# The IntensiCarb Technology as a Vacuum-Enhanced Fermentation and Anaerobic Digestion System

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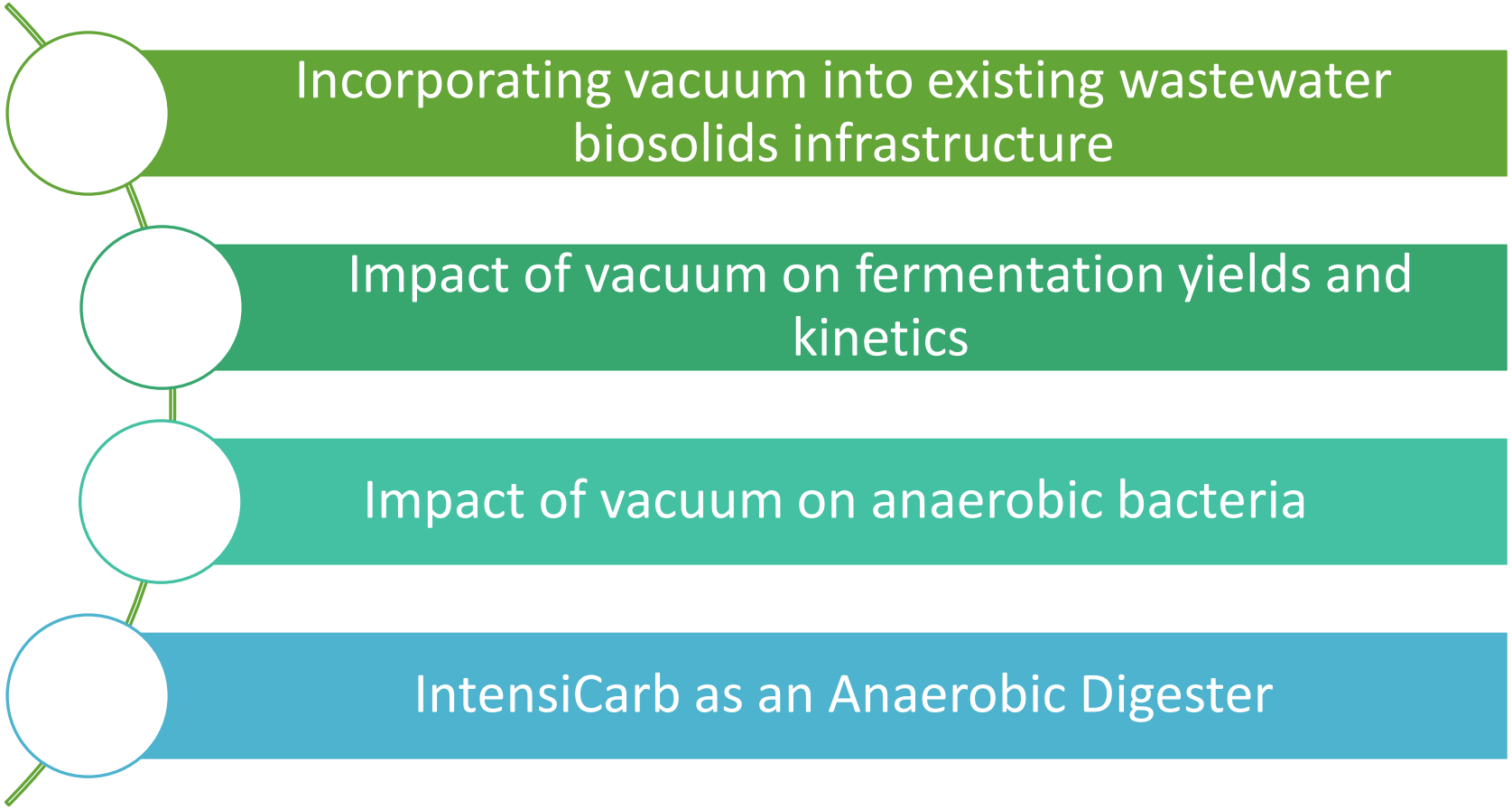
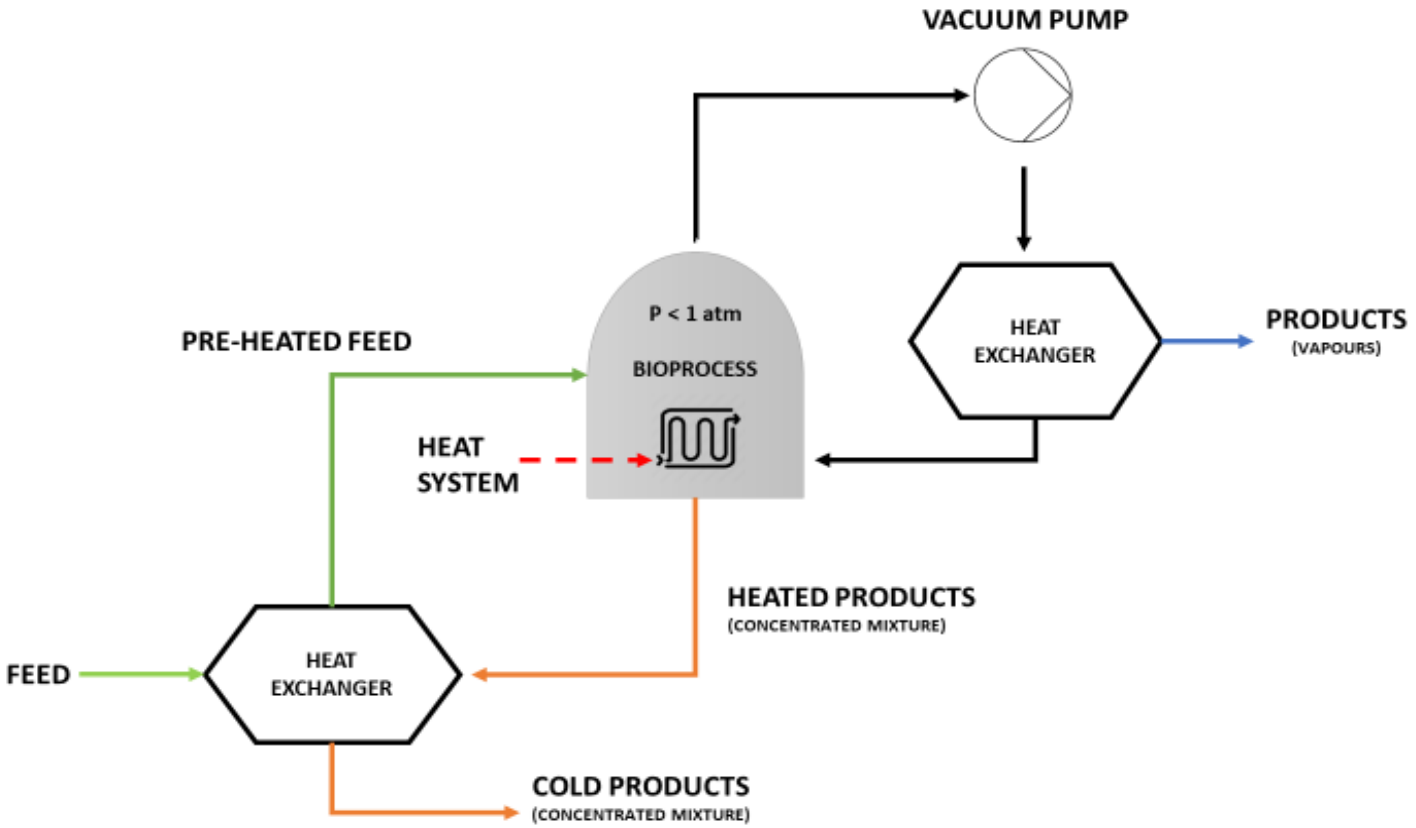
# Outline


