (1993). High tolerance of methanogens in granular sludge to oxygen. Biotechnology and Bioengineering, 42(11), 1360-1366.

Levine, A.D., Tchobanoglous, G., and Asano, T. (1991). Size distributions of particulate contaminants in wastewater and their impact on treatability. Water Research, 25(8), 911-922.

Lim, J.W. and Wang, J.Y. (2013). Enhanced hydrolysis and methane yield by applying microaeration pretreatment to the anaerobic co-digestion of brown water and food waste. Waste Management, 33, 813-819.

Manginot, D. (2013). Refining and Marketing; the Refining Industry and Sustainable Development. Total Professors Association (Sheet Handout, Bangkok, Thailand).

Parkin, G.F., Sneve, M.A., and Loos, H. (1991). Anaerobic filter treatment of sulfate-containing wastewaters. Water Science and Technology, 23, 1283-1291.

Rapport, J., Zhang, R., Jenkins, B.M., and Williams, R.B. "Current Anaerobic Digestion Technologies Used for Treatment of Municipal Organic Solid Waste." Department of Biological and Agricultural Engineering; University of California. March 2008. Accessed on October 18, 2013 <http://www. calrecycle. ca.gov/Publications/Documents/Organics%5C2008011.pdf>.

Robin, E. "Structure of lignocelluloses." Scitable by Nature Education. 2008. Accessed on October 10, 2013 <http://www.nature.com/scitable/content/ structure-of-lignocellulose-14464273>.

Sanders, W.T.M. "Anaerobic Hydrolysis during Digestion of Complex Substrates." Wageningen University. 2001. Accessed on October 10, 2013 <http://edep ot.wur.nl/198997>.

Siddiqui, Z., Horan, N., and Anaman, K. (2011). Optimisation of C:N ratio for co-digested processed industrial food waste and sewage sludge using the BMP test. International Journal of Chemical Reactor Engineering, 9(9), 1-15.

Todar, K. "Nutrition and growth of bacteria." Todar's Online Textbook of Bacteriology. 2008. Accessed on March 10, 2014 <http://textbookofbacteriology.net/nutgro_4.html>.

Veeken, A., Kalyuzhnyi, S., Scharff, H., and Hamelers, B. (2000). Effect of pH and VFA on hydrolysis of organic solid waste. Environmental Engineering, 126(12), 1076-1081.

Weiland, P. (2010). Biogas production: current state and perspectives. Applied Microbiology and Biotechnology, 85(4), 849-860.

Yu, H., Zhu, Z., Hu, W., and Zhang, H. (2002). Hydrogen production from rice winery wastewater in an upflow anaerobic reactor by using mixed anaerobic cultures. International Journal of Hydrogen Energy, 27, 1359-1365.

Zhu, M., Lu, F., Hao, L.P., He, P.J., and Shao, L.M. (2009). Regulating the hydrolysis of organic wastes by microaeration and effluent recirculation. Journal of Waste Management, 29, 2042-2052.

Zitomer, D.H. and Shrout, J.D. (1998). Feasibility and benefits of methanogenesis under oxygen-limited conditions. Waste Management, 18, 107-116.

Zitomer, D.H. and Shrout, J.D. (1999). High-sulfate, high-chemical oxygen demand wastewater treatment using aerated methanogenic fluidized beds. Water Environment Research, 72(1), 90-97.

"Anaerobic Digestion." National Non-Food Crops Centre and The Andersons Centre. 16 Nov 2011. Accessed on November 3, 2013 <http://www.nnfcc.co.uk/publications/nnfcc-renewable-fuels-and-energy-factsheet-anaerobic-digestion>.

"Biogas Composition." Naskeo Environnement. 2009. Accessed on November 3, 2013 <http://www.biogas-renewable-energy.info/biogas_composition.html>.

“Strategic Environmental Assessment; An Assessment of the Impact of Cassava Production and Processing on The Environment and Biodiversity.” Food and Agriculture Organization of The United Nations. April 2000. Accessed on November 3, 2013 <http://www.fao.org/docrep/007/y2413e/ y2413e00. html>.

