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

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

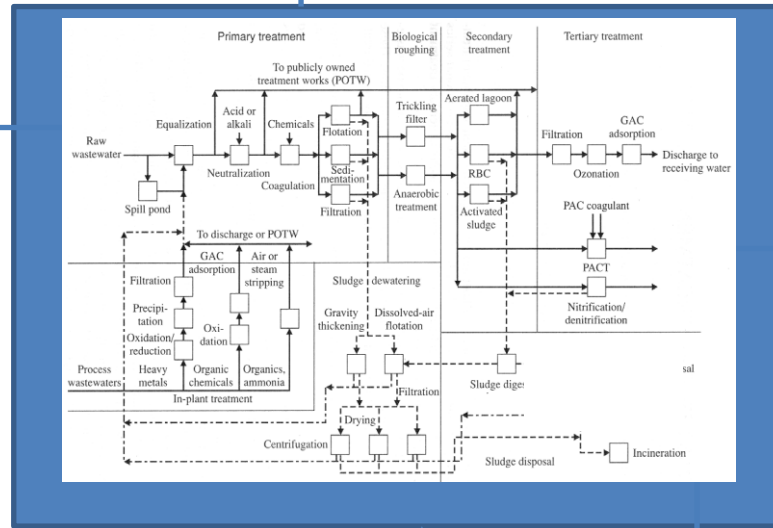
Damien Batstone
Advanced Water Management Centre

From This...



per person
200 L
1.3 MJ
10 gN
2 gP

N₂, CO₂



200 L

500 g Sludge



0.15 kWh

2 g Chemicals



Problems, Hassles, Incidents



To This...

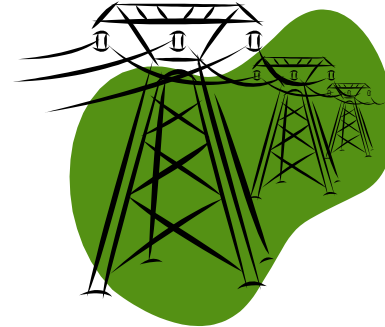


per person
200 L
1.3 MJ
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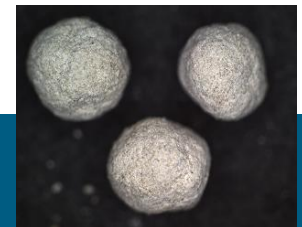


200 L

0.1-0.3 kWh

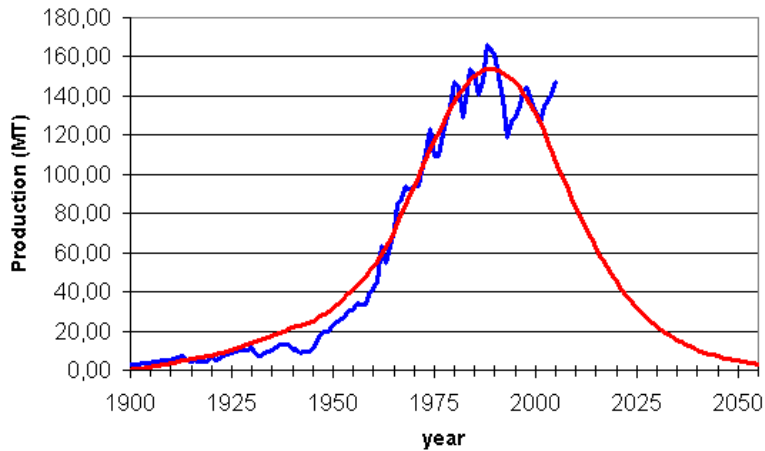


50 g Fertilizer

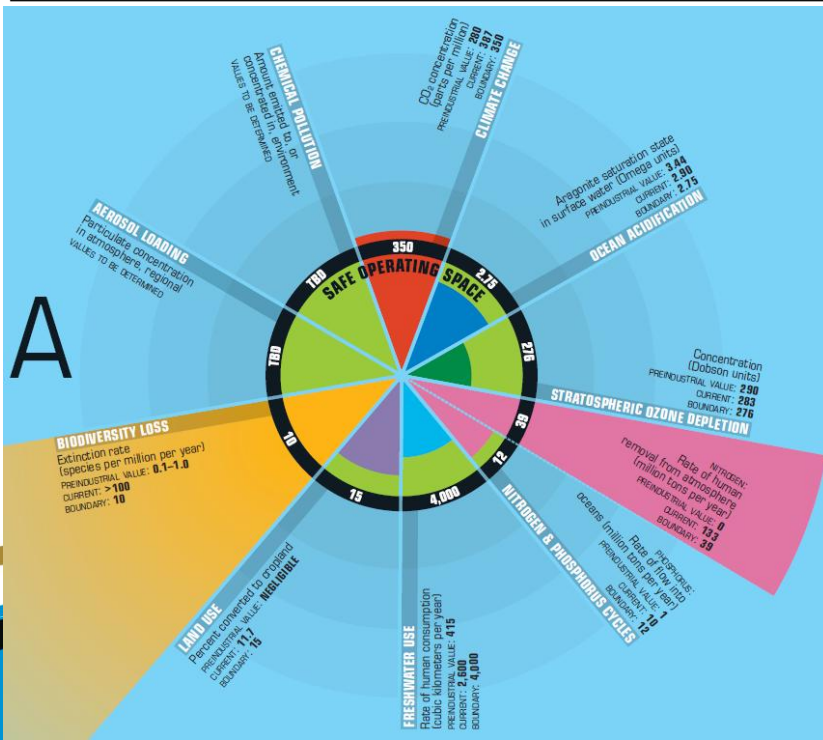


Why?

World rock phosphate production



- 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

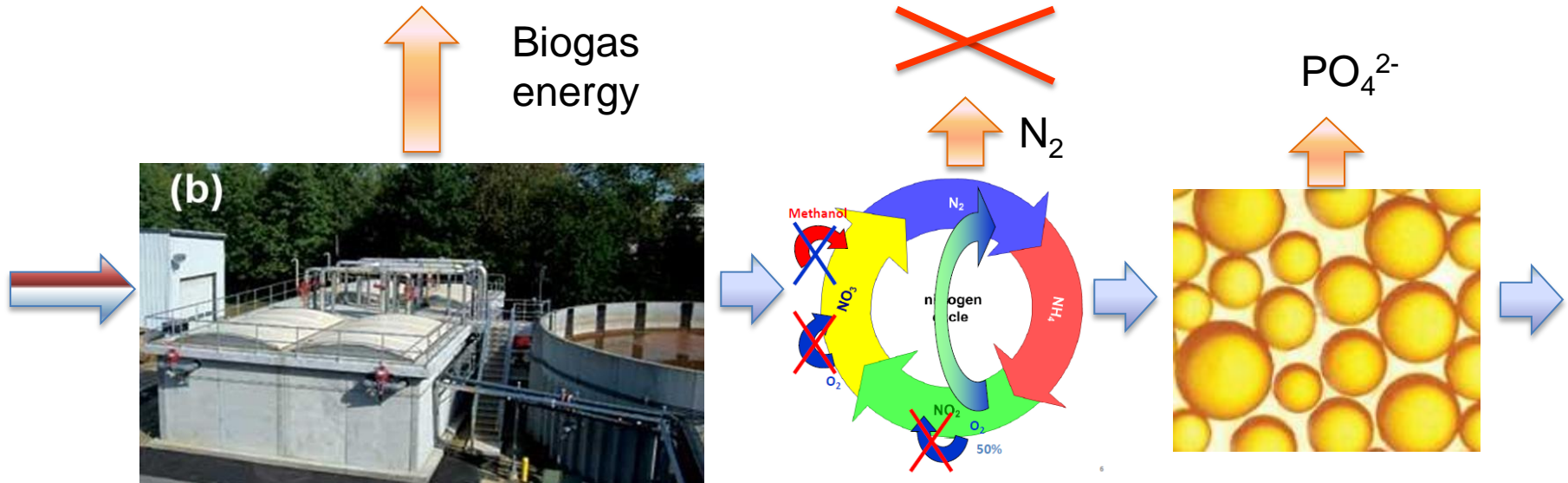
- Sewer mining (Front-end MF-RO) – Verstraete
- Mainline low energy - McCarty
- Partition-release-recover - UQ