Incorporating vacuum into existing wastewater biosolids infrastructure
Impact of vacuum on fermentation yields and kinetics
Impact of vacuum on anaerobic bacteria
IntensiCarb as an Anaerobic Digester

# Integrating vacuum into existing infrastructure



# How we tested Intensi-Carb™ fermentation

3 L vacuum reactors

Batch feed and wasting

Operating Temperatures, Pressures

- 45 °C, 110 mbar
- 60 °C, 150 mbar

Feed: 50/50 primary sludge and TWAS

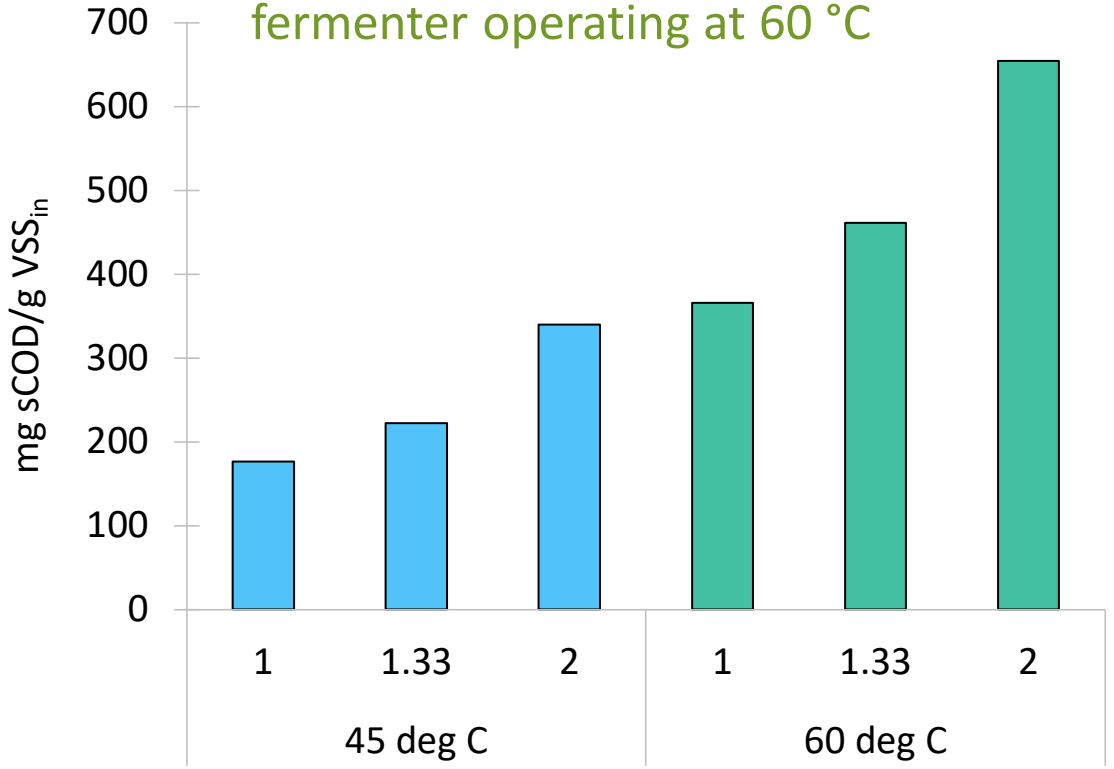
**Test Matrix**

| | SRT | HRT | Intensification Factor |
|---|---|---|---|
| Control | 3 | 3 | 1 |
| IC-1 | 3 | 2.25 | 1.3 |
| IC-2 | 3 | 1.5 | 2 |

