Judging Adaptability of Anaerobic Biomass to Changed Feed Substrates through Methanogenic Activity Tests and its Verification

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Introduction

Anaerobic Processes investigated for

- **Sudden/gradual change in operational/ environmental conditions – short duration impacts (without any change in feed type)**
  - **Hydraulic shock**
  - **Organic shock**
  - **Other shock types**

✓ **Focused on temporal performance of processes**

- **Feeds causing secondary operational problems**
  - Sludge bulking
  - Foaming
  - Difficulty in biomass settling

✓ **Identified sludge settleability as a serious problem**

Reactor maintained on a typical substrate suddenly fed with altogether different substrate type?

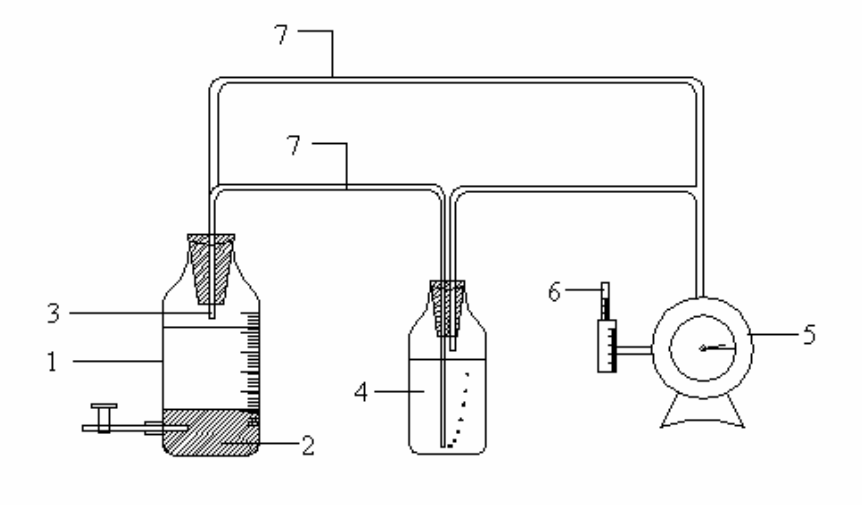
Relevant for developing countries?

Objective

Assessing anaerobic biomass adaptability to sudden change in feed substrate through methanogenic activity tests

Experimental

Suspended growth batch reactors: R1, R2 and R3



- Aspirator Bottle
- Anaerobic Biomass
- Gas Outlet
- 11.2% (w/v) KOH Trap
- Gas Flow Meter
- Thermometer
- Rubber Tubes/Connectors

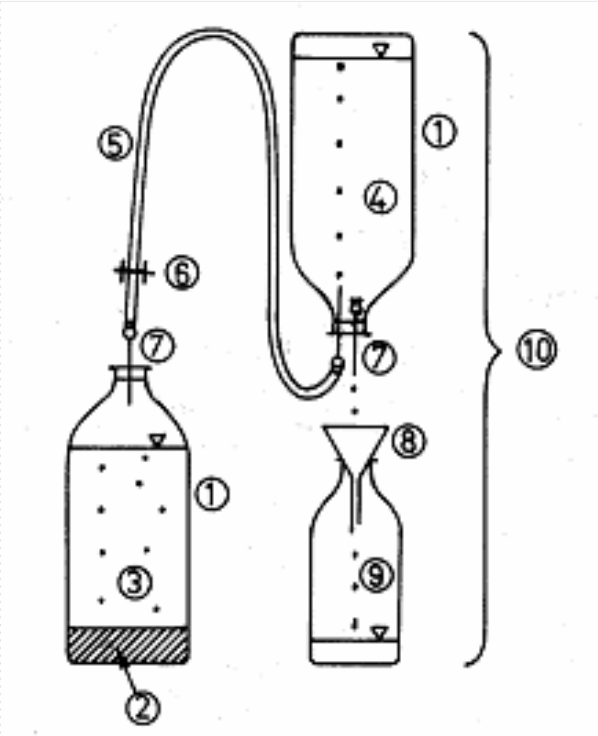
Reactor Charging: 1.5 L of anaerobic seed + 3.5 L of tap water

Feeding: Once in a day (250 mL of supernatant replaced with feed)

Selected feed substrate types:

Substrate	Characteristics
Jaggery (Soluble)	per 100 g: Sucrose sugar=65-85 g, Reducing sugar=5-15 g, Protein =0.4 g, Fat=0.1 g, Calcium=8 mg, Phosphorous=3-4 mg, Total minerals=0.6-1 g, Moisture content=3-8 g, Carotene (Vitamin A)= 280 μg, Nicotinic acid=1 μg, Thiamine (Vitamin B)=20 μg, Colour =Golden yellow to brown, Energy=383 kcal.
	COD=957±22 mg/g Jaggery
Cerelac (Suspended)	per 100 g: Carbohydrate=67.9 g, Protein=15 g, Fat=9 g, Calcium= 480 mg, Potassium=500 mg, Sodium=150 mg, Phosphorous=370 mg, Moisture content=2.5 g, Folic acid=25 μg, Thiamine (Vitamin B)=0.8 mg, Ash=3.2 g, Colour=White, Energy=413 kcal.
	COD=1055±49 mg/g Cerelac
Neutralized acetic acid (Acetate)	100 mL AR grade acetic acid + 50 mL distilled water + AR grade NaOH pellets to obtain a pH of 7 and final volume made up to 500 mL with distilled water to give a stock acetate solution.
	COD=161±2 mg/mL of stock solution

Methanogenic activity test set-up



. **Serum Bottle**

. **Anaerobic Biomass**

. **Reaction Mixture**

. **CO_2 Scrubber (11.2% w/v KOH + thymol blue indicator)**

. **Rubber Tubing**

. **Pinch-Cock**

. **Hypodermic Needle**

. **Conical Funnel**

. **Displaced Liquid**

0. **Liquid Displacement System Serum**

Operating Conditions:

- Three different phases maintained
- OLR = 1.40 kg COD/m^3 d
- Room temperature (18-26 ^oC)

Phase – I

Aim: To obtain similar steady responses

Feed: Model Feed (Jaggery) to R1, R2 & R3

Period: 65 days

Phase – II

Aim: To impose changed feed substrate types

Feed: Model feed (Jaggery) to R1
Cerelac to R2 &
Neutralized acetic acid to R3

Period: 64 days

Phase – III

Aim: To discontinue changed feeds & to restore Phase - I model feed

Feed: Model feed (Jaggery) to R1, R2 & R3

Period: 54 days

Performance Monitoring:

- COD (feed & effluent) – alternate day
- VFA & BA – every 2-3 days
- Room temp. & biogas or CH_4 production – daily
- Methanogenic activity tests – in Phase II