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

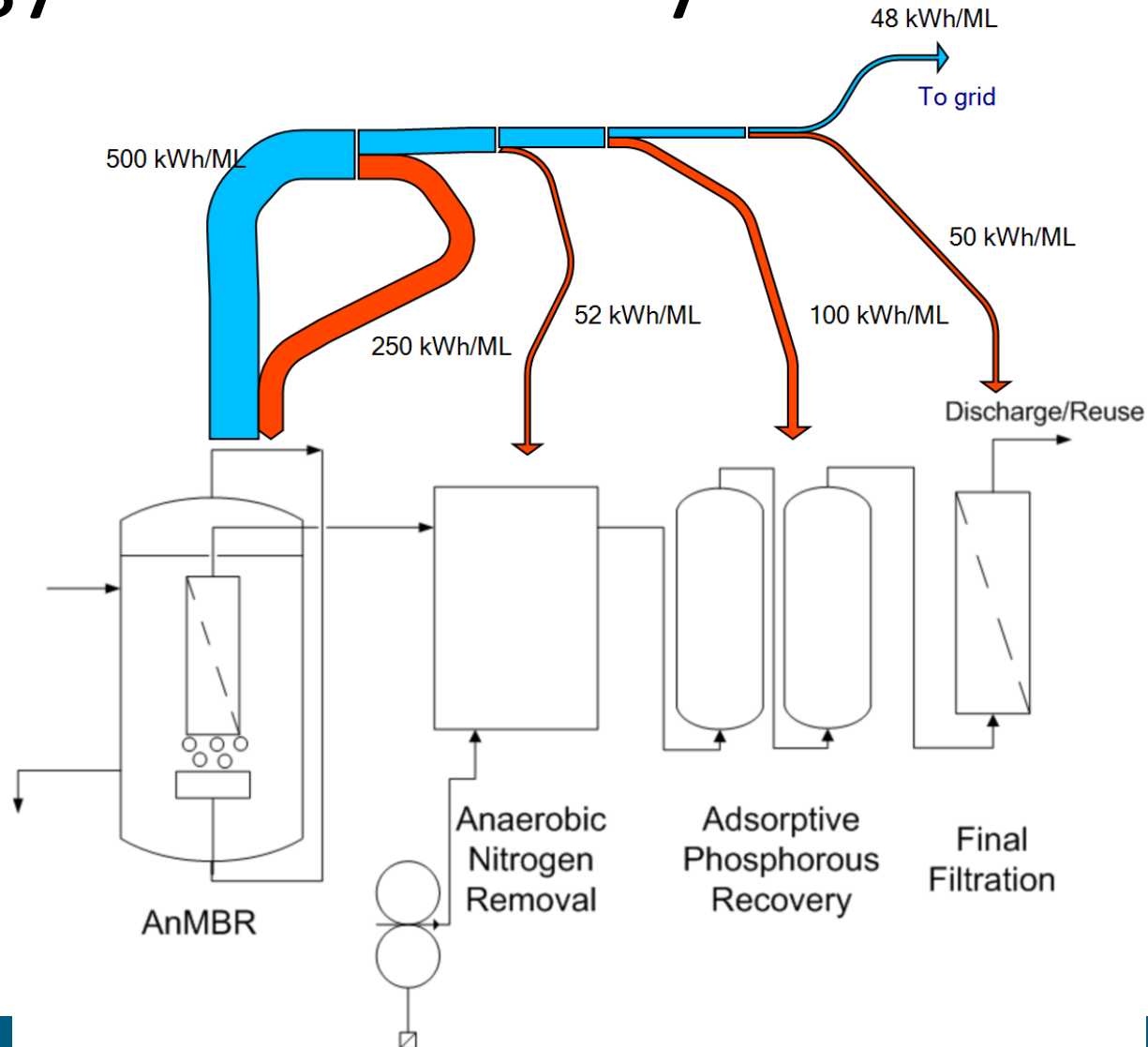
McCarty PL, Bae J, Kim J: **Domestic Wastewater Treatment as a Net Energy Producer—Can This be Achieved?** *Environmental Science & Technology* 2011, 45:7100-7106.

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

Mainline Low Energy Treatment

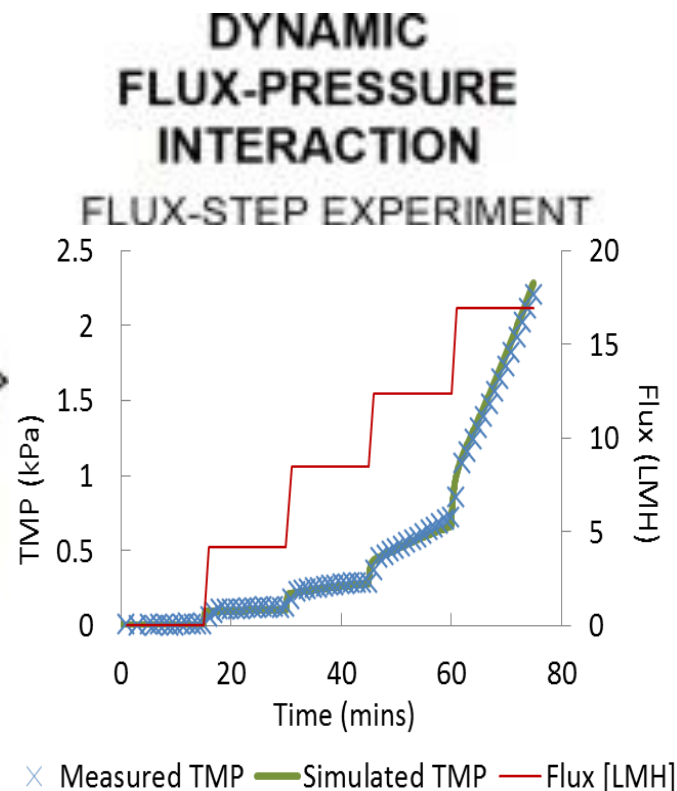
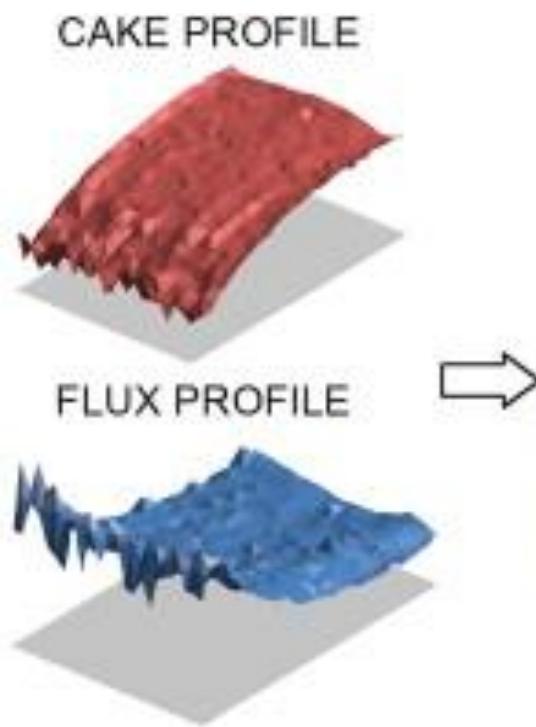
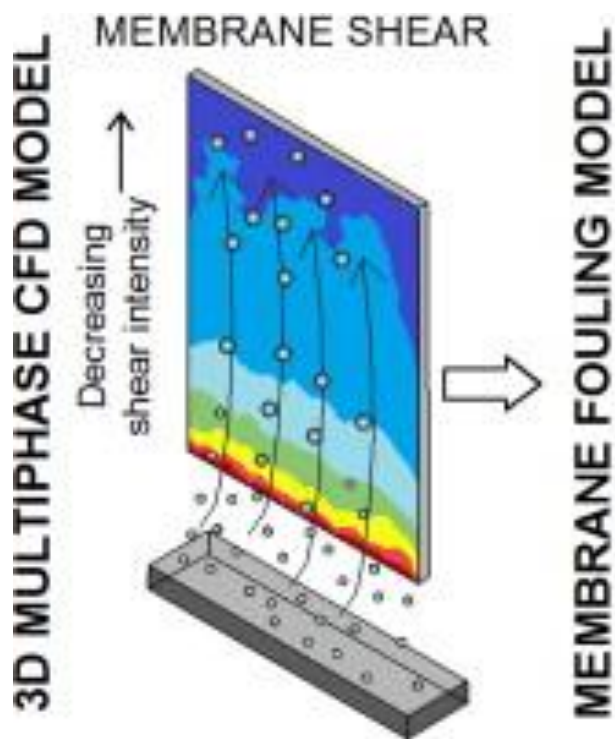


