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RECYCLES WORKSHOP

Metagenomics and metabarcoding approaches to describe ecological systems and infer their development

5th, 6th & 7th of July 2022

Enhanced biogas production from sulfate rich waste water generated from concentrated latex factory

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GA: 872053 – H2020 - MSCA - RISE-2019

European Commission

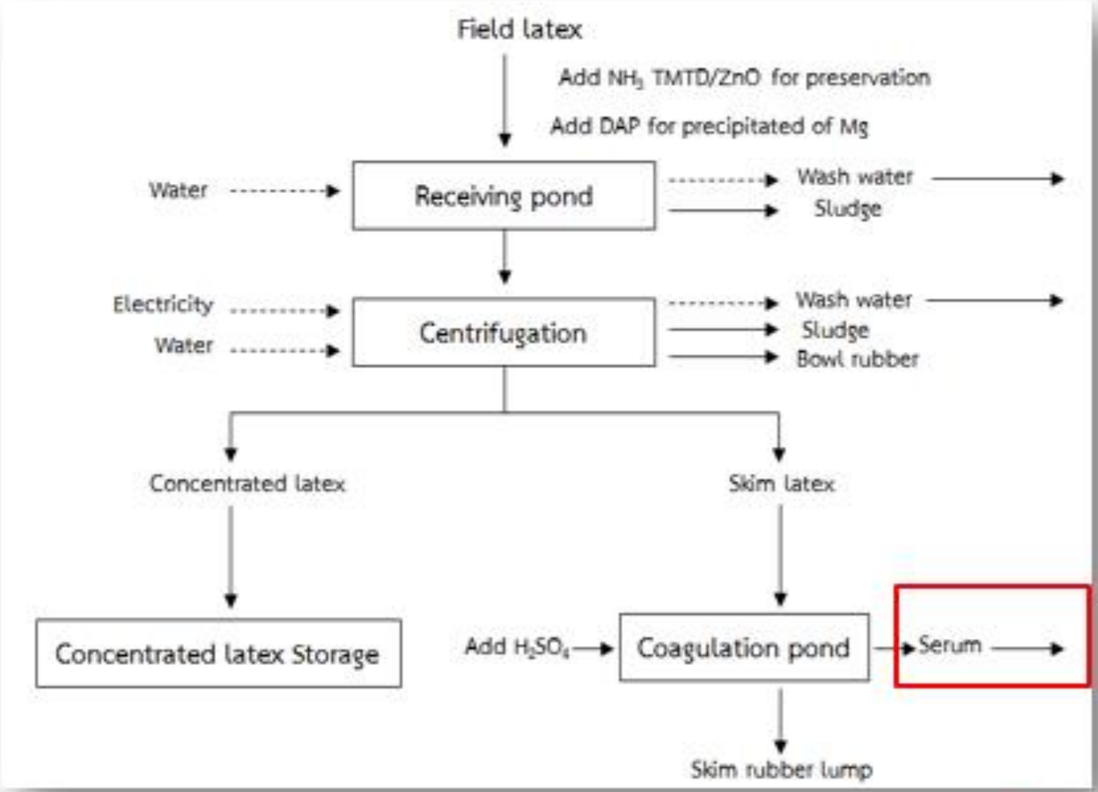
Outline

- ✓ Wastewater from concentrated latex factory
  >> high sulfate wastewater so-called skim latex serum (SLS) **(4,000-8,000 mg/L)**

- ✓ Two-stage anaerobic digestion of SLS
  - ✓ Acidogenesis and sulfate reduction in the first stage
  - ✓ Methanogenesis of the effluents from the first stage

- ✓ Removal of sulfate in SLS
  - ✓ To reduce sulfate in SLS prior anaerobic digestion by using rubber wood ash (RWA)

Wastewater from concentrated latex factory



latex serum (SLS)

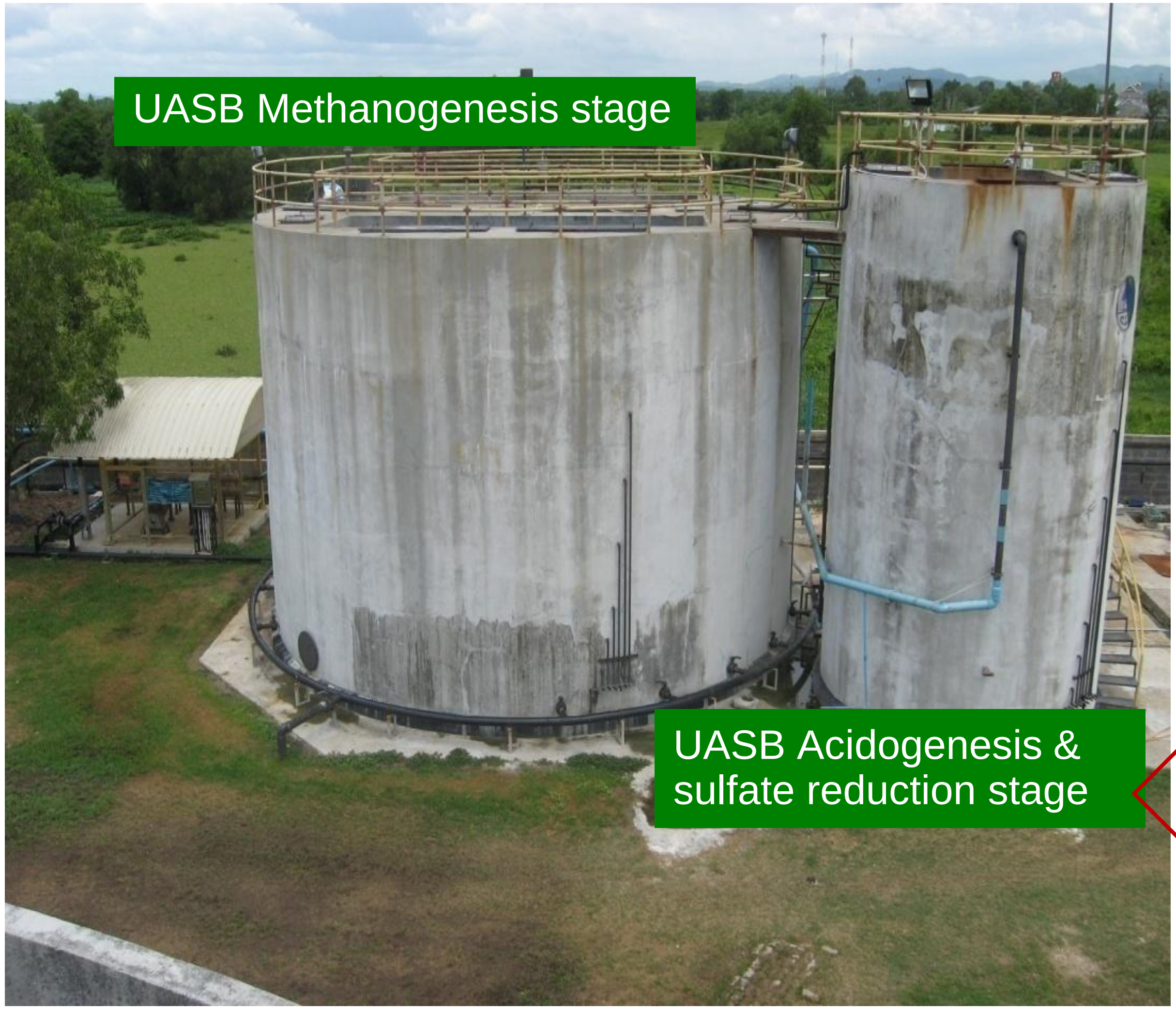
1. Wastewater from concentrated latex factory

