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Comparing the performance of common ammonia stripping configurations for enhancing the biogas potential of poultry manure

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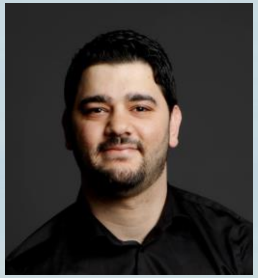
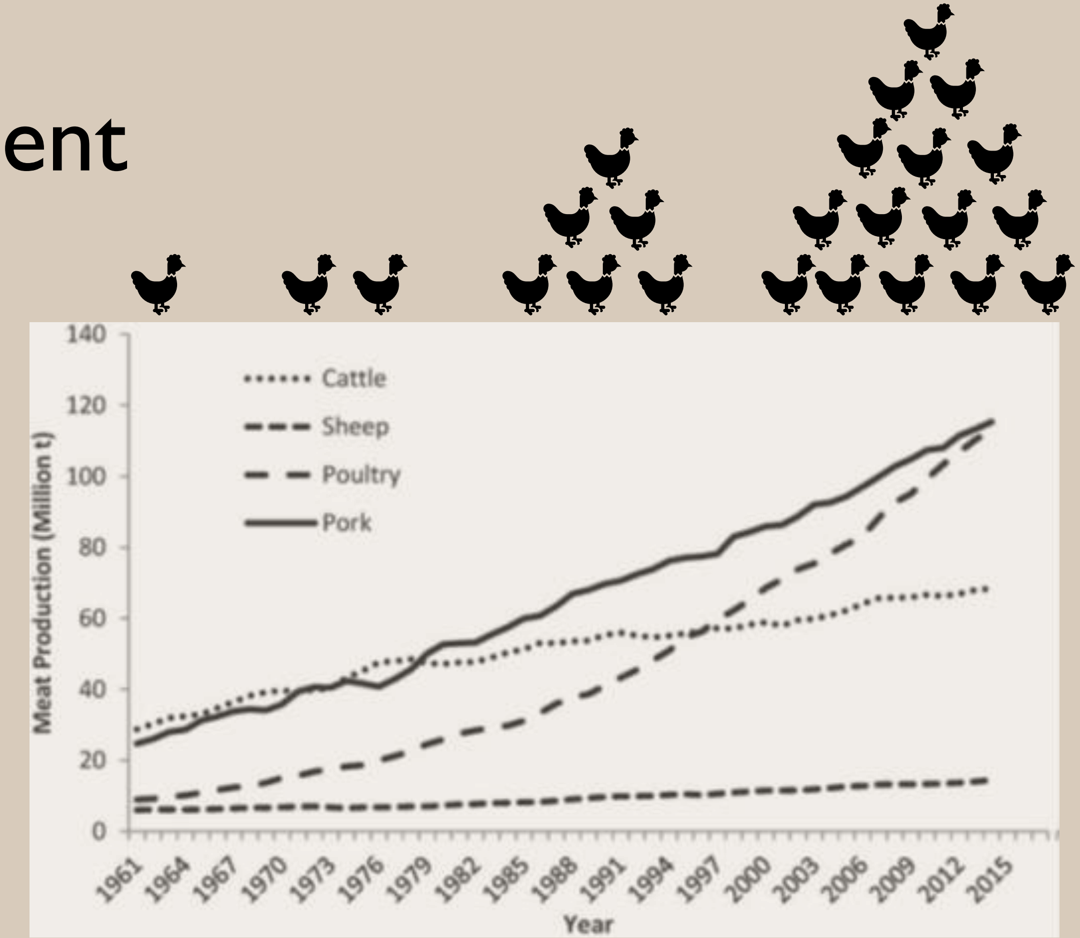


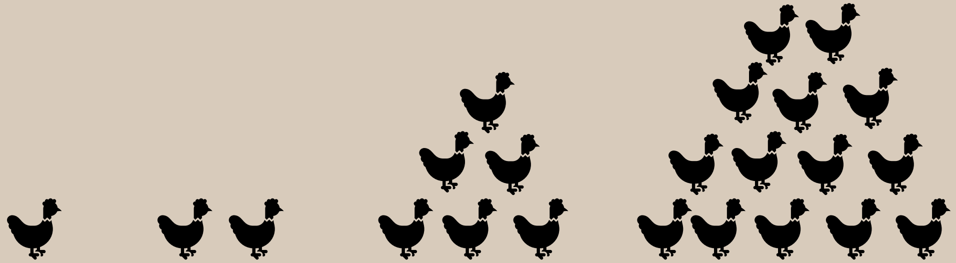
CH FOUR BIOGAS
Your Organic Energy Potential Realized.

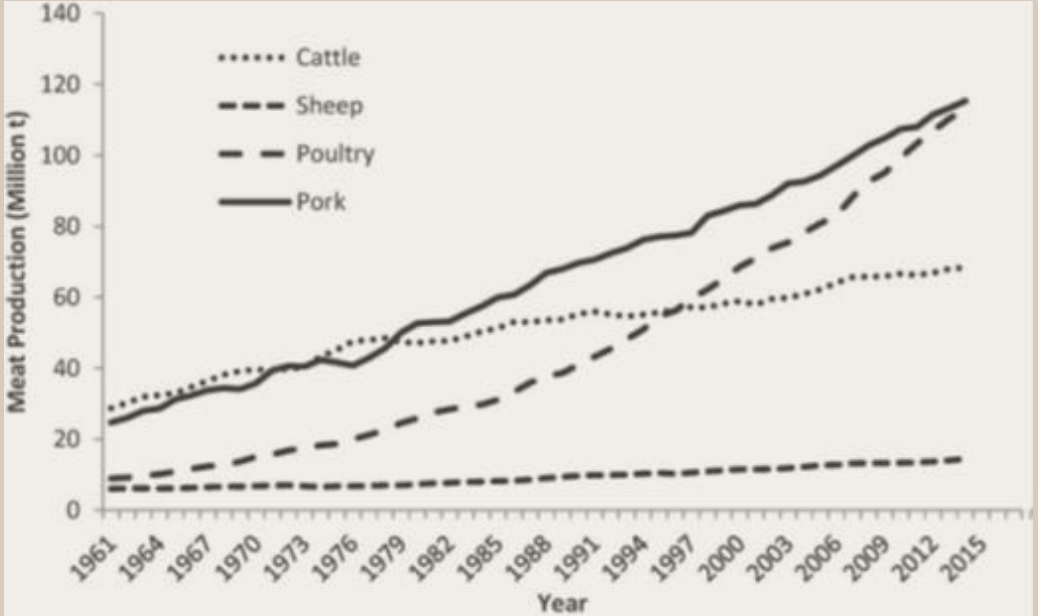
Problem Statement



World meat production of cattle (including buffalo), sheep (including goats), poultry, and pork from 1961 to 2014 (Million t; Michalk et al.,2019).

Problem Statement





World meat production of cattle (including buffalo), sheep (including goats), poultry, and pork from 1961 to 2014 (Million t; Michalk et al.,2019).

348 Million Headcount (Canada)

Most widely available livestock

120 kg manure per 1000 layer chicken

About 15.2 Million tons per year (Canada)