INTENSIFICATION FACTOR: $\frac{SRT}{HRT}$

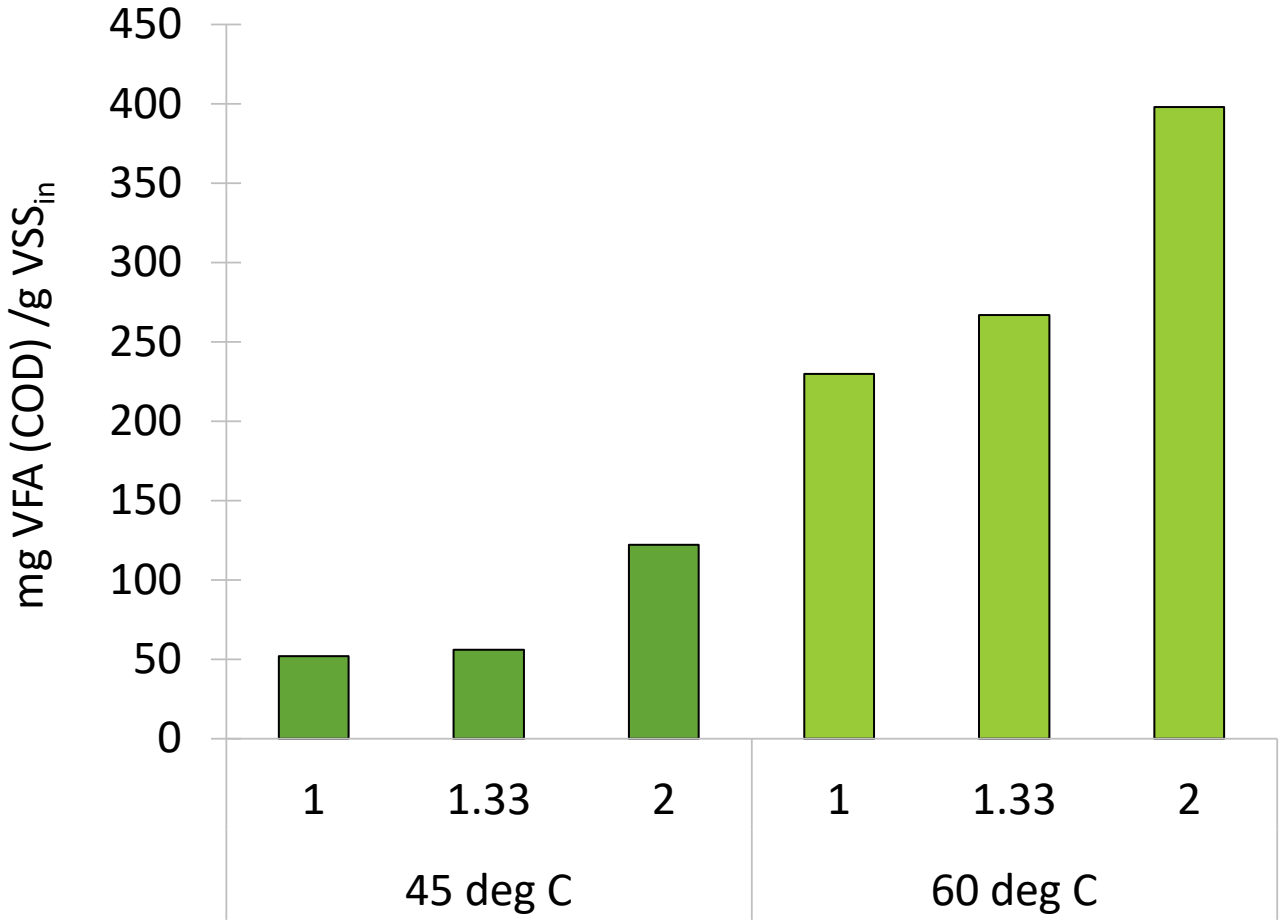
# Hydrolysis can be significantly enhanced with solid-liquid separation

At an IF 2 the hydrolysis rate at 45 °C was equivalent to the conventional fermenter operating at 60 °C



