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Ammonia removal: opening opportunities for new feedstocks and nutrient recycling

Alba Serna Maza, Wei Zhang, Sonia Heaven, Charles Banks
University of Southampton

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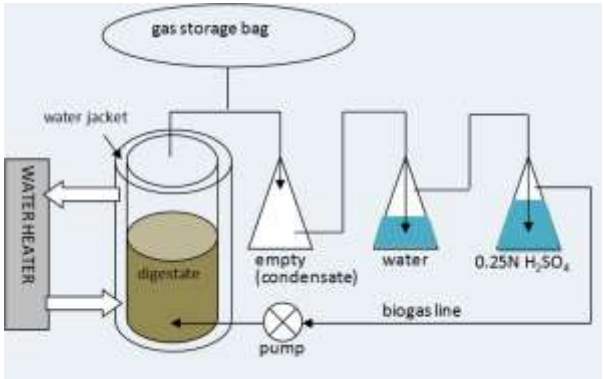
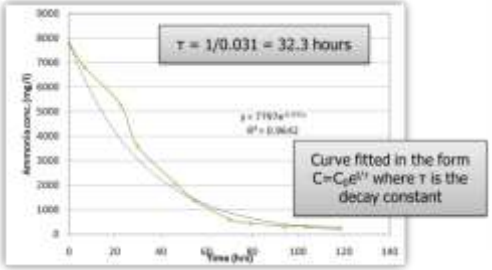
Why strip ammonia from digesters?

- Ammonia becomes toxic when it reaches a high concentration
  - In mesophilic digesters > 4 g N L^{-1} causes problems
  - Acetoclastic methanogens more sensitive than hydrogenotrophic
  - Up to ~8 g N L^{-1}, problems in mesophilic digesters can be alleviated using trace elements; but not in thermophilic conditions or with higher ammonia
- Removing ammonia could make it possible to run thermophilic digesters on food waste and other high N substrates
- It could be useful to recover ammonia
  - As a product: high-value fertiliser for crop use e.g. leaf spray
  - N removal balances the nutrient load in the digestate and increases the land capacity, especially in NVZs

Initial work

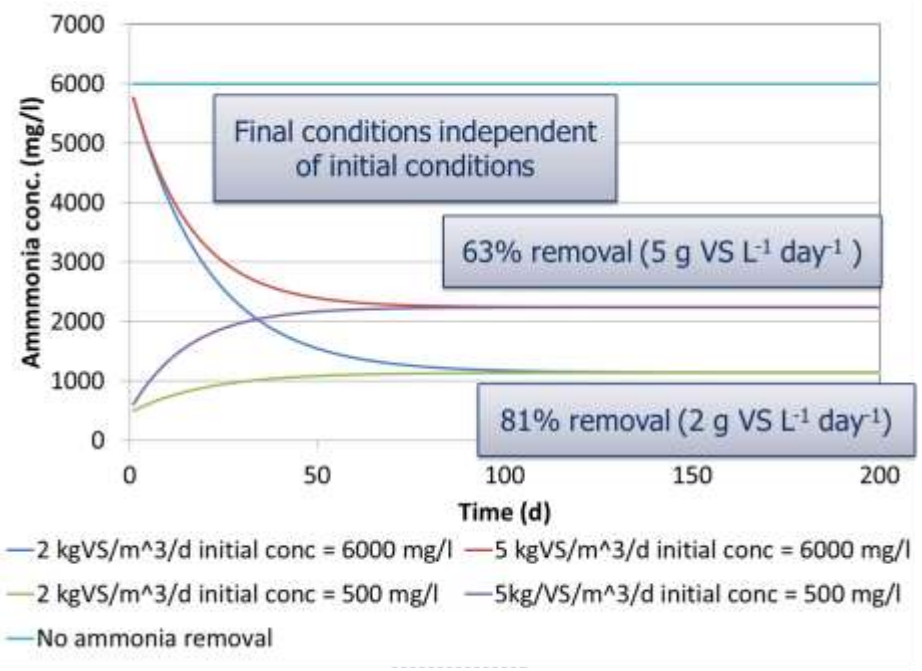
- Batch experiments to establish stripping parameters
  - Angeles de la Rubia using N_2 and other gases
  - Mark Walker using high VFA digestates before and after storage
  - Alba Serna Maza using fresh food waste digestates
  - Determine time constants for removal in different stripping conditions (pH, temperature)