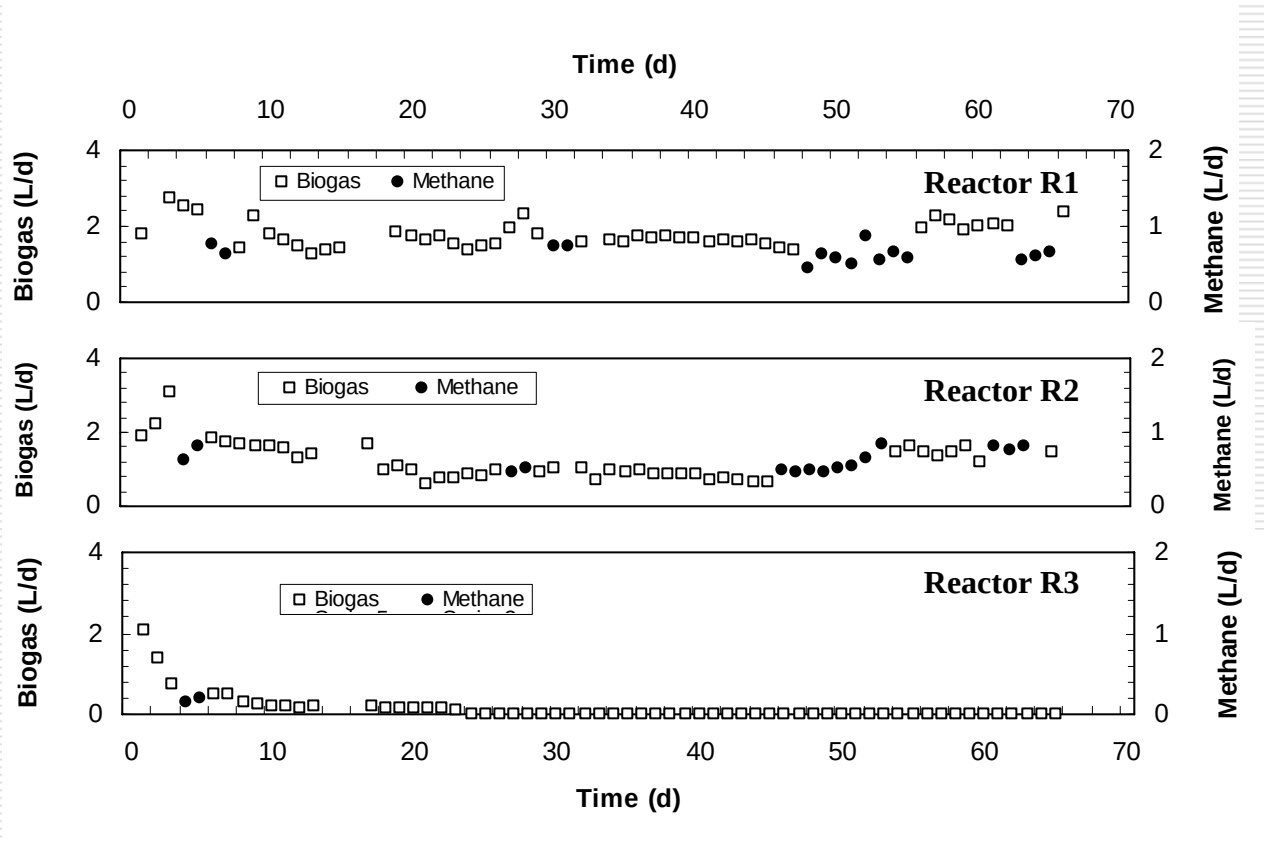
Results and Discussion

Steady Response in Phase – I:

Parameters	Reactor	Phase–I 50–65 d Temp = 25±0 °C
Biogas Produced (L/d)	R1	2.09±0.07 (13)
	R2	1.91±0.11 (14)
	R3	2.15±0.14 (13)
Methane Produced (L/d)	R1	0.59±0.02 (2)
	R2	0.73±0.01 (2)
	R3	0.67±0.12 (2)

- Phase – I: Similar steady response for biogas/methane

Response in Phase – II (under shock conditions):



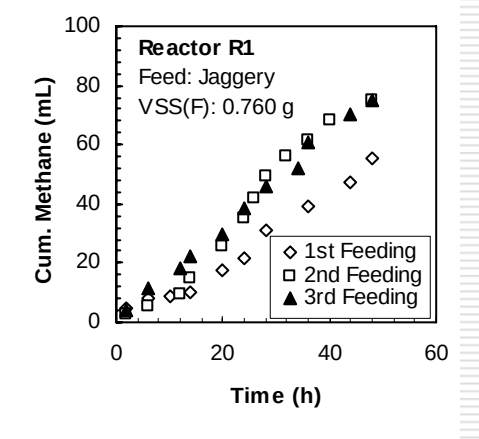
Variation in biogas and methane production

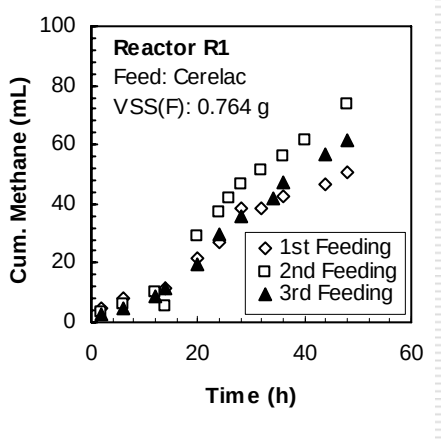
Steady Response in Phase – II:

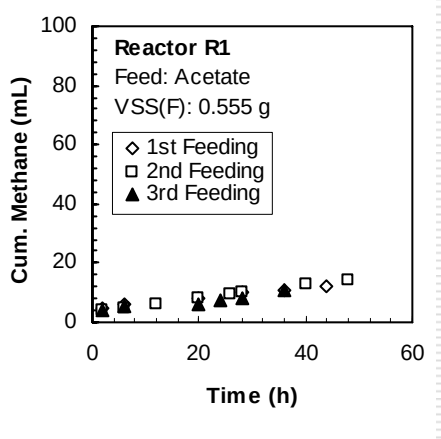
Parameters	Reactor	Phase–II 44–66 d Temp = 19±1 °C
Biogas Produced (L/d)	R1	1.96±0.31 (9)
	R2	1.27±0.30 (8)
	R3	--
Methane Produced (L/d)	R1	0.60±0.11 (11)
	R2	0.58±0.15 (11)
	R3	--