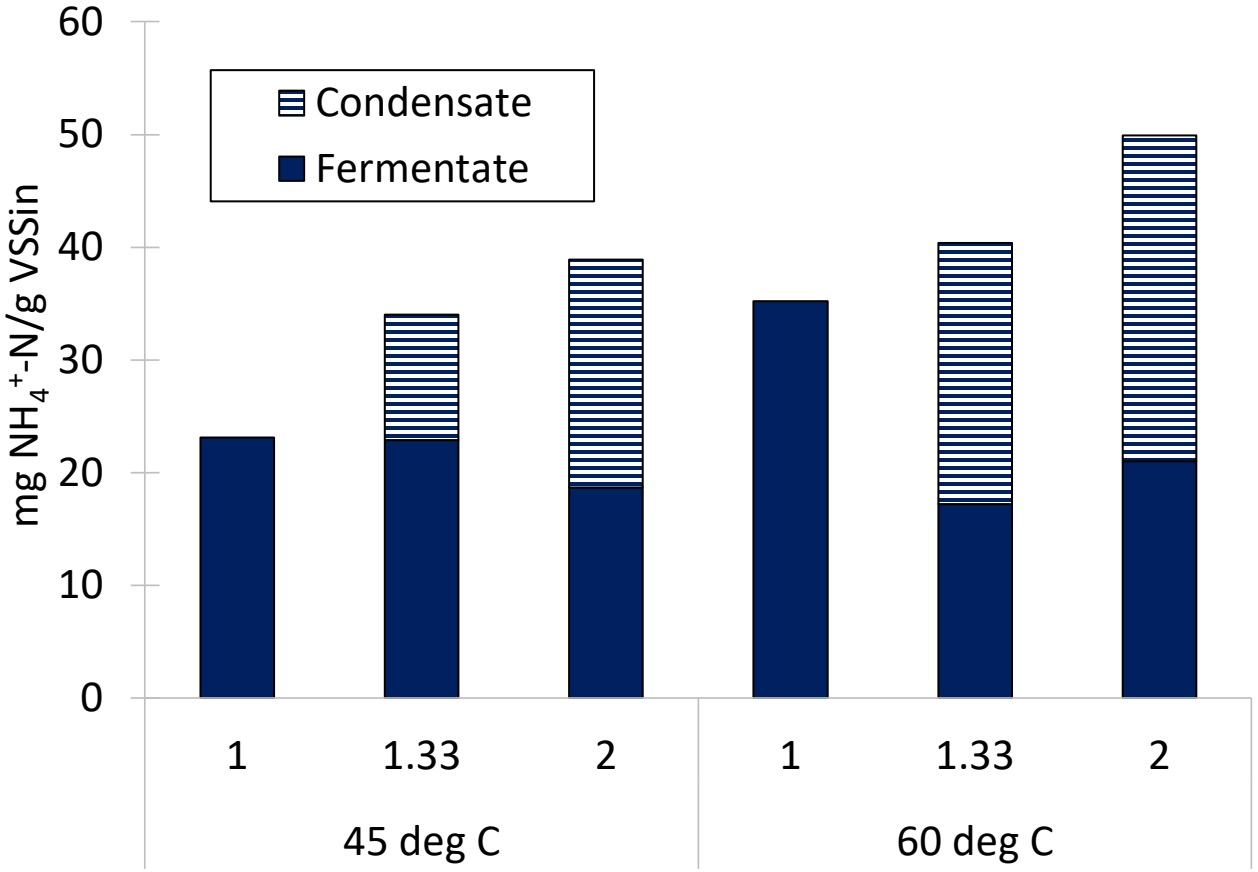

| | Condition | Biomass specific hydrolysis rate (mg sCOD/g VSS$_r$/d) |
|---|---|---|
| 45 °C | IF 1 | 109 ± 5.1 |
| | IF 2 | 140 ± 3.7 |
| 60 °C | IF 1 | 141 ± 3.1 |
| | IF 2 | 158 ± 1.9 |

# VFA production was notably enhanced only at the highest intensification factor.




| | Condition | Biomass specific acidification rate (mg sCOD/g VSS$_r$/d) |
|---|---|---|
| 45 °C | IF 1 | 28 ± 2.1 |
| | IF 2 | 43 ± 1.1 |
| 60 °C | IF 1 | 32 ± 1.0 |
| | IF 2 | 54 ± 1.9 |

