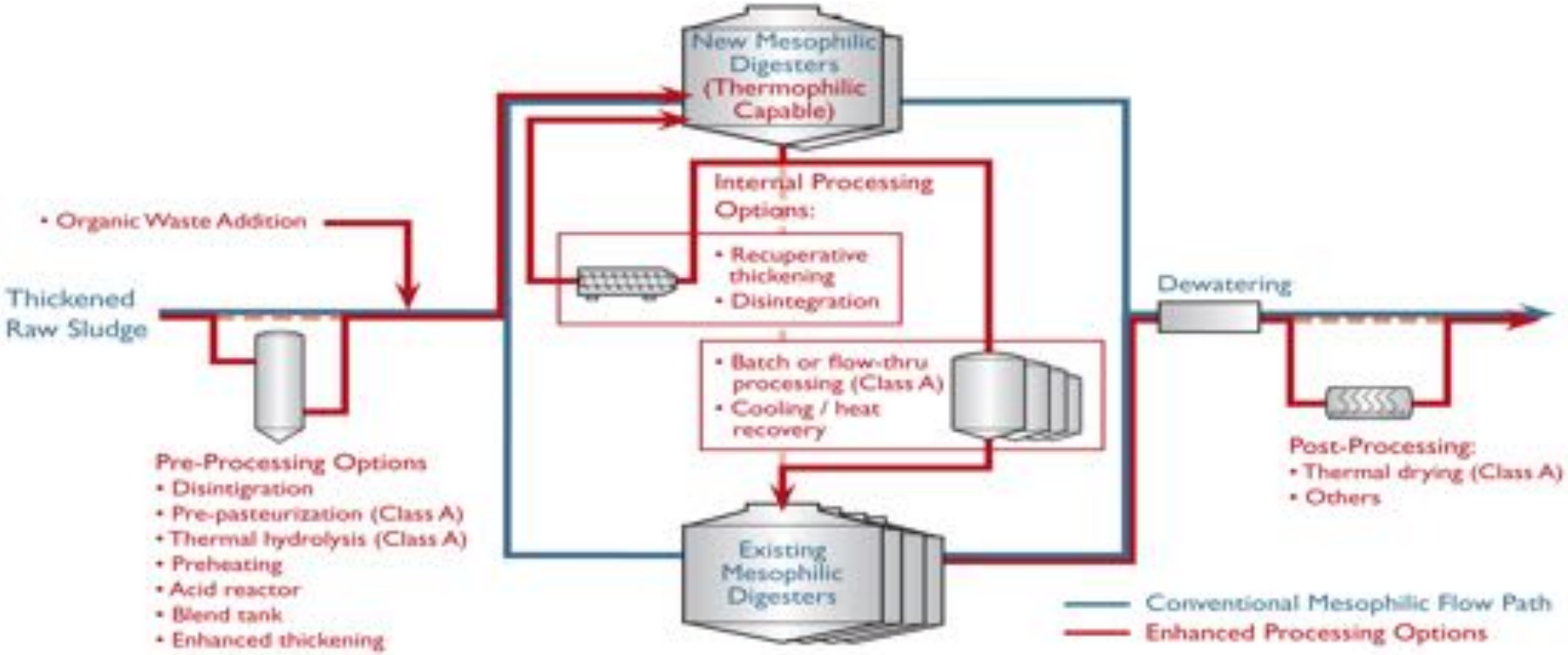
NEBRA Digestion Roundtable

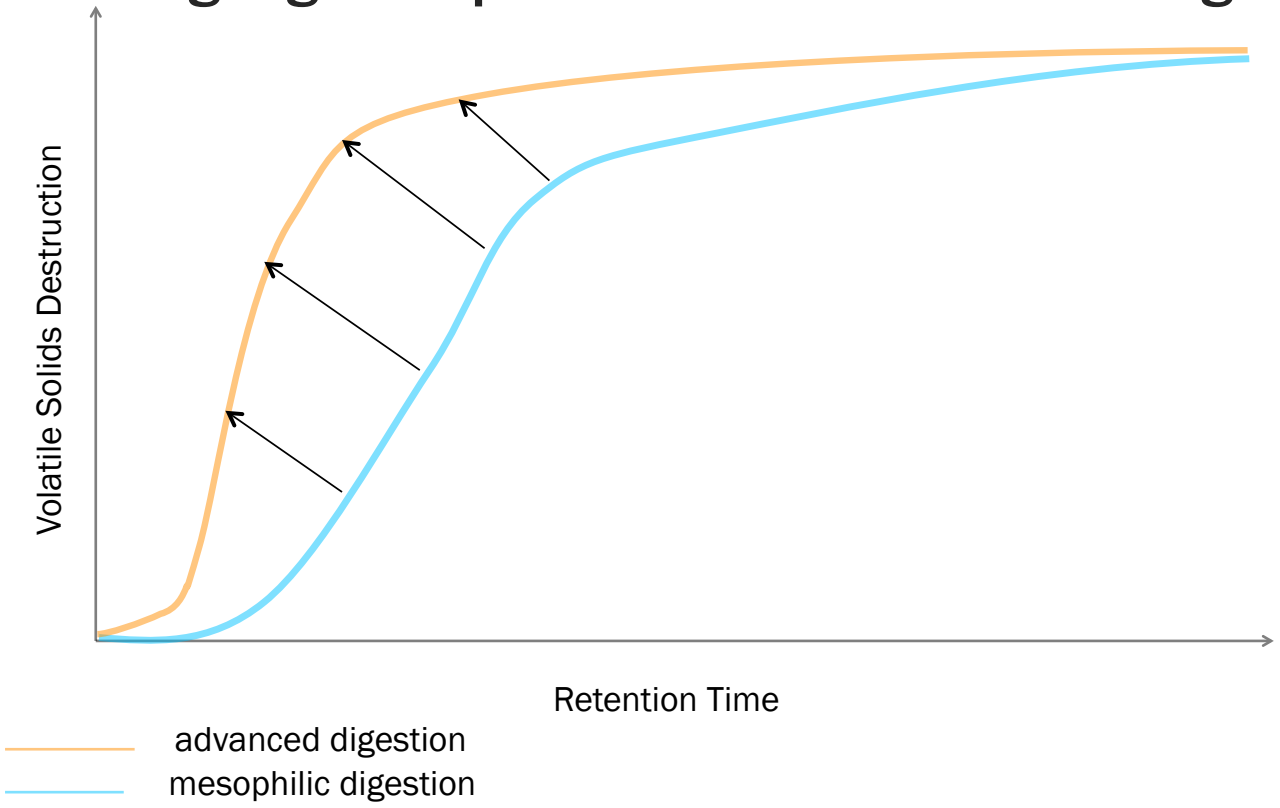
Anaerobic digestion –opportunities to optimize and enhance digestion