Initial work

- Modelling of different process configurations
  - post-hydrolysis, *in situ*, side stream, post digestion
  - in situ appears attractive but requires very high gas flow rates (violent mixing)



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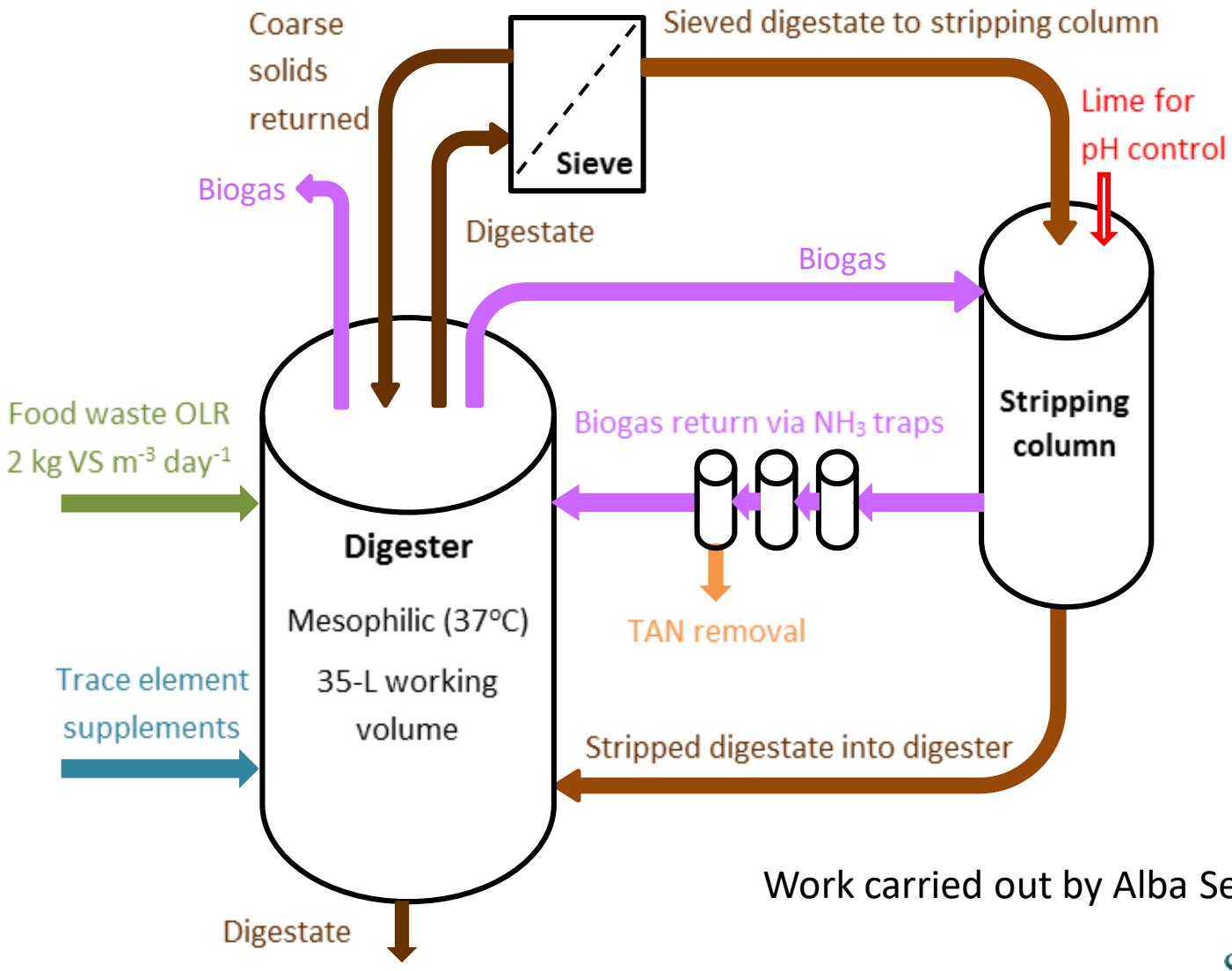
Mesophilic trial