- Reduced biogas production in reactor R2
- Complete cessation of biogas production in reactor R3

Methanogenic Activity Tests in Phase – II: Reactor R1



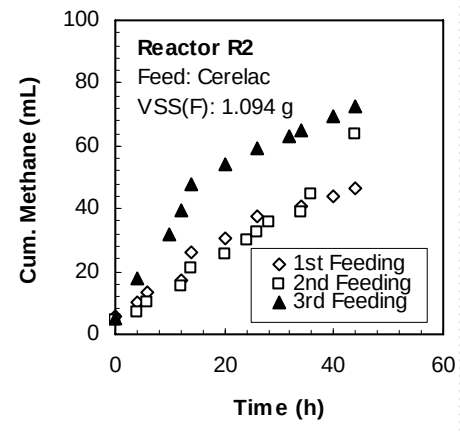


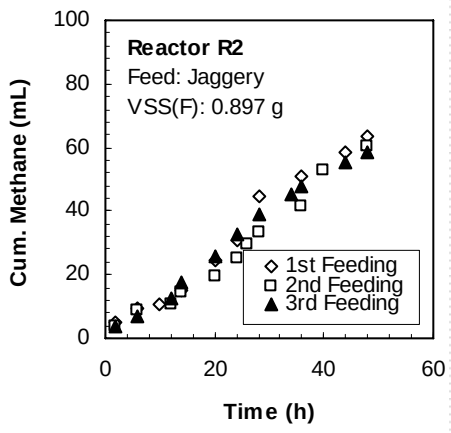


$MA_{Jaggery}$ = 0.126 g CH_4-COD/g VSS d $MA_{Cerelac}$ = 0.126 g CH_4-COD/g VSS d $MA_{Acetate}$ = 0.033 g CH_4-COD/g VSS d

- Good adaptability of biomass from model feed to cerelac feed
- Non-adaptability of biomass from model feed to acetate feed

Biomass Adaptability to Model Feed: Phase – II (Reactor R2)



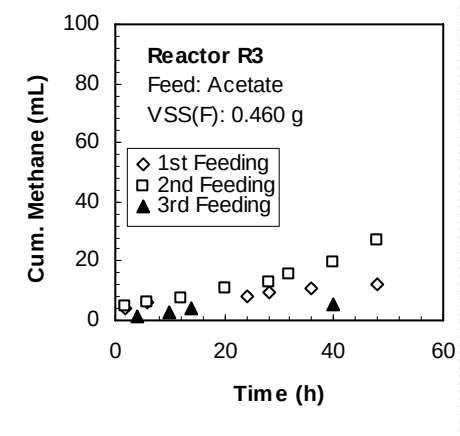


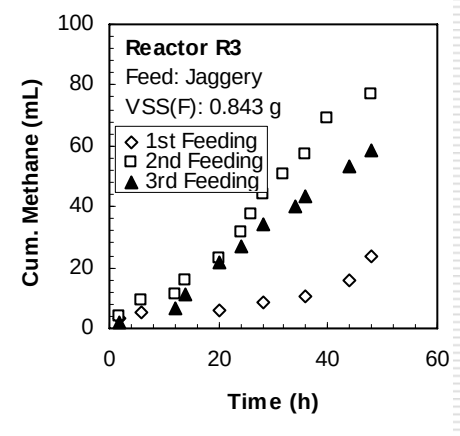
$MA_{Cerelac}$ = 0.088 g CH_4-COD/g VSS d

$MA_{Jaggery}$ = 0.120 g CH_4-COD/g VSS d

- Indicates good adaptability of biomass from cerelac to model feed

Biomass Adaptability to Model Feed: Phase – II (Reactor R3)