July 7, 2017

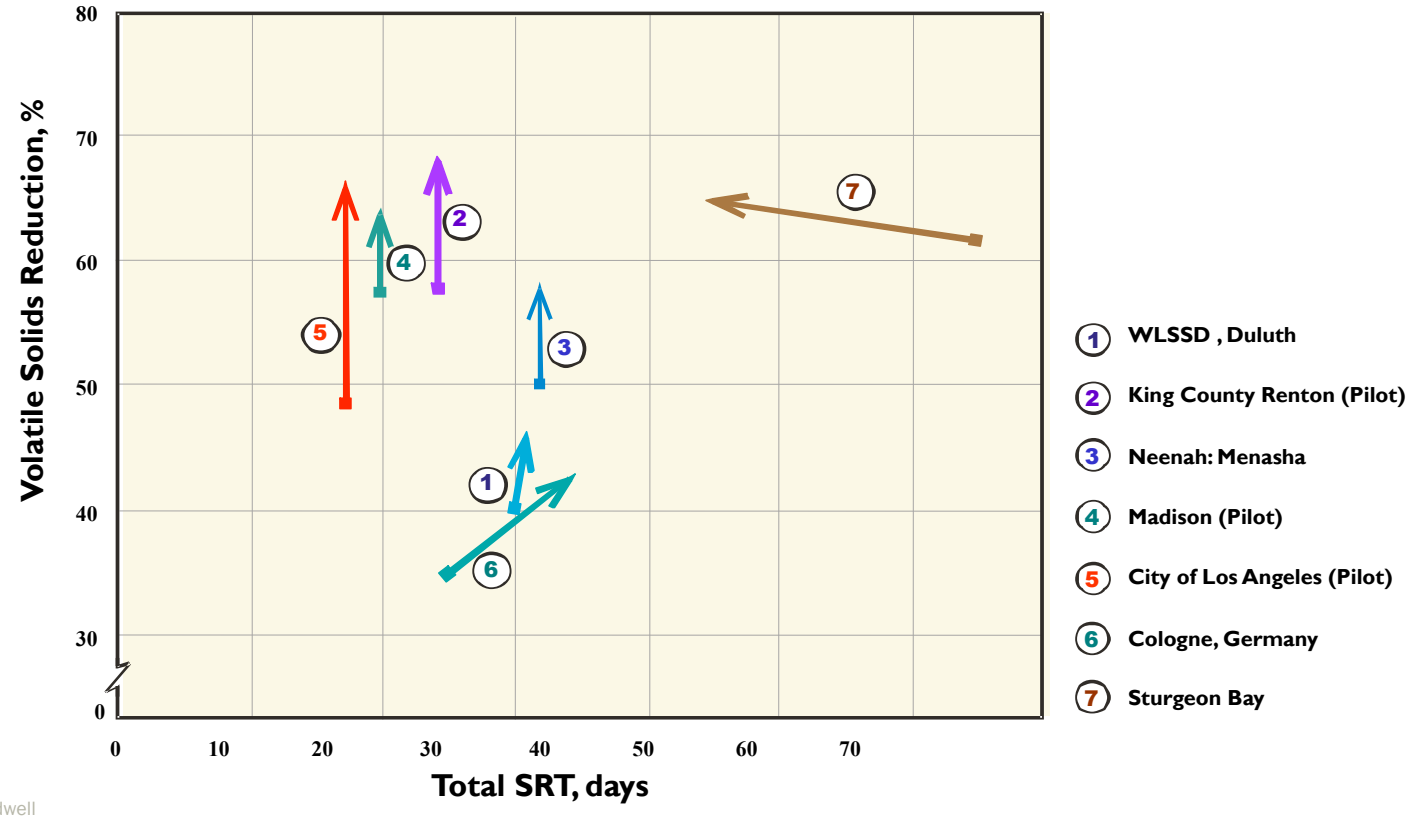
Looking to get more out of your digester(s) can take many forms.



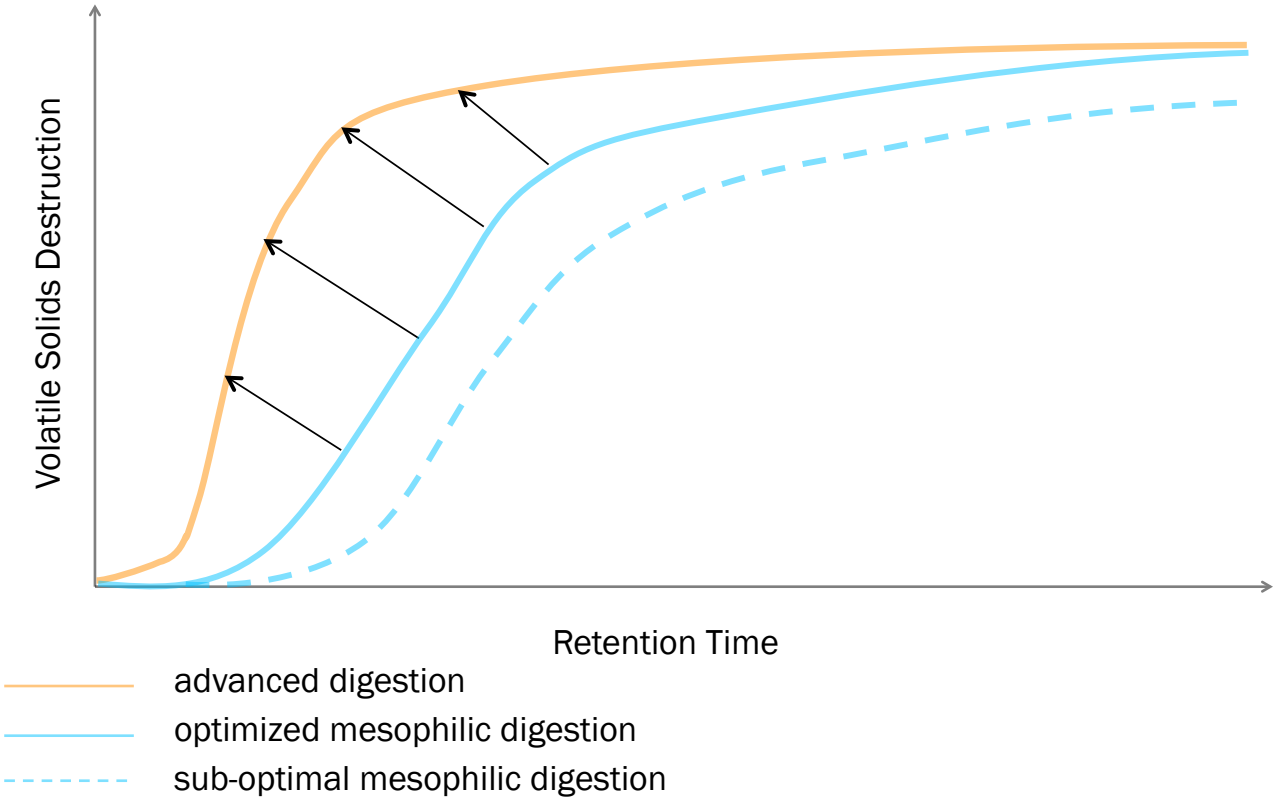
In a fixed volume digester the rate of digestion is a means of enhancing digester performance and increasing capacity