APPENDICES

Appendix A Calibration Curves

Table A1 Calibration curve for acetic acid

Concentration of acetic acid (mg/l)	Peak area
1,000	0.04
2,000	0.15
3,000	0.29
4,000	0.37
5,000	0.48

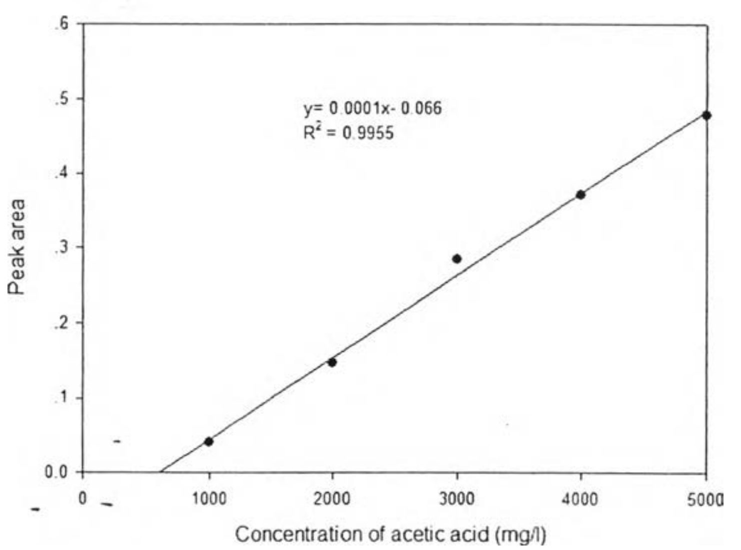

Figure A1 The relationship between concentration of acetic acid and peak area.

Equation

$$\text{Amount of acetic acid} = \frac{\text{Peak area} + 0.066}{0.0001}$$

Table A2 Calibration curve for propionic acid

Concentration of propionic acid (mg/l)	Peak area
1,000	0.14
2,000	0.36
3,000	0.59
4,000	0.77
5,000	0.95

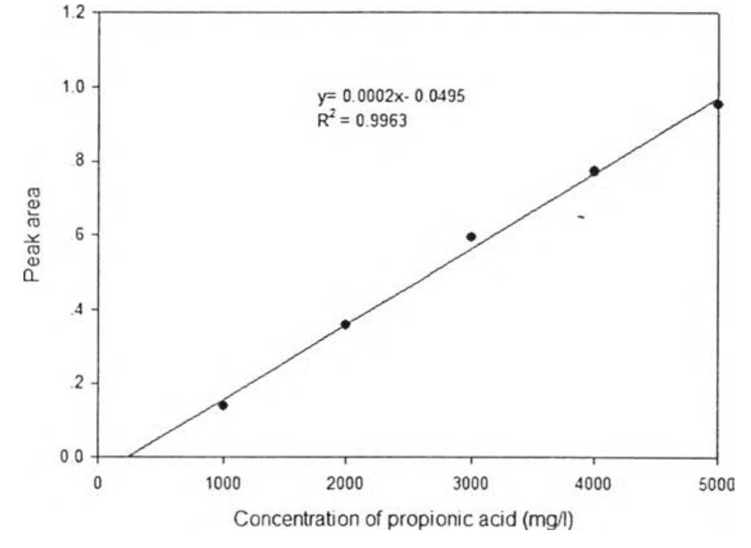

Figure A2 The relationship between concentration of propionic acid and peak area.

Equation

$$\text{Amount of propionic acid} = \frac{\text{Peak area} + 0.0495}{0.0002}$$

Table A3 Calibration curve for butyric acid

Concentration of butyric acid (mg/l)	Peak area
1,000	0.23
2,000	0.48
3,000	0.83
4,000	1.11
5,000	1.31

