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Role of anaerobic digestion in next generation wastewater treatment and biosolids management

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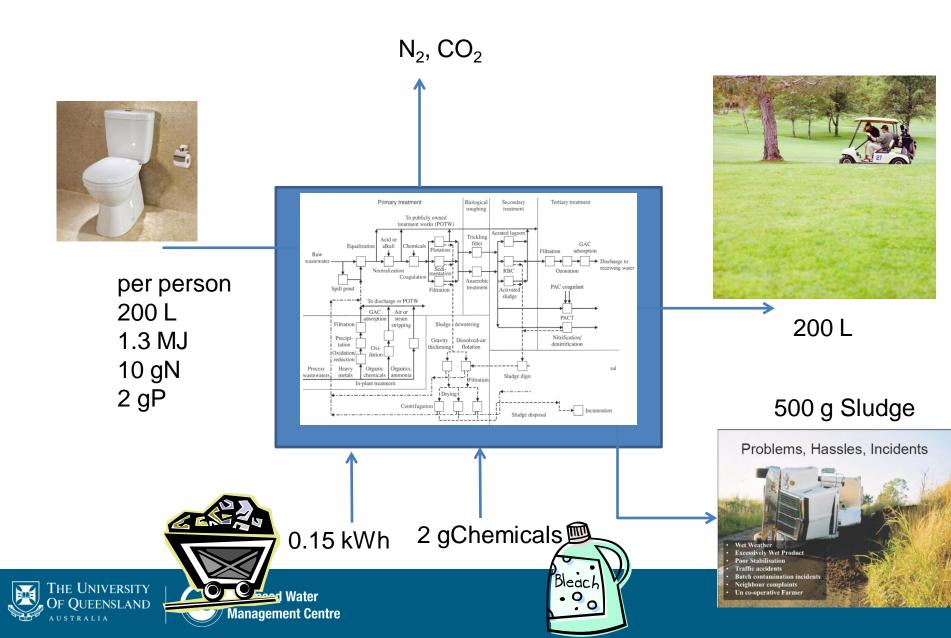
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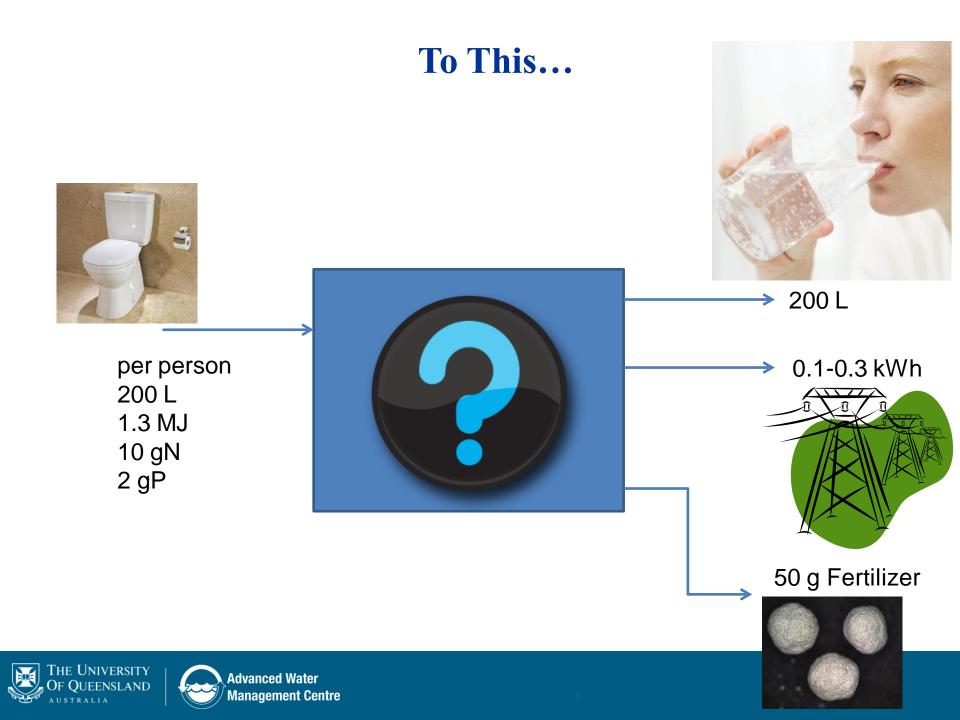