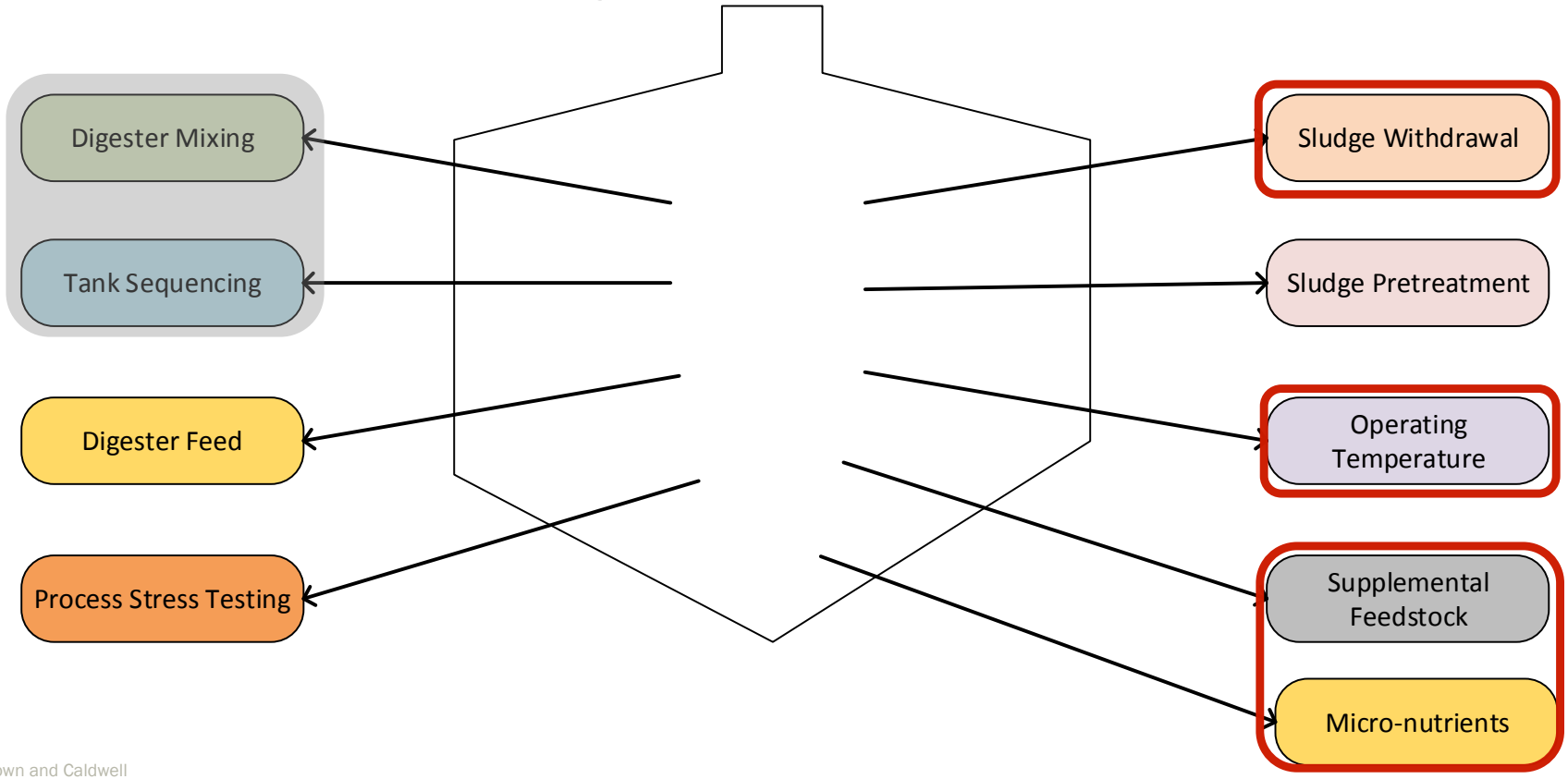
Example: conversion from conventional mesophilic digestion to temperature phased AD



You don’t always have to move to a new process to get more from your system



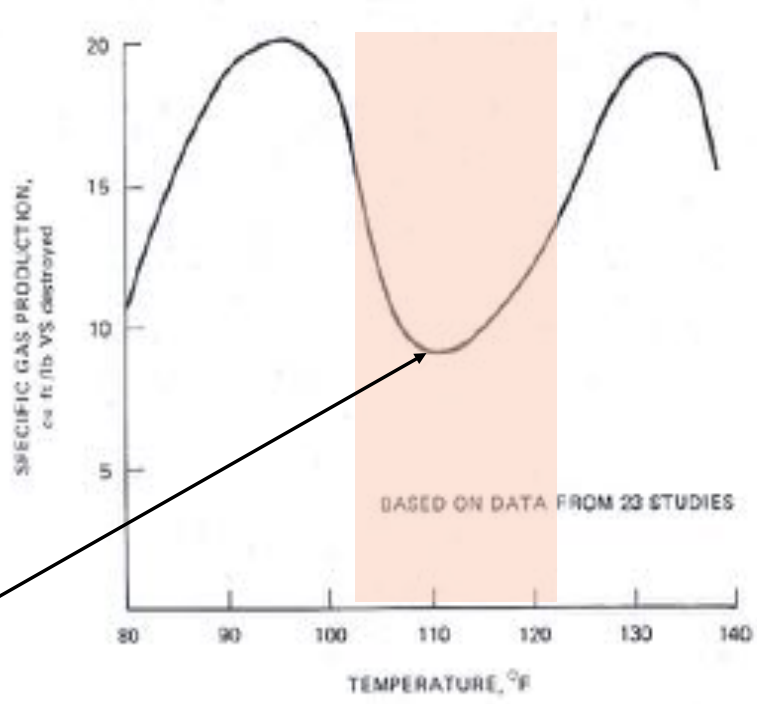
Some changes in your operation can improve the overall performance and stability




How hot is too hot?-
Temperature Considerations

Digester Operating Temperature

- What is best?
  - Reference Manuals
  - Grady, Diagger, Lim (1999) mesophilic (77-104°F), thermophilic (122 -140 °F)
  - Metcalf and Eddy (2003) mesophilic (77-104°F), thermophilic (122 -134°F)
  - WEF MOP 8 – maintain temperatures +/- 1 °C of target at all times