Energy dominated by Anaerobic Step

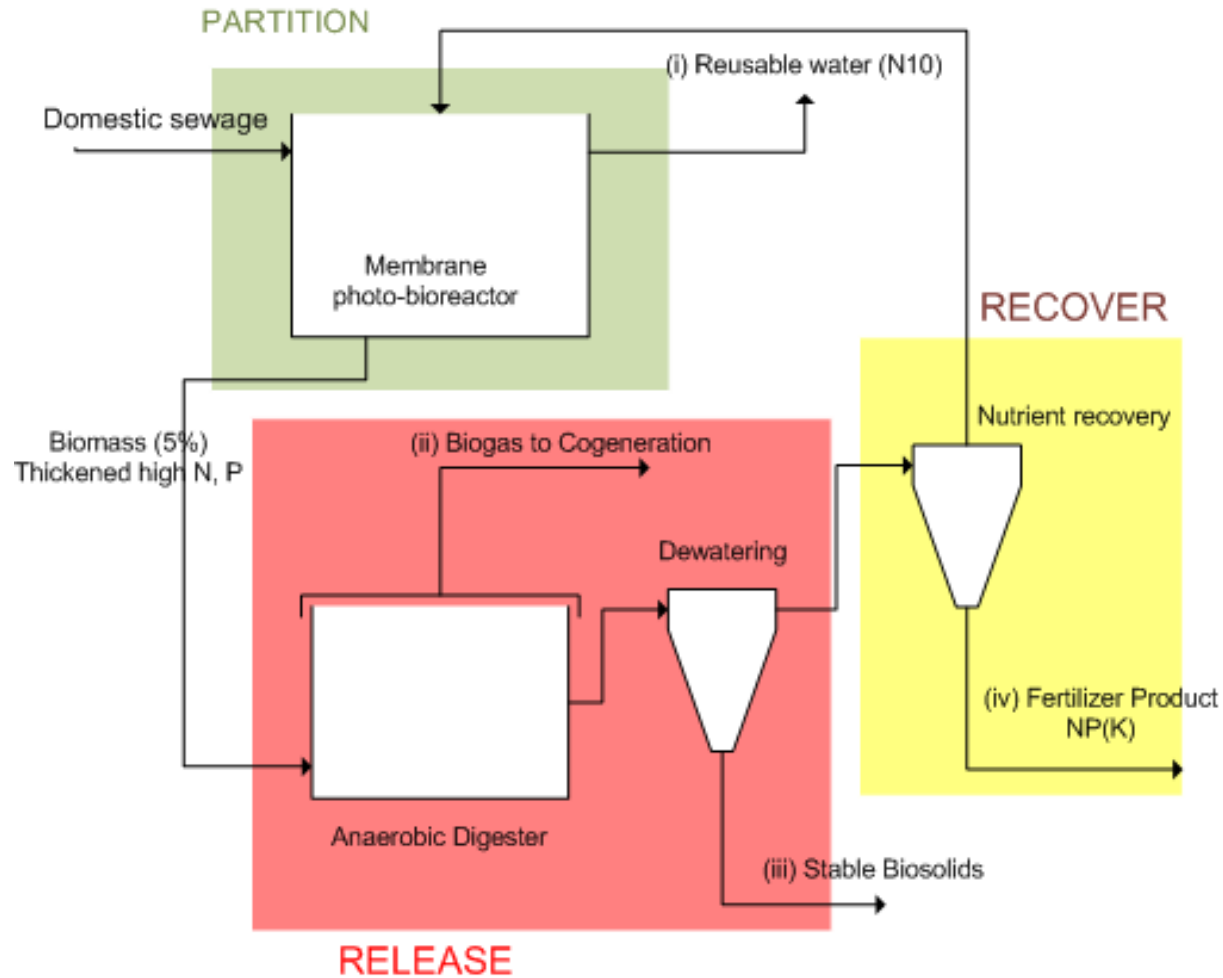




Modelling applied to AnMBR

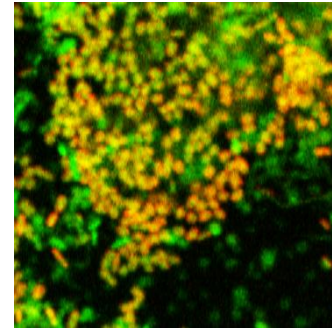


Partition-Release-Recover

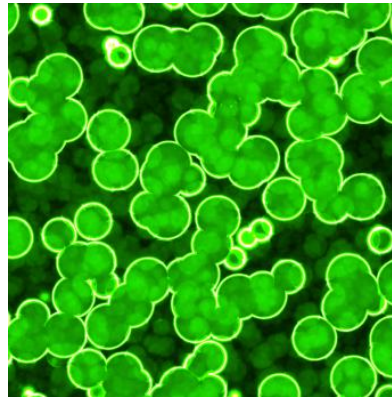


Partition

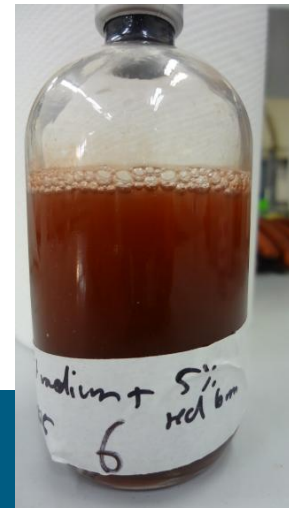
- Activated sludge (2 d SRT)



- Algae
Natural light

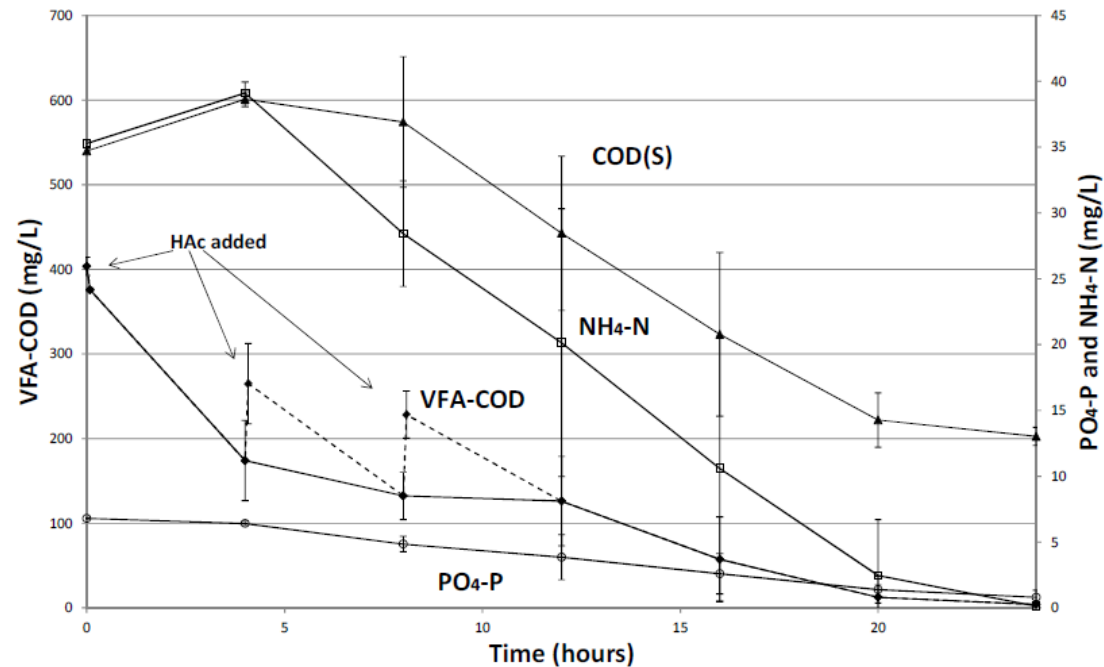
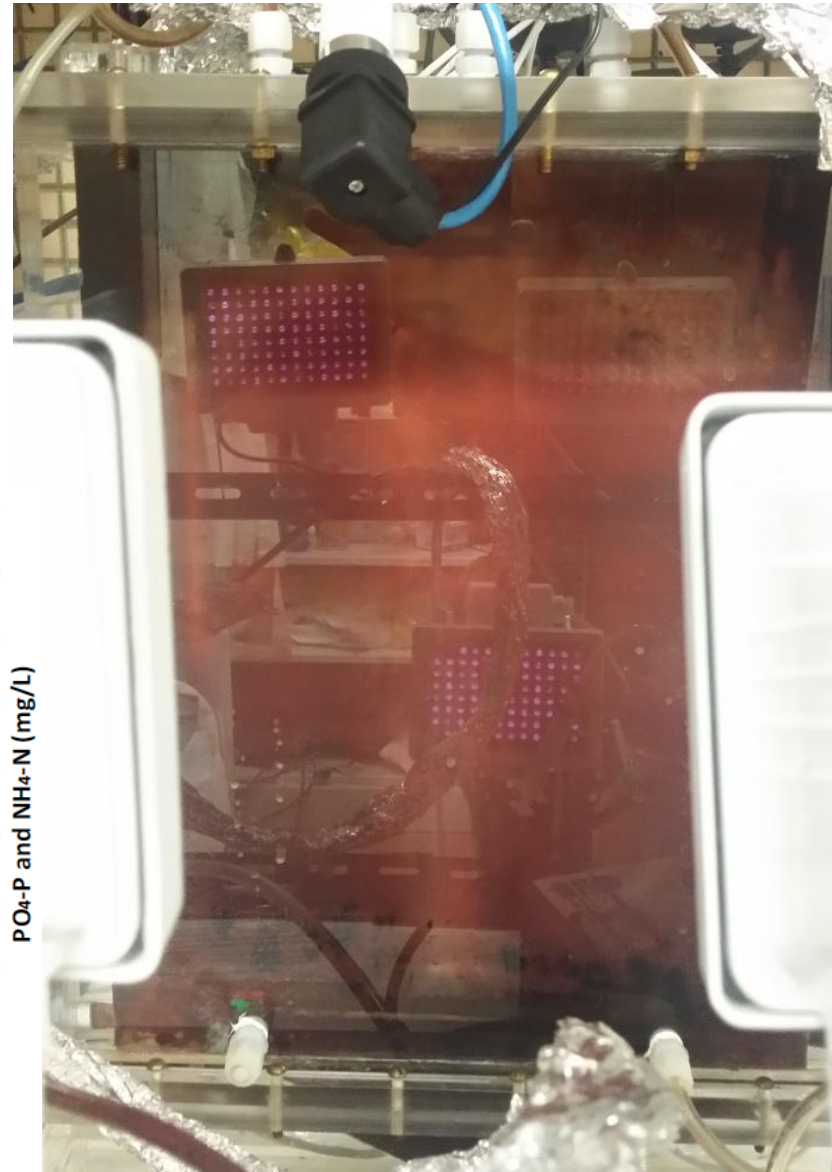


- Purple phototrophic bacteria
IR – Yes these are anaerobes

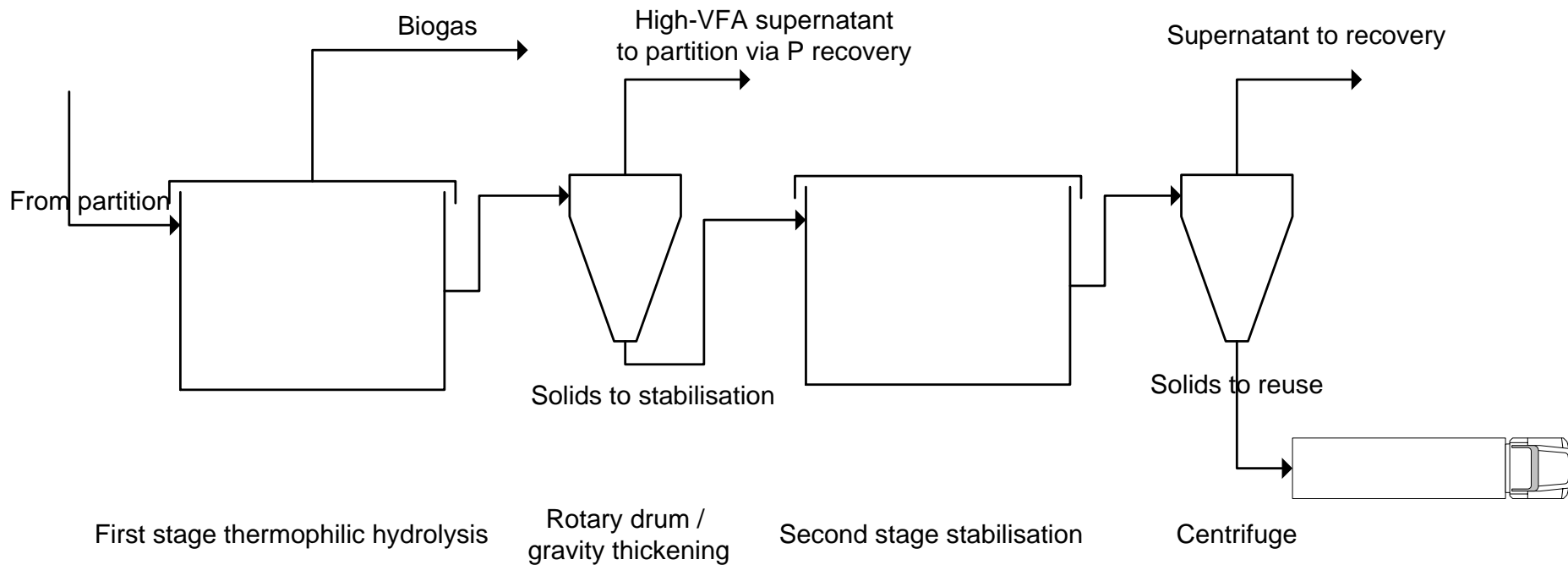


The key is in partitioning

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



Where to get Carbon from?