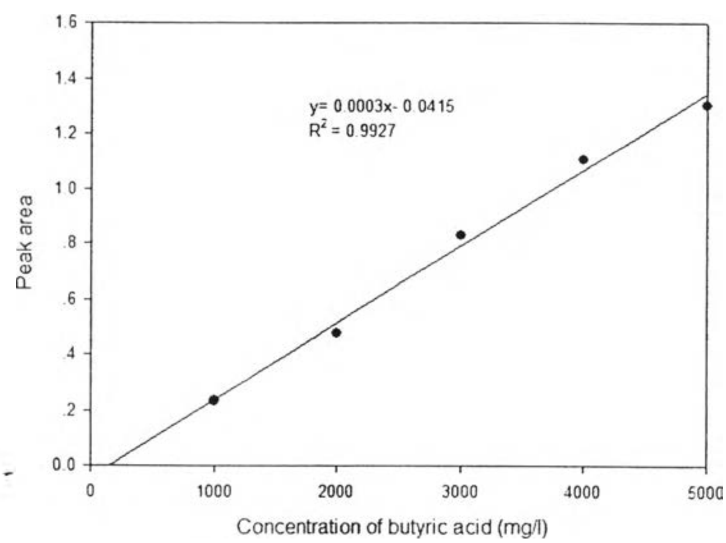

Figure A3 The relationship between concentration of butyric acid and peak area.

Equation

$$\text{Amount of butyric acid} = \frac{\text{Peak area} + 0.0415}{0.0003}$$

Table A4 Calibration curve for valeric acid

Concentration of valeric acid (mg/l)	Peak area
1,000	0.21
2,000	0.51
3,000	0.80
4,000	1.19
5,000	1.36

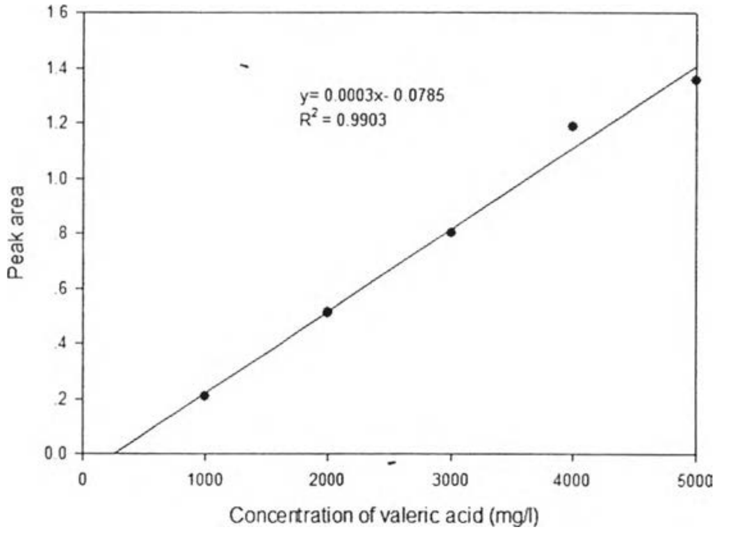

Figure A4 The relationship between concentration of valeric acid and peak area.

Equation

$$\text{Amount of valeric acid} = \frac{\text{Peak area} + 0.0785}{0.0003}$$

Table A5 Calibration curve for ethanol

Concentration of ethanol (mg/l)	Peak area
1,000	0.21
2,000	0.53
3,000	0.78
4,000	1.05
5,000	1.35

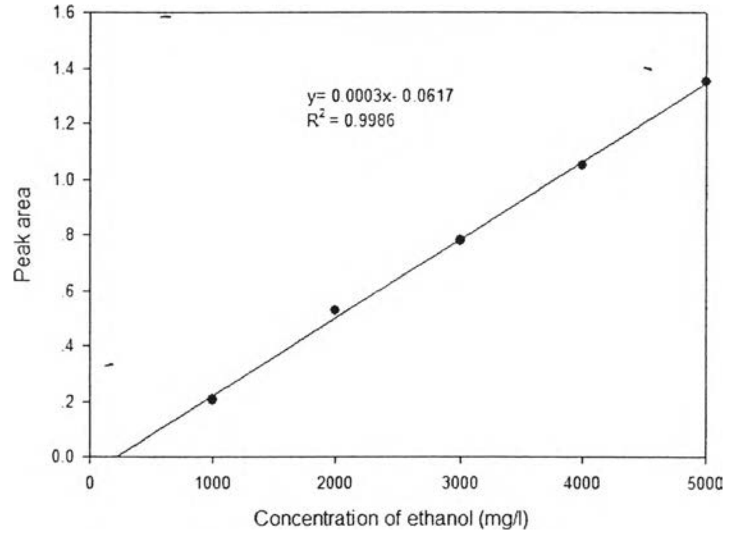

Figure A5 The relationship between concentration of ethanol and peak area.