USEPA 1979 indicates avoiding range between 104 to 122 °F

Temperature instability can lead to process deterioration and instability

Stepwise Temperature Change

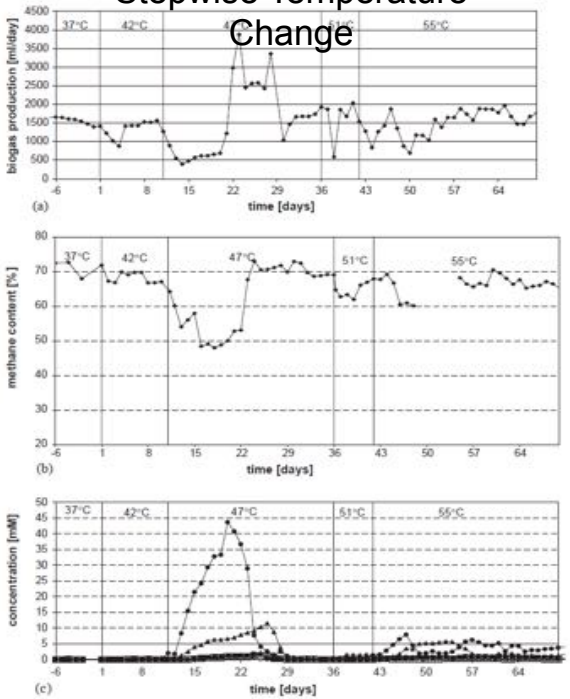


Fig. 1. Process performances during step-wise temperature increase in operational temperature (Reactor A) during the anaerobic digestion of a mixture of primary- and activated-sludge: (a) Biogas production in mL of biogas produced per day. (b) Biogas composition in % of methane in biogas. (c) VFA concentration in mM: ●—acetate; ▲—propionate; ■—iso-butyrate; ○—butyrate; □—iso-valerate; △—valerate.

Dynamic Temperature Change

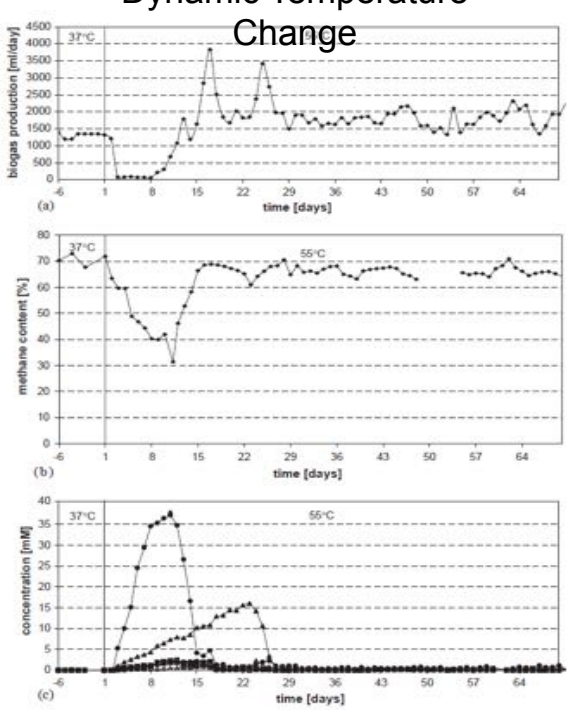
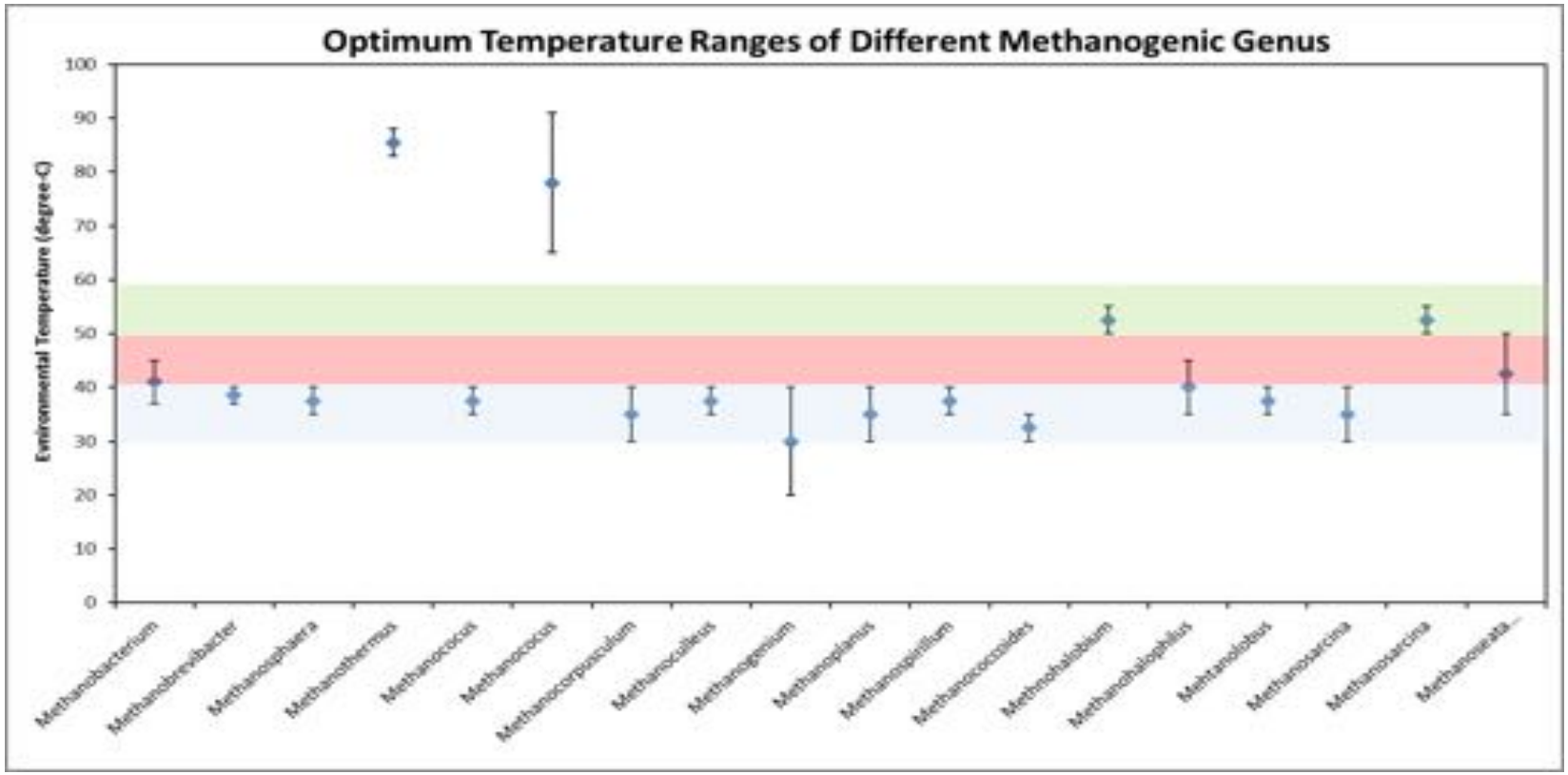


Fig. 2. Process performances during one-step temperature increase in operational temperature (Reactor B) during the anaerobic digestion of a mixture of primary- and activated-sludge: (a) Biogas production in mL of biogas produced per day. (b) Biogas composition in % of methane in biogas. (c) VFA concentration in mM: ●—acetate; ▲—propionate; ■—iso-butyrate; ○—butyrate; □—iso-valerate; △—valerate.