# Vacuum evaporation partitions ~25%-50% of released ammonia to the condensate.



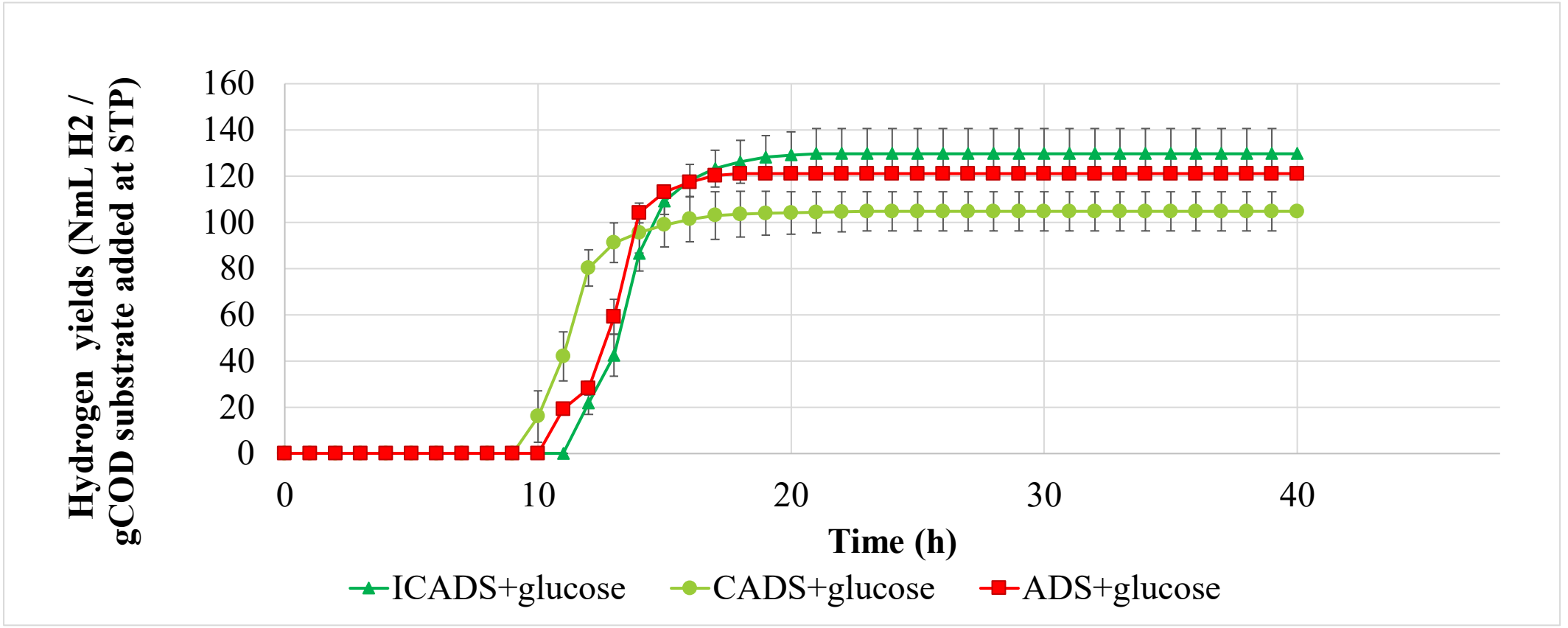

Fermentation Impact: reduced ammonia in the digestate. Condensate is very clean water, suitable for resource recovery

Digestion Impact: reduces load of N to the digester potentially improving the C:N ratio and alleviating ammonia toxicity. For example, at IF 2, 1400 mg $NH_3$-N/L was reduced to 980 mg $NH_3$-N/L

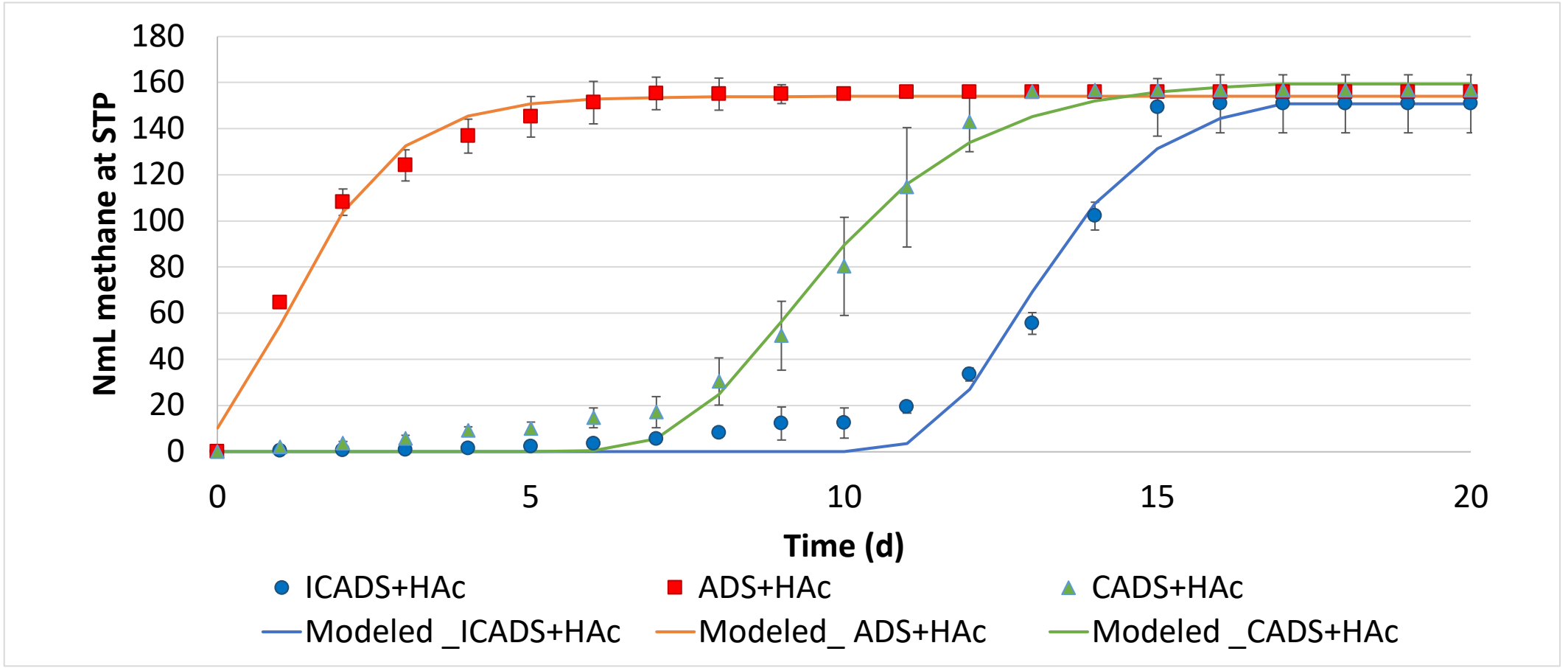
# Liquid fermentate provides carbon comparable to supplemental sources

| | | 45 °C | 60 °C |
|---|---|---|---|
| **Acetic Acid** | sDNR (mg $NO_3$-N/mg VSS/d) | 0.18 ± 0.03 | 0.11 ± 0.01 |
| | sCOD:N (mg/mg) | 8.8 | 10.3 |
| **Fermentate** | sDNR (mg $NO_3$-N/mg VSS/d) | 0.16 ± 0.05 | 0.12 ± 0.01 |
| | sCOD:N (mg/mg) | 10.7 | 12.6 |
| | VFA:N (mg COD/mg) | 3.5 | 4.4 |
| | VFA/sCOD (%) | 33 | 35 |