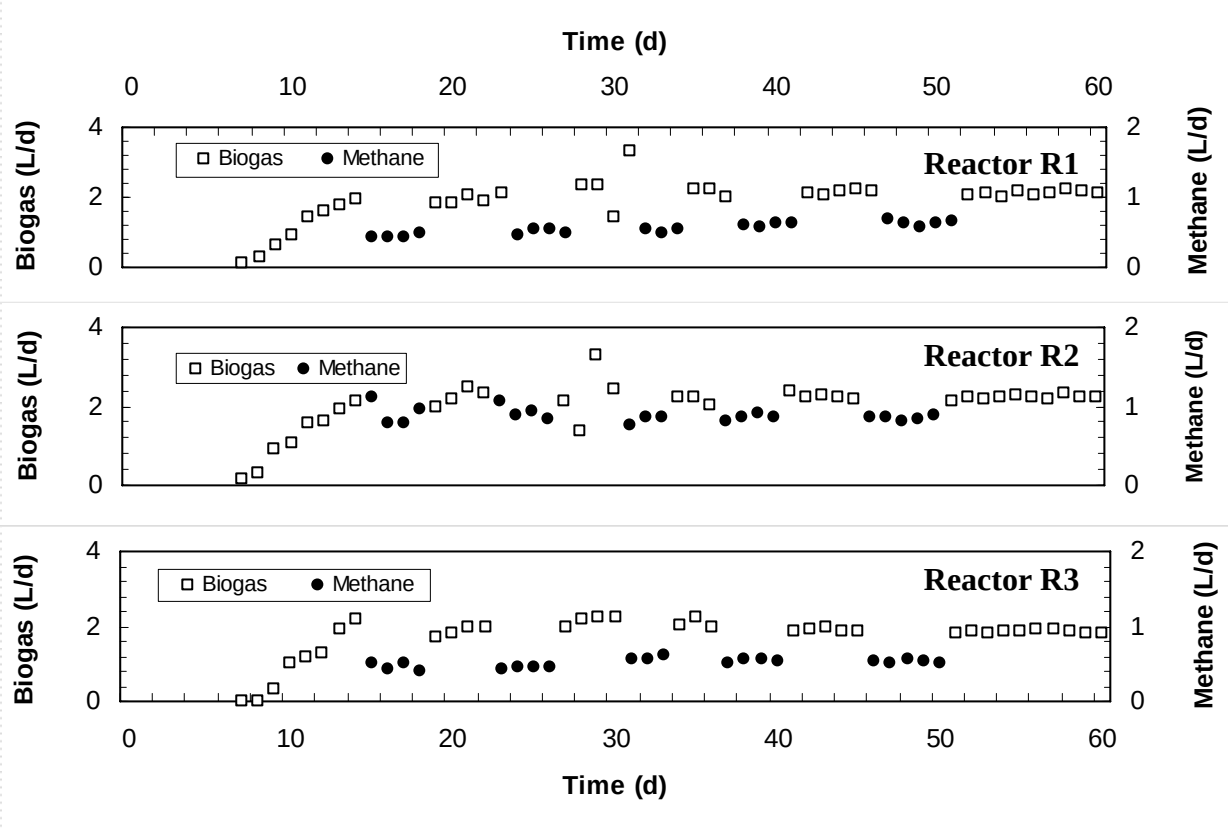


$MA_{Acetate}$ = 0.027 g CH_4-COD/g VSS d

$MA_{Jaggery}$ = 0.136 g CH_4-COD/g VSS d

- Indicates good adaptability of biomass from acetate to model feed

Response in Phase – III (model feed again):



Variation in biogas and methane production

Steady Response in Phase – III:

Parameters	Reactor	Phase–III 30–60 d Temp = 25±1 °C
Biogas Produced (L/d)	R1	2.16±0.33 (18)
	R2	2.11±0.10 (19)
	R3	1.92±0.14 (19)
Methane Produced (L/d)	R1	0.60±0.10 (12)
	R2	0.79±0.04 (12)
	R3	0.54±0.03 (12)

- Comparable performances as of Phase – I
- Complete recovery of reactor R3 in Phase – III

Summary

- Impact of change in feed types (Phase – II)
  - Steady biogas production for R2 goes down
  - Complete cessation in biogas production for R3
  - Biomass adaptability to cerelac but not to acetate
  - MA values for reactor R1 indicated:

    Adaptability to cerelac feed but not to acetate feed
  - MA values for reactor R2 and R3 indicated:

    Adaptability to model feed
- Impact of restoration of model feed (Phase – III)
  - Reactors recover steady responses of Phase – I

Adaptability of anaerobic biomass to newer feed substrate types may be assessed through methanogneic activity tests

Thank You