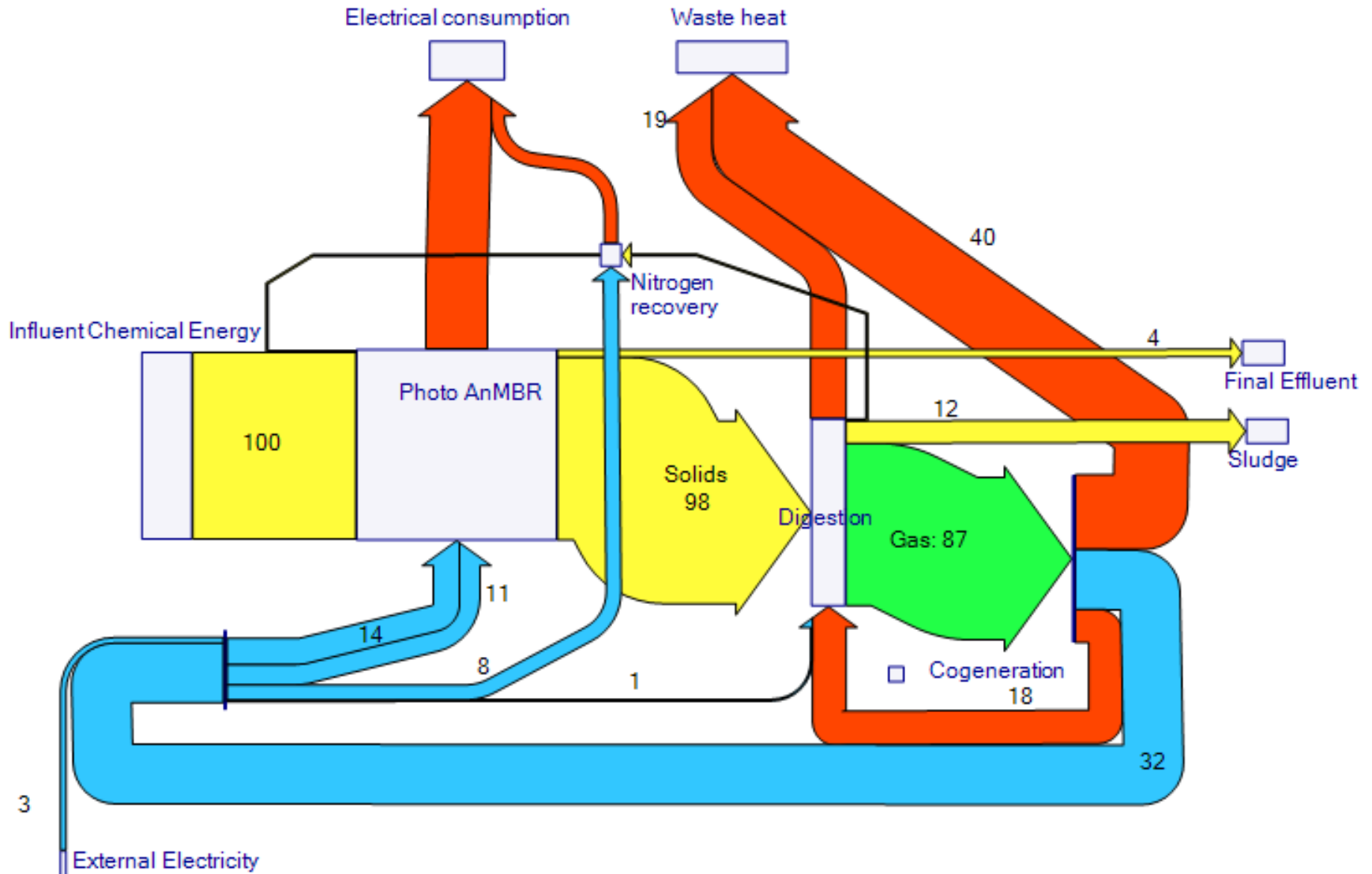


How to preferentially extract/release VFAs?
How to predict VFA distribution?

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)

PRR Energy Flows

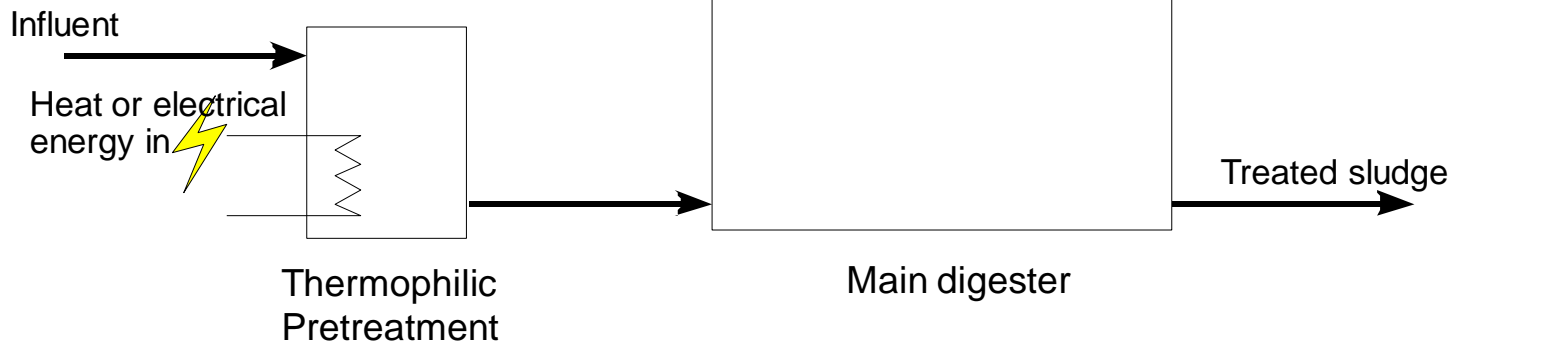
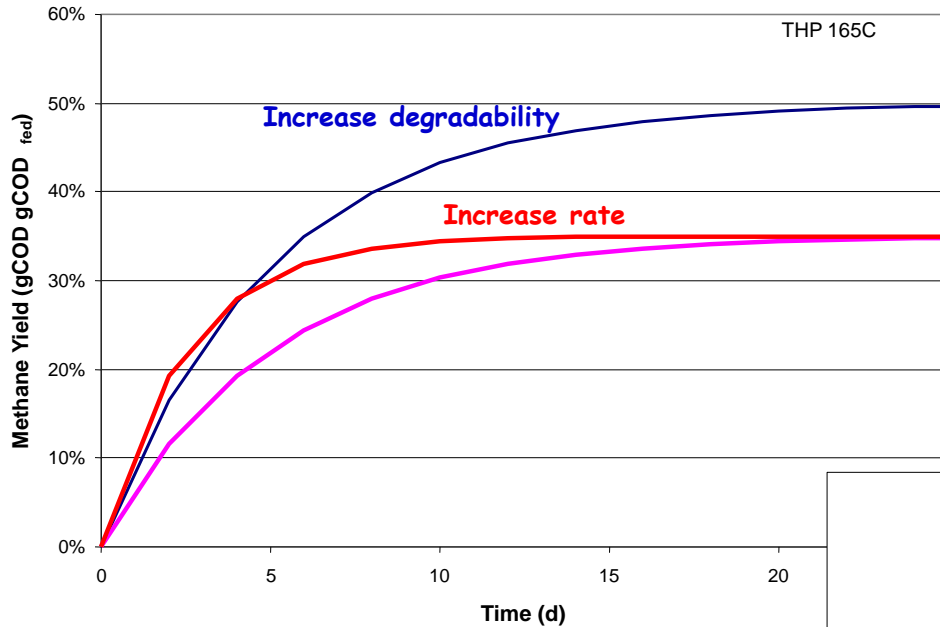