ROLE OF ANAEROBIC DIGESTION IN NEXT GENERATION WASTEWATER TREATMENT AND BIOSOLIDS MANAGEMENT

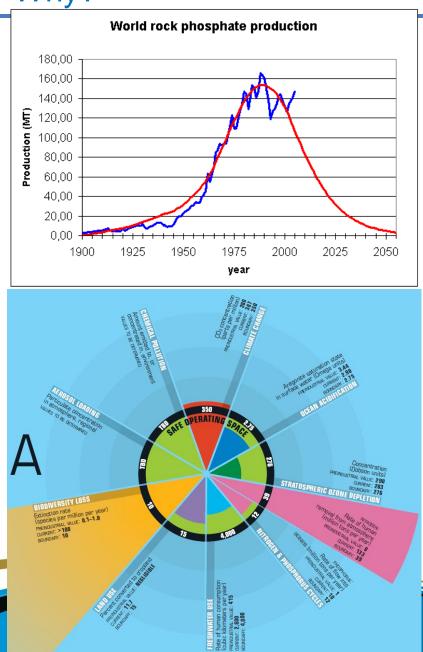
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From This...





Why?



- Peak P
- Rise in P prices due to fertilizer demand
- Recovered P can fully address fertilizer
 market
- N price fluctuations are related to the LPG price
- 2% of world energy dedicated to N production
- N cycle management major challenge to long-term sustainability
- N and P are major challenges for waste and wastewater management

Options

- Sewer mining (Front-end MF-RO) Verstraete
- Mainline low energy McCarty
- Partition-release-recover UQ

Verstraete W, Van de Caveye P, Diamantis V: Maximum use of resources present in domestic "used water". *Bioresource Technology 2009, 100:5537-5545.*

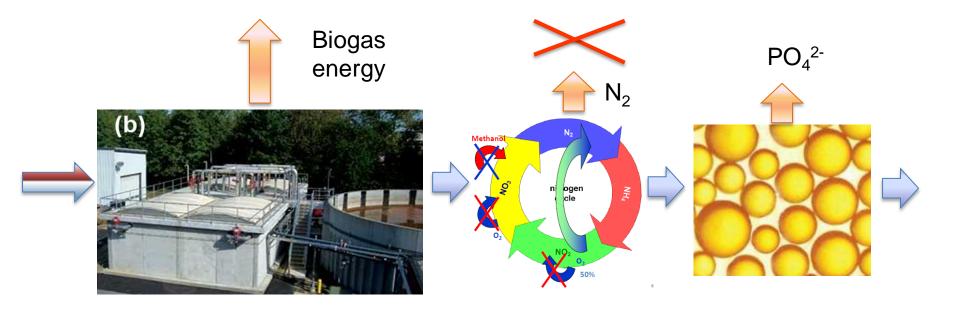
McCarty PL, Bae J, Kim J: Domestic Wastewater Treatment as a Net Energy Producer–Can This be Achieved? *Environmental Science & Technology 2011, 45:7100-7106.*

Batstone DJ, Hülsen T, Mehta C, Keller J: Platforms for energy and nutrient recovery from domestic wastewater: a review. *Chemosphere*