Problem Statement - Current Management

Land Application

Advantages

Good fertilizer

Cheap and widely available

Disadvantages

High methane emissions

Eutrophication

Smell & Odor

No energy generation

Composting

Advantages

Valuable product for agriculture or household

Stabilized waste

Controlled emissions

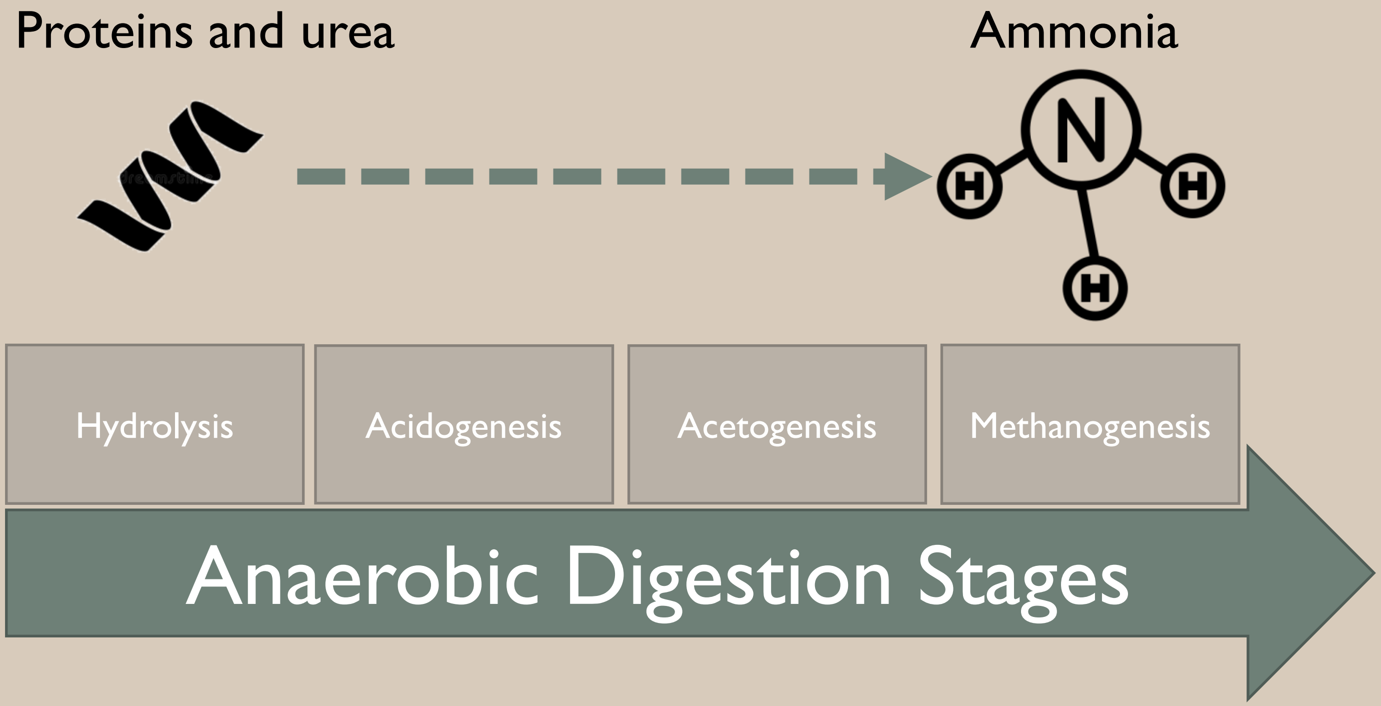
Disadvantages

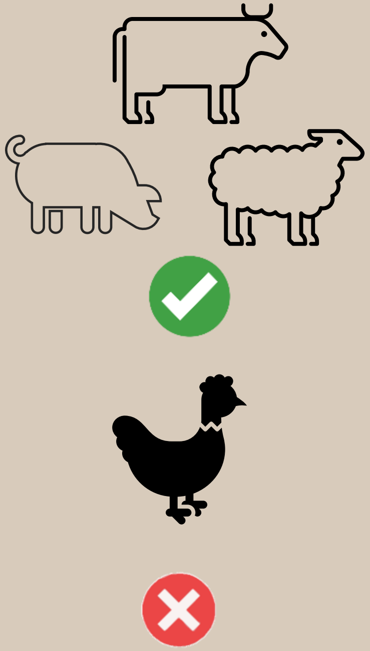
Smell & Odor

Energy consumption

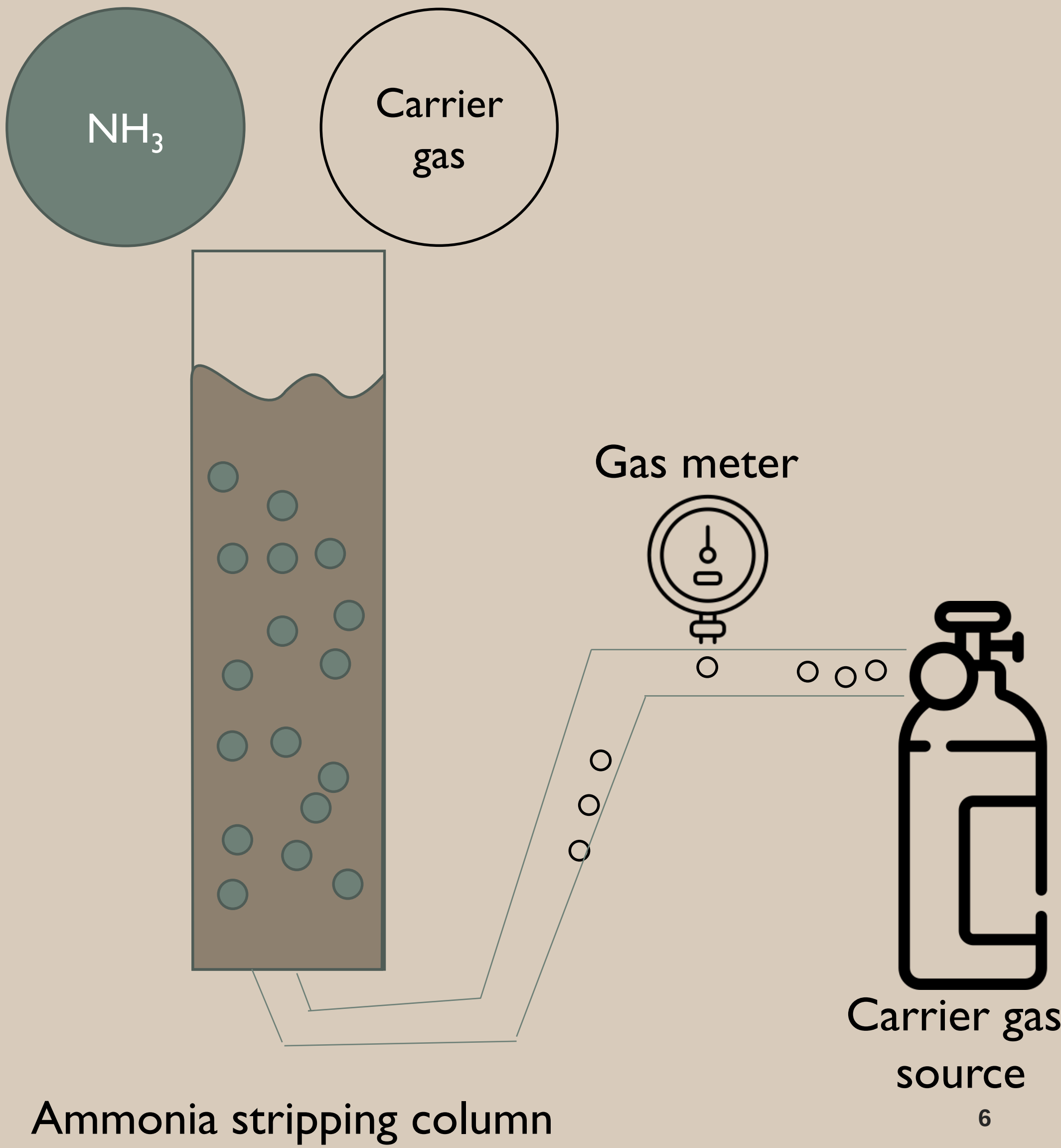
No energy generation

Anaerobic Digestion – Ammonia inhibition

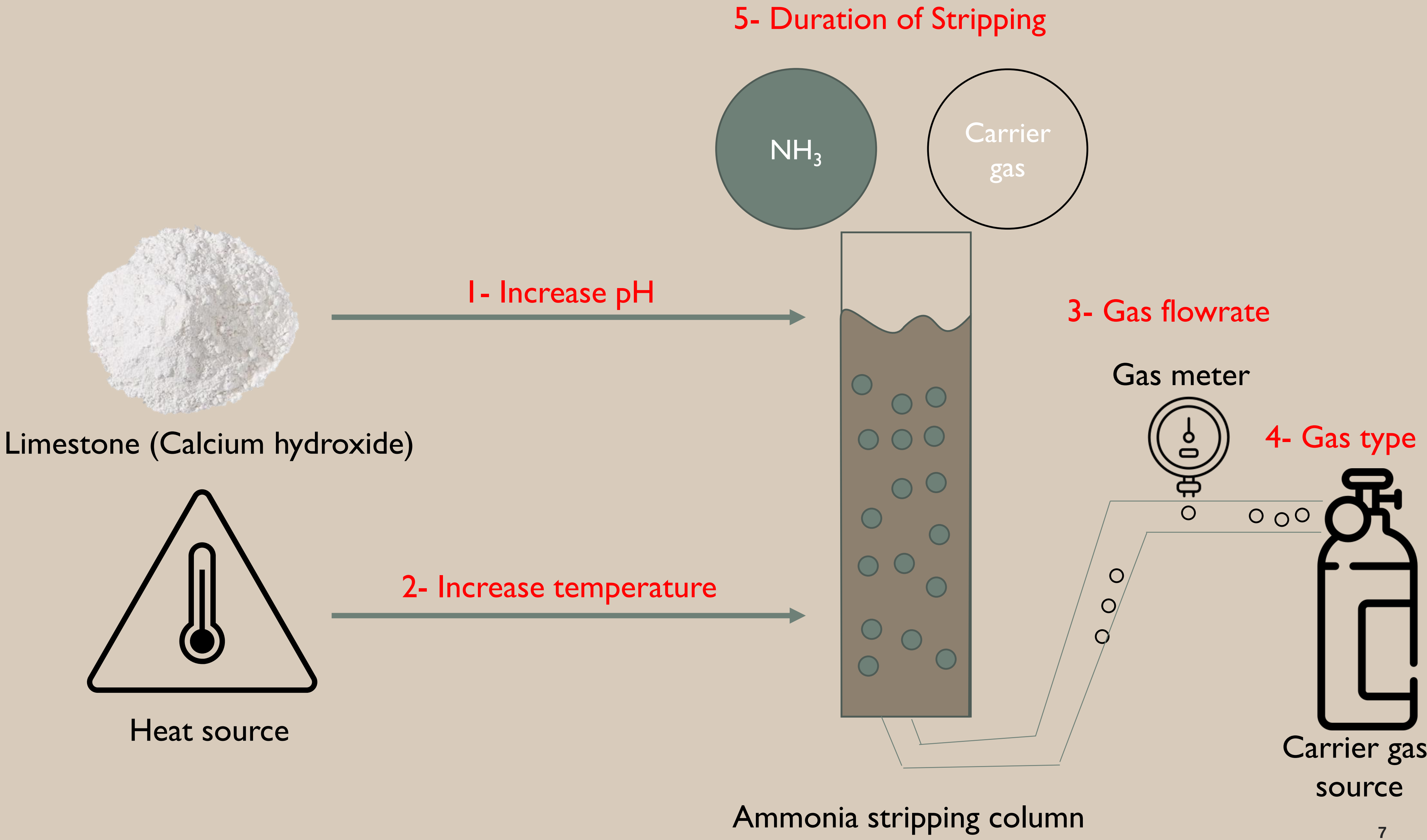




Ammonia Stripping

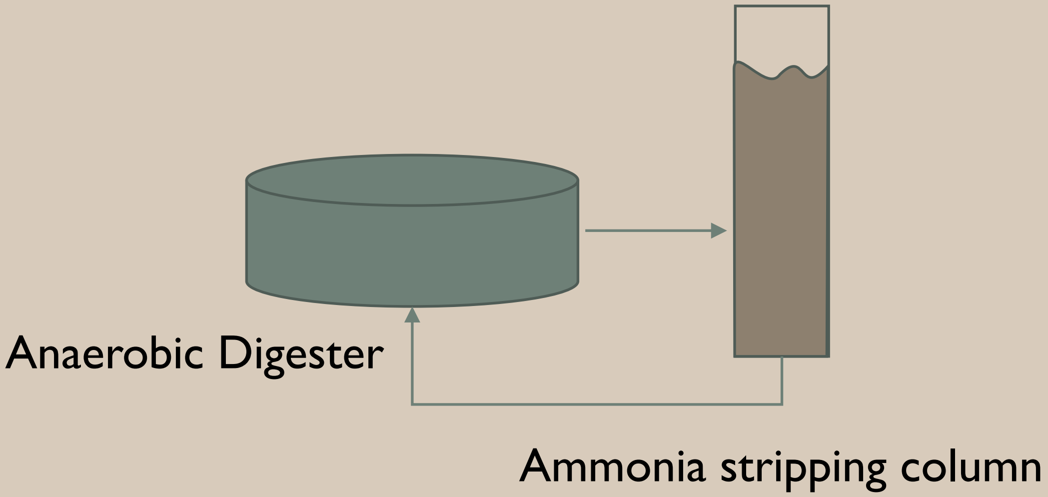


Ammonia Stripping



Ammonia Stripping Configurations

Side-stream (SSAS)



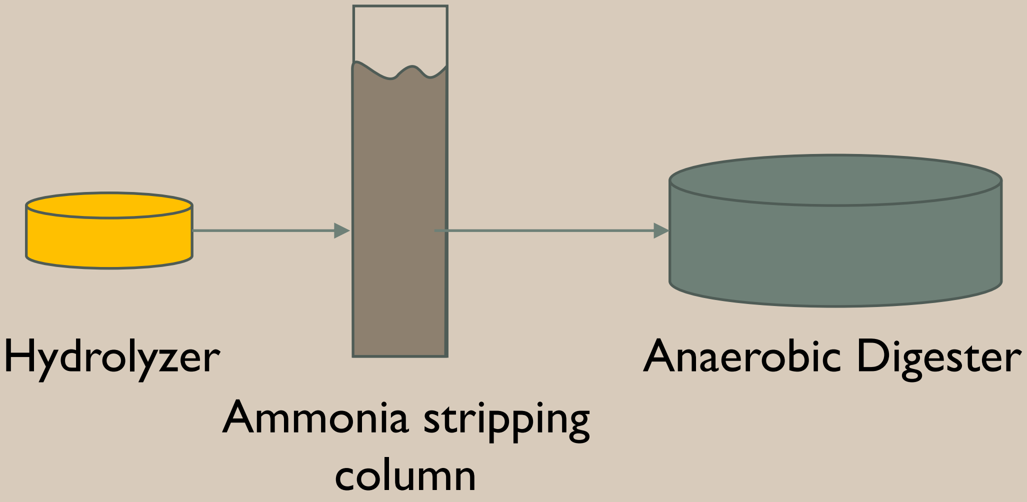
Most common method

Targets high-ammonia levels
Low energy demand

Requires solid/liquid separation to minimize microorganisms shock

Carrier gas selection is often restricted

Post-hydrolysis (PHAS)