Digester is also important

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



Enhancement Technologies



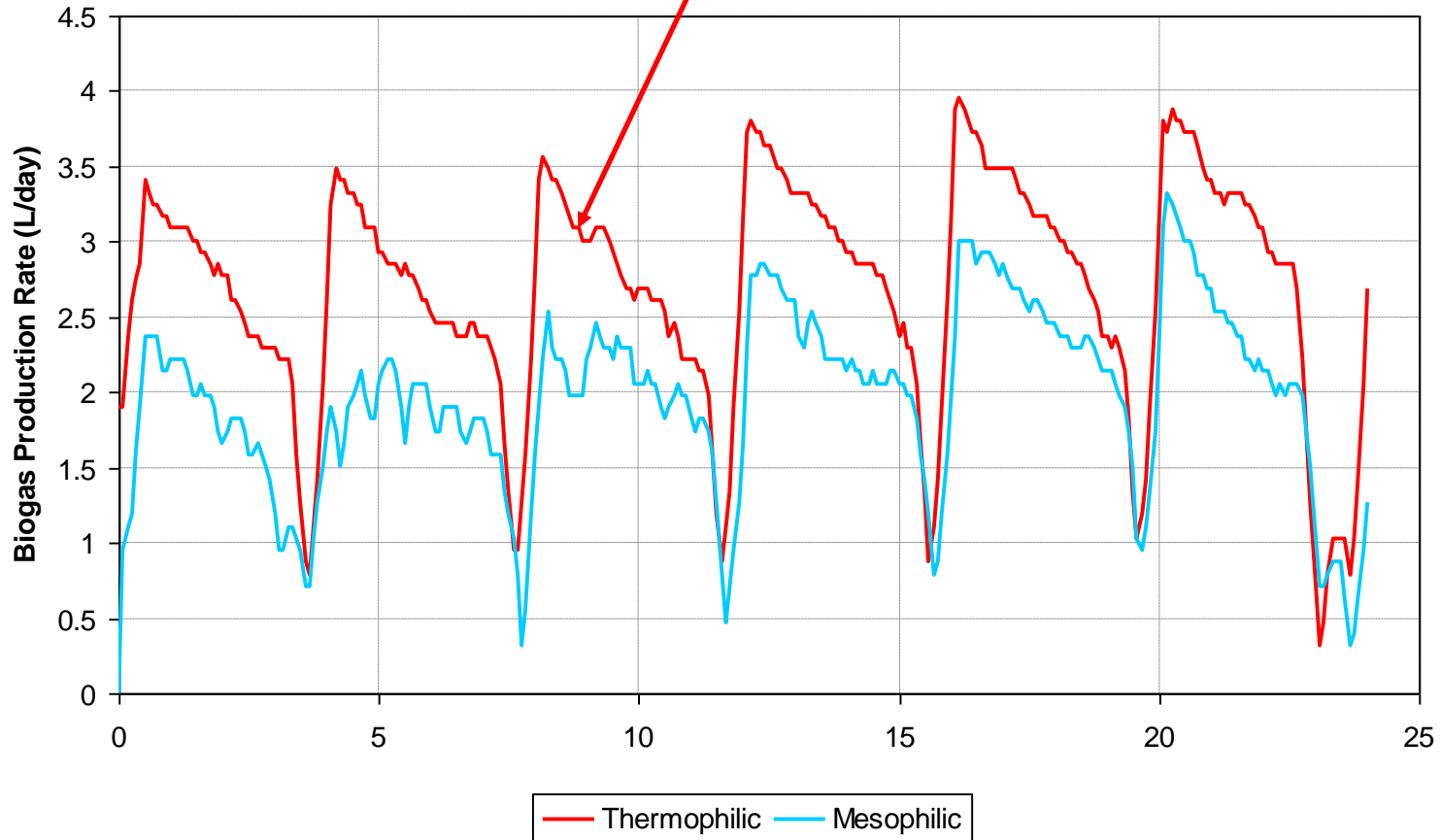
TPAD

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



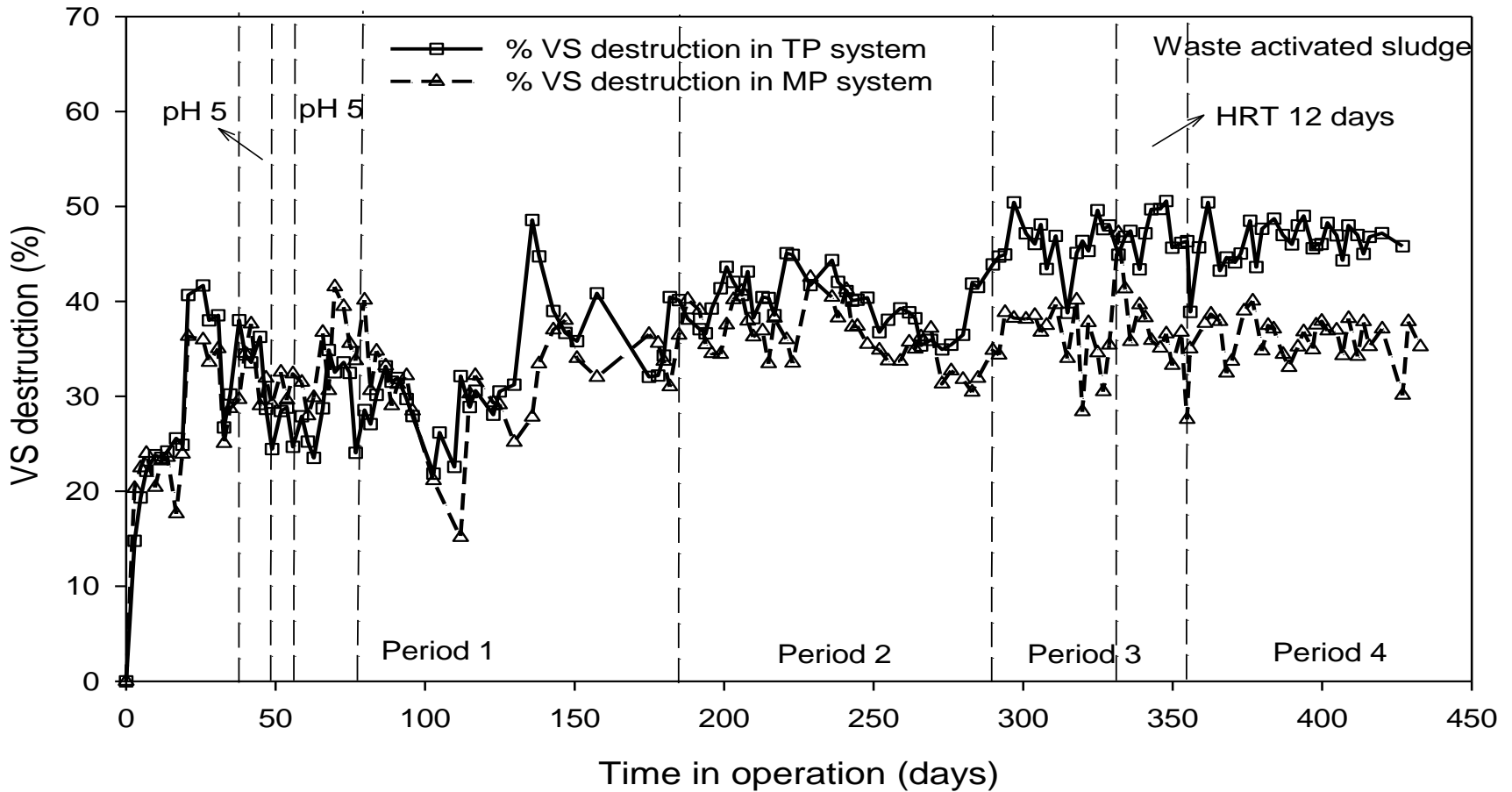
Does it Work?