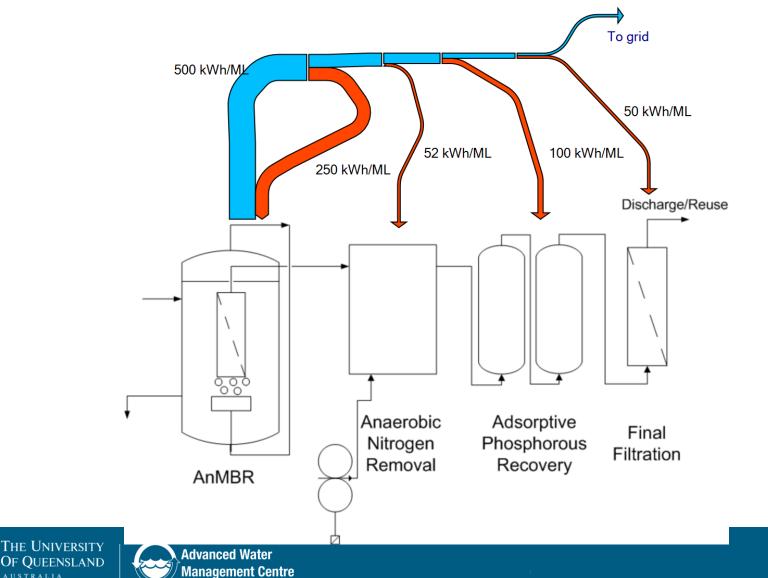
Mainline Low Energy Treatment





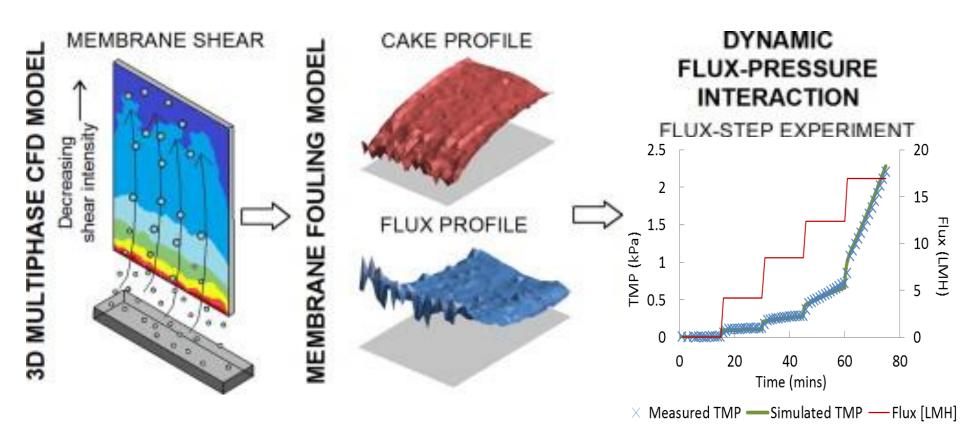
Advanced Water Management Centre McCarty PL, Bae J, Kim J: Domestic Wastewater Treatment as a Net Energy Producer–Can This be Achieved? *Environmental Science & Technology 2011, 45:7100-7106.* Batstone DJ, Virdis B: The role of anaerobic digestion in the emerging energy economy. *Current Opinion in Biotechnology* 2014 **27:** 142-149

Energy dominated by Anaerobic Step





Modelling applied to AnMBR

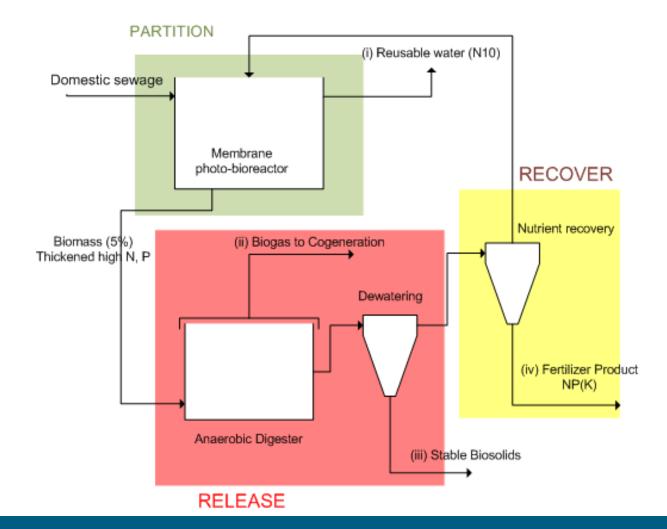






Boyle-Gotla A, Jensen PD, Yap SD, Pidou M, Wang Y, Batstone DJ: **Dynamic multidimensional modelling of submerged membrane bioreactor fouling**. *Journal of Membrane Science*.

Partition-Release-Recover



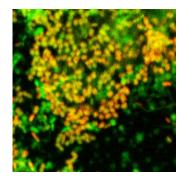


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Batstone DJ, Hülsen T, Mehta C, Keller J: Platforms for energy and nutrient recovery from domestic wastewater: a review. Chemosphere

Partition

• Activated sludge (2 d SRT)