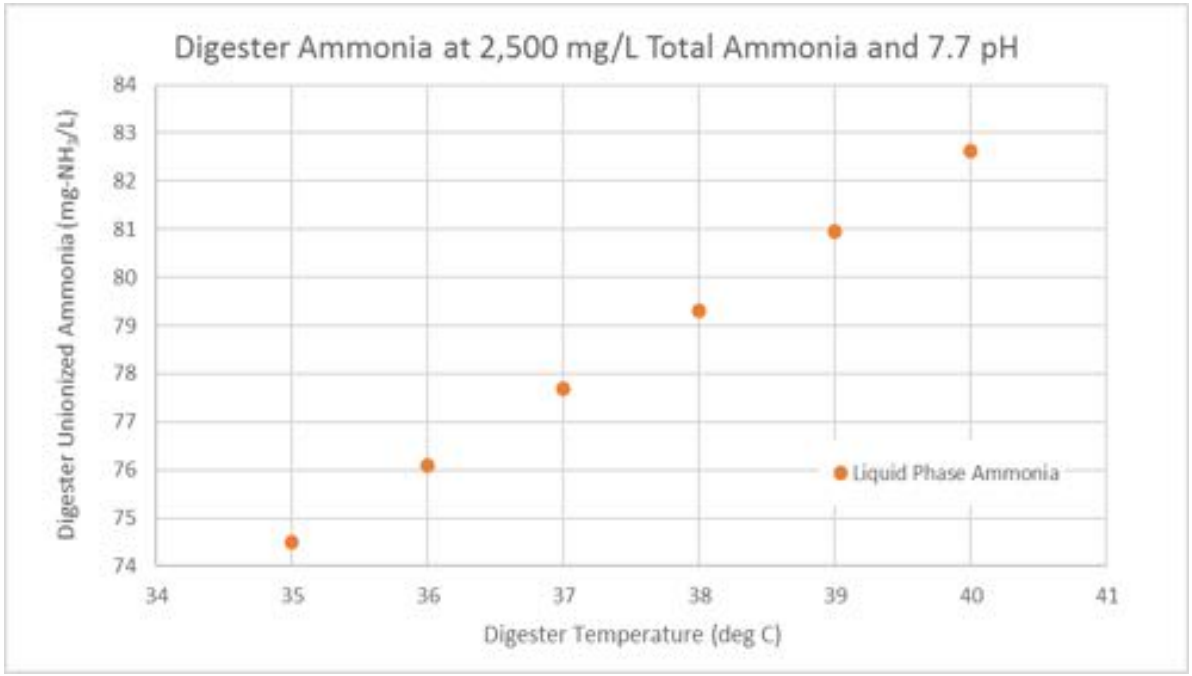
Bouškovᡠ, A, M. Dohányos, J.E. Schmidt, I Angelidaki, (2005)"Strategies for Changing Temperature From Mesophilic to Thermophilic Conditions in Anaerobic CSTR Reactors Treating Sewage Sludge", Water Research,**39**, 1481-1488.

Many of known methanogens are optimal in mesophilic conditions



Adapted from: Gerardi, M.H., The Microbiology of Anaerobic Digesters. Wiley-Interscience, Hoboken NJ, 2003.

Operating temperature can also impact toxicity levels in the digester (ex. Ammonia)



- Increasing temperature decreases the pKa which increases the unionized ammonia concentration

$$NH_4^+ \rightleftharpoons NH_3 + H^+$$

Process Considerations
- Thermal hydrolysis (high solids)
- Thermophilic digestion
- Co-digestion of high nitrogen content wastes (ex. blood wastes)
- High solids digestion process

Considerations for variable temperature operations

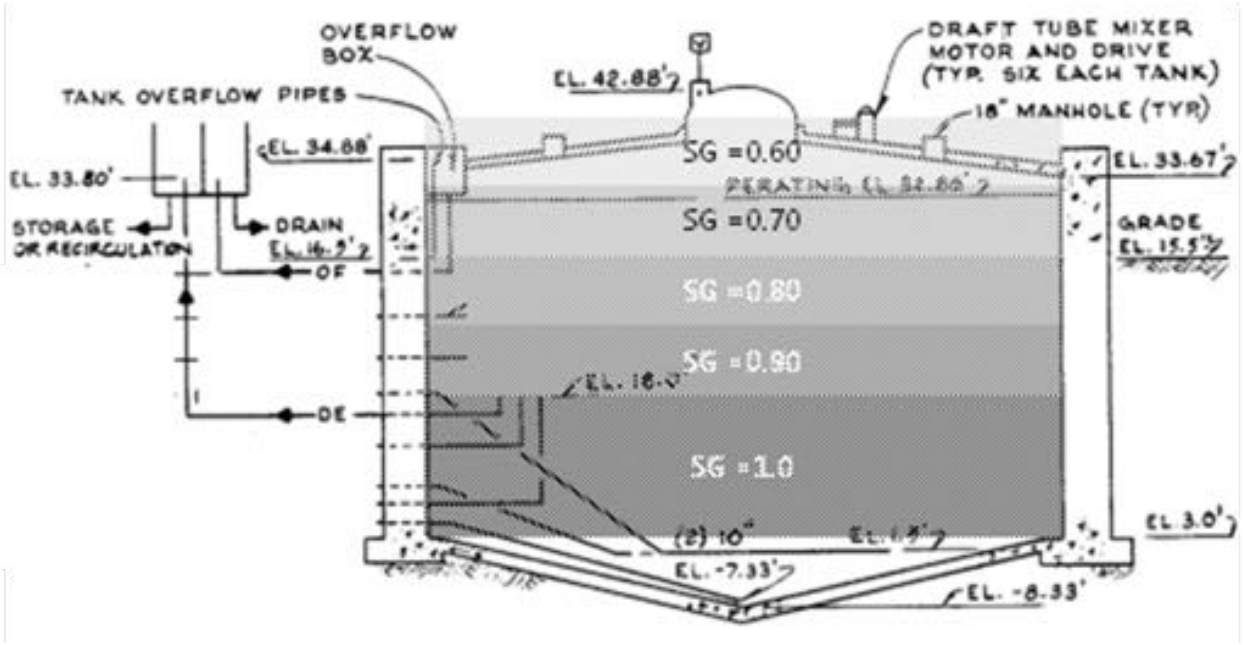
- Increase heating or heat transfer capacity
  - New boilers or heat exchangers, etc.
- Increase heat loop temperature
  - Avoid cooking sludge on walls
- Increase feed solids thickness
  - Reduces sludge heating demands
    - Need to evaluate impacts of changed sludge rheology on your system (pumping and heat exchange)
  - Consider additional capacity and performance benefits