20%-30% additional gas

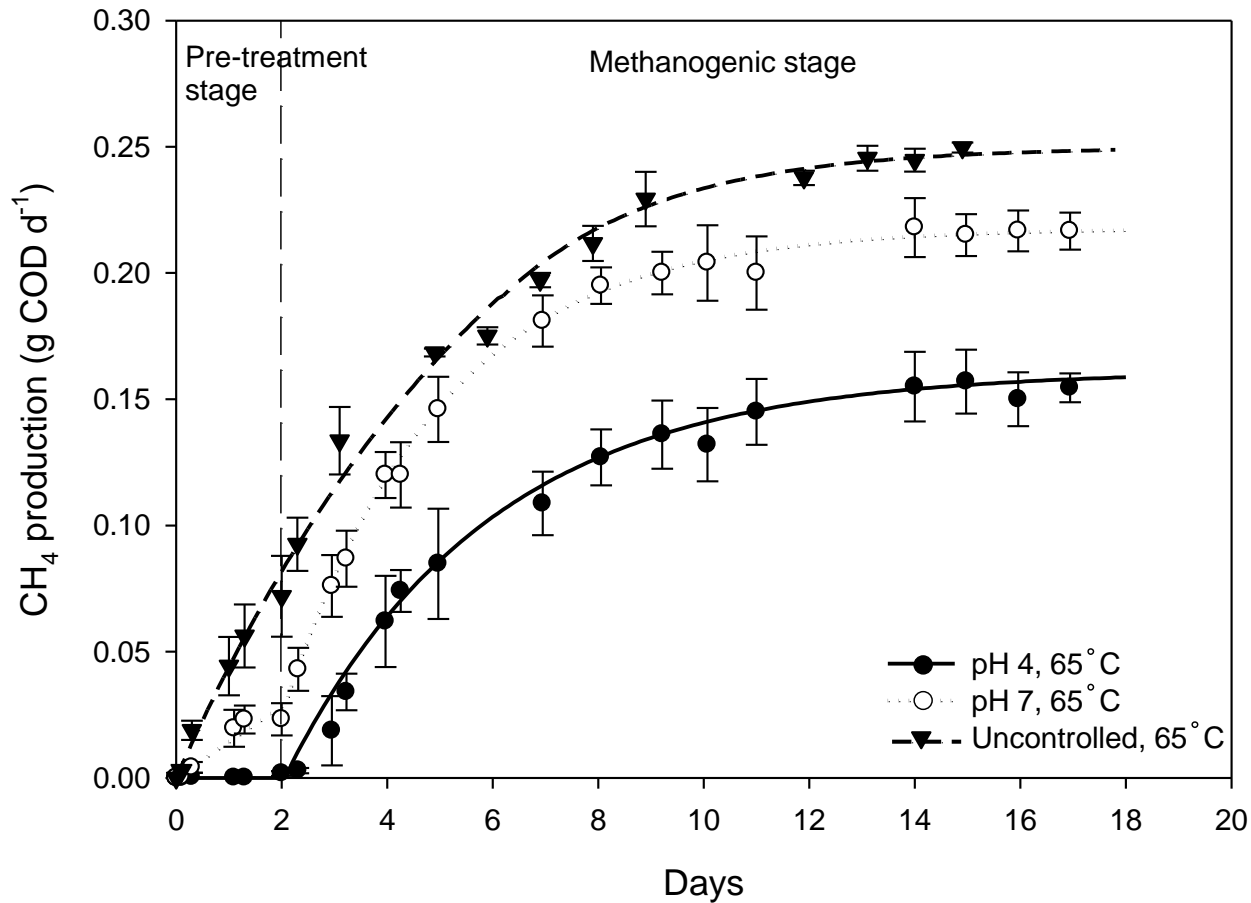




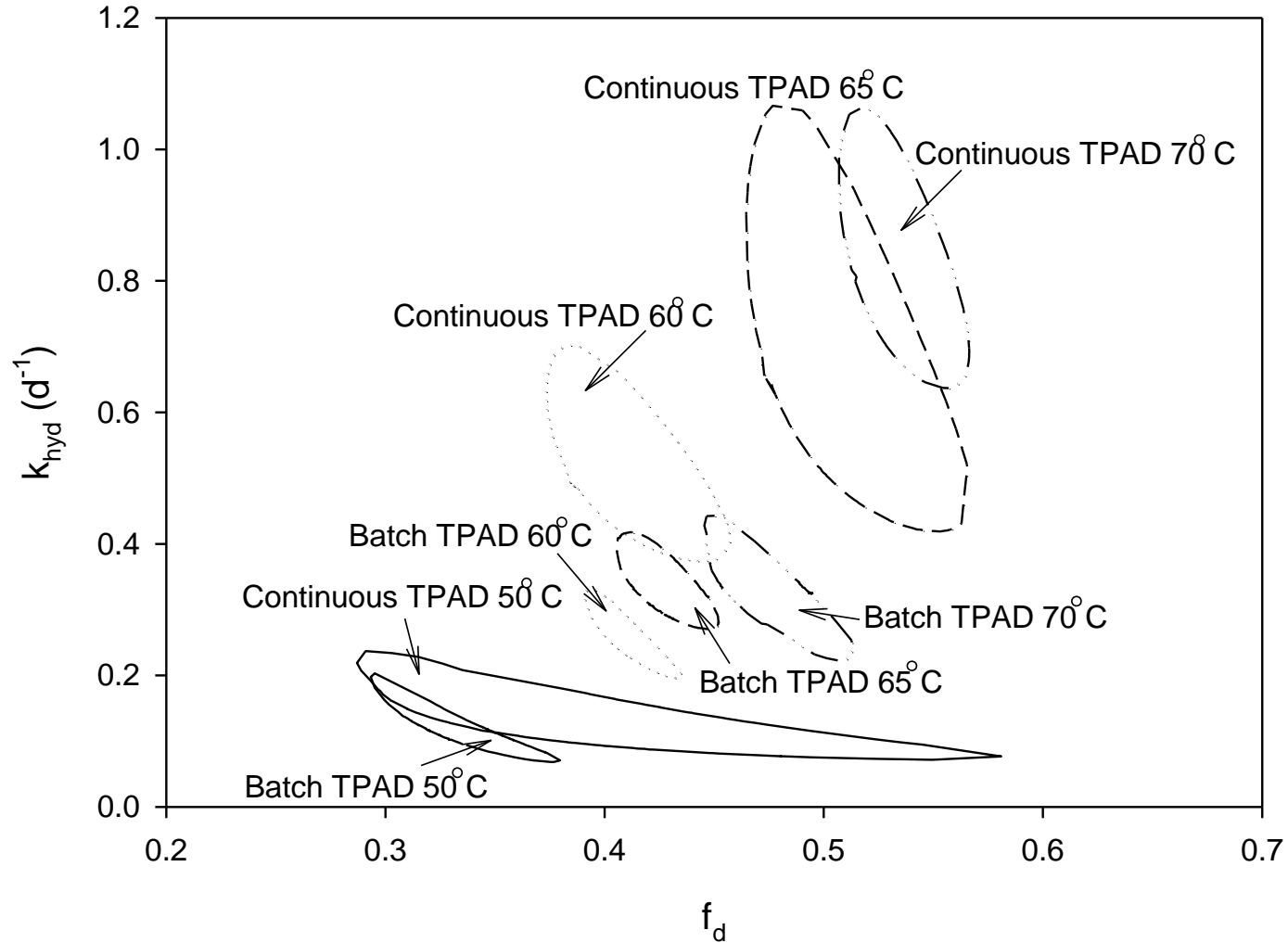
Lots of Testing



Lots more Testing...

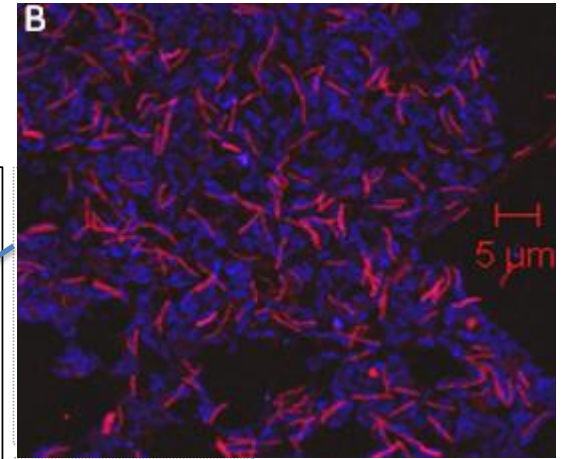
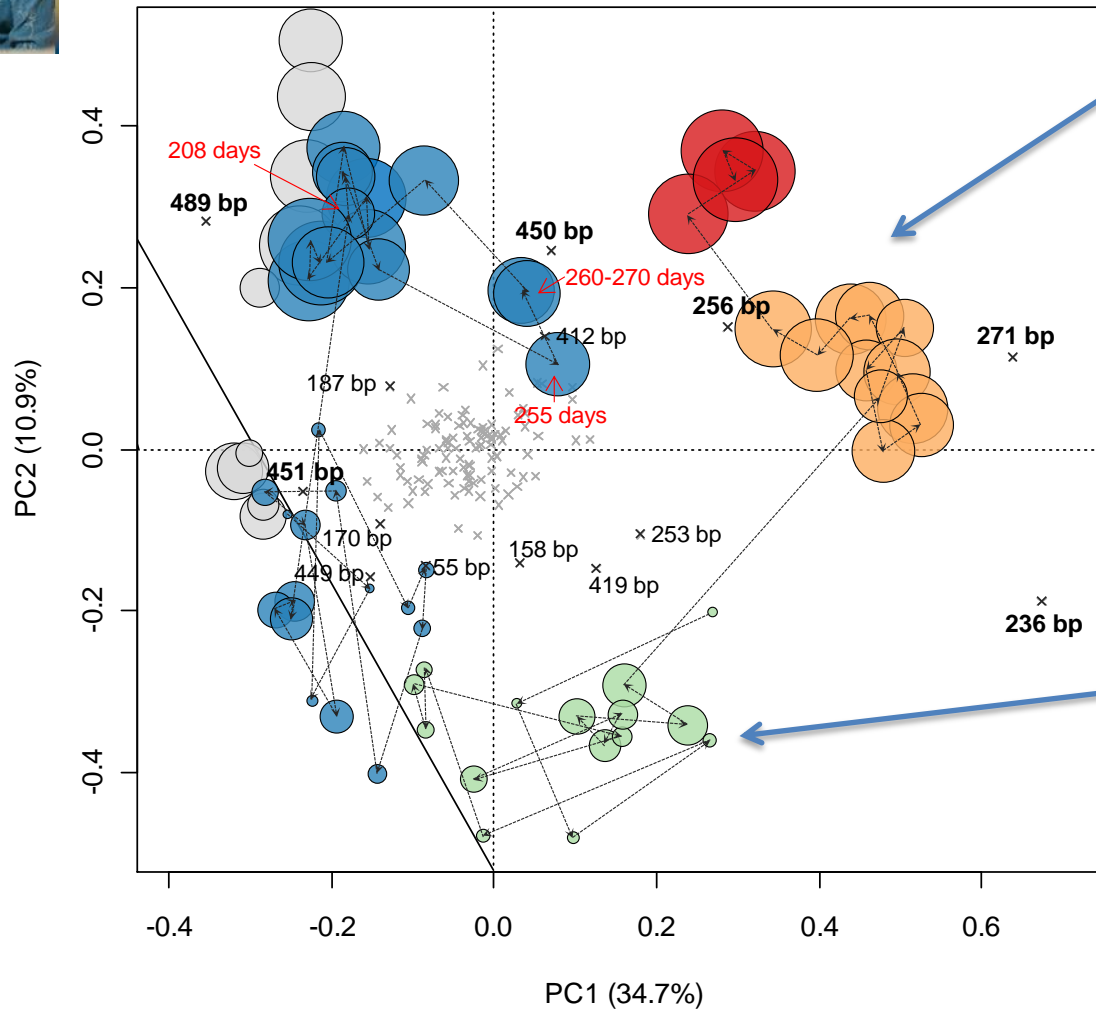


Summary Outcome (WAS)

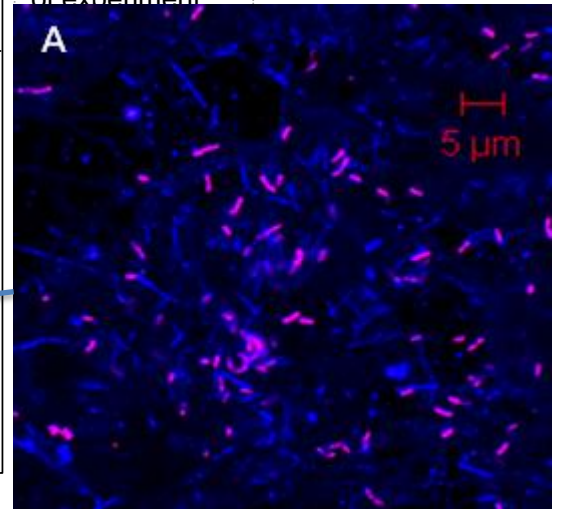




Why?