Equation

$$\text{Amount of ethanol} = \frac{\text{Peak area} + 0.0617}{0.0003}$$

Table A6 Gas chromatograph's calibration curves for hydrogen (H_2)

Volume of Hydrogen (ml)	Peak Area
0.02	1101005
0.04	2016179
0.08	3680042
0.1	5675328
0.2	11471761
0.4	22832569

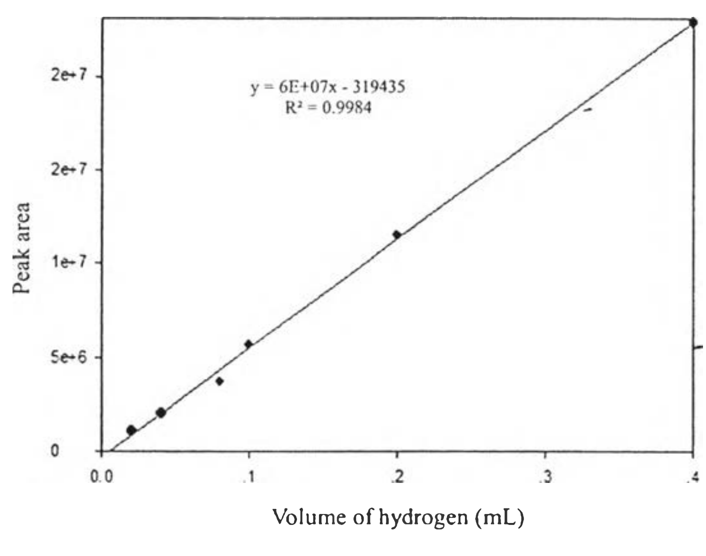

Figure A6 The relationship between amount of hydrogen (H_2) and peak area.

Equation

$$\text{Amount of hydrogen} = \frac{\text{Peak area} + 319435}{6 \times 10^7}$$

Table A7 Gas chromatograph's calibration curves for nitrogen (N_2)

Volume of Nitrogen (ml)	Peak Area
0.02	69431
0.04	188161
0.08	426068
0.1	478146
0.2	1008515
0.4	2155800
0.6	3309337

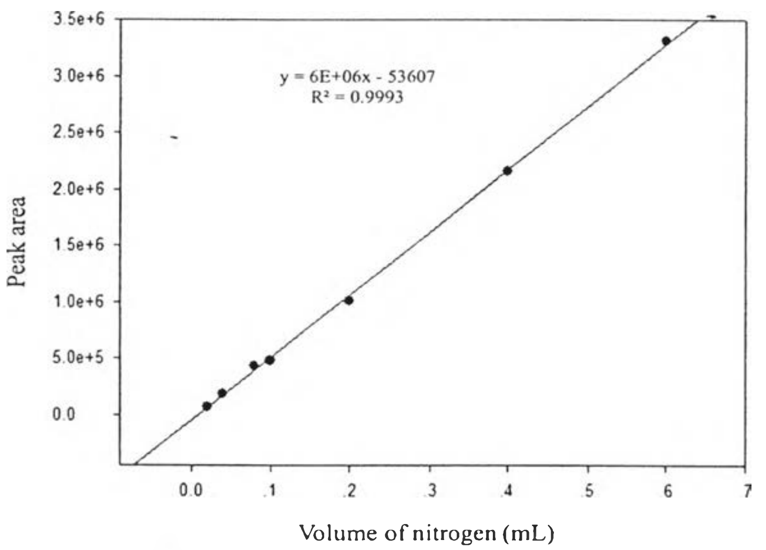

Figure A7 The relationship between amount of nitrogen (N_2) and peak area.