which + Si'm

Algae
 Natural light



Purple phototrophic bacteria
 IR – Yes these are anaerobes

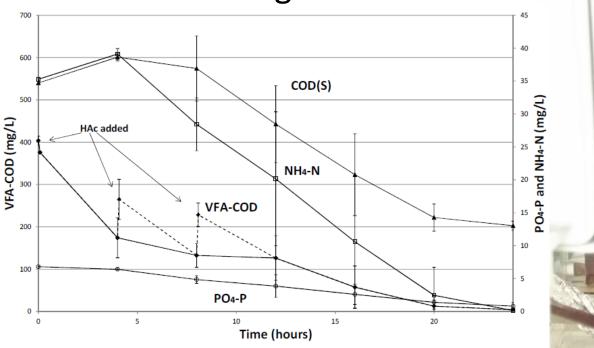


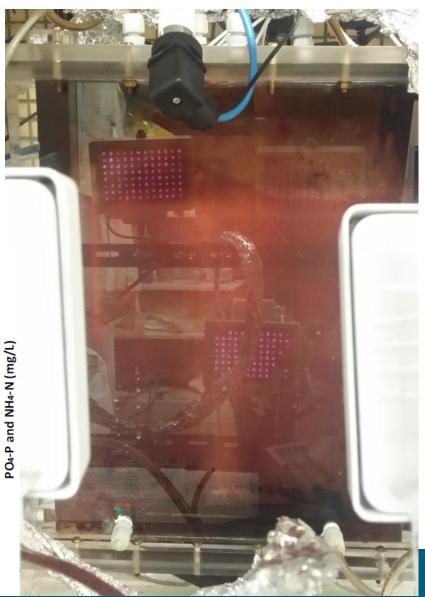




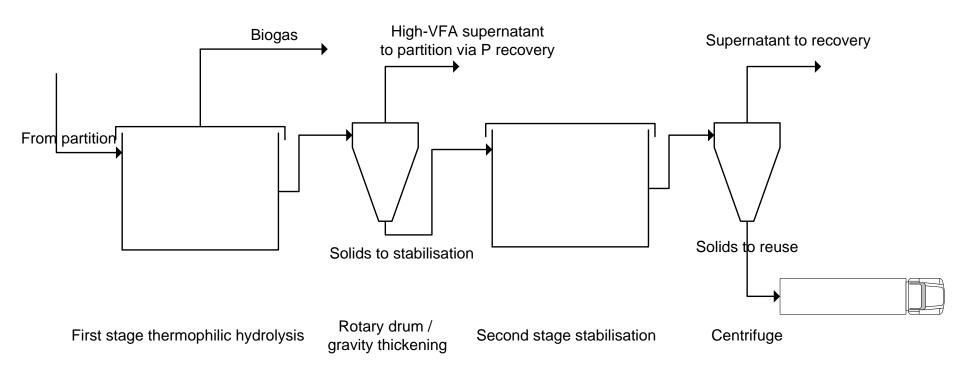
The key is in partitioning

- How to partition CPNK fully?
- Activated sludge C,P only
- Algae need light & CO₂
- PPB need IR light&COD





Where to get Carbon from?



How to preferentially extract/release VFAs? How to predict VFA distribution?



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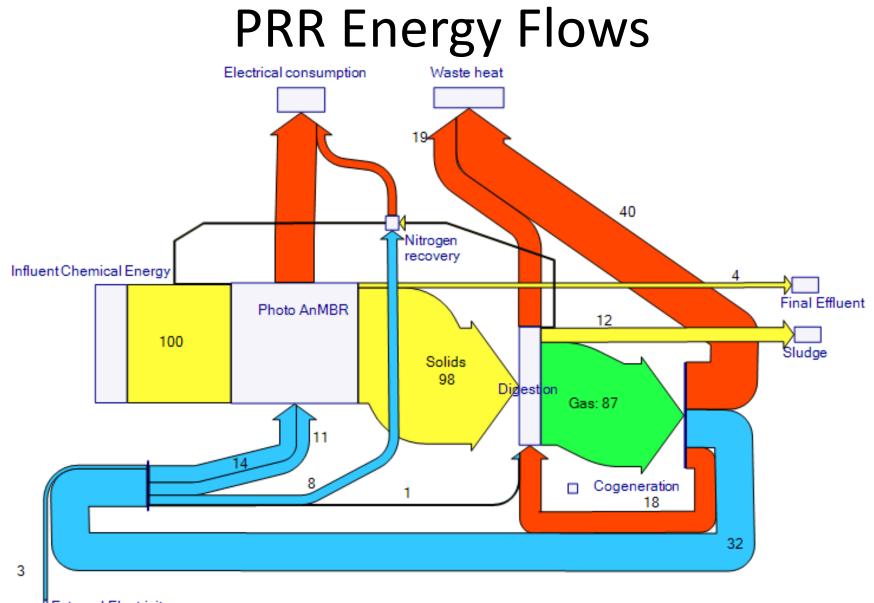
Batstone DJ, Hülsen T, Mehta C, Keller J: Platforms for energy and nutrient recovery from domestic wastewater: a review. Chemosphere

Modelling Challenges

- Unlike any other process (ASM, ADM, etc)
- COD from light changes carbon redox
- Virtually no separate catabolism (under most conditions)
- Light adds a degree of freedom some key conditions...
 - Heterotrophic growth (light, COD, N)
 - Autotrophic growth (light, No COD, N)
 - Accumulation (light, COD, no N or P)
 - Photo-assimilative redn (light, No COD, no N or P)
 - All non-light process
 - All aerobic processes (with/without light)







External Electricity





Batstone DJ, Hülsen T, Mehta C, Keller J: Platforms for energy and nutrient recovery from domestic wastewater: a review. Chemosphere