Most recent advancement

Targets high-ammonia levels
Low energy demand

No solid/liquid separation

Carrier gas selection is flexible

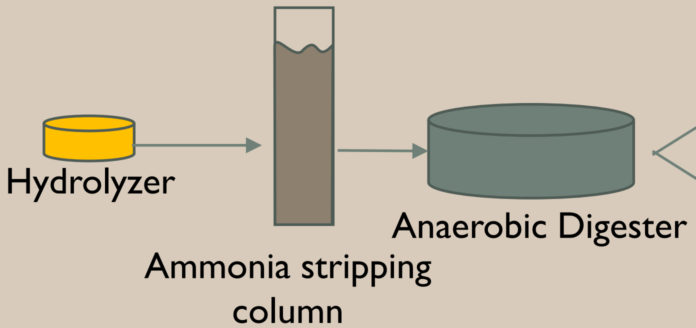
Study Objectives

- Compare the performance of PHAS and SSAS under similar ammonia stripping conditions
- Test RNG as a stripping medium in semi continuous mode for PHAS and SSAS
- Test PHAS in semi-continuous mode for the first time
- Provide high-nitrogen organic waste producers with more sustainable treatment options

Methodology

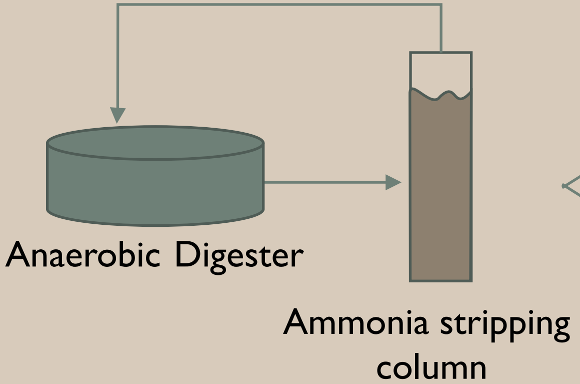
	Stripping medium	Treatment portion

Post-hydrolysis Ammonia Stripping (PHAS)



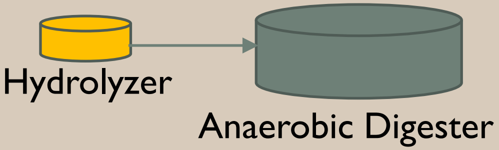
- Air → All hydrolysis effluent (5% digester volume per day)
- RNG → All hydrolysis effluent (5% digester volume per day)

Side-stream Ammonia Stripping (SSAS)



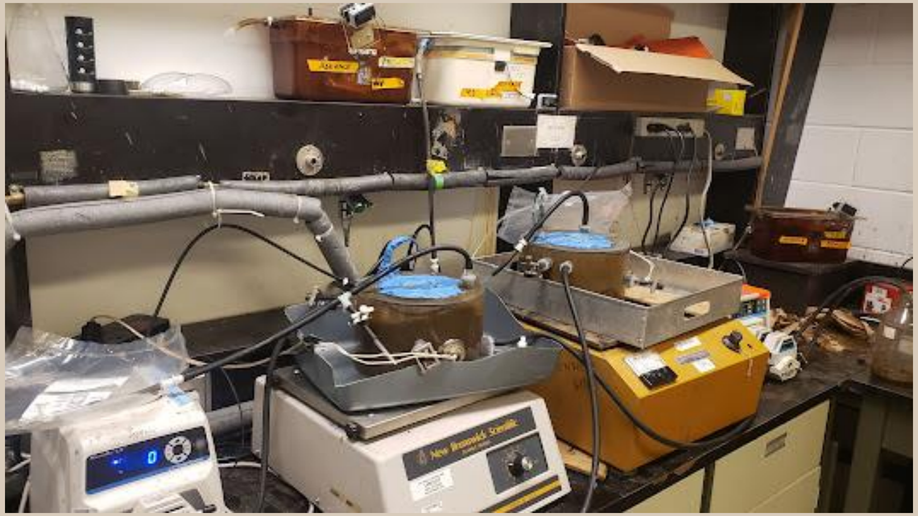
- RNG → 20% digester volume per day
- RNG → 10% digester volume per day
- Air → 10% digester volume per day