- Over 2,000,000 m^3/year of SLS generated from sulfuric acid coagulation of skim latex
- High concentrations of
  - Organic matters (Carbohydrates, Protein, and Fat)
  - Sulfuric acid ----> Cause difficulty in an anaerobic digestion (AD) process
  - Ammonium

Characteristics of Skim Latex Serum (SLS)

Parameter	Concentration
Chemical Oxygen Demand : COD (g/L)	35.83
Sulfate (mg/L)	3580
pH	4.97
Total Alkalinity (mg/L-$CaCO_3$)	553
Total Nitrogen (TKN) (g/L-N)	11.0
Total organic Nitrogen (g/L)	2.1
Carbohydrates (g/L)	5.1
Protein	13.0
Total Solid (g/L)	41.3
Volatile Solid (g/L)	38.0

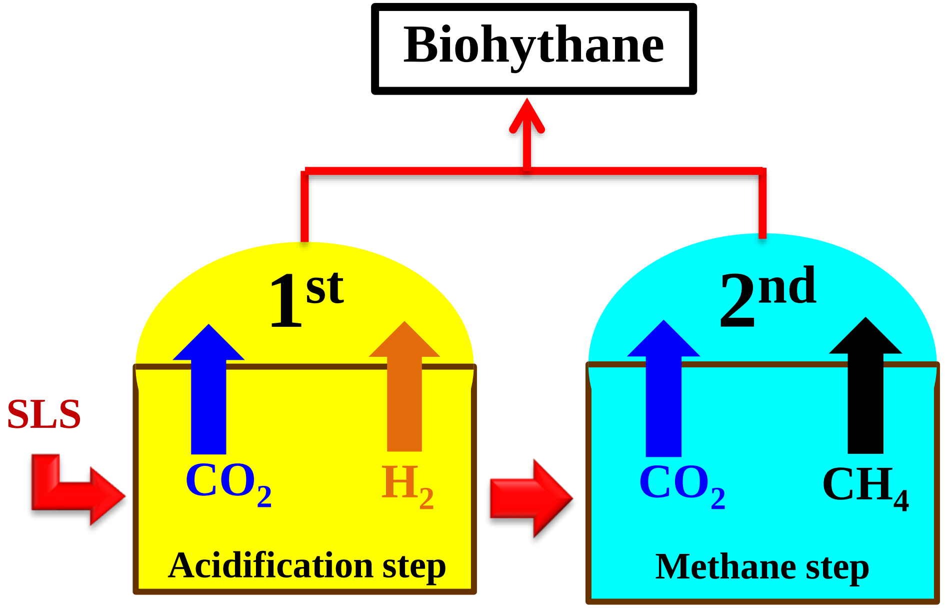
2-stage anaerobic digestion of Concentrated latex wastewater



Biogas scrubber to remove H_2S

Concentrated latex wastewater
(Washing water + SLS)

Two-stage anaerobic digestion of SLS



First stage

- Hydrolysis, acidogenesis and acetogenesis step
- Produce H_2 and VFAs
- Sulfate reducing to H_2S