Work carried out by Alba Serna Maza

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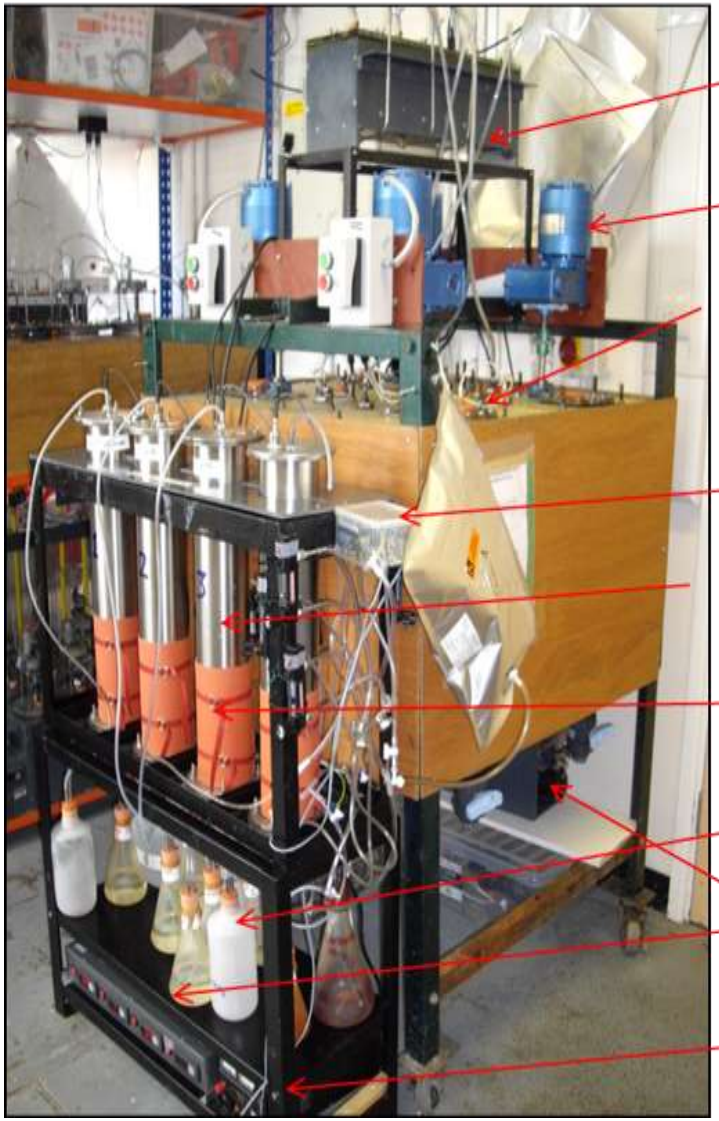
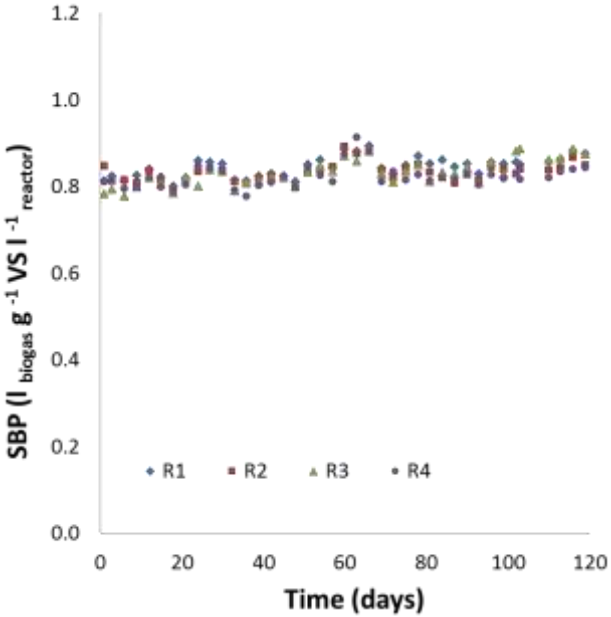
In practice