Equation

$$\text{Amount of nitrogen} = \frac{\text{Peak area} + 53607}{6 \times 10^6}$$

Table A8 Gas chromatograph's calibration curves for oxygen (O_2)

Volume of Oxygen (ml)	Peak Area
0.02	81122
0.04	233918
0.08	514527
0.1	662766
0.2	1366208
0.4	2738126

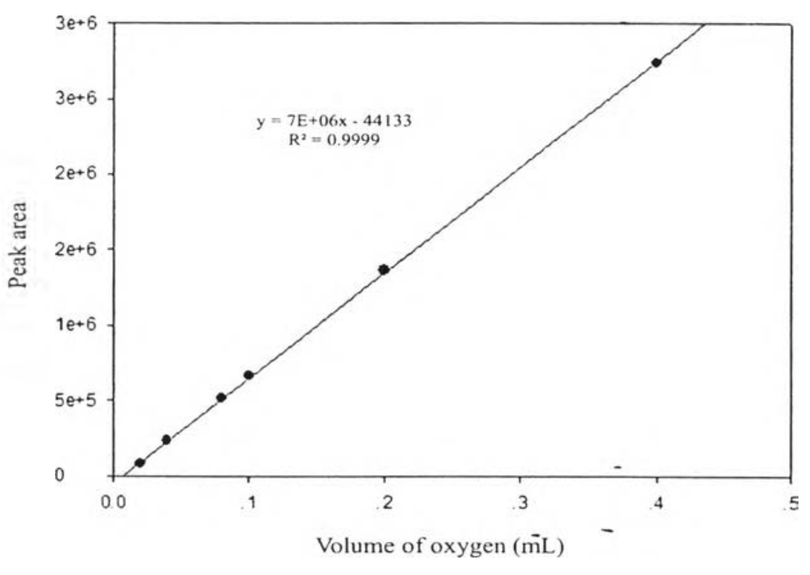

Figure A8 The relationship between amount of oxygen (O_2) and peak area.

Equation

$$\text{Amount of oxygen} = \frac{\text{Peak area} + 44133}{7 \times 10^6}$$

Table A9 Gas chromatograph's calibration curves for methane (CH_4)

Volume of Methane (ml)	Peak Area
0.02	151094
0.04	523919
0.08	998851
0.1	1366651
0.2	2898103
0.4	5880444

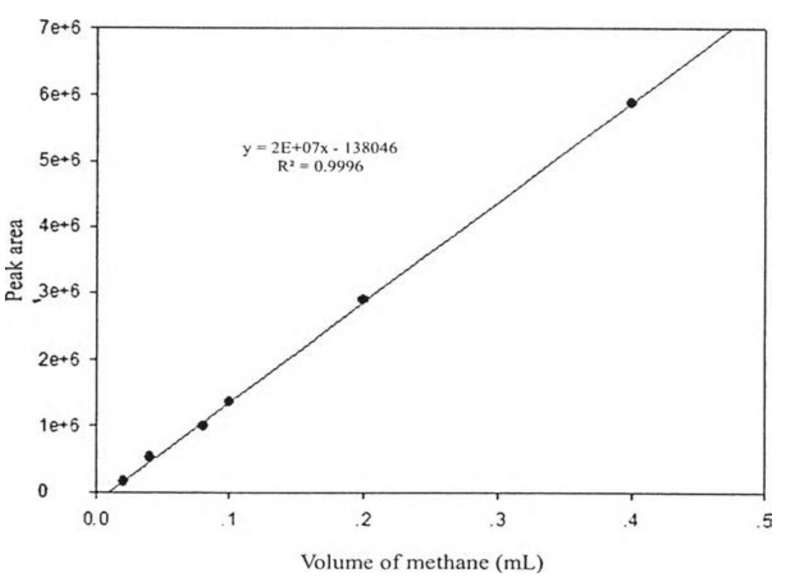

Figure A9 The relationship between amount of methane (CH_4) and peak area.