New HEX at Rockland, MA WWTP

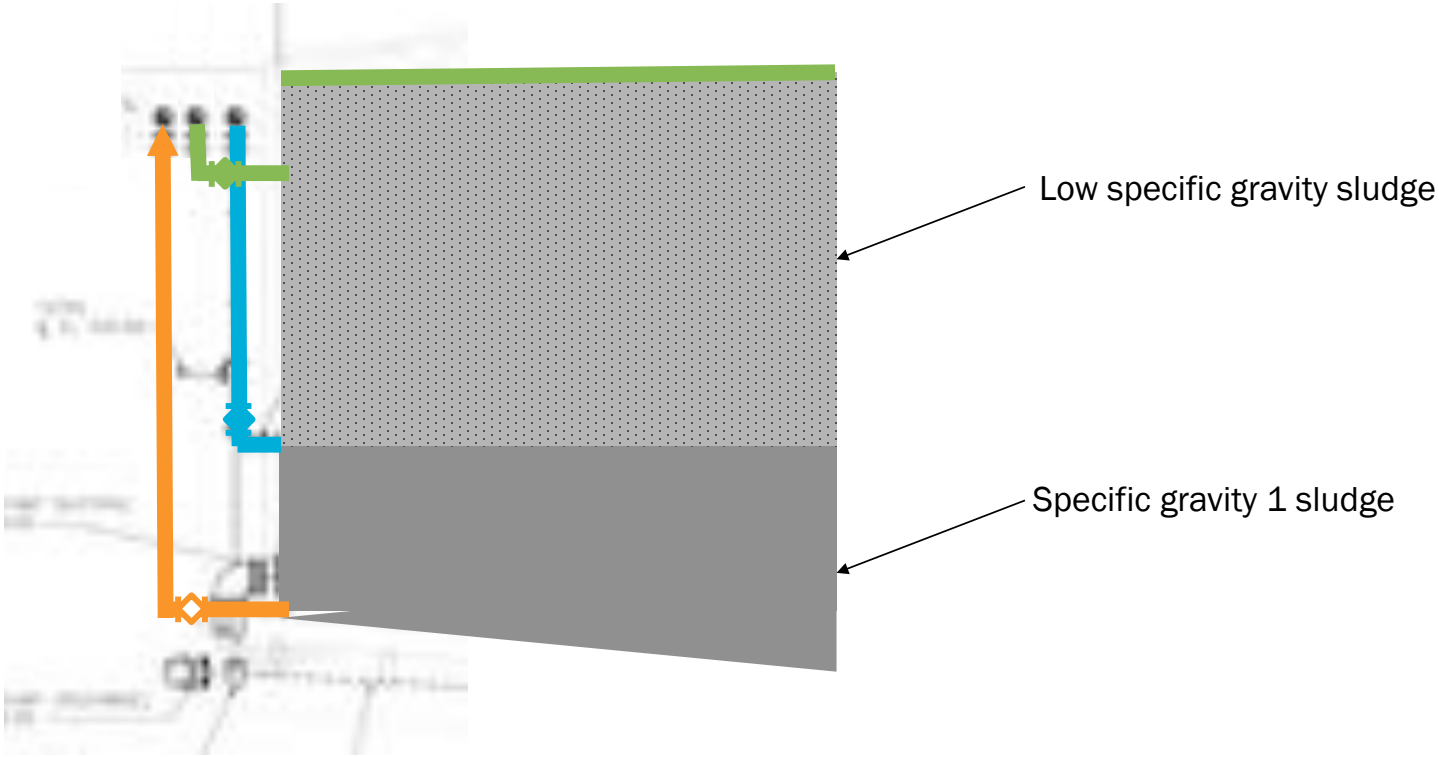
Tuning HEX for Tacoma's dual digestion process (ATAD-TPAD)


Surface Wasting: Get that low specific gravity sludge out of my digester!

Some wasting configurations may trap low specific gravity sludge. Why should I care?