Digester is also important

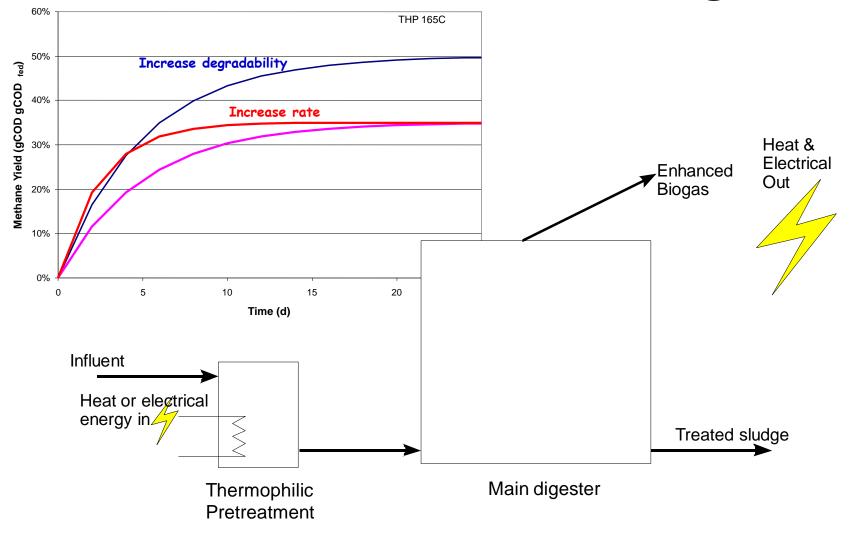
- 50%+ of Capex
- mixing 10 kWh/kL/d
- Energy recovery
- Transport & disposal costs
- Foaming etc







Enhancement Technologies





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TPAD

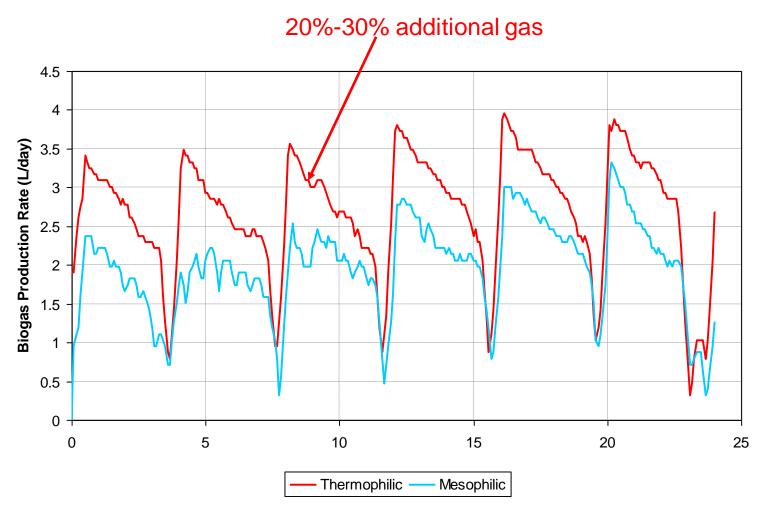
- 2-4 days 55C-65C
- 12 days 35C
- 2 MJ/kg DS (~4-5%)
- Generally sufficient heat from cogen







Does it Work?

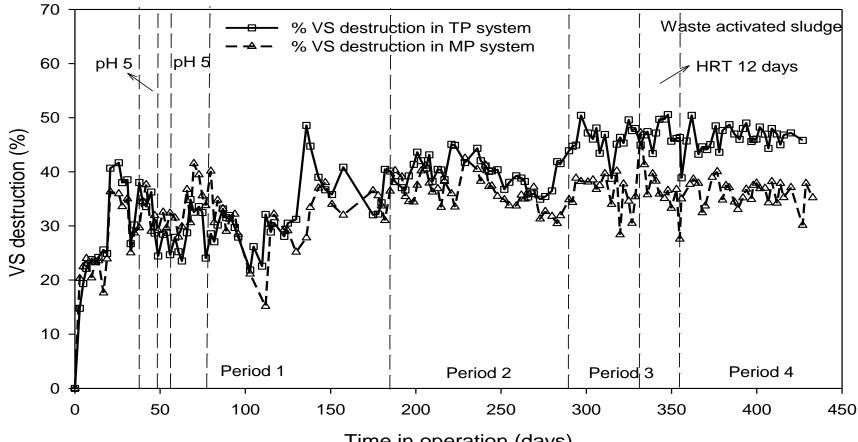




Advanced Water Management Centre Ge H, Jensen PD, Batstone DJ. (2010) Pre-treatment mechanisms during thermophilicmesophilic temperature phased anaerobic digestion of primary sludge. Water Research 44(1):123-130.