Equation

$$\text{Amount of methane} = \frac{\text{Peak area} + 138046}{2 \times 10^7}$$

Table A10 Gas chromatograph's calibration curves for carbon dioxide (CO_2)

Volume of Carbon Dioxide (ml)	Peak Area
0.02	4238
0.04	188166
0.08	293029
0.1	354304
0.2	747872
0.4	1515064

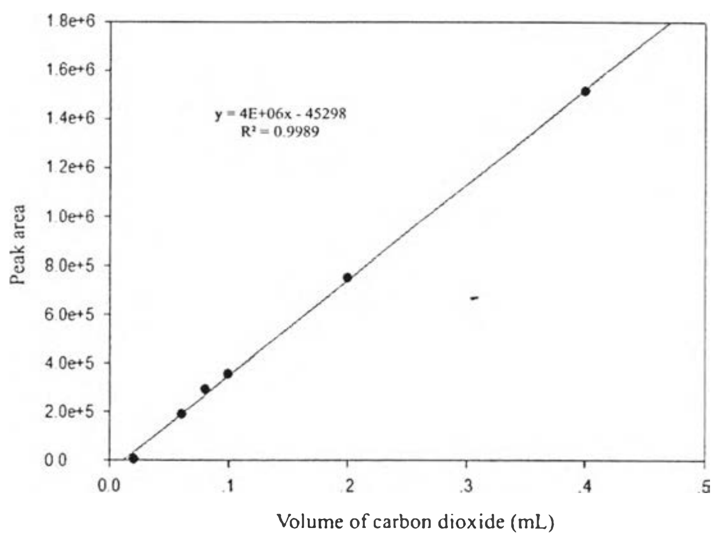

Figure A10 The relationship between amount of carbon dioxide (CO_2) and peak area.

Equation

$$\text{Amount of carbon dioxide} = \frac{\text{Peak area} + 45298}{4 \times 10^6}$$

Table A11 Gas chromatograph's calibration curves for hydrogen sulfide (H_2S)

Volume of Hydrogen Sulfide (ml)	Peak Area
0.02	3365.86
0.04	7829.54
0.08	12694.31
0.1	18716.25
0.2	35487.49
0.4	70213.68

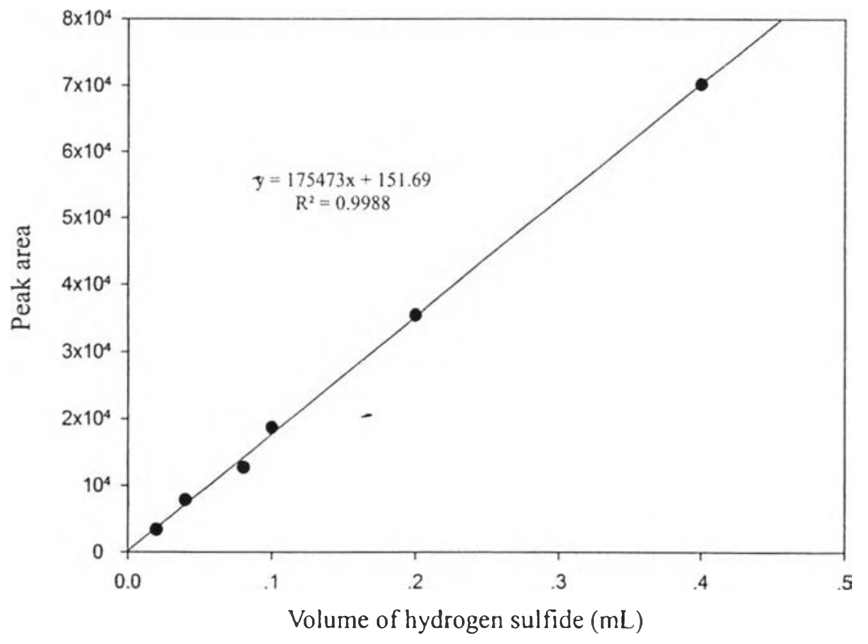

Figure A11 The relationship between amount of hydrogen sulfide (H_2S) and peak area.