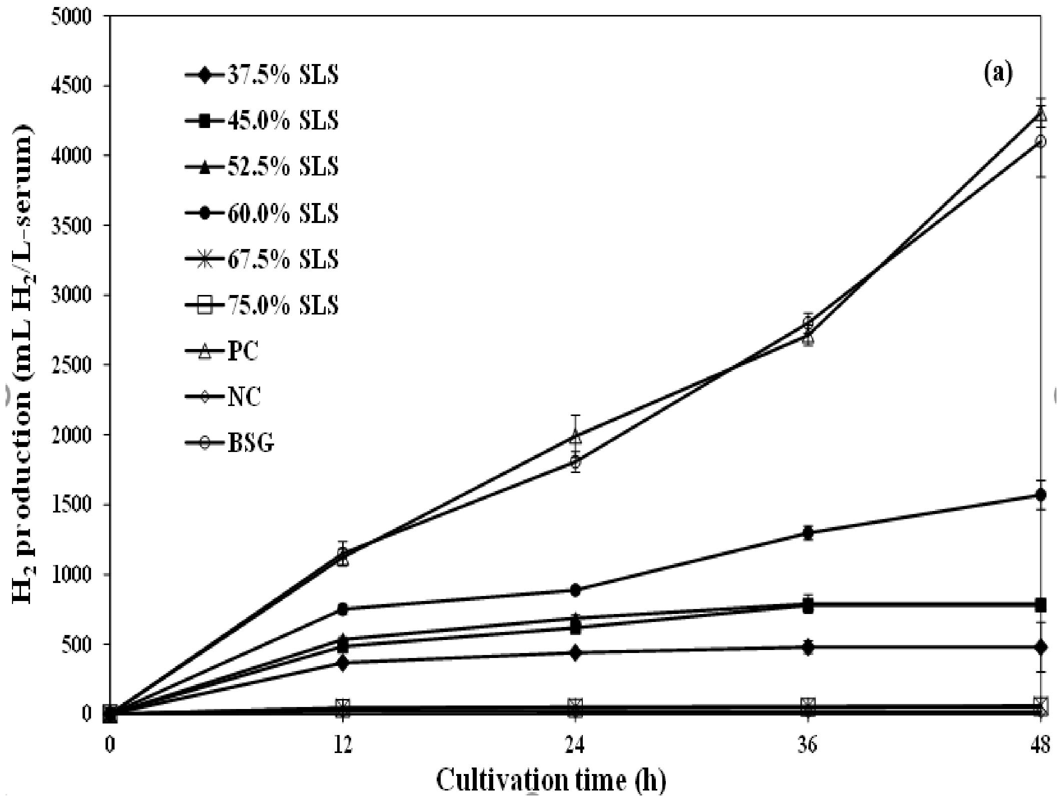
Second stage

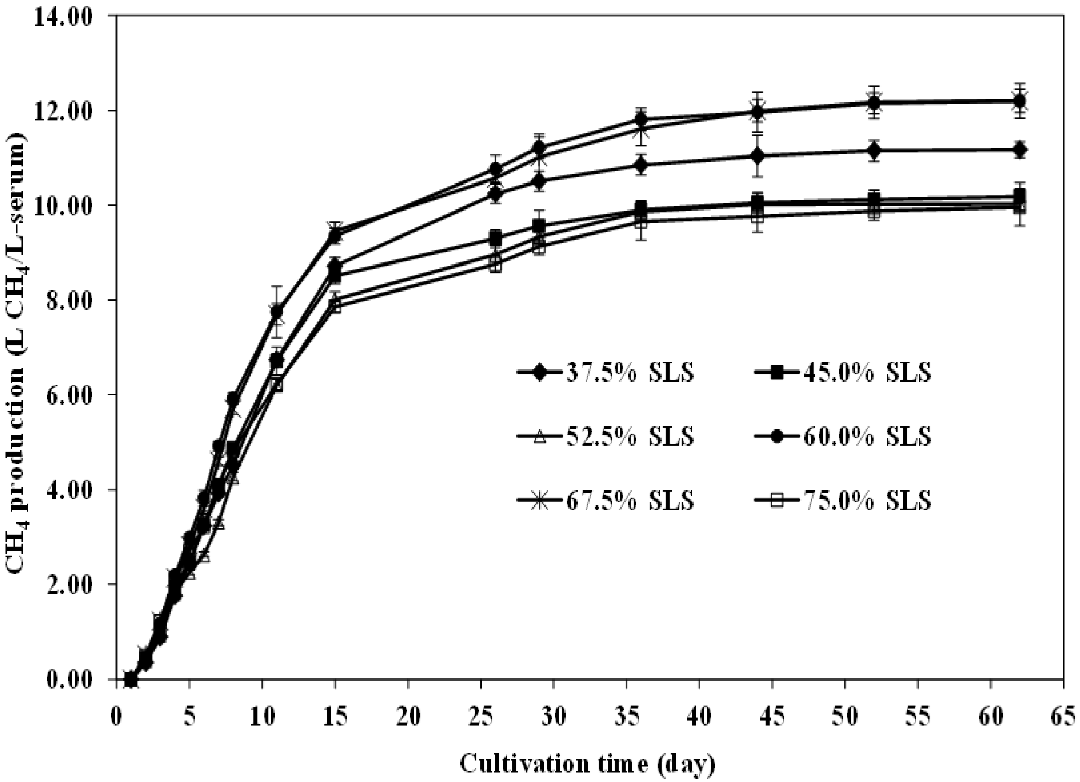
- VFAs are used as substrates
- Methanogenesis step
- Produce CH_4
- Positive energy yield 40–90%

Advantages of Two-stage anaerobic digestion

- ✓ Quicker overall treatment
- ✓ Prevention of inhibition between acidogenesis and methanogenic step (pH, toxics, temperature).
- ✓ Less detention time
- ✓ Higher gas conversion efficiency