Control scenario

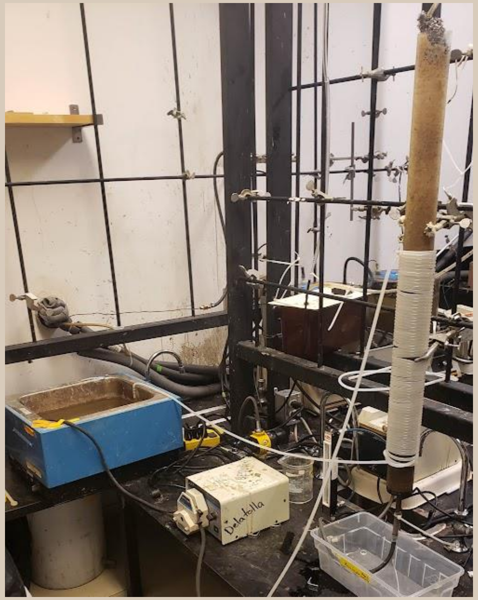


- Conducted at the end
- No treatment
- Baseline to evaluate biogas enhancement

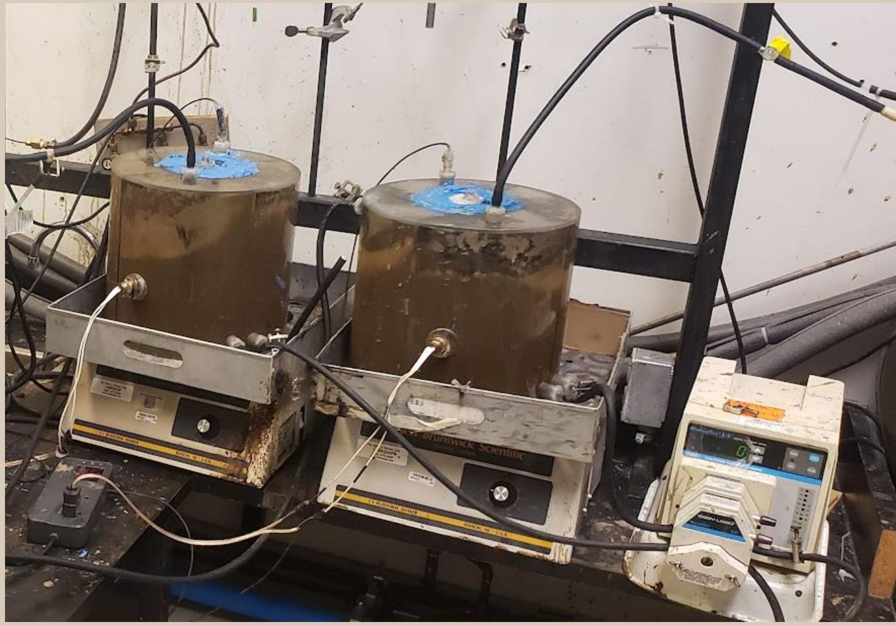
Methodology



5 L semi-continuous hydrolysis reactors
10 L working volume



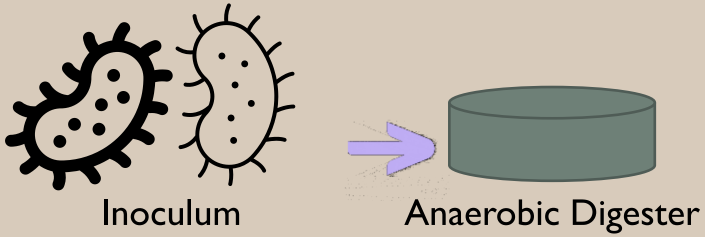
Ammonia stripping column with
hot water recirculation system



15 L semi-continuous Biogas reactors

Results: Semi-continuous CSTR Biogas Production

Inoculation



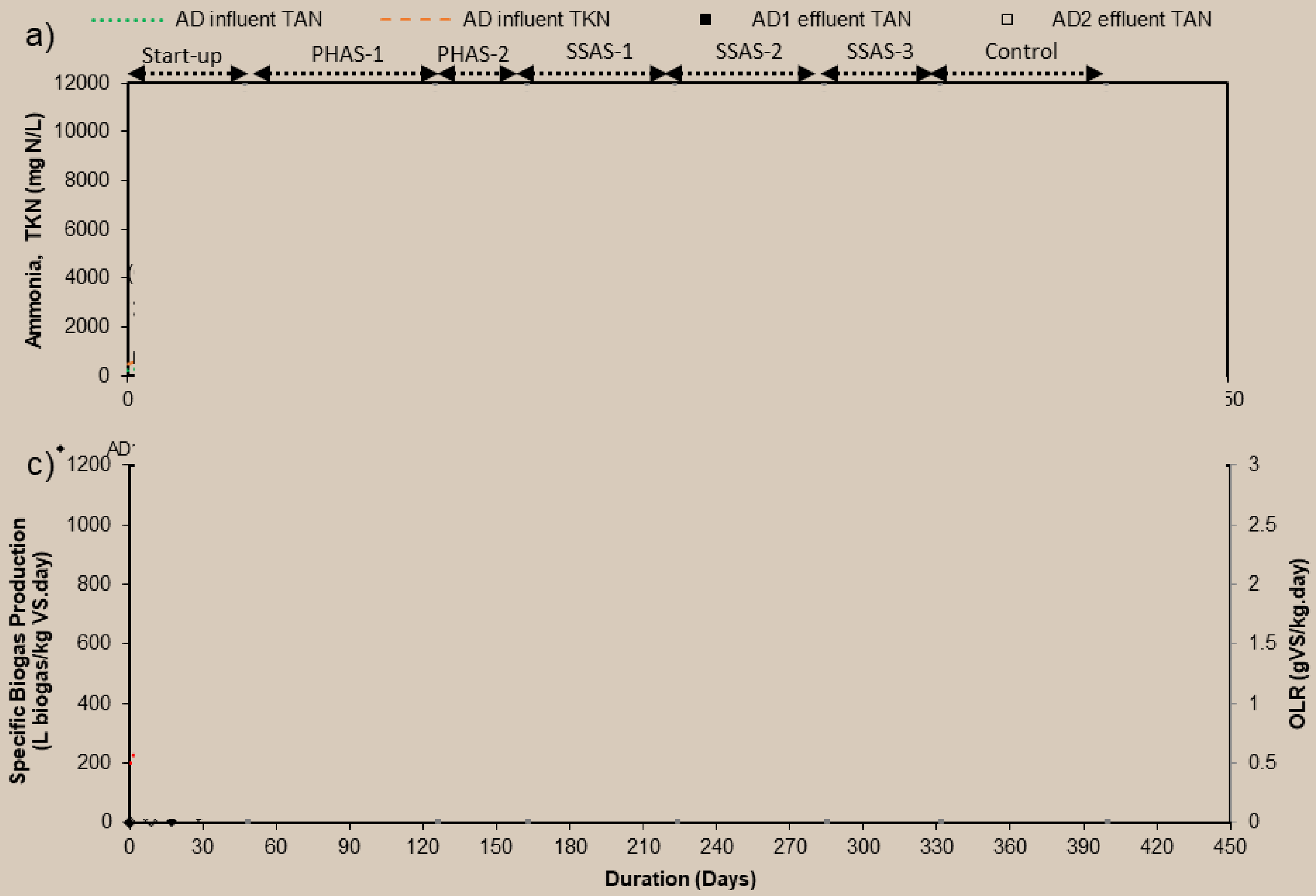


Figure 7-2

Inoculation

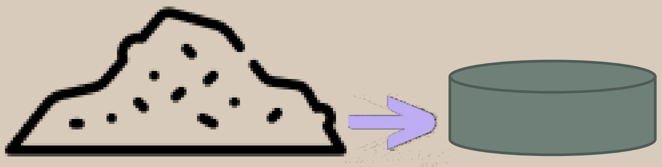
TAN Levels | 709 mg/L

Biogas Production

Enhancement to Control/Blank

Results: Semi-continuous CSTR Biogas Production

Startup Phase



Diluted (low TAN) PM

Anaerobic Digester

Start-up	
TAN Levels	1000 mg/L
Biogas Production	600 L biogas/kg VS.day
Enhancement to Control/Blank	N/A