For some Tanks, the “Fix” is easy and FREE



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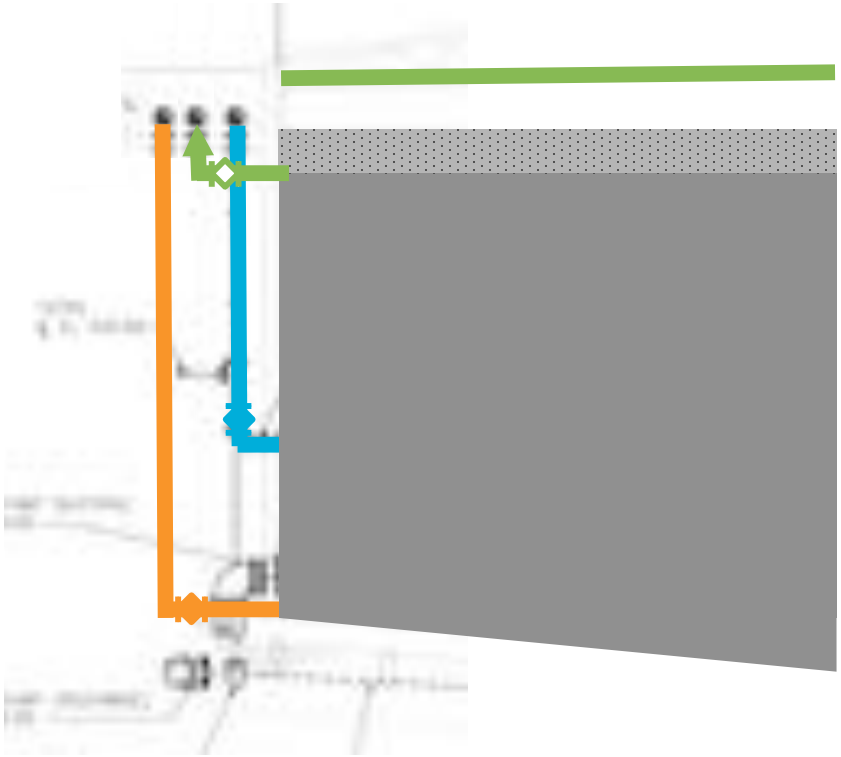
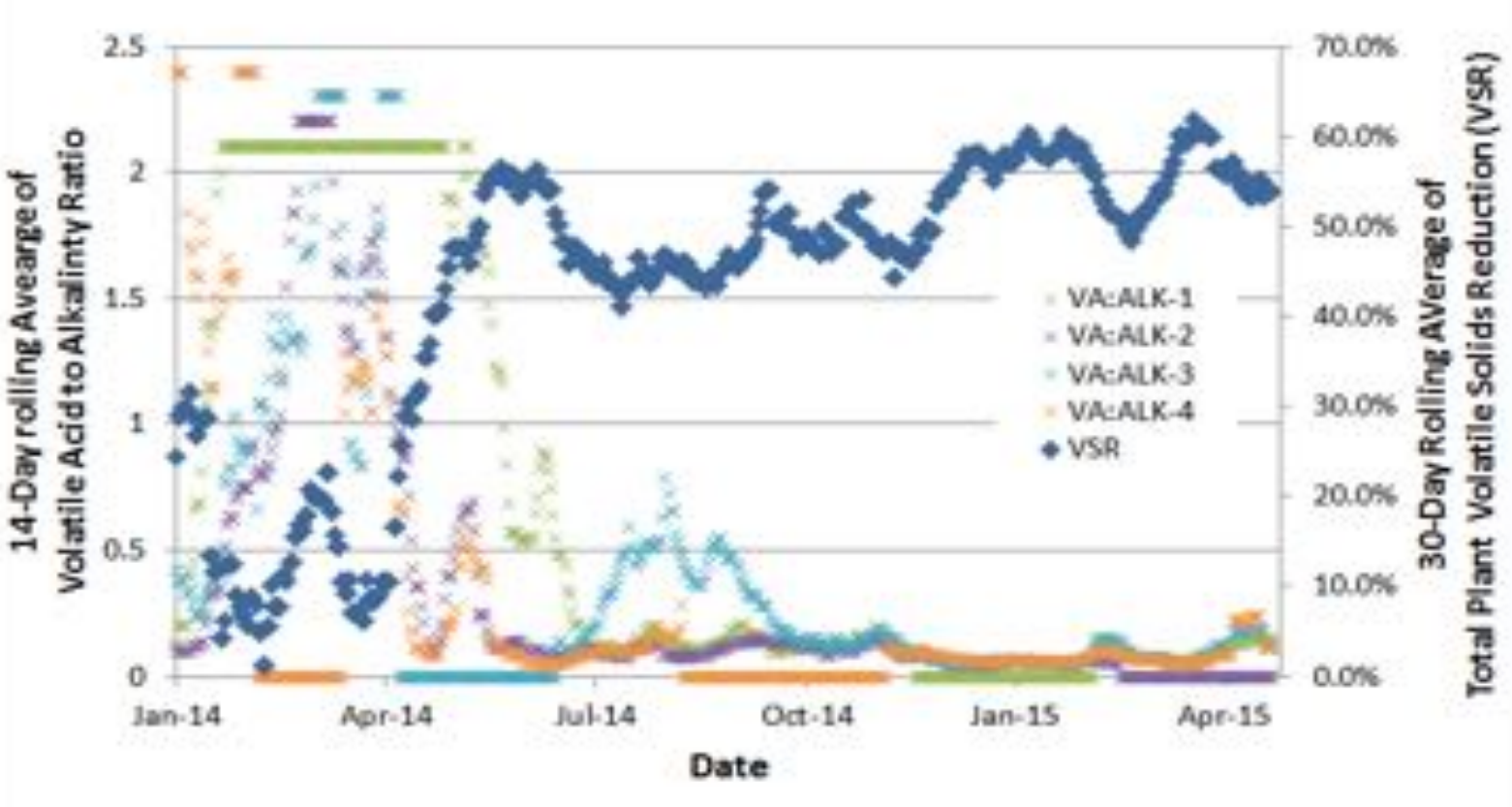


Solution at Owls Head

Owls Head Conversion Performance

Cautioned that surface wasting was NOT the only digester enhancement

Owls Head Conversion Performance




Research in to factors impacting digester efficiency. The future of optimization?

Synergistic digestion- artifact or reality

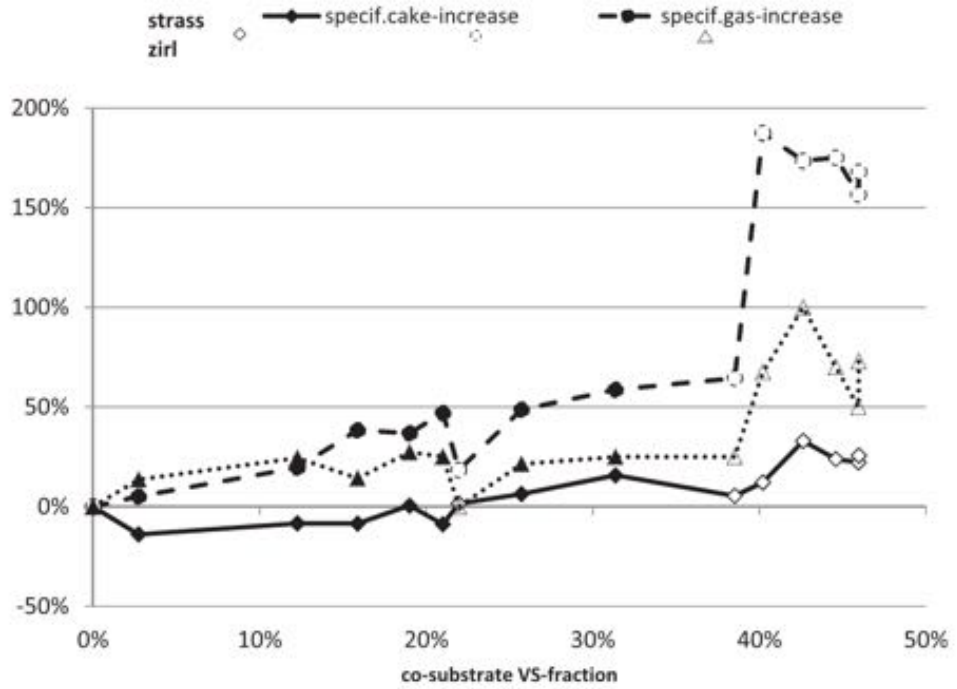


Fig. 4. Specific biogas production, cake production and ammonia return load based on co-substrate addition for Zirl WWTP and Strass WWTP.