BHP and BMP results form 2-stage AD of SLS

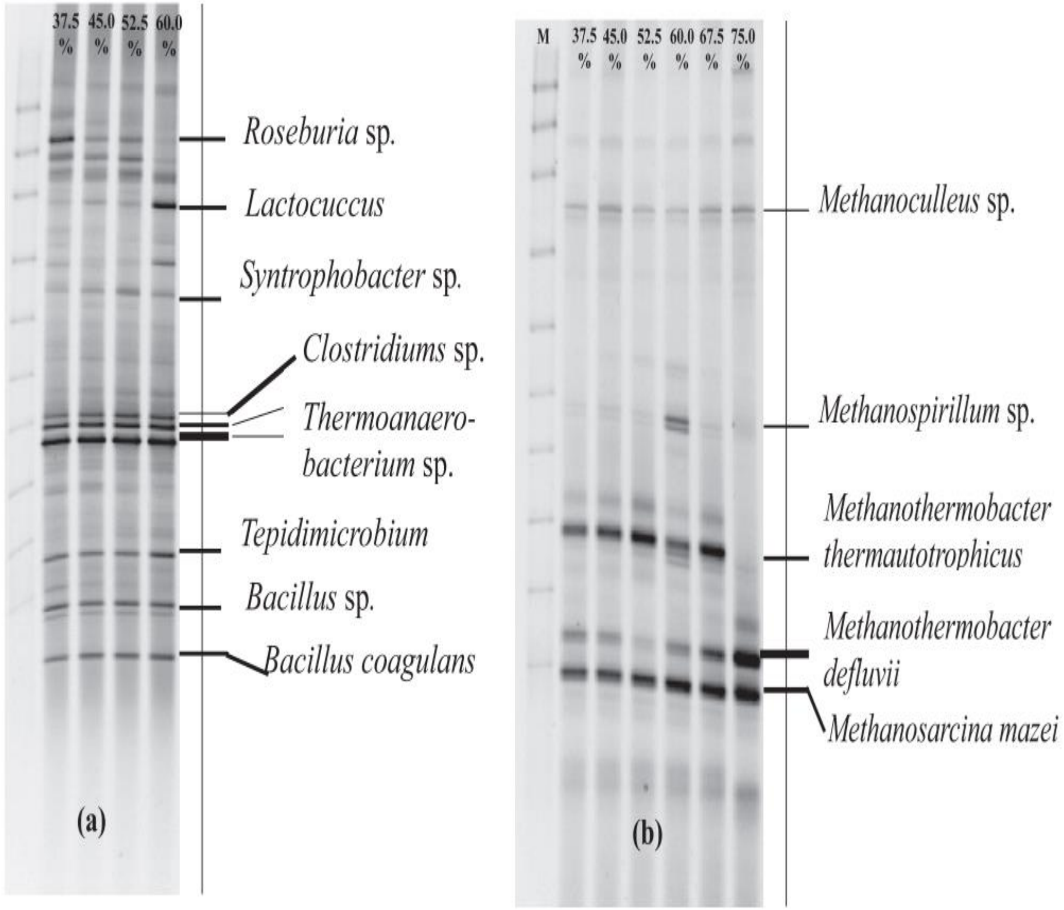




Thermophilic conditions (55 °C)

BHP and BMP results form 2-stage AD of SLS

PCR-DGGE analysis



Bacteria in the first stage

Archaea in the first stage

BHP and BMP results form 2-stage AD of SLS

SLS concentration		Yield (mL/g VS)		% of theoretical yield		Energy Production (kJ/g VS)		
(%V/V)	g VS/L	H_2	CH_4	H_2	CH_4	H_2	CH_4	Total
37.5	14.25	12.63	293.95	2.54	78.81	0.14	10.58	10.72
45.0	17.10	20.53	267.89	4.12	71.82	0.23	9.64	9.87
52.5	19.95	20.79	263.95	4.17	70.76	0.23	9.50	9.73
60.0	22.80	41.32	321.05	8.30	86.07	0.45	11.56	12.01
67.5	25.65	0.00	321.05	0.00	86.07	0.00	11.56	11.56
75.0	28.50	0.00	260.53	0.00	69.85	0.00	9.38	9.38

Lab scale of a series of UASB reactor

Reactor: Jacket glass column

Working volume: 1.35 Litre (H_2 stage)

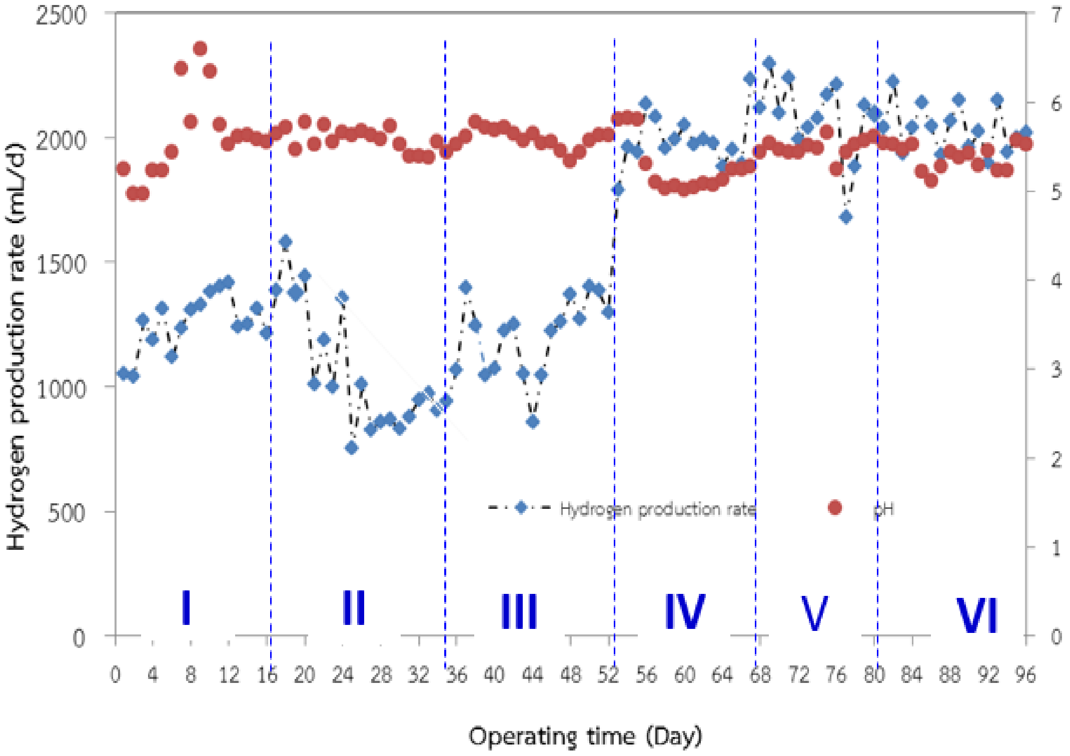
: 2.8 Litre (CH_4 stage)

