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



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# Introduction

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## 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
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➤ **Feeds causing secondary operational problems**

➤ **Sludge bulking**

➤ **Foaming**

➤ **Difficulty in biomass settling**

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

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

Relevant for developing countries?

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# Objective

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

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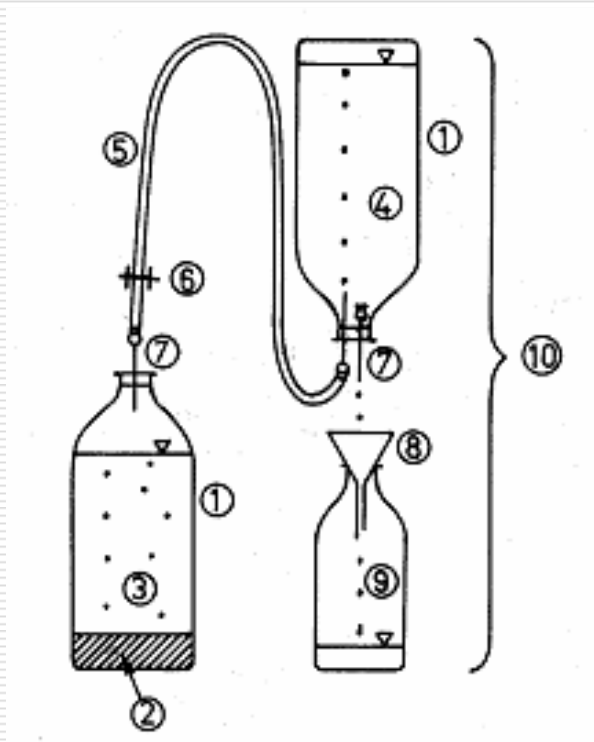
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## Selected feed substrate types:

Substrate	Characteristics
<b>Jaggery (Soluble)</b>	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
<b>Cerelac (Suspended)</b>	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
<b>Neutralized acetic acid (Acetate)</b>	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

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# Methanogenic activity test set-up



- . Serum Bottle
- . Anaerobic Biomass
- . Reaction Mixture
- . CO<sub>2</sub> Scrubber (11.2% w/v KOH + thymol blue indicator)
- . Rubber Tubing
- . Pinch-Cock
- . Hypodermic Needle
- . Conical Funnel
- . Displaced Liquid
- 0. Liquid Displacement System Serum

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## Operating Conditions:

- Three different phases maintained
- OLR = 1.40 kg COD/m<sup>3</sup> d
- Room temperature (18-26 °C)

### Phase – I

**Aim:** To obtain similar steady responses

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

**Period:** 65 days

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## 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

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## Performance Monitoring:

- COD (feed & effluent) – alternate day
  - VFA & BA – every 2-3 days
  - Room temp. & biogas or CH<sub>4</sub> production – daily
  - Methanogenic activity tests – in Phase II
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# Results and Discussion

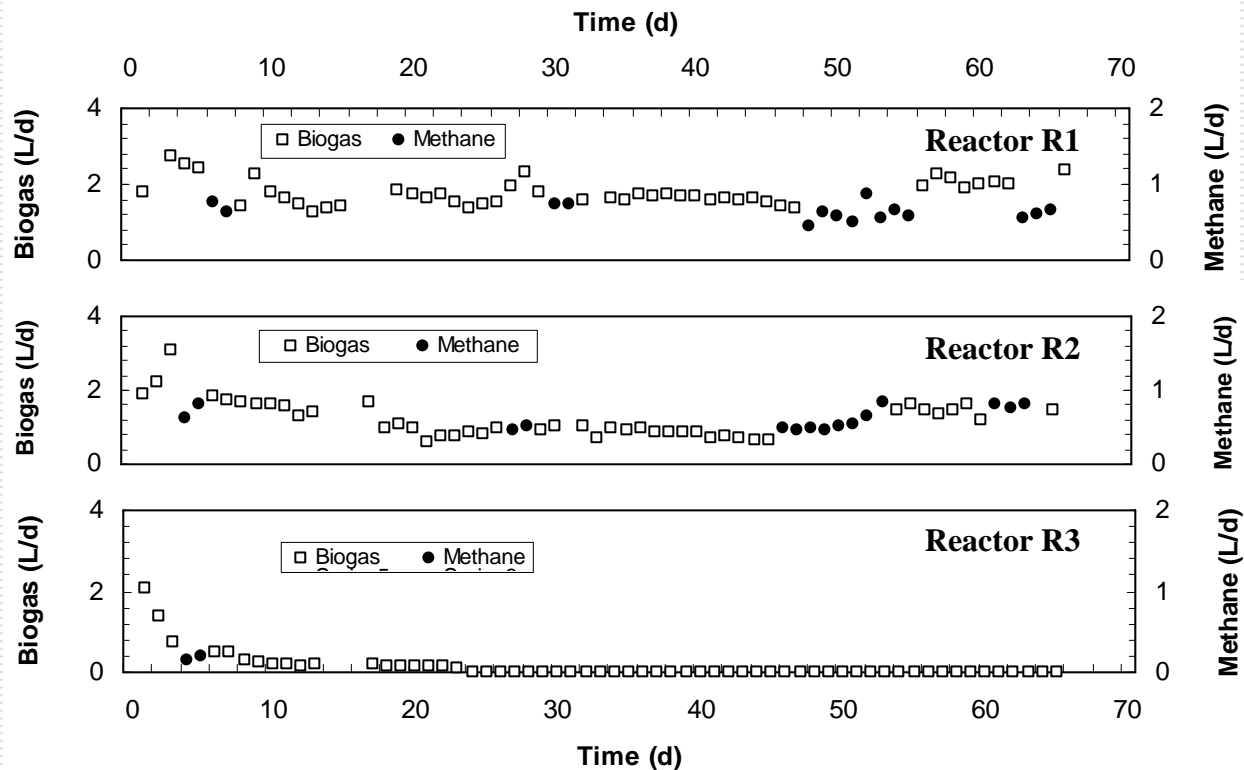
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## Steady Response in Phase – I:

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
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## Response in Phase – II (under shock conditions):



Variation in biogas and methane production

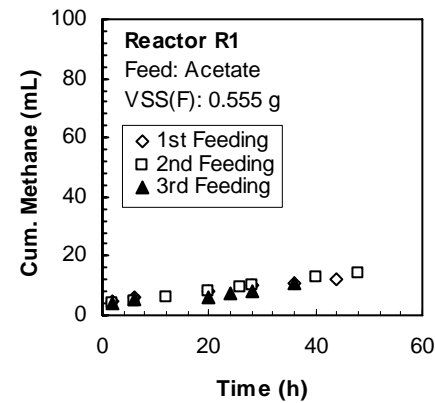
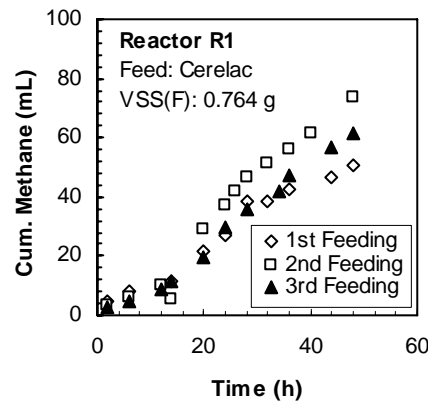
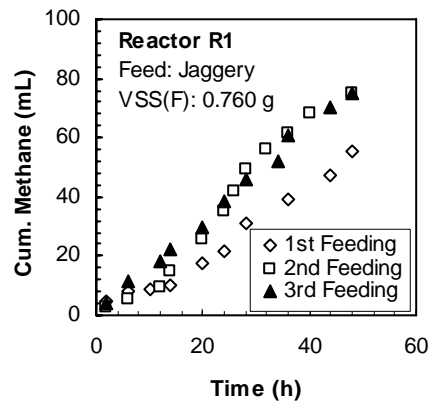
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## Steady Response in Phase – II:

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
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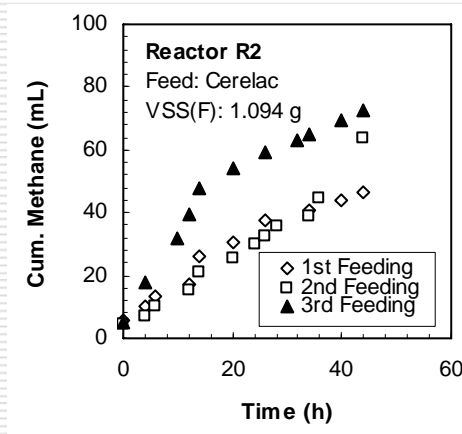
## Methanogenic Activity Tests in Phase – II: Reactor R1



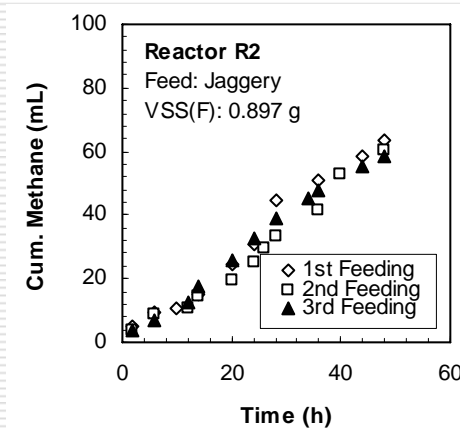
$MA_{\text{Jaggery}} = 0.126 \text{ g CH}_4\text{-COD/g VSS d}$      $MA_{\text{Cerelac}} = 0.126 \text{ g CH}_4\text{-COD/g VSS d}$      $MA_{\text{Acetate}} = 0.033 \text{ g CH}_4\text{-COD/g VSS d}$

- 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)