Gas counter
Motor
Continuous stirred-tank reactors (mesophilic) 35-l volume
Gas pump
Ammonia stripping towers
Heating mat
Ammonia traps
Temperature control
Pump power supply

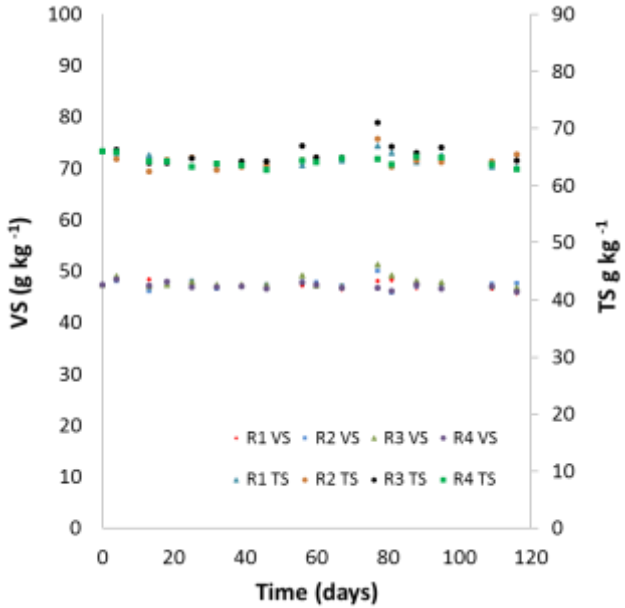
Phase 1 – establishing a baseline

- Initially all digesters operated at OLR 2 g VS L^{-1} day^{-1} for 1.1 HRT without stripping to establish baseline