Temp. : 55 ºC

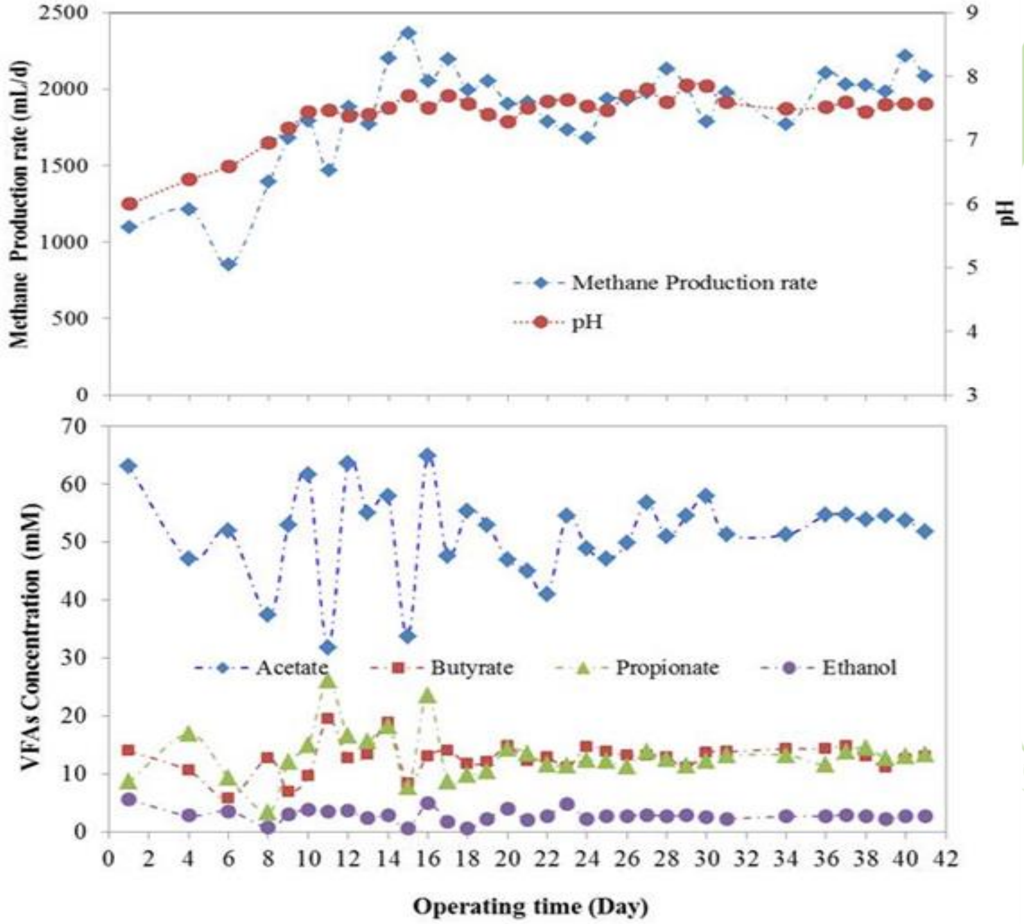
Substrate: SLS + 5.2 g/L ($NaHCO_3$)

Inoculum: from BHP and BMP

H_2- UASB reactor



Step	HRT (hr)	OLR (g-VS/d·L-reactor)
I	67.2	8.6
II	60	15.2
III	48	19
IV(VI)	36	25.3
V	24	38.0



HRT 9 day/ 4.2 g-VS/d L-reactor

2-stage AD of SLS performance

- ➢ Feasible for producing hydrogen and methane and organic matters degradation, simultaneously
  - 62% organic matters removal (COD)
    - ✓ H_2 yield 59 mL-H_2/g-VS
    - ✓ CH_4 yield 170 ml-CH_4/g-VS

❖ High concentration of H_2S in produced gas up to 60,000 - 70,000 ppm)>> requires efficient gas purification unit

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Bio-hydrogen and bio-methane potentials of skim latex serum in batch thermophilic two-stage anaerobic digestion

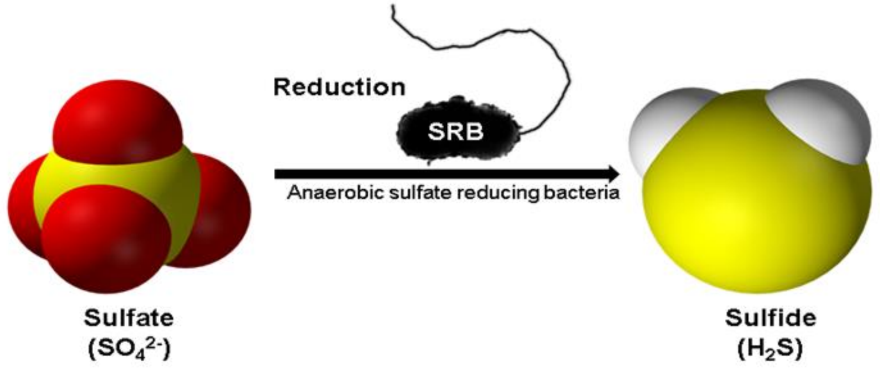
Rattana Jariyaboon [a,b,*], Sompong O-Thong [c,d], Prawit Kongjan [a,b]

INTERNATIONAL JOURNAL OF HYDROGEN ENERGY 39 (2014) 19343–19348
Available online at www.sciencedirect.com
ScienceDirect
journal homepage: www.elsevier.com/locate/he

Anaerobic digestion of skim latex serum (SLS) for hydrogen and methane production using a two-stage process in a series of up-flow anaerobic sludge blanket (UASB) reactor

Prawit Kongjan [a,b,], Rattana Jariyaboon [a,b], Sompong O-Thong [c,d]*

3. Removal of sulfate in SLS



The SLS consists high of concentration of organic matters COD is 7,996 mg/L and **sulfate is 4,000-8,000 mg/L**.

The SRB and MPB competition to substance, which H_2S is inhibitory to MPB, slowing or stopping methane production.

Disadvantages of sulfate in biogas system

- High H_2S production
- Reduced COD removal efficiency
- Low CH_4 production
- Deterioration of anaerobic digestion system

Sulfate concentrations ***above 500 mg/L*** poses toxic effects to microorganism communities inside the biogas system.