Lots of Testing

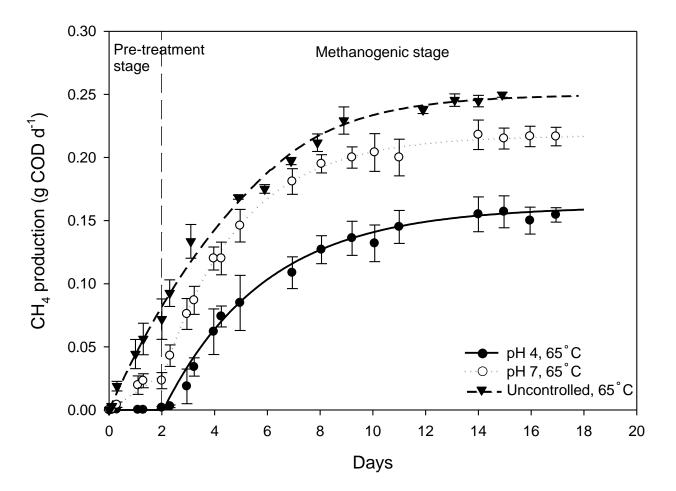


Time in operation (days)



Advanced Water **Management Centre** Ge H, Jensen PD, Batstone DJ. (2011) Temperature phased anaerobic digestion increases apparent hydrolysis rate for waste activated sludge. Water Research 45(4):1597-1606.

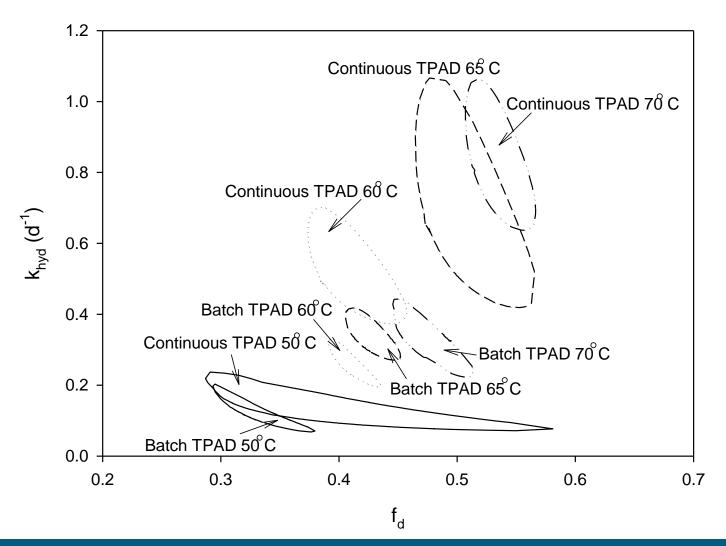
Lots more Testing...





Advanced Water Management Centre Ge H, Jensen PD, Batstone DJ. (2011) Increased temperature in the thermophilic stage in temperature phased anaerobic digestion (TPAD) improves degradability of waste activated sludge. Journal of Hazardous Materials 187(1-3):355-361.

Summarv Outcome (WAS)

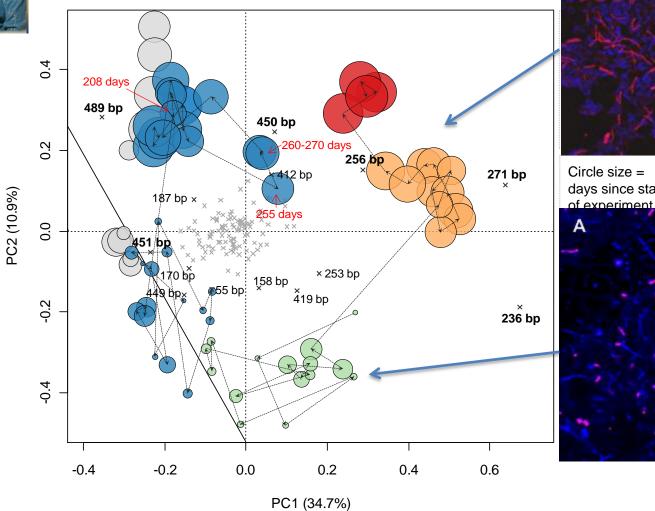


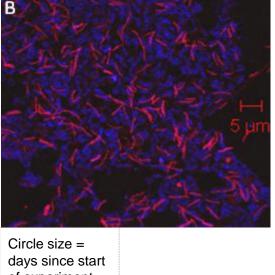


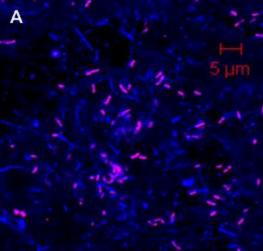
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Why?