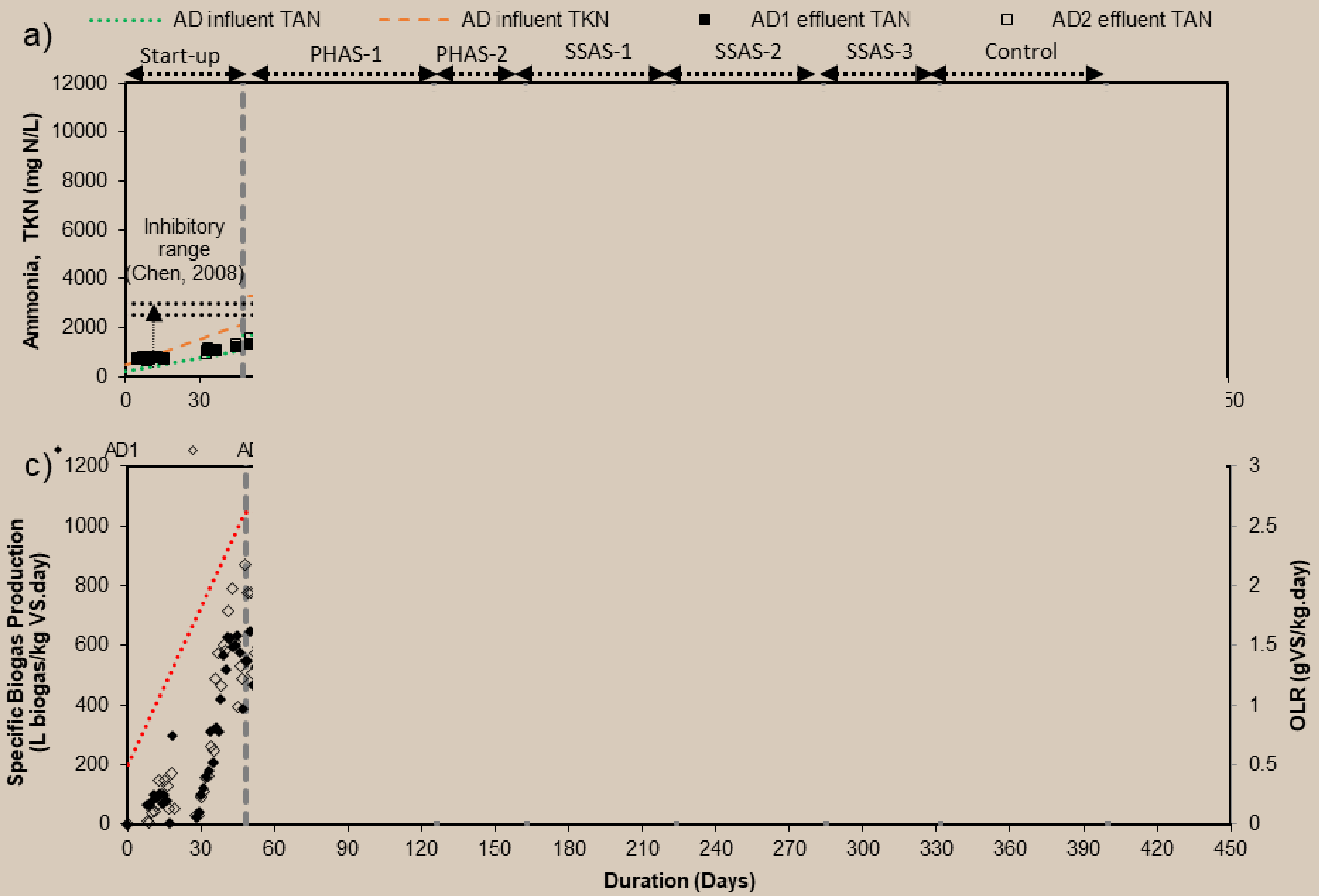
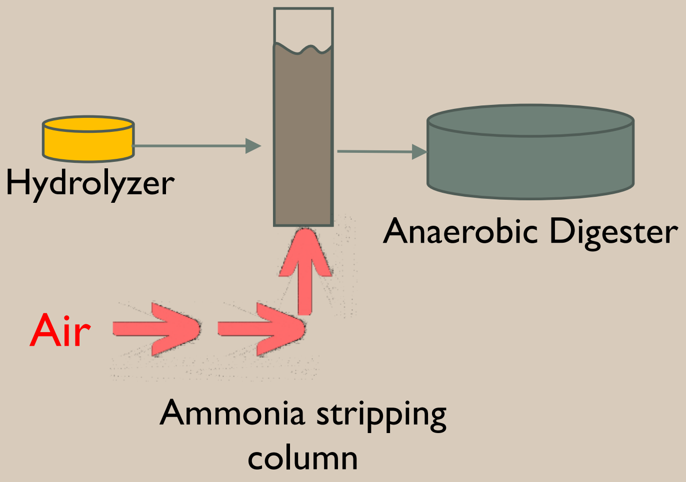