Rubber Wood Ash (RWA)

- ✓ Biological treatment
- ✓ Ion exchange
- ✓ Adsorption
- ✓ **Chemical precipitation**

Rubber wood ash is alternatively interesting option for precipitation of sulfate. Due to the elements of rubber wood ash has high calcium content.

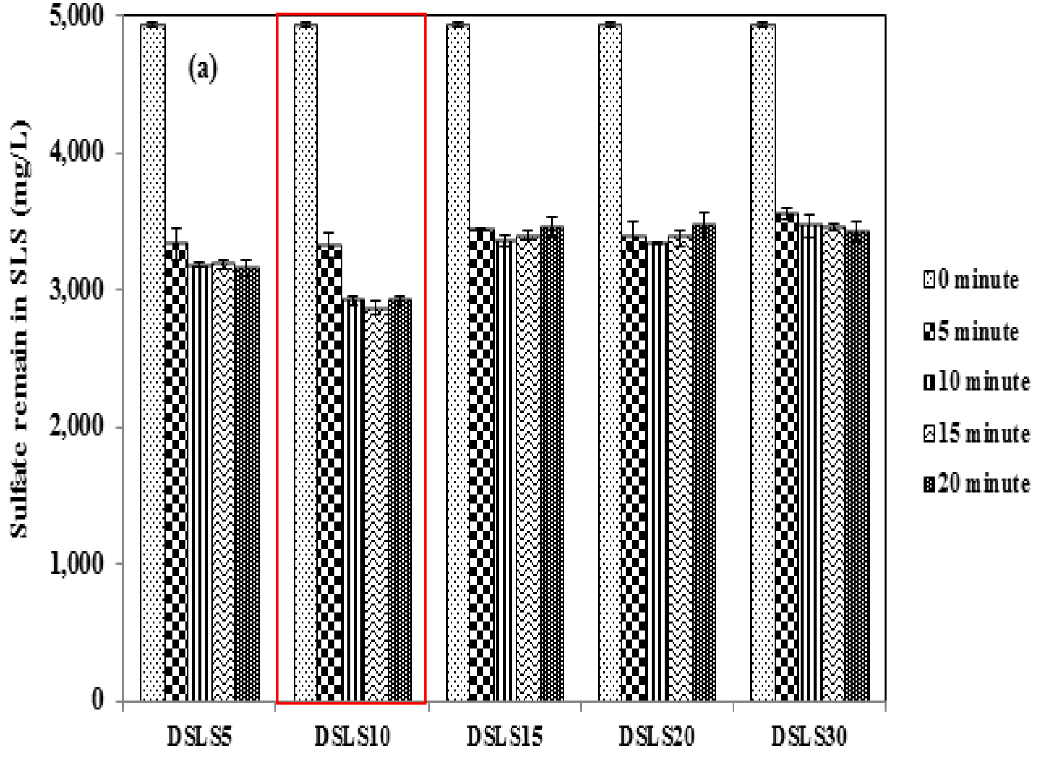
The reduction of sulfate by precipitation has been study by comparing the use of fly ash, lime and **ash from rubber wood**, the result shown that sulfate reduction efficiency were 2.4%, 3.21% and **5.32%** respectively (Inthong, 2008).

Parameters	Unit	Value
pH		5.22 - 5 78
TS	(g/L)	33.28 - 44 74
VS	(g/L)	32.64 - 37 94
Ash	(g/L)	6.30 - 7 41
COD	(g/L)	33.02 - 43 11
TOC	(g/L)	14.25 –.15 12
Sulfate	(mg/L)	4,993 – 7,500
Alkalinity	(mg-$CaCO_3$/L)	2,867 - 3,287
TKN	(mg/L)	1,548 – 1,588

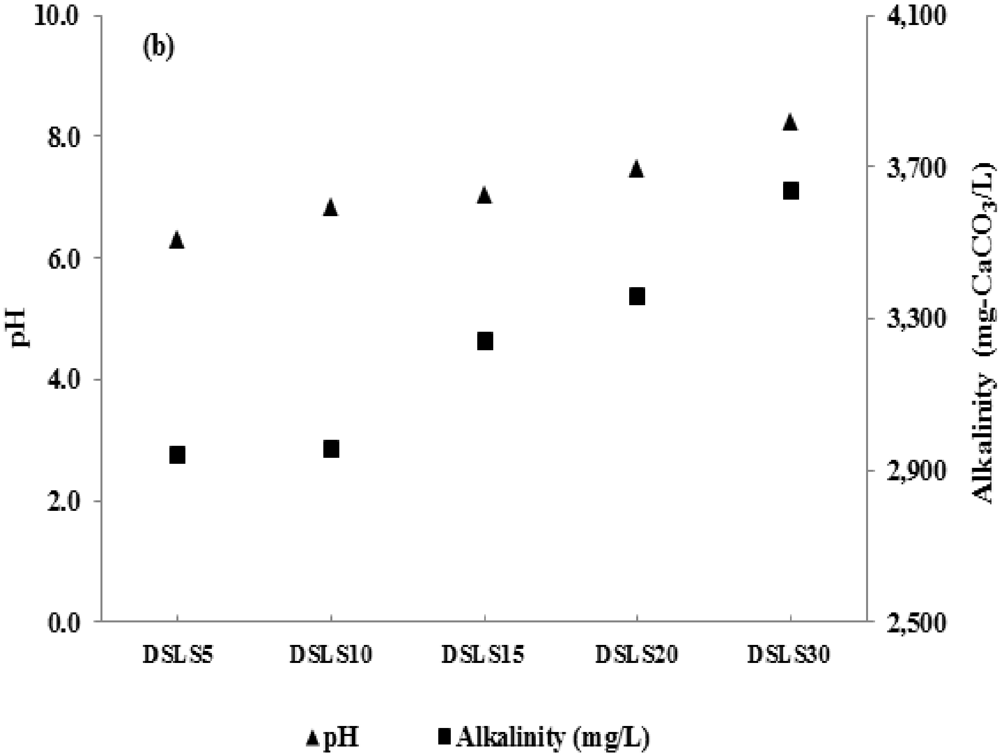
Dissolved elements	Concentration (mg/L)		
	Raw SLS	DSLS10	DI10
Calcium (Ca)	12.91 ± 0.05	302.40 ± 6.56	275.00 ± 5.57
Cobalt (Co)	< 0.003	< 0.003	< 0.003
Copper (Cu)	< 0.016	0.18 ± 0.02	< 0.016
Iron (Fe)	0.60 ± 0.02	1.34 ± 0.02	0.30 ± 0.01
Magnesium (Mg)	32.41 ± 0.06	66.41 ± 0.10	12.61 ± 0.29
Manganese (Mn)	0.14 ± 0.00	2.69 ± 0.00	0.17 ± 0.00
Sodium (Na)	10.62 ± 0.02	12.22 ± 0.09	2.21 ± 0.07
Nickel (Ni)	< 0.005	0.06±0.01	< 0.005
Phosphorus (P)	223.90 ± 2.64	209.20 ± 1.56	1.33 ± 0.07
Potassium (K)	3,728.00 ± 47.85	4,015.00 ± 59.26	403.80 ± 4.47
Zinc (Zn)	295.70 ± 3.93	240.80 ± 2.88	< 0.003