- Original observations came from Millbrae, CA with introduction of FOG,
- Aichinger (2015) – noted reduction in sludge production with organic waste addition up to 20 percent of VS load
- Hypothesis is that the carbon to nitrogen ratio is improved making the process more effective.

Citation: Aichinger et al (2015), Synergistic co-digestion of solid-organic-waste and municipal sewage-sludge: 1 plus 1 equals more than 2 in terms of biogas and solids reduction" Water Research, 87, 2015, 416-423.

Is synergy a C:N issue, or is it more complex?

Table 3—BMP results.

Waste	Concentration range tested (g COD/L)	BMP (mL CH_4/g COD)	Biogas methane (%)
ADF	0.50 to 2.2[a]	350 ± 30	61 ± 15
Yeast production	0.50 to 2.5	2270 ± 340[b]	60 ± 3
Food flavorings production	0.05 to 0.25	940 ± 450[b]	69 ± 1
Restaurant	0.60 to 12	490 ± 260	68 ± 2
Brewery	0.50 to 2.5	410 ± 20	58 ± 6

[a] Higher concentrations caused inhibition and lower BMP values (Zitomer et al., 2001).
[b] Suspect value that is significantly greater than the theoretical maximum of 400 mL CH_4/g COD.

- Zitomer (2008) – noted enhanced methane production with the digestion of yeast waste with sewage sludge, 4-18 percent additional COD destruction needed to balance.
- Attributed the improved digestion to supplemental nutrients and co-factors in yeast from production process
- Produced more gas than is theoretically possible without digestion of the sludge

Citation: Zitomer et al (2008), Municipal Anaerobic Digesters for Codigestion, Energy Recovery, and Greenhouse Gas Reductions" Water Environment Research, 80, 3, 229-237.

Iron addition enhances TPAD operation in laboratory study. Is the assumption micronutrients are not an issue for muni AD correct?

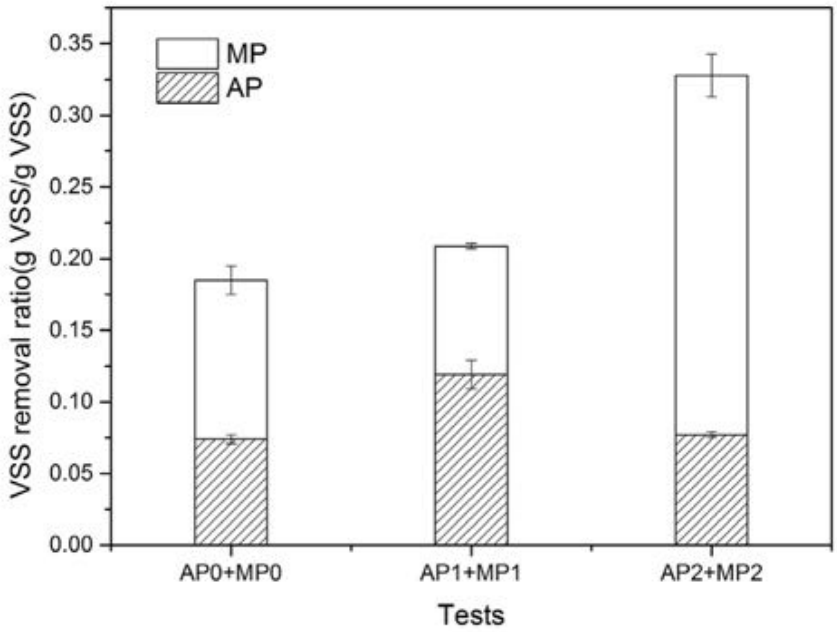
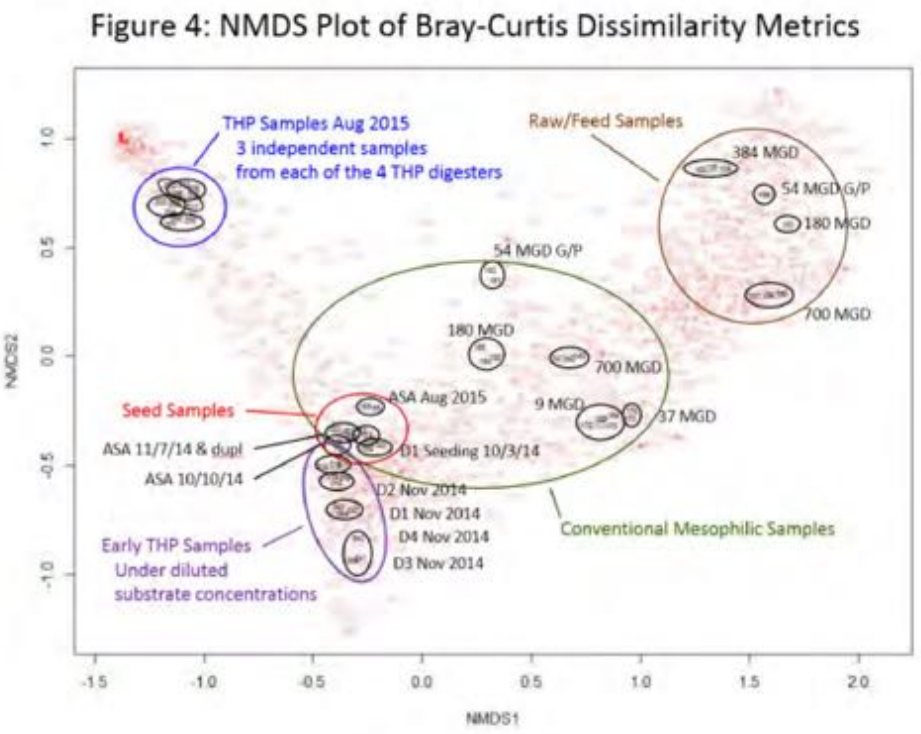


Fig. 3. VSS removal ratios in the main experiments.

- Speece identified a cocktail of trace metals can stimulate digestion.
- Hao et al (2017)- investigated adding waste iron shavings to acid and gas phases of an acid gas system
  - Analysis based on waste activated sludge digestion
  - Observed strongest stimulatory effect when added to the methane phase.
  - Methanogens in acid phase enhanced with the addition of WIS

Citation: Hao et al (2017), "Analyzing the mechanisms of sludge digestion enhanced by iron" Water Research, 117, 2015, 58-67.

Population dynamics with process changes



Citation: Mah et al (2017), Proceedings of the WEF Residuals and Biosolids Conference 2017, Seattle, WA

- Mah (2017) looked at population profiles of mesophilic and THP enhanced digestion.
- Showed distinct population shifts between the processes
- Others have suggested THP increases hydrogen utilizing methanogenesis.
- TPAD shows different population profiles depending on operating conditions
- **Research Question:** Is there a distinct population profile that equates to optimized digestion operation for each process?

QUESTIONS?

it's about connecting

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