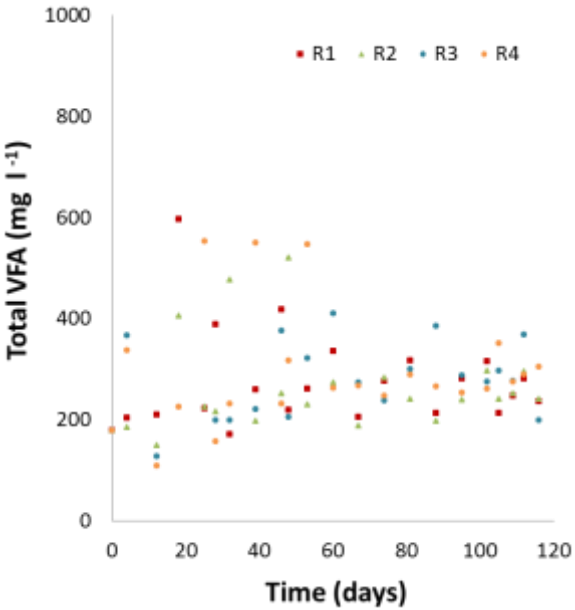
Specific biogas production



TS and VS



Total VFA



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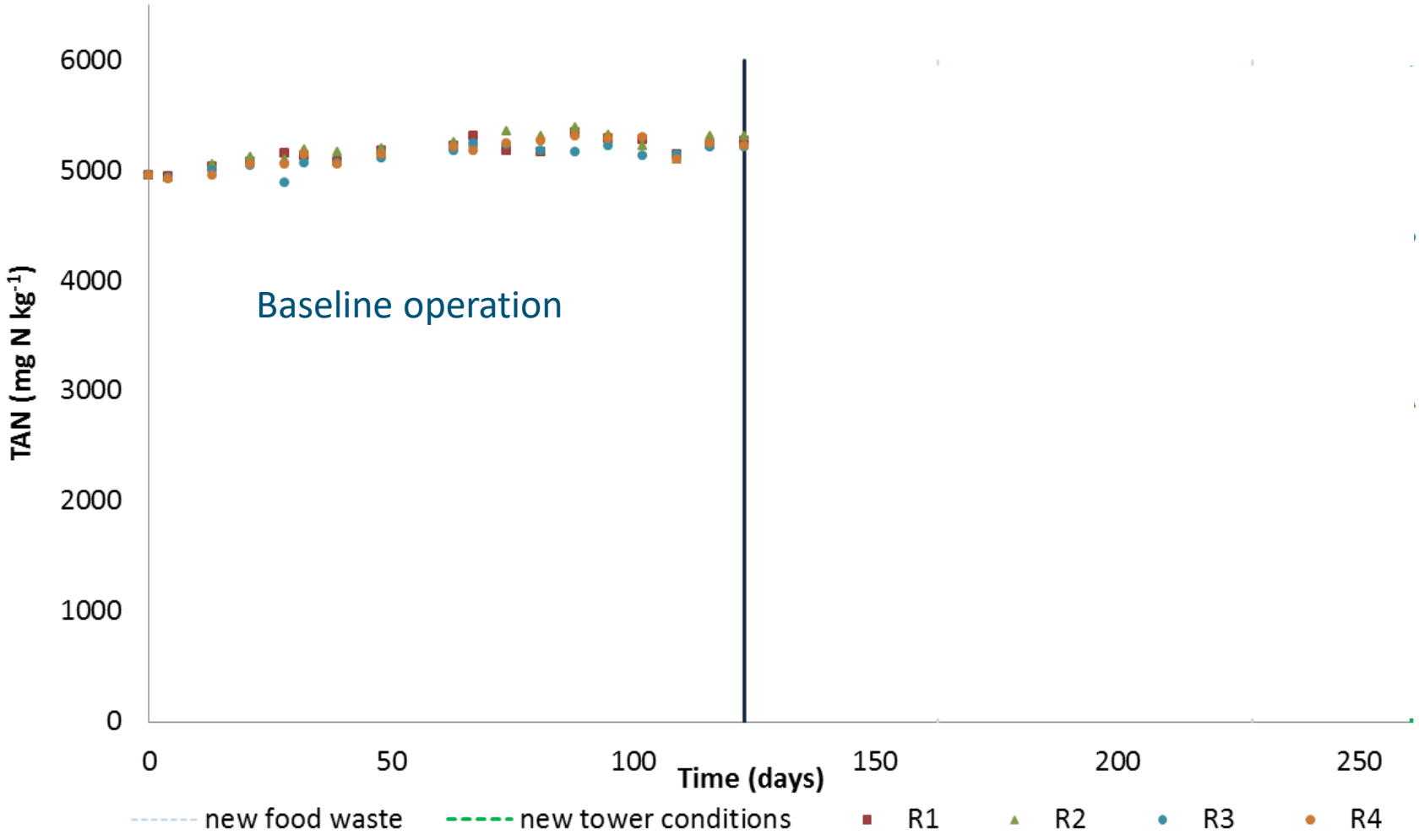
Phase 2 – side-stream stripping