Sulfate removal by RWA adsorption

Initial solid loadings of RWA: 5, 10, 15, 20, and 30 g/L

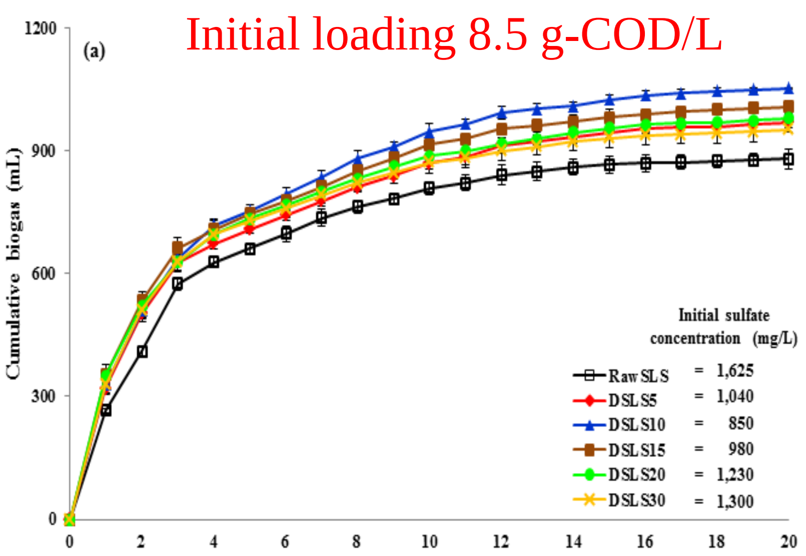


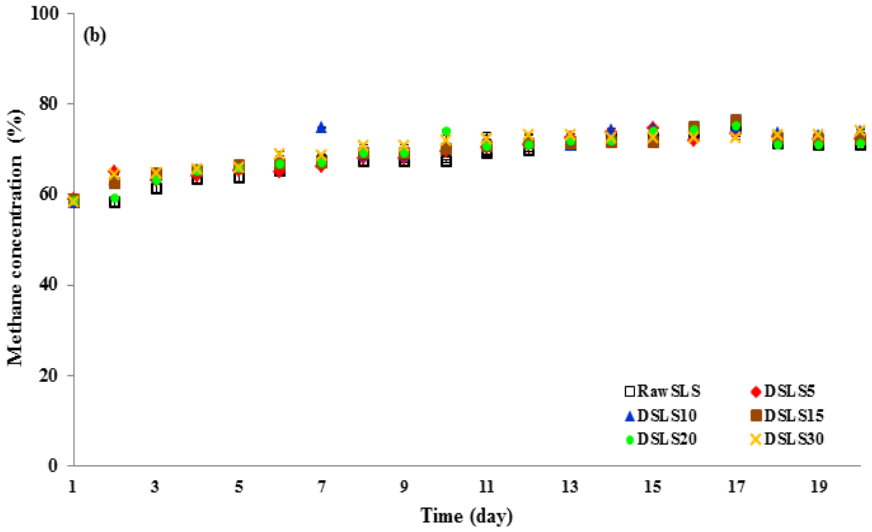
pH and alkalinity of SLS at 10 min mixing time