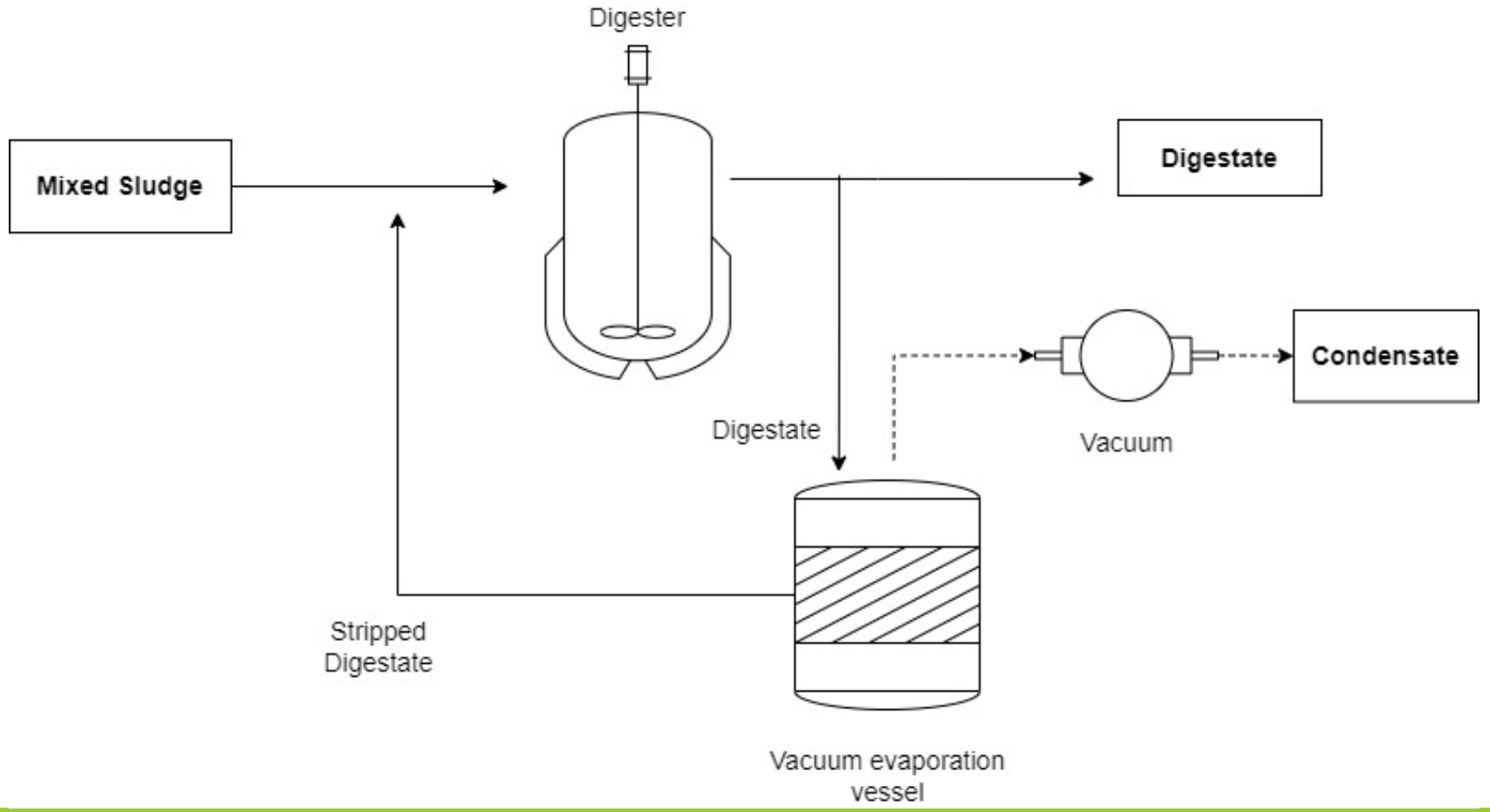
# Short-term vacuum did not inhibit hydrogen yield of fermentative bacteria