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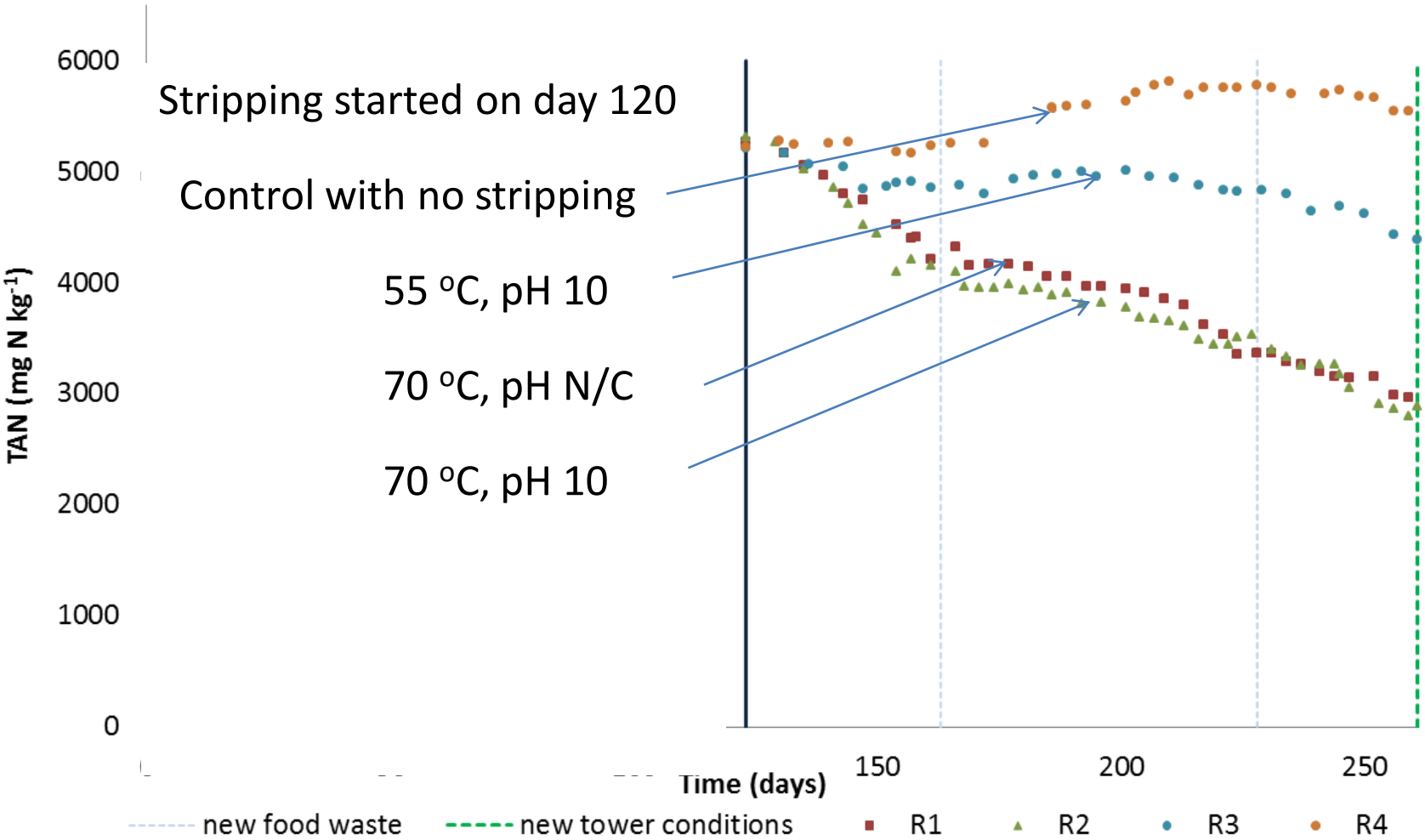