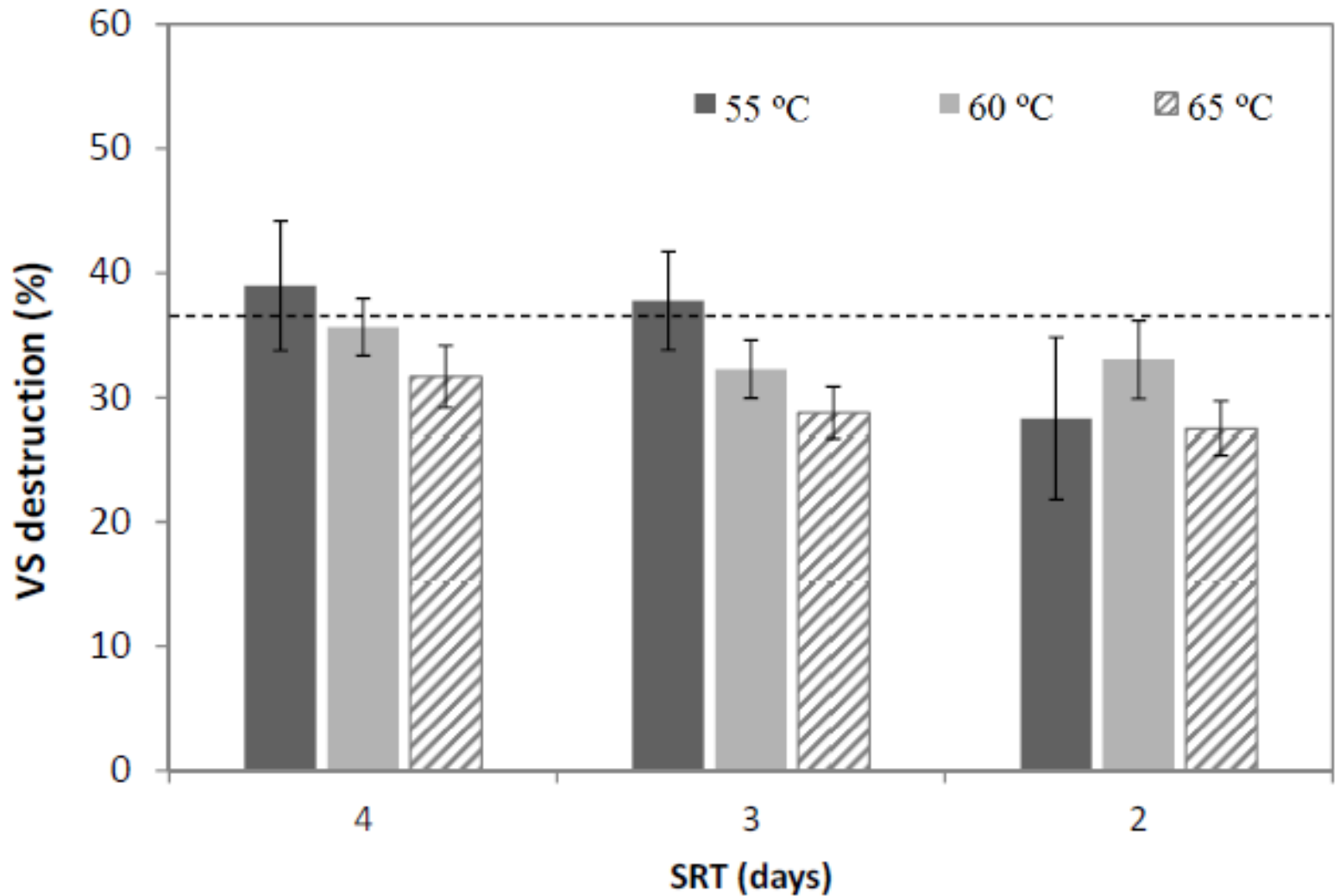


Circle size = days since start of experiment

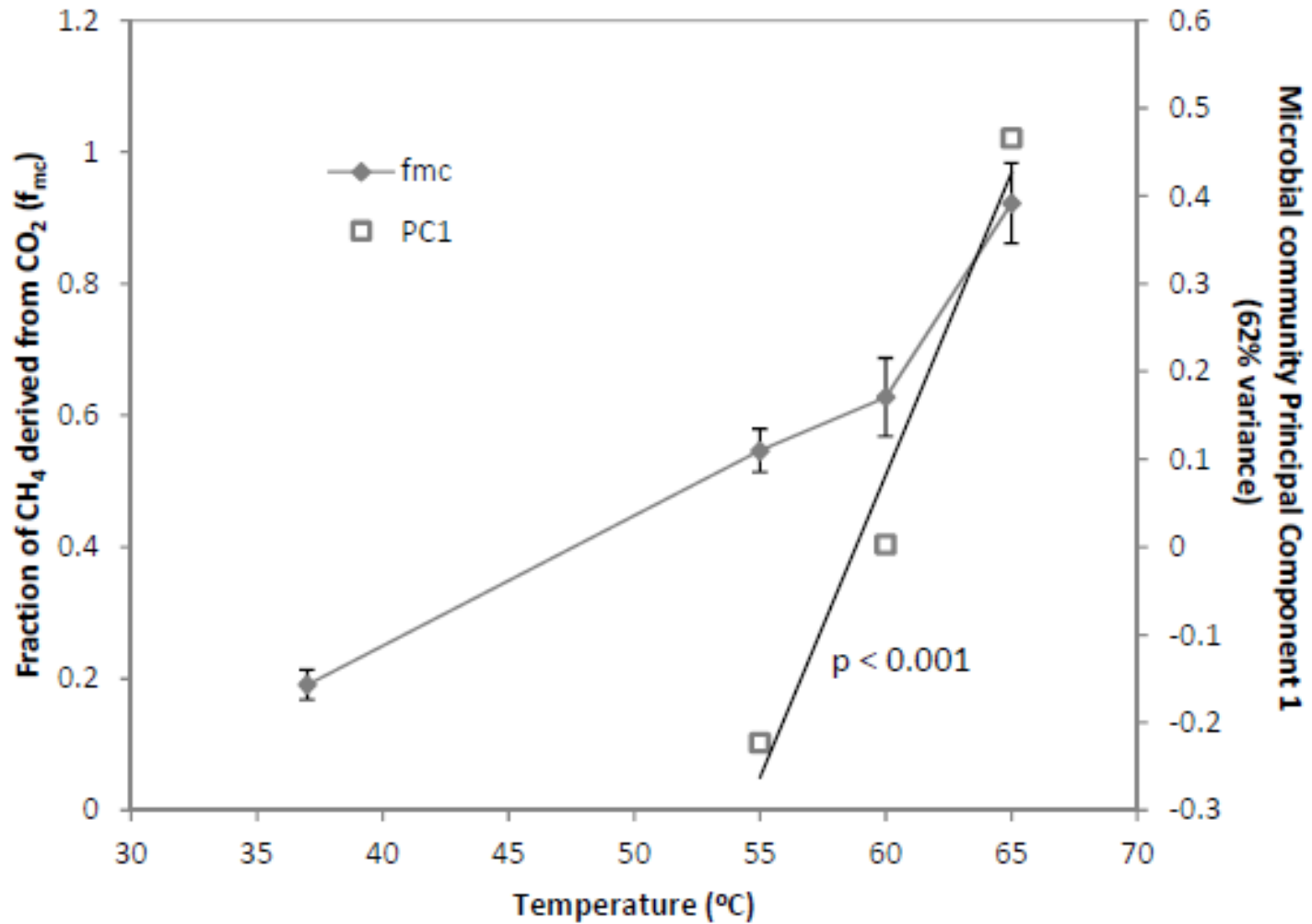




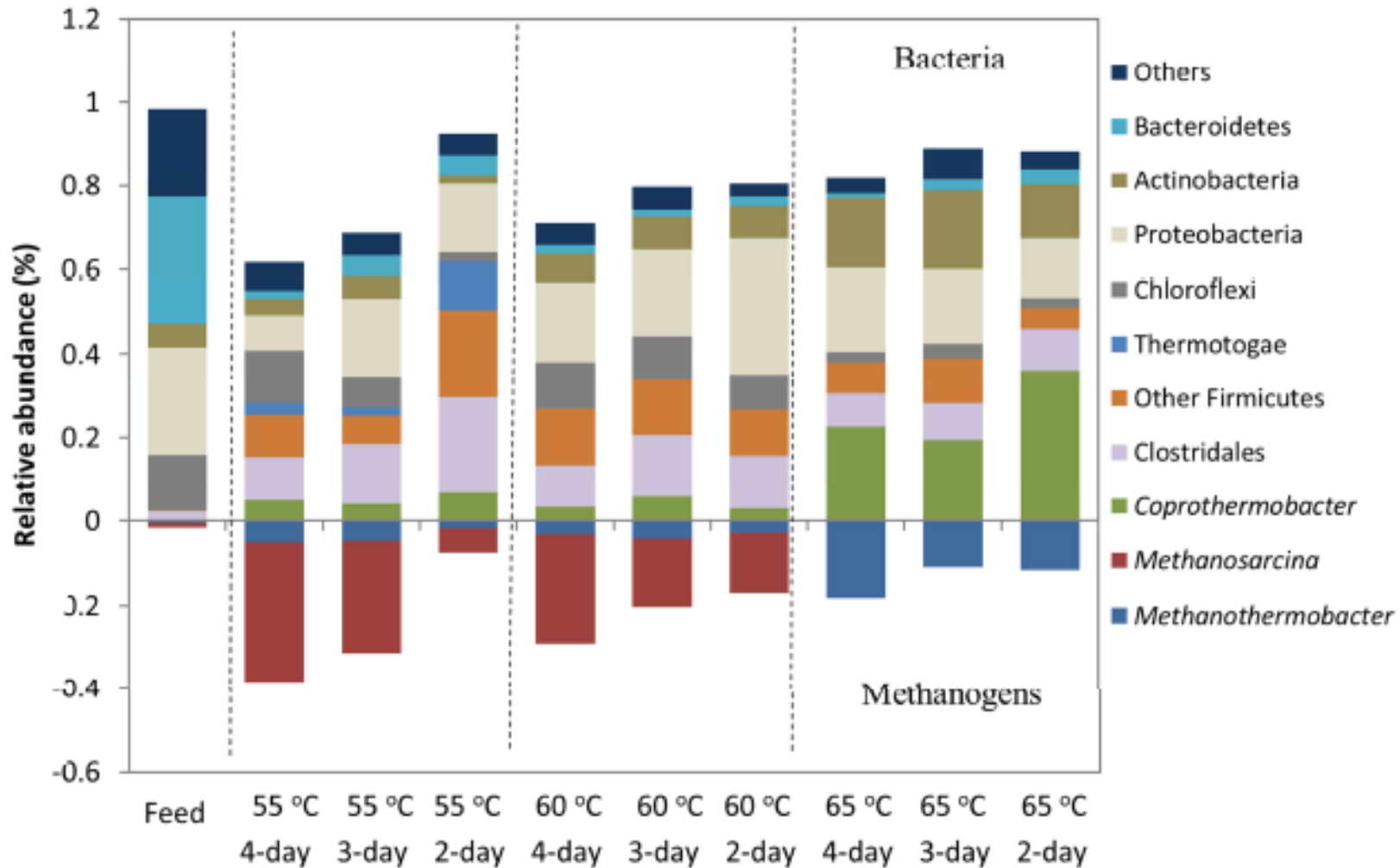
3 d High-Rate Anaerobic Digestion



Why 1?