# Vacuum increased lag-phase of methanogens but no impact on methane yield



# IntensiCarb for Anaerobic Digestion

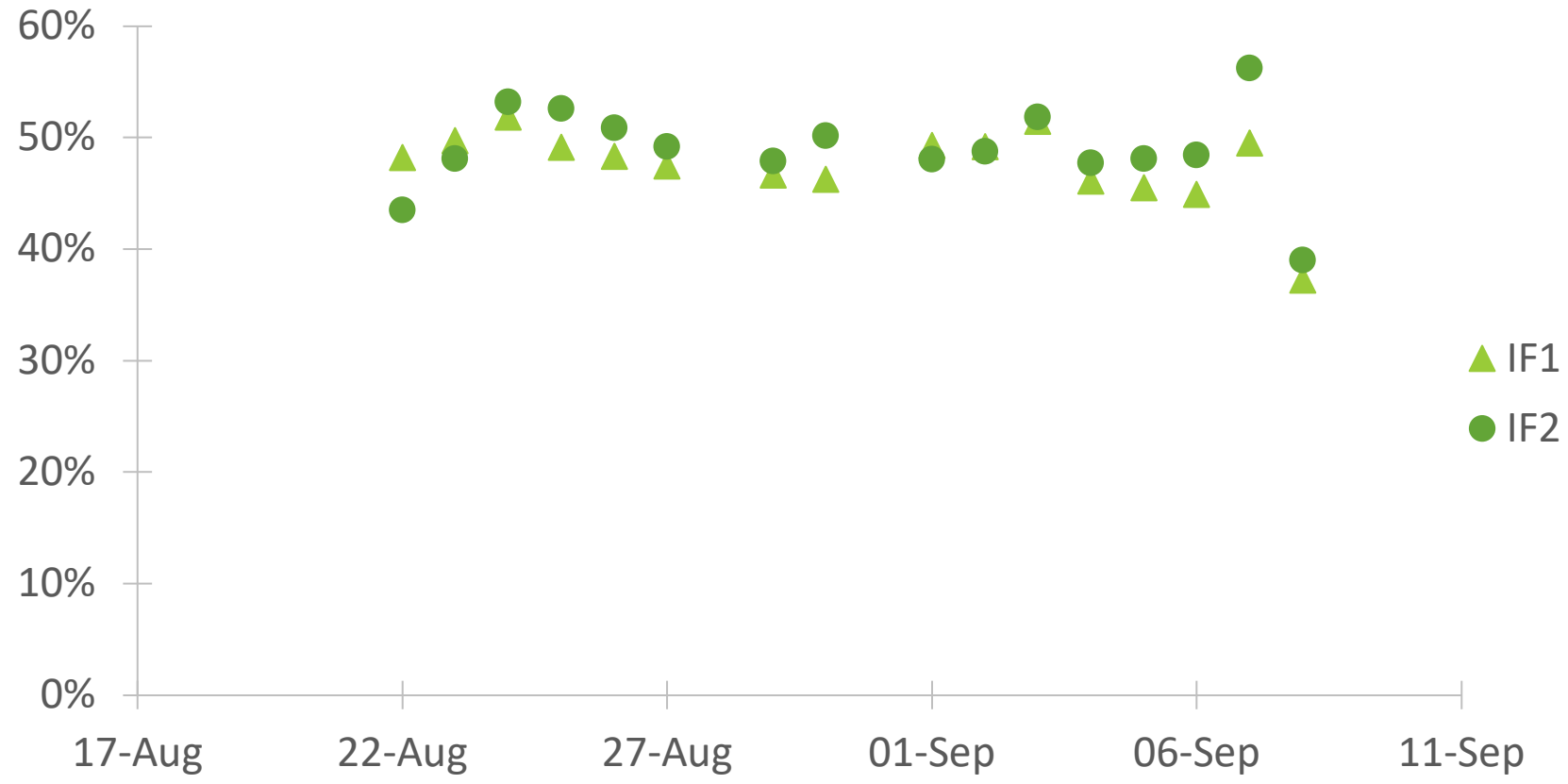


# Testing IntensiCarb Anaerobic Digestion (Ongoing)

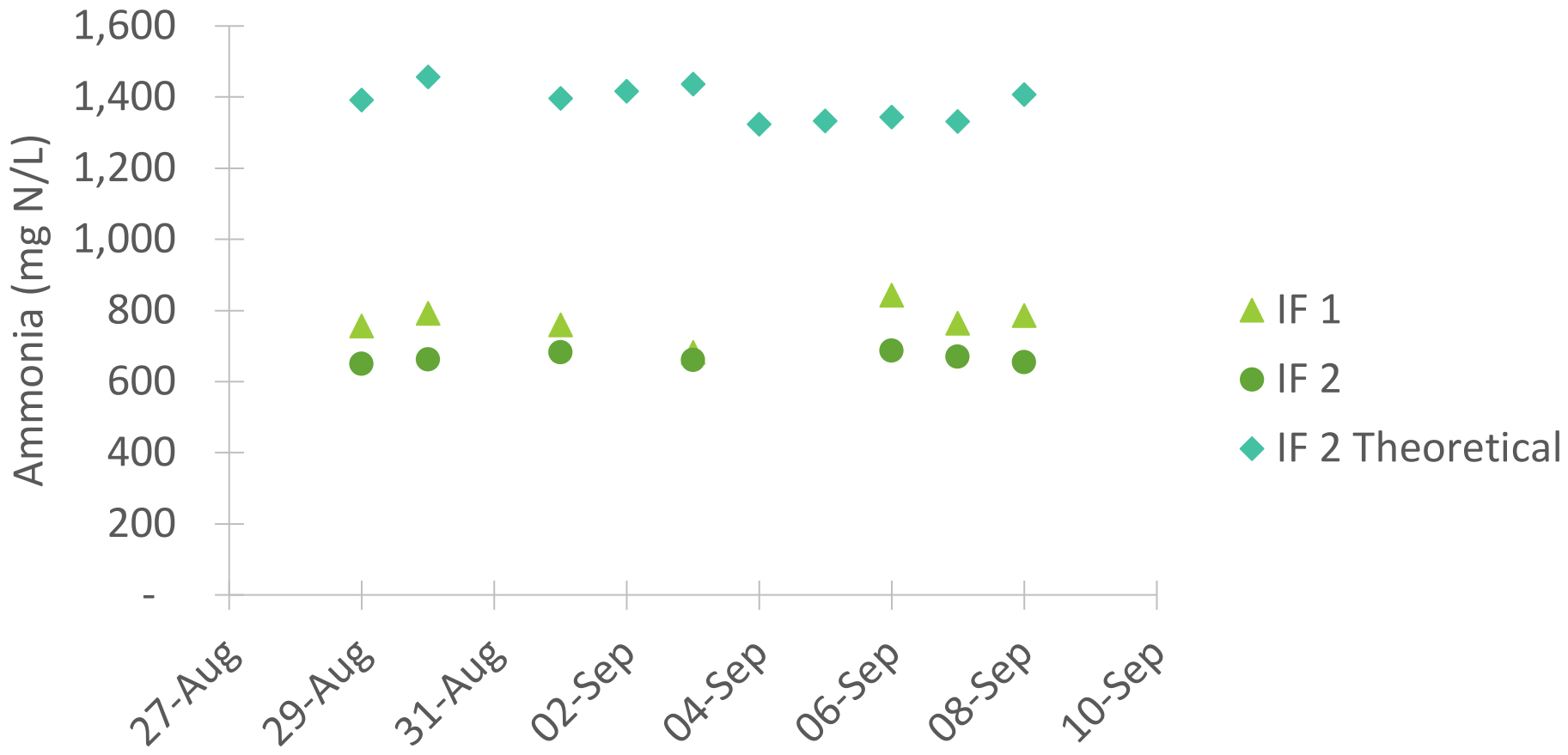
- 1.8 L working volume
- 35 ± 2 °C
- Feed is 50:50, TWAS : PS
- Side stream treated at 150 mbar, 55 °C
- 58 days of operation
- OLR = 1.5 to 2 g COD/L/day and 3 to 4 g COD/L/day