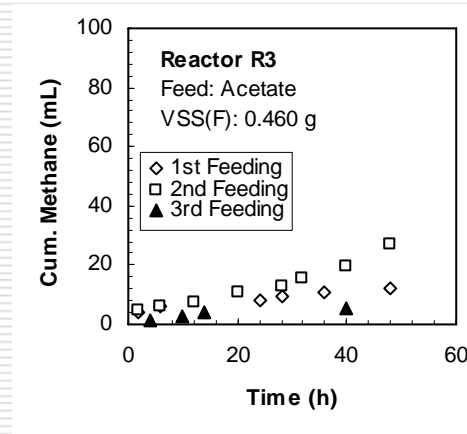
$$MA_{\text{Cerelac}} = 0.088 \text{ g CH}_4\text{-COD/g VSS d}$$



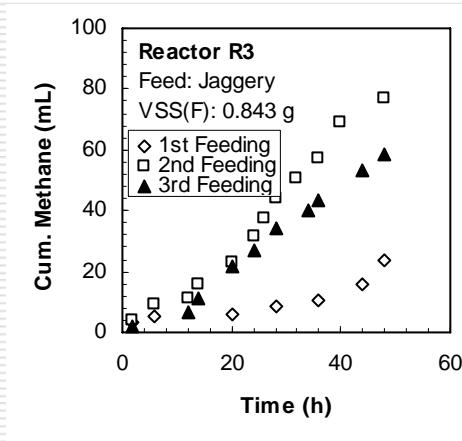
$$MA_{\text{Jaggery}} = 0.120 \text{ g CH}_4\text{-COD/g VSS d}$$

- Indicates good adaptability of biomass from cerelac to model feed

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



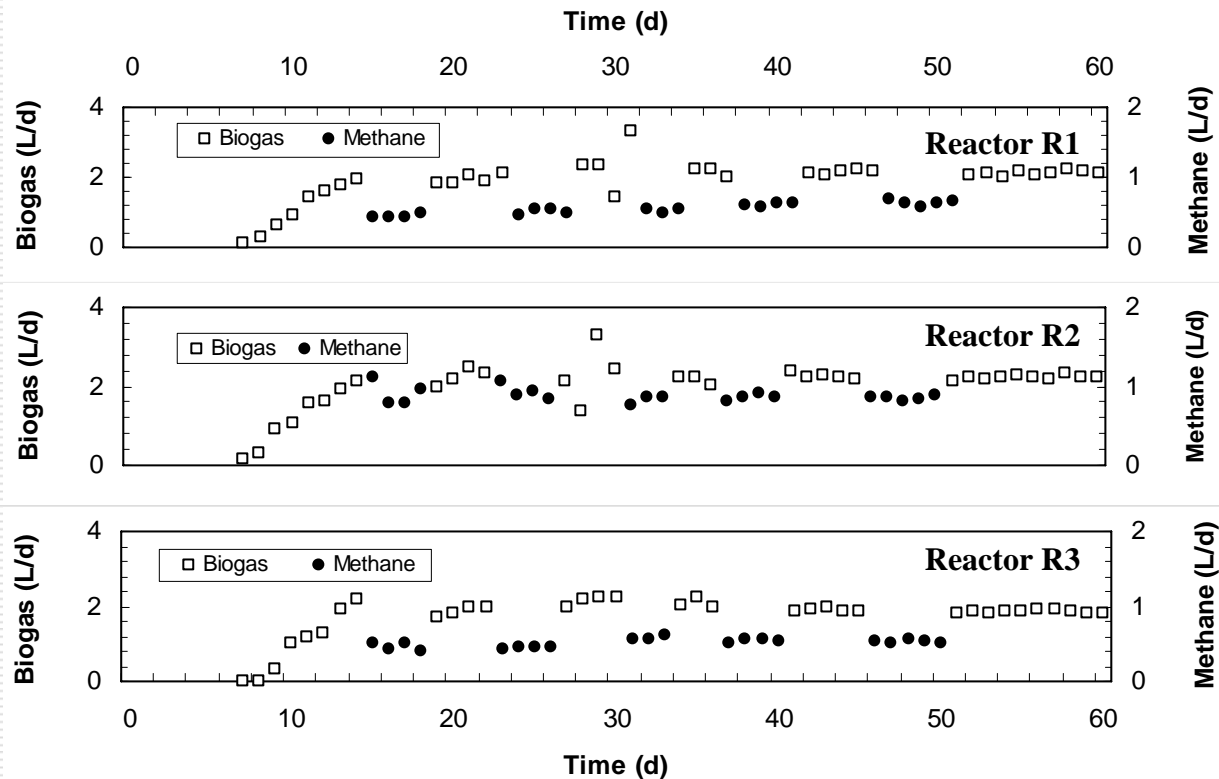
$$MA_{\text{Acetate}} = 0.027 \text{ g CH}_4\text{-COD/g VSS d}$$



$$MA_{\text{Jaggery}} = 0.136 \text{ g CH}_4\text{-COD/g VSS d}$$

- Indicates good adaptability of biomass from acetate to model feed

## Response in Phase – III (model feed again):



Variation in biogas and methane production

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## 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**
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# Summary

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- **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**
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**Adaptability of anaerobic biomass to newer  
feed substrate types may be assessed through  
methanogenic activity tests**

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**Thank You**

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