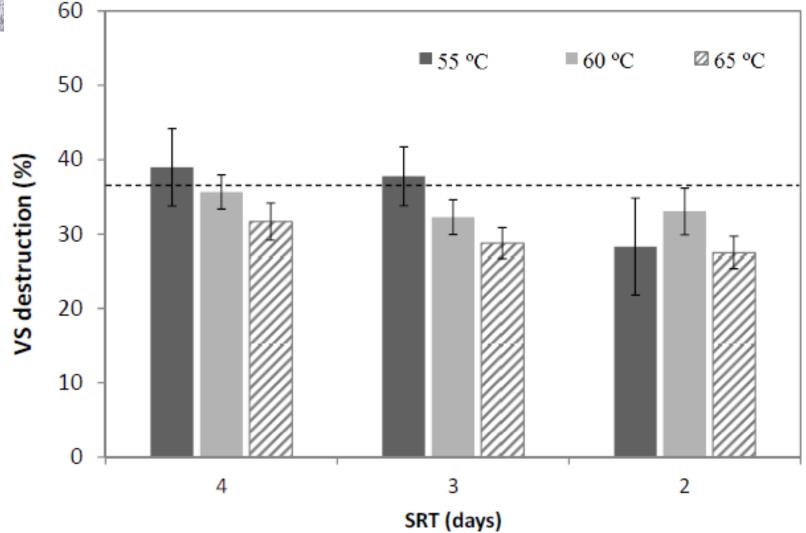




Advanced Water Management Centre Pervin, Dennis, Tyson, Batstone, Bond, Wat. Res.



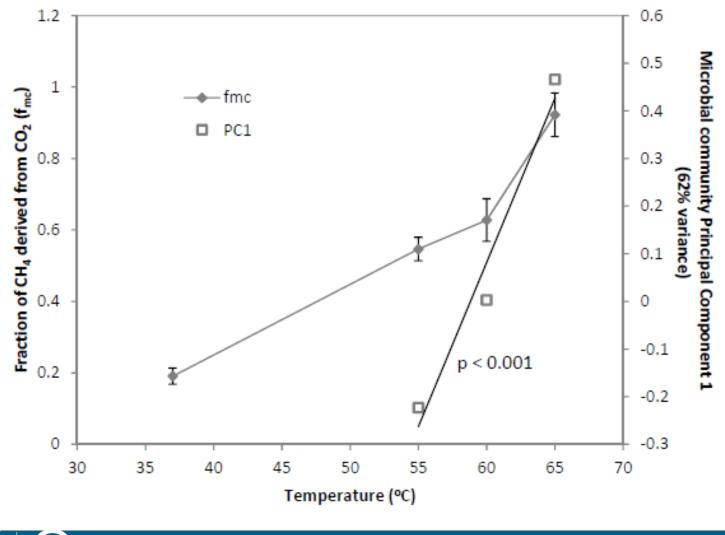
3 d High-Rate Anaerobic Digestion



THE UNIVERSITY OF QUEENSLAND

Advanced Water Management Centre Ho D, Jensen P, Batstone D: Effects of Temperature and Hydraulic Retention Time on Acetotrophic Pathways and Performance in High-Rate Sludge Digestion. *Environmental Science & Technology* 2014, **48**:6468-6476.

Why 1?

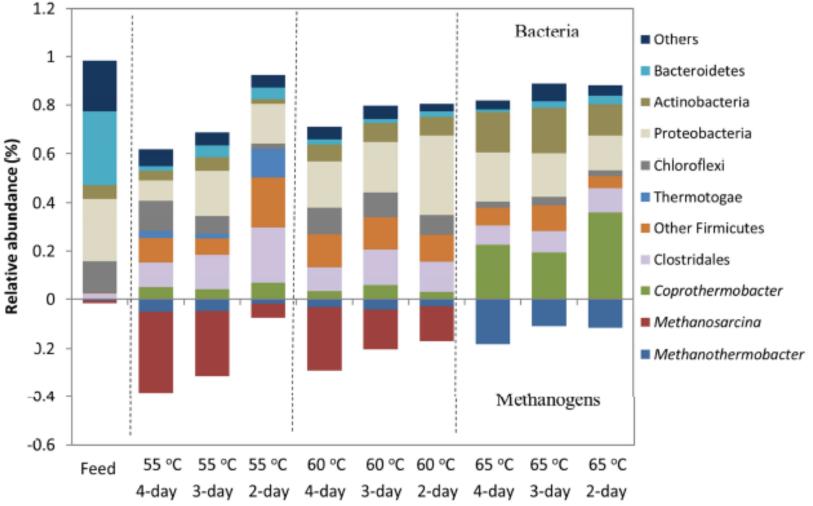




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Why 2?