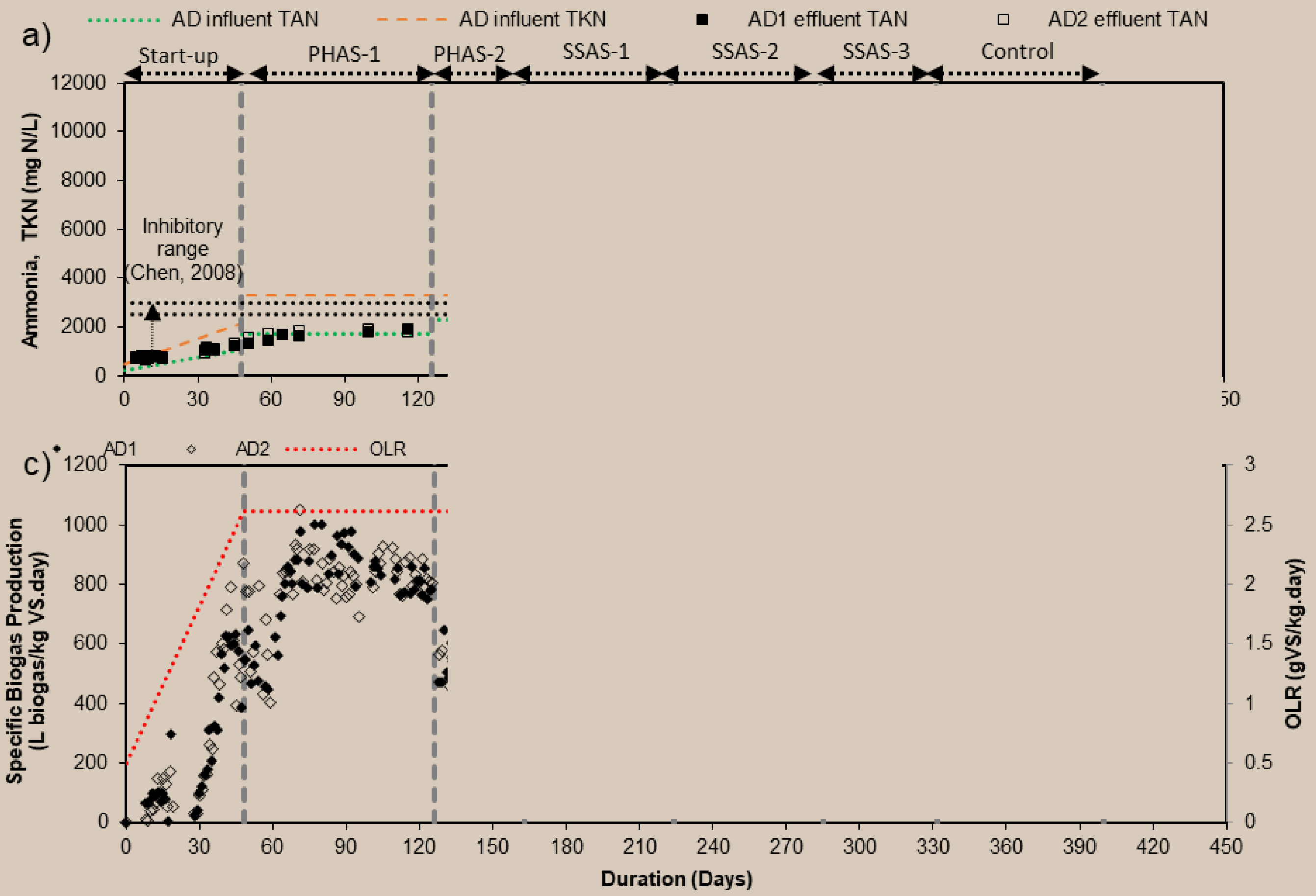
Figure 7-2

Results: Semi-continuous CSTR Biogas Production

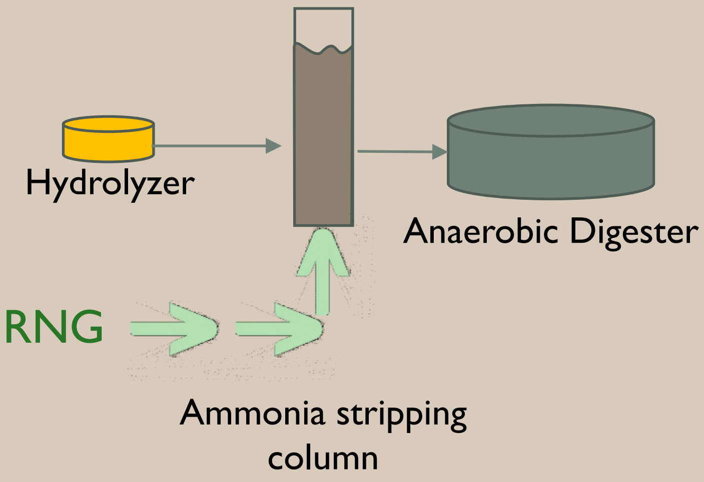
Post-hydrolysis Ammonia Stripping (PHAS)



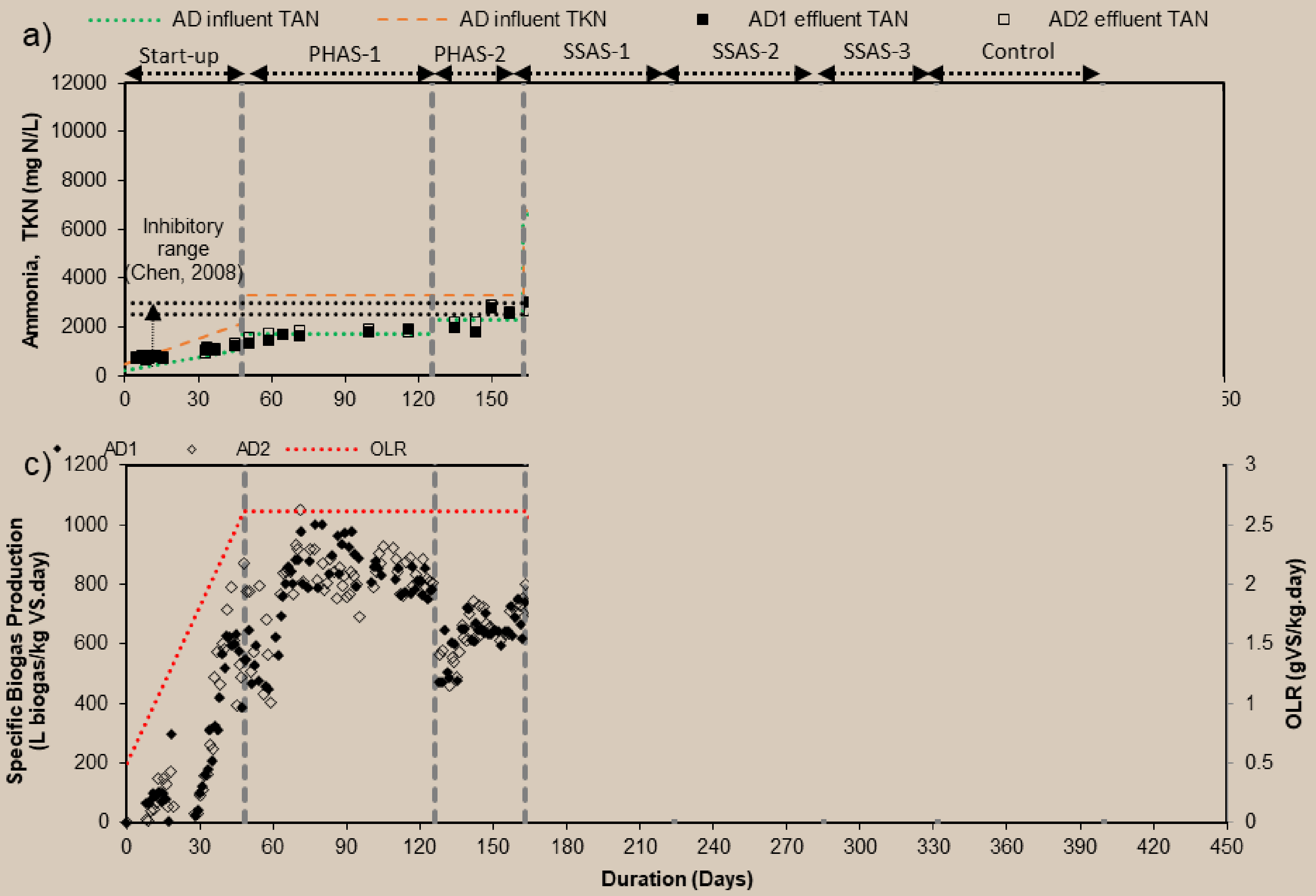
PHAS-1 (Air)	
TAN Levels	1800 mg/L
Biogas Production	830 L biogas/kg VS.day
Enhancement to Control/Blank	432%



Post-hydrolysis Ammonia Stripping (PHAS)

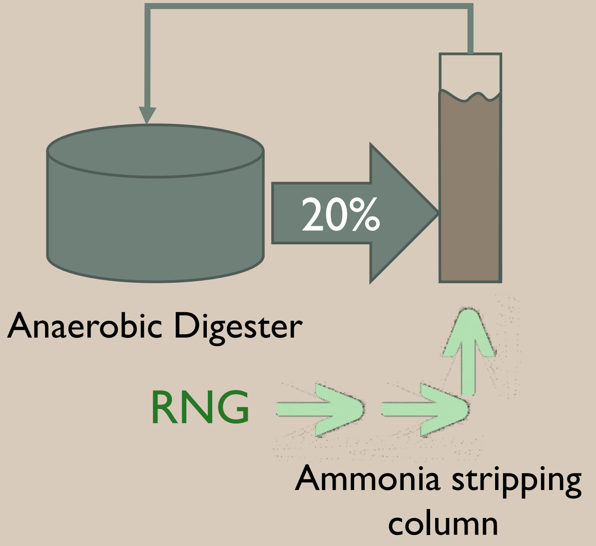


PHAS-2 (RNG)	
TAN Levels	2484 mg/L
Biogas Production	680 L biogas/kg VS.day
Enhancement to Control/Blank	336%