Equation

$$\text{Amount of hydrogen sulfide} = \frac{\text{peak area} - 151.69}{1.75 \times 10^5}$$

Appendix B Volatile Fatty Acids (VFA) Quantification by Distillation Method

B 1. Acetic Acids Stock Solution Preparation for Recovery Factor (f) Determination

Concentration of fresh acetic acid (liquid)	=	99.7%
Density of acetic acid	=	1.07 g/ml
Molecular weight of acetic acid	=	60

Determination of fresh acetic acids concentration in term of molar

$$= \frac{0.997 \text{ L of acetic acid}}{\text{L of solution}} \times \frac{1.07 \text{ g of acetic acid}}{\text{mL of acetic acid}} \times \frac{1 \text{ mol of acetic acid}}{60 \text{ g of acetic acid}}$$

= 17.78 M

Preparation of acetic acid at concentration of 2,000 mg/L

$$= 2{,}000 \frac{\text{mg of acetic acid}}{\text{L of solution}} \times \frac{1 \text{ mole of acetic acid}}{60 \text{ g of acetic acid}}$$

= 0.0333 M

Dilution of acetic acid

N_1V_1	=	N_2V_2	
V_1	=	N_2V_2/N_1	
	=	(0.0333x1)/17.78	
	=	1.873×10^{-3}	L

B 2. Standard Sodium Hydroxide (0.1 M) Preparation

Concentration of fresh NaOH (solid)	=	99%
Molecular weight of acetic acid	=	40

Preparation of acetic acid at concentration of 0.1 M

$$= \frac{0.1 \text{ mol}}{1 \text{ L}} \times \frac{40 \text{ g}}{1 \text{ mol}} \times \frac{100}{99}$$

= 4.04 g

B 3. Recovery Factor (f) Determination

Distill 150 ml of 0.0333 M of acetic acid in distillation apparatus

Calculate the recovery factor

$$f = \frac{a}{b}$$

where

a = volatile acid concentration recovered in distillate, mg/L

b = volatile acid concentration in standard solution used, mg/L

Find volatile acid concentration recovered in distillate by titration with 0.1 M of NaOH (MW of acetic acid = 60.5)

1) Distillate 50 ml NaOH 11.7 ml

Used NaOH	=	$11.7 \times 10^{-3} \times 0.1$
	=	1.17×10^{-3} mol
Acetic acid in distillate	=	1.17×10^{-3} mol
	=	$1.17 \times 10^{-3} \times 60.5$
	=	0.07 g
Concentration of acetic acid in distillate		
	=	0.07/50
	=	1.405×10^{-3} g/ml
	=	1,405 mg/l

2) Distillate 25 ml NaOH 5.7 ml

Used NaOH	=	$5.7 \times 10^{-3} \times 0.1$
	=	5.7×10^{-4} mol
Acetic acid in distillate	=	5.7×10^{-4} mol
	=	$5.7 \times 10^{-4} \times 60.5$
	=	0.034 g
Concentration of acetic acid in distillate		
	=	0.034/25
	=	1.368×10^{-3} g/ml
	=	1,368 mg/l

Average	=	1,387	mg/l
Recovery factor (f)	=	1,387/2,000	
	=	0.6935	

CURRICULUM VITAE

Name : Ms. Oijai Khongsumran

Date of Birth : June 27, 1987

Nationality : Thai

University Education :

2006-2010 Bachelor Degree of Industrial Chemistry, Faculty of Applied Science, King Mongkut 's University of Technology North Bangkok (First Class Honour)

Working Experience:

2010-2011 Position: Laboratory Staff
Company name: Yushiro (Thailand) Co.,Ltd.

Proceedings:

1. Khongsumran, O.; Leethochawalit, M.; Chavadej, S.; and Rangsunvigit, P. (2014, April 22) Effects of Microaeration on the Anaerobic Digestion of Cellulosic Fraction in Wastewater. Proceedings of The 5th Research Symposium on Petrochemical, and Materials Technology and The 20th PPC Symposium on Petroleum, Petrochemicals, and Polymers, Bangkok, Thailand.