| IF | HRT | SRT | Feed Volume (mL) | Sludge sent for stripping (mL) | Condensate (mL) | Stripped Sludge back to digesters (mL) | Waste from digesters (mL) |
|---|---|---|---|---|---|---|---|
| 1 | 20 | 20 | 90 | 0 | 0 | 0 | 90 |
| 2 | 10 | 20 | 180 | 180 | 90 | 90 | 90 |

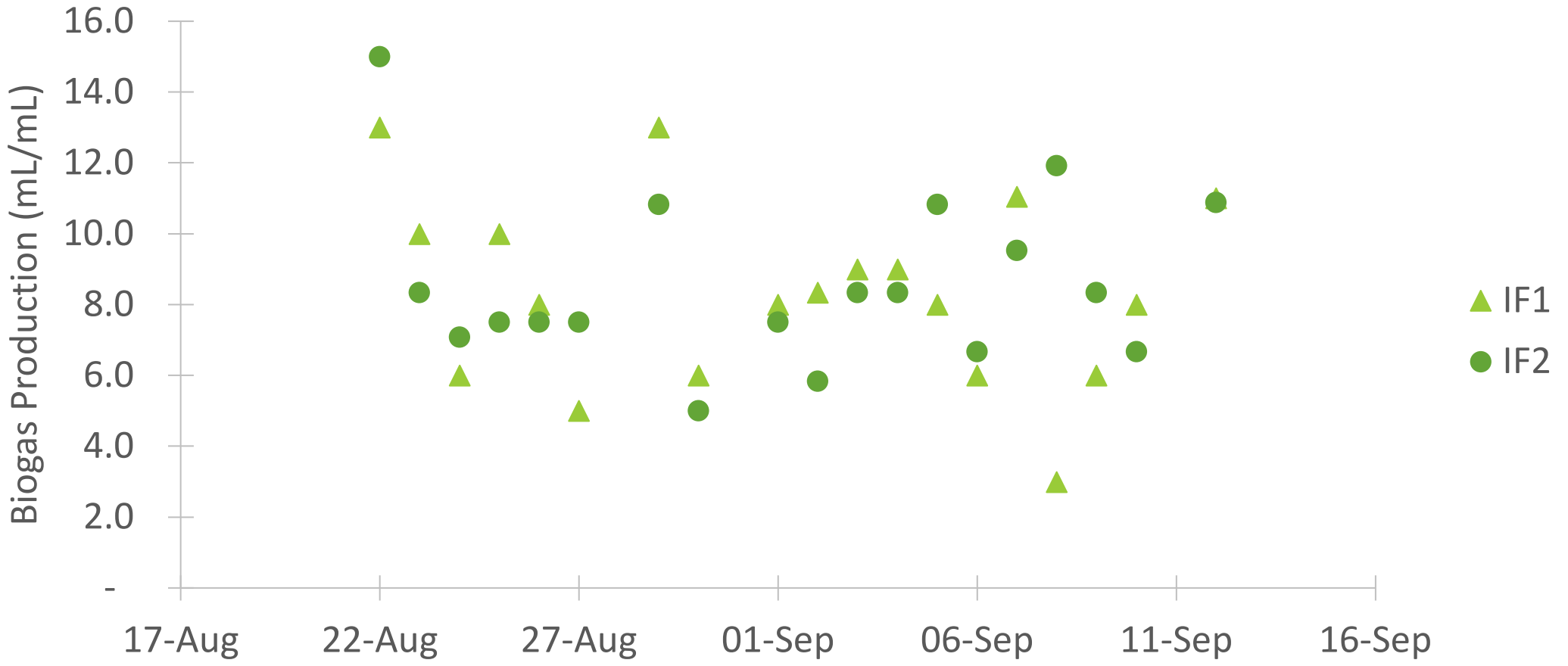
# IntensiCarb as an Anaerobic Digester –
## VS Destructions



# IntensiCarb as an Anaerobic Digester –
## Ammonia concentrations in the reactor



# IntensiCarb as an Anaerobic Digester –
## Biogas production is maintained during intensification



# Observations to date

- Decoupling of SRT from HRT with vacuum results in a significant increase in hydrolysis and acidification rates.
- Fermentate from vacuum reactor provides carbon comparable to supplemental sources
- Vacuum did not show long term impact on fermentative and methanogenic bacteria
- Able to double the organic loading while maintaining digester performance
- Ammonia removal during fermentation and anaerobic digestion presents nutrient recovery, diversion and downstream process benefits.

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