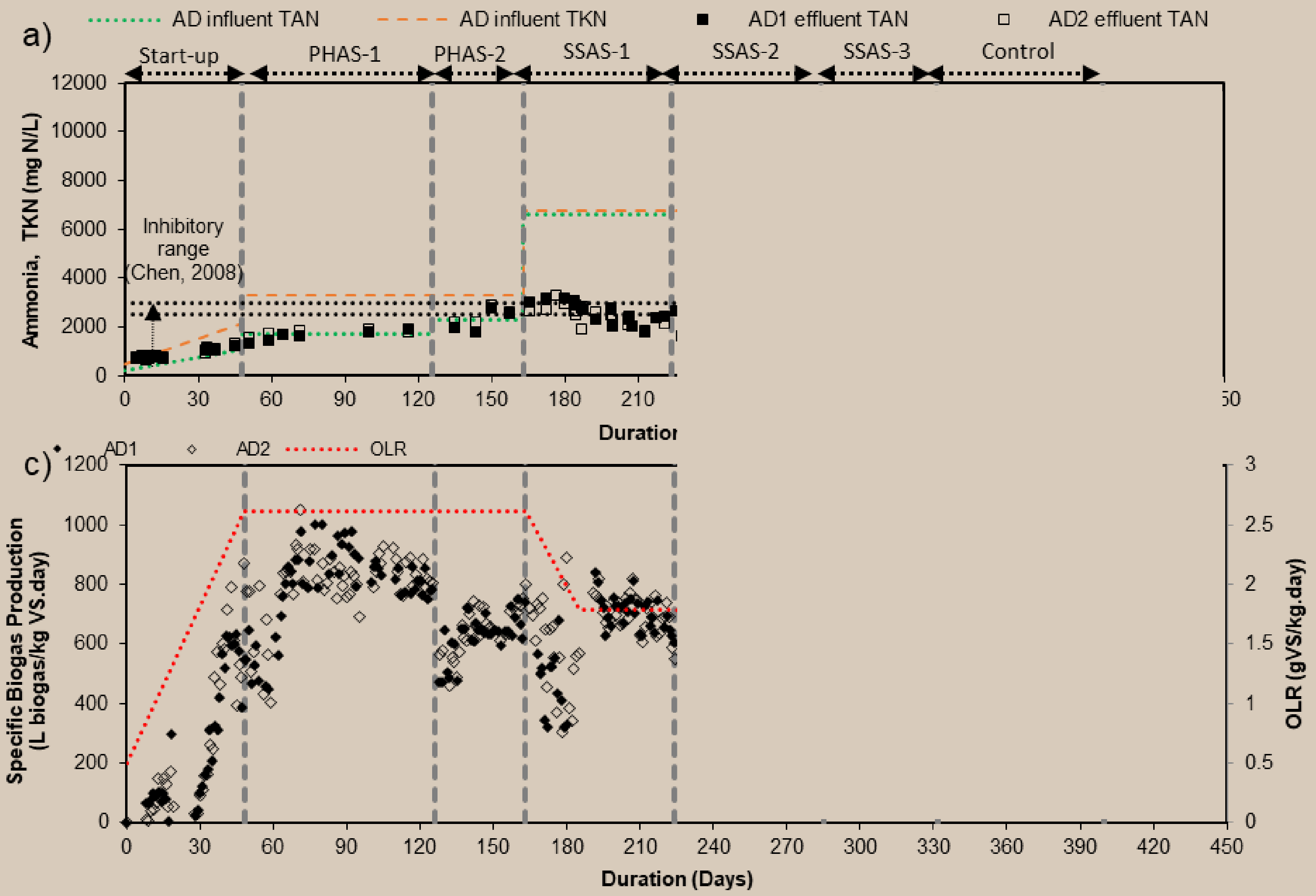


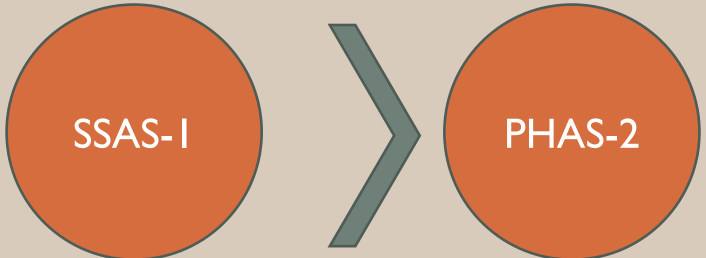
Results: Semi-continuous CSTR Biogas Production

Side-stream Ammonia Stripping (SSAS)



SSAS-1 (RNG at 20%)	
TAN Levels	2056 mg/L
Biogas Production	703 L biogas/kg VS.day
Enhancement to Control/Blank	351%

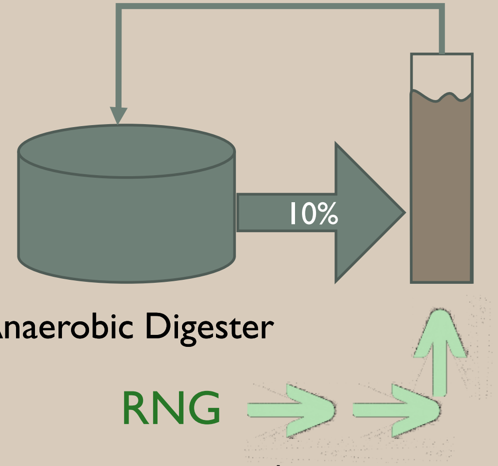




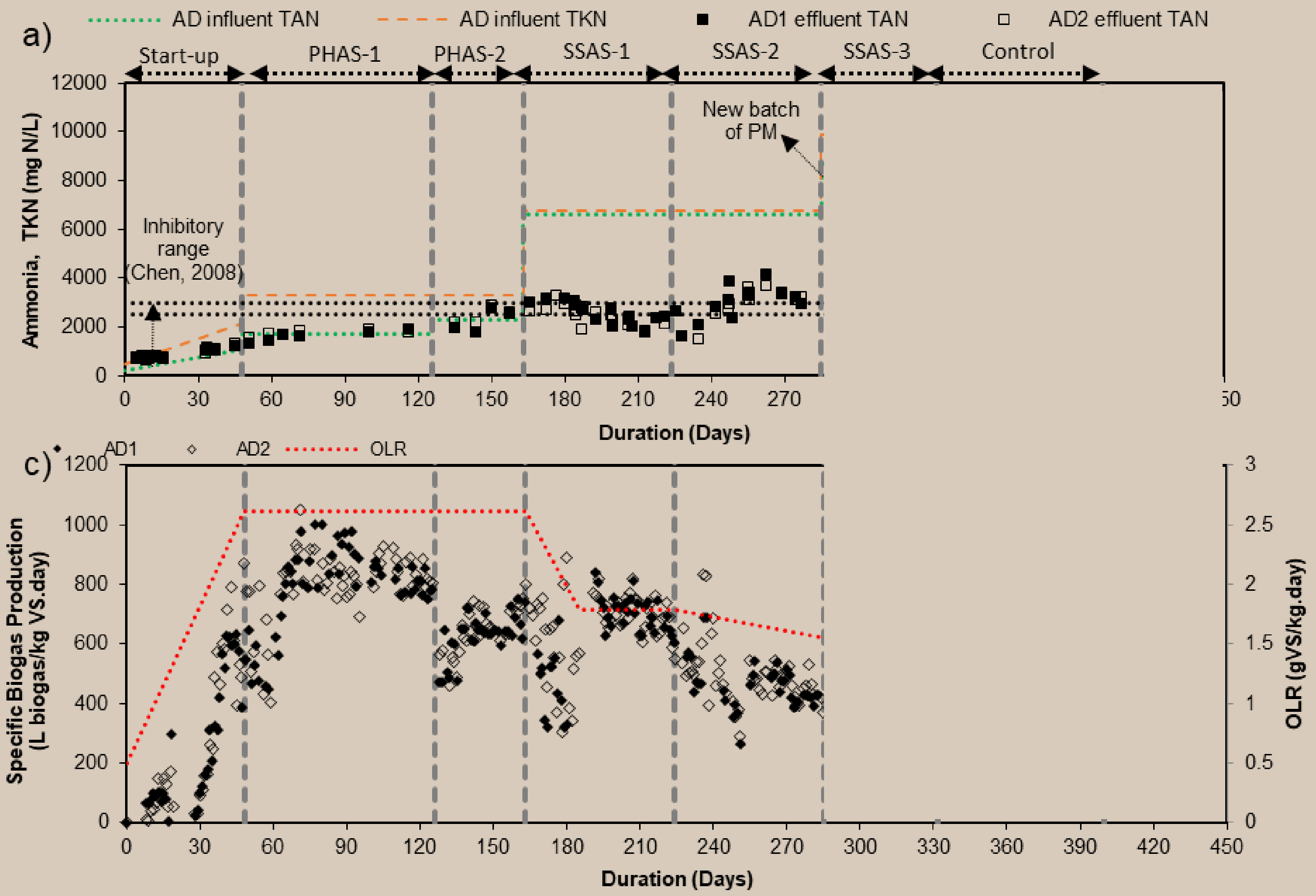
Biogas Variation

3%

Side-stream Ammonia Stripping (SSAS)



SSAS-2 (RNG at 10%)	
TAN Levels	3153 mg/L
Biogas Production	485 L biogas/kg VS.day
Enhancement to Control/Blank	211%