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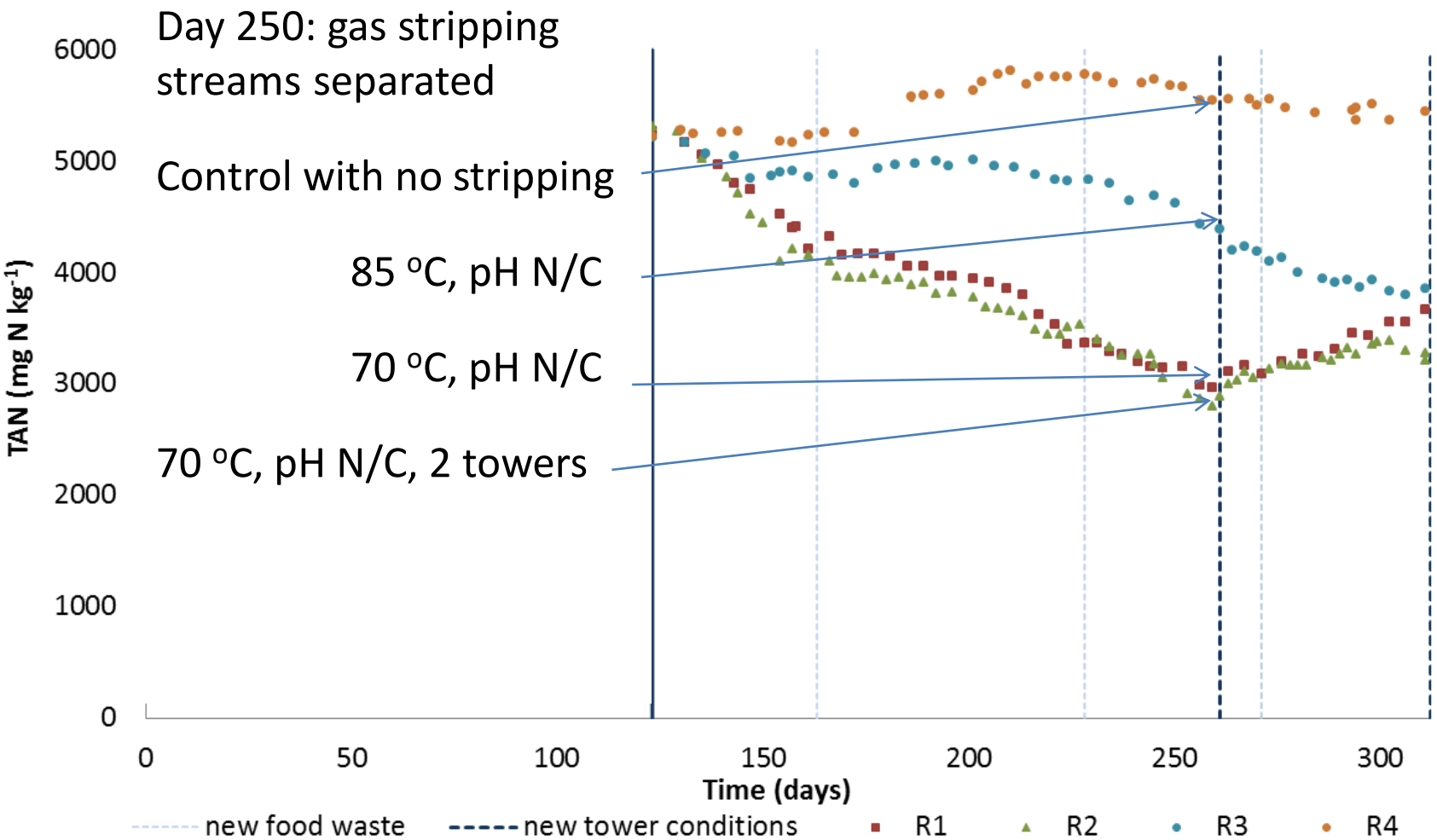

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