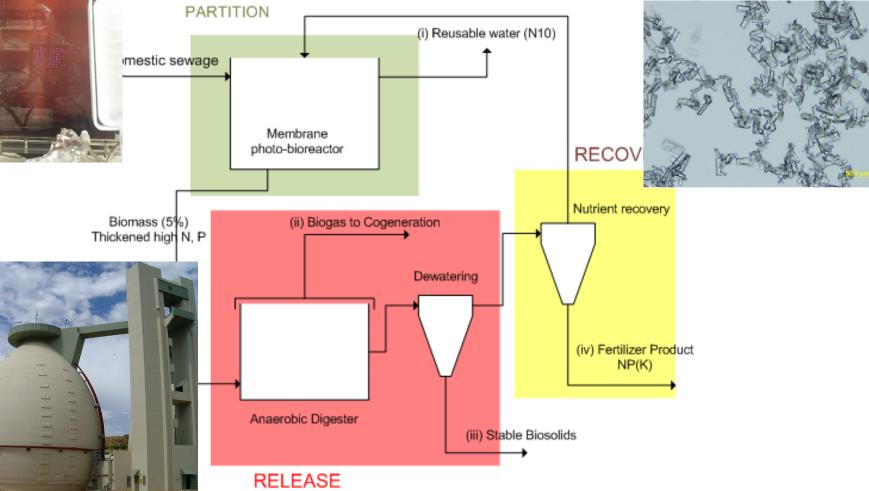
ADM1 generally OK for modelling, but need acetate oxidation



Advanced Water Management Centre Ho D, Jensen P, Batstone D: Effects of Temperature and Hydraulic Retention Time on Acetotrophic Pathways and Performance in High-Rate Sludge Digestion. *Environmental Science & Technology* 2014, **48**:6468-6476.



Plant Wide Analysis





Needs – Towards Generalized PCM

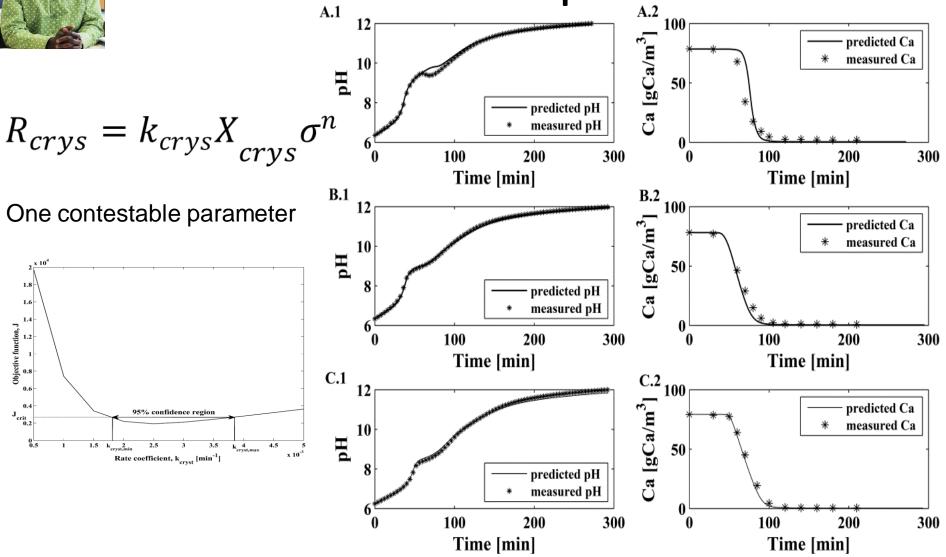
- Emerging processes *highly* dependent on PC processes:-
 - Gas stripping and absorption
 - Adsorption
 - Precipitation
 - Electroseparation
- Generally have wider swings in Ionic Strength, Controlling Mechanisms
- Conventional modelling also needs better PCM





Batstone DJ, Amerlinck Y, Ekama G, Goel R, Grau P, Johnson B, Kaya I, Steyer JP, Tait S, Takaćs I and others. (2012) Towards a generalized physicochemical framework. Water Science and Technology 66(6):1147-1161.

Generalized Precipitation Model





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Conclusions

- Key processes are *mostly* anaerobic or physicochemical (Anammox is partly aerobic)
- No nutrient recovery processes based on activated sludge
- New challenges range from:-
 - Applying existing models & tools to new processes
 - Better integration of fields of modelling
 - Totally new fundamental models incorporating light





Further Information



CRC for Water Sensitive Cities

AWMC Position Paper (Chemosphere)

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Grains **Research &** Development Corporation