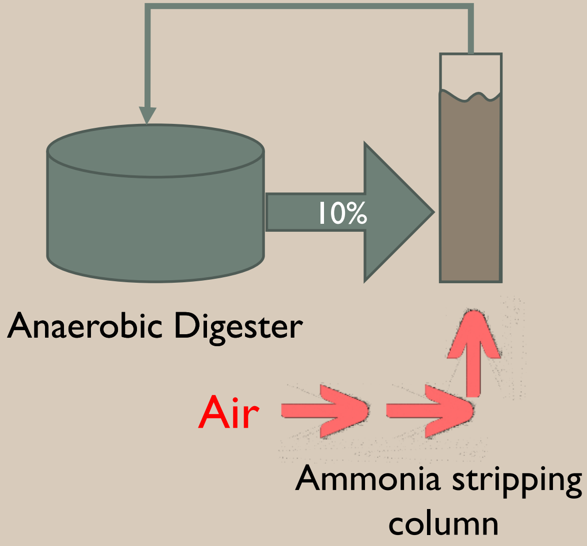
SSAS-2 〈 PHAS-2

Biogas Variation

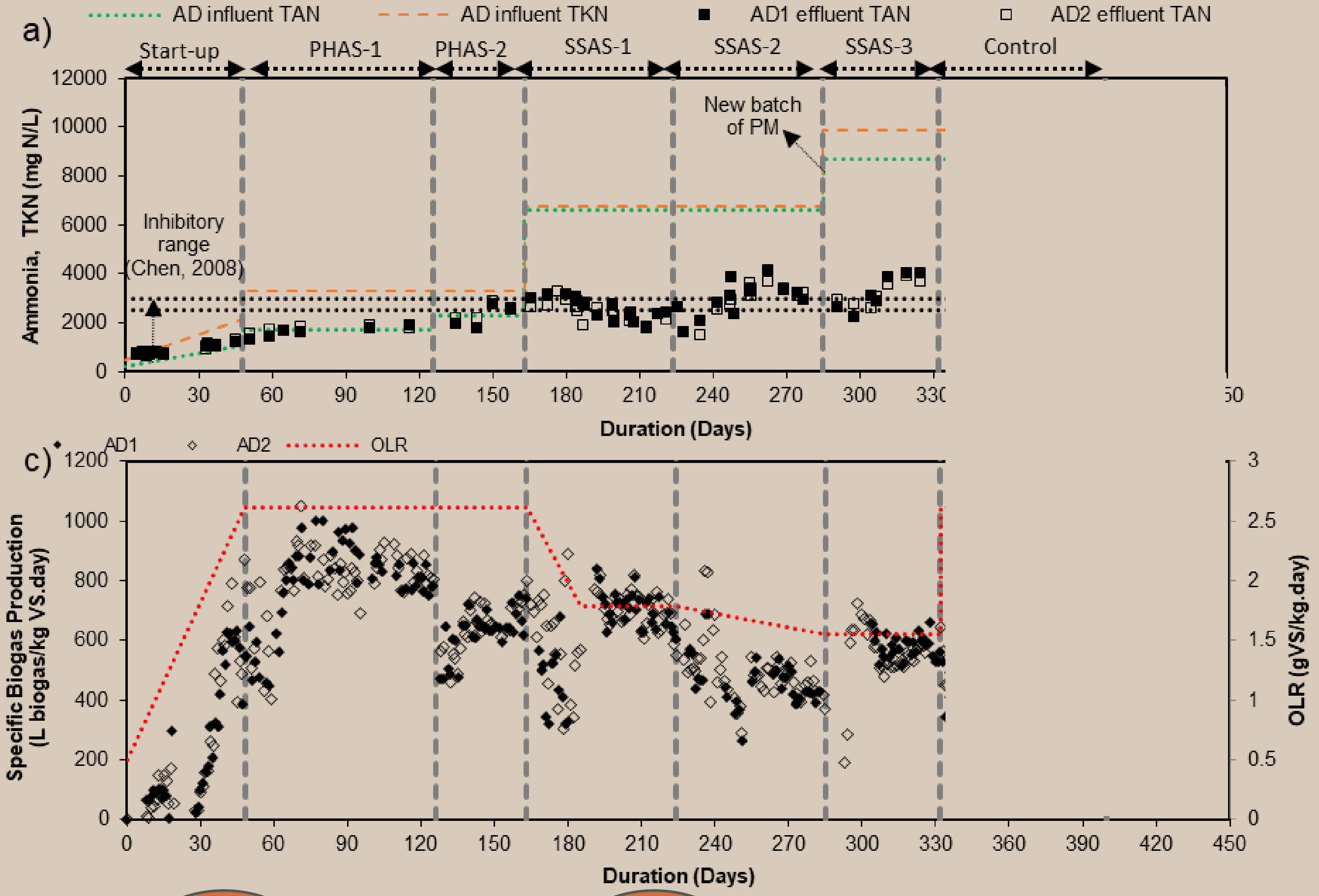
29%

Results: Semi-continuous CSTR Biogas Production

Side-stream Ammonia Stripping (SSAS)



SSAS-3 (Air at 10%)	
TAN Levels	3227 mg/L
Biogas Production	565 L biogas/kg VS.day
Enhancement to Control/Blank	262%



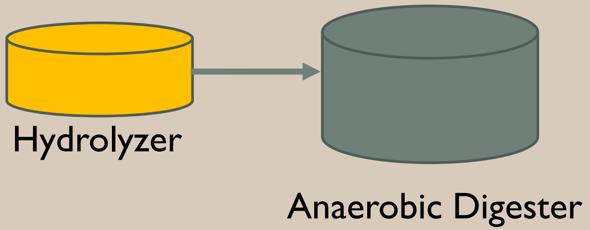
SSAS-3 < PHAS-1

Biogas Variation

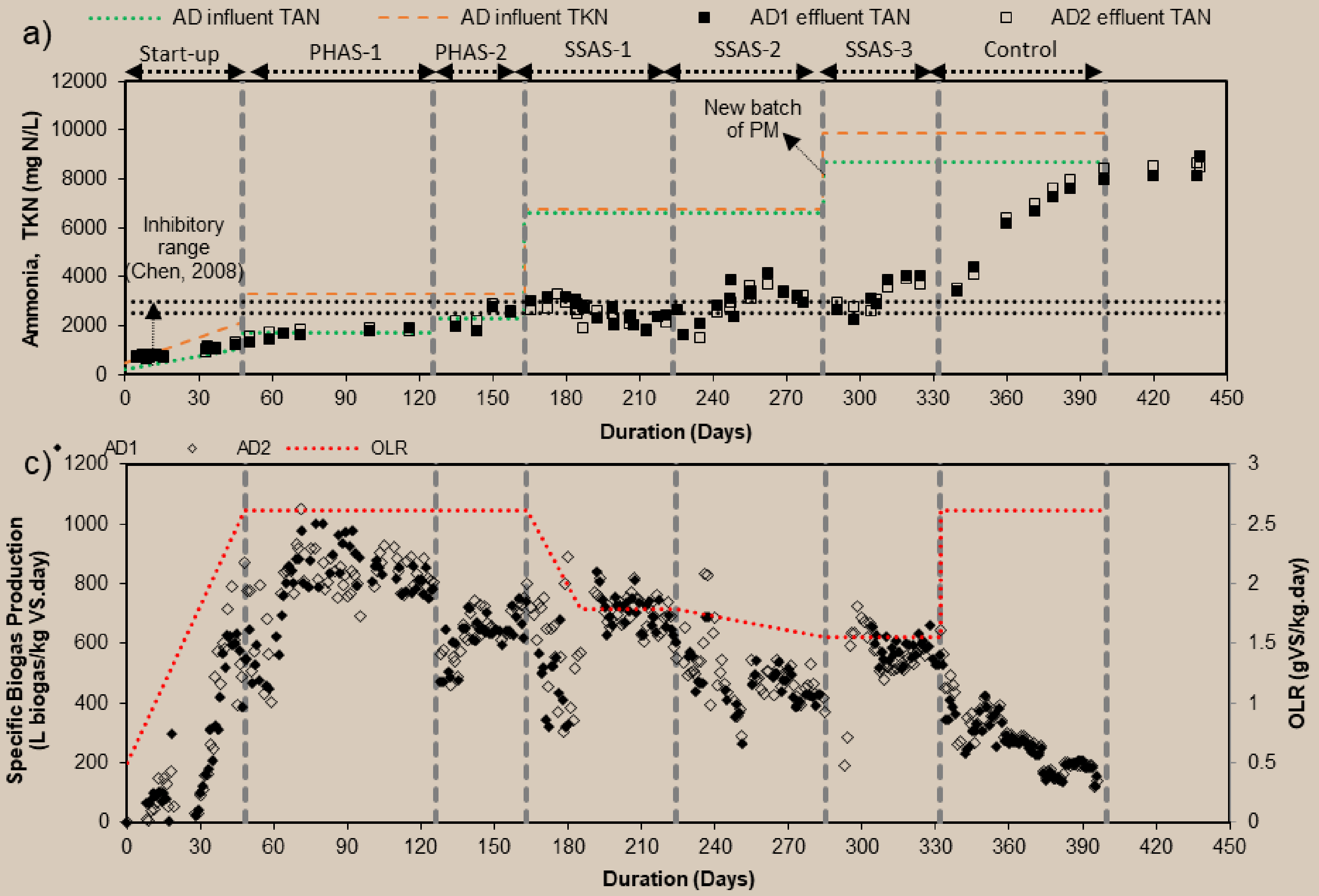
32%

Results: Semi-continuous CSTR Biogas Production

Control Scenario



Control (no treatment)	
TAN Levels	7943 mg/L
Biogas Production	156 L biogas/kg VS.day
Result	Inhibited



Conclusions

1. Semi-continuous PM mono-digestion is feasible

2. PHAS showed higher flexibility and lower treatment requirements than SSAS, eventually reducing the cost, energy, and space requirements

3. SSAS can be performed with air or RNG, but is less effective than PHAS

Thank You!