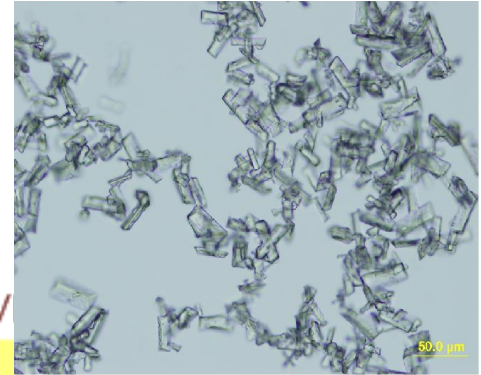
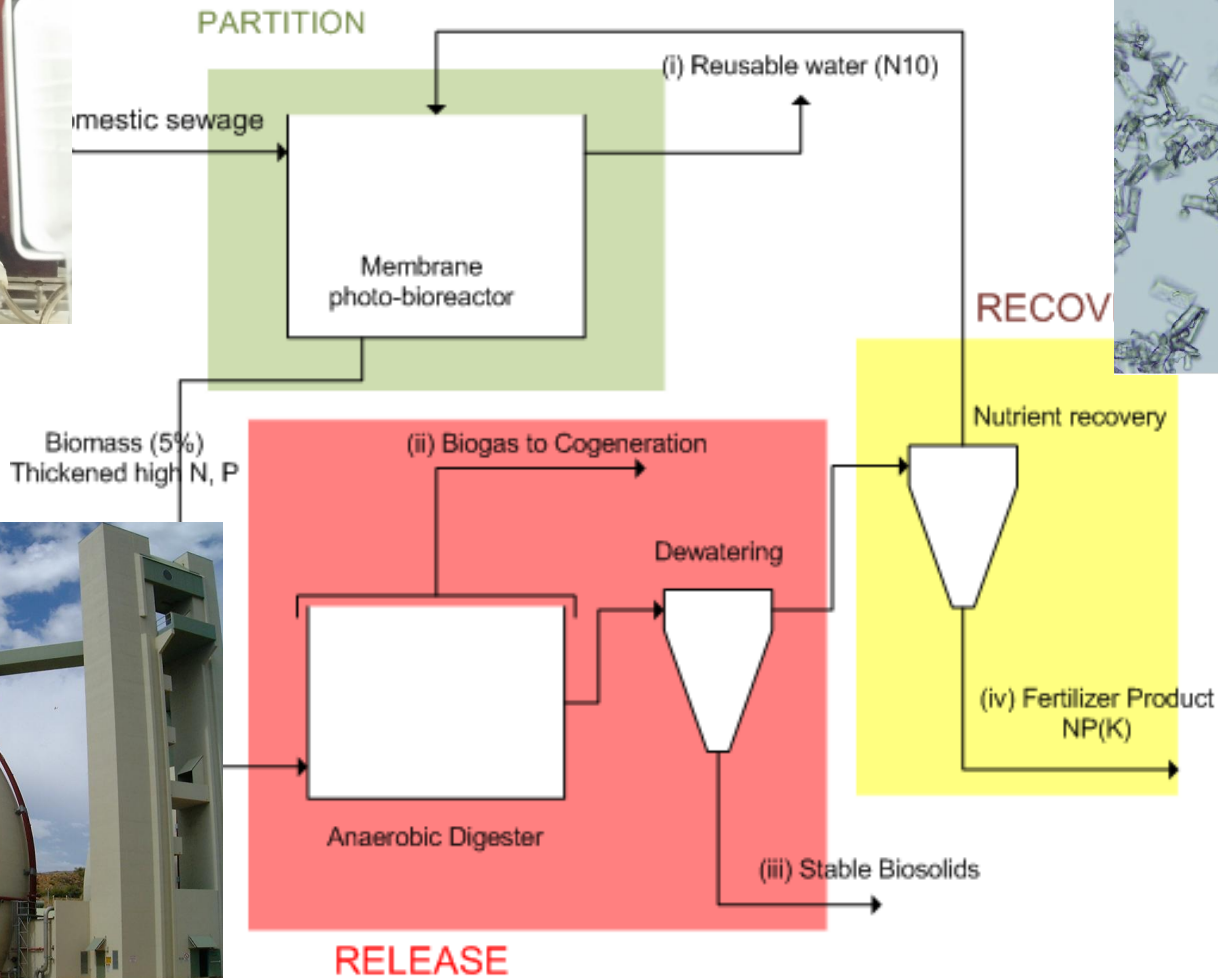


Why 2?



ADM1 generally OK for modelling, but need acetate oxidation

Plant Wide Analysis



Needs – Towards Generalized PCM

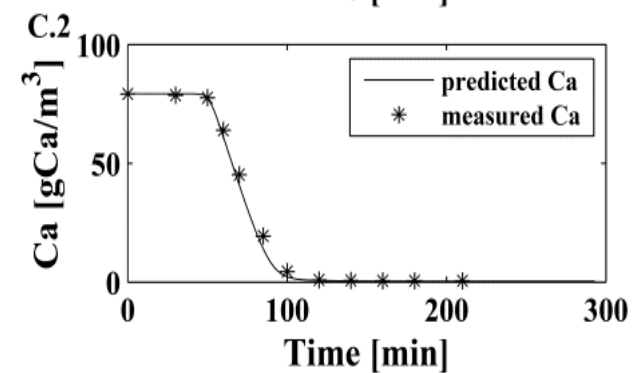
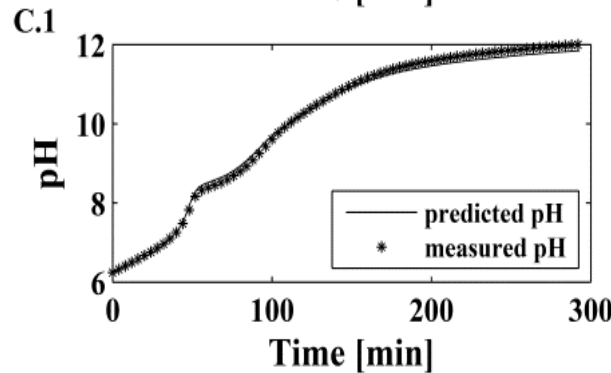
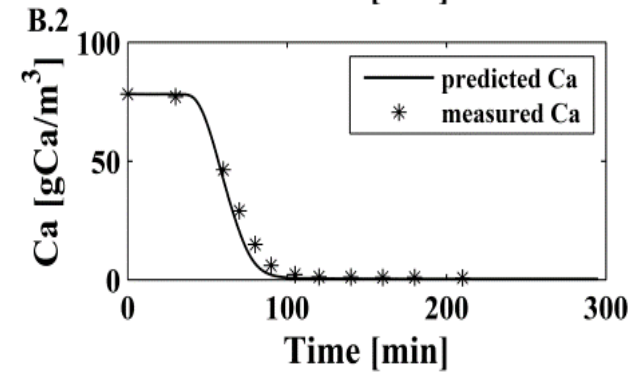
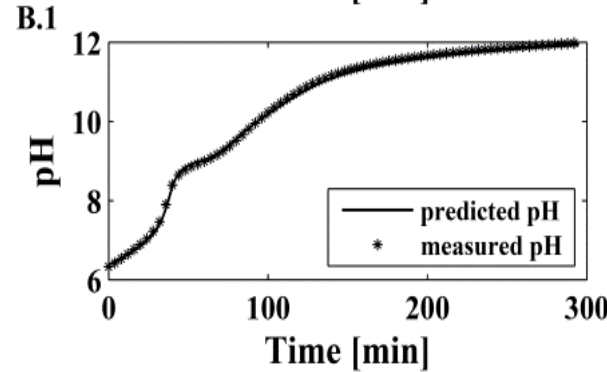
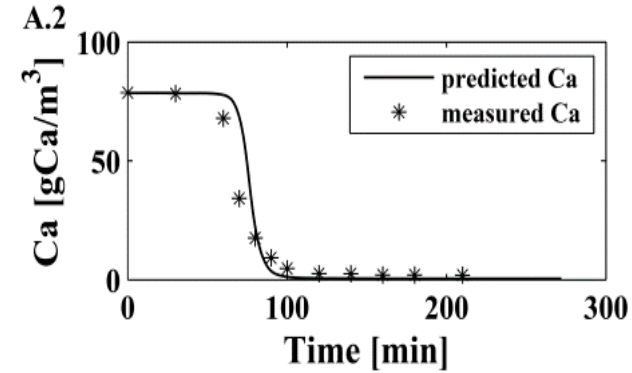
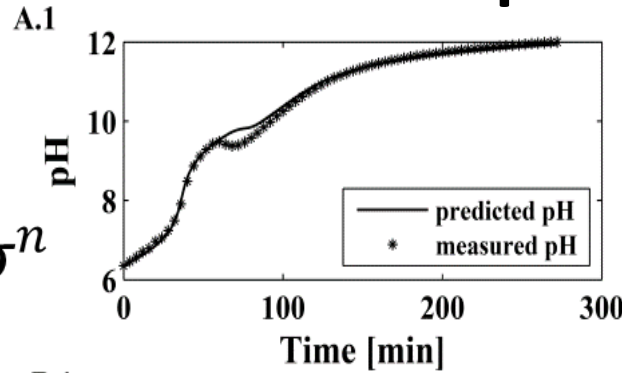
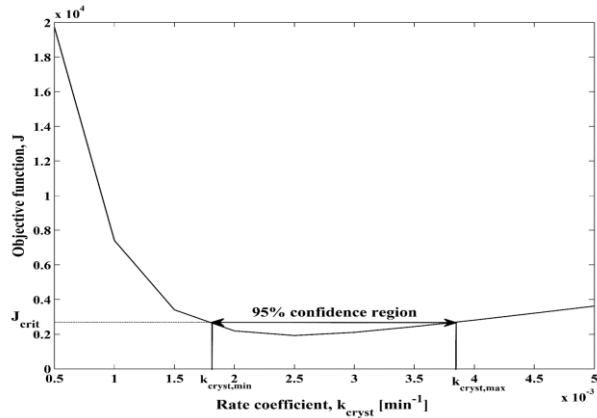
- Emerging processes *highly* dependent on PC processes:-
 - Gas stripping and absorption
 - Adsorption
 - Precipitation
 - Electroseparation
- Generally have wider swings in Ionic Strength, Controlling Mechanisms
- Conventional modelling also needs better PCM

Generalized Precipitation Model



$$R_{crys} = k_{crys} X_{crys} \sigma^n$$

One contestable parameter



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

AWMC Position Paper
(Chemosphere)

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