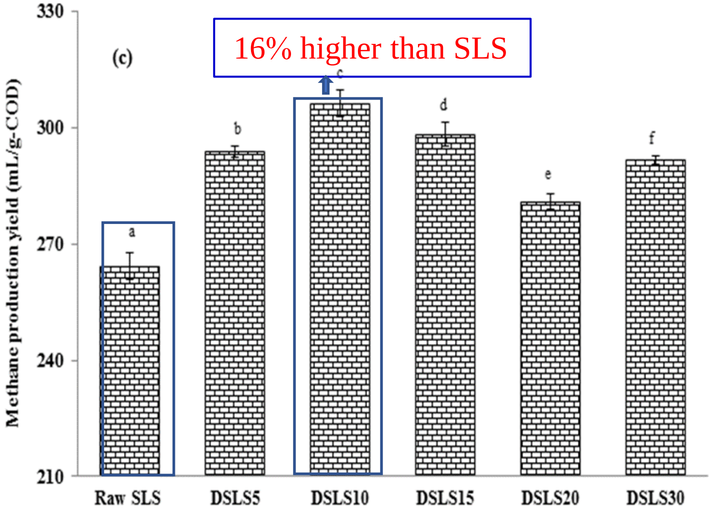


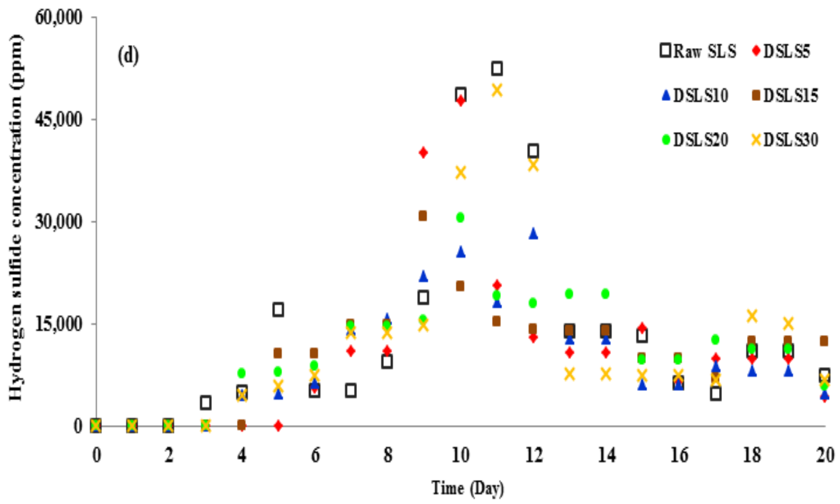
✓Maximum sulfate removal efficiency 42%
@ 10 g/L of RWA and mixing time 10 min

BMP of desulfate SLS









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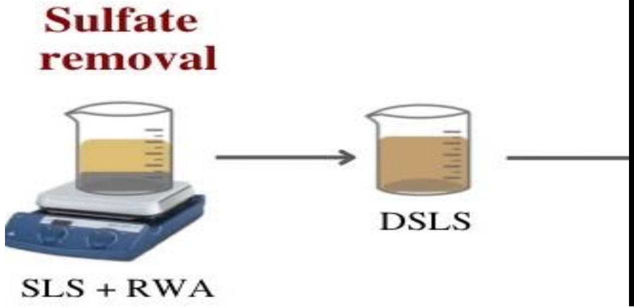
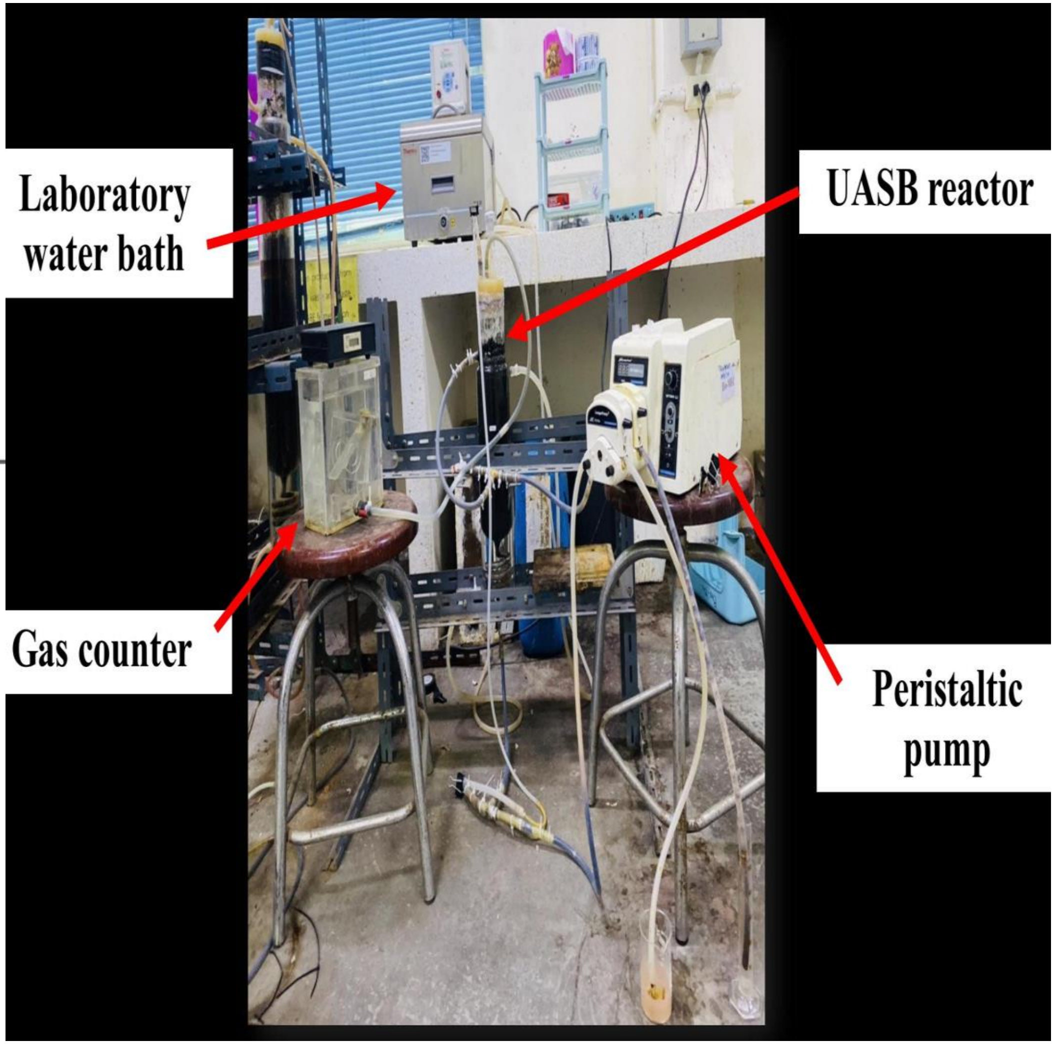
Sulfate removal using rubber wood ash to enhance biogas production from sulfate-rich wastewater generated from a concentrated latex factory

Marisa Raketh [a, c], Rattana Jariyaboon [b, c], Prawit Kongjan [b, c], Eric Trably [d], Alissara Reungsang [e], Burachat Sripitak [a, c], Saowapa Chotisuwan [b]

Current investigation on DSLS

AD: Anaerobic digestion
SLS: Skim latex serum
DSLS: Desulfated SLS
RWA: Rubber wood ash





OLR: Organic loading rate
HRT: Hydraulic retention time
UASB: Up-flow anaerobic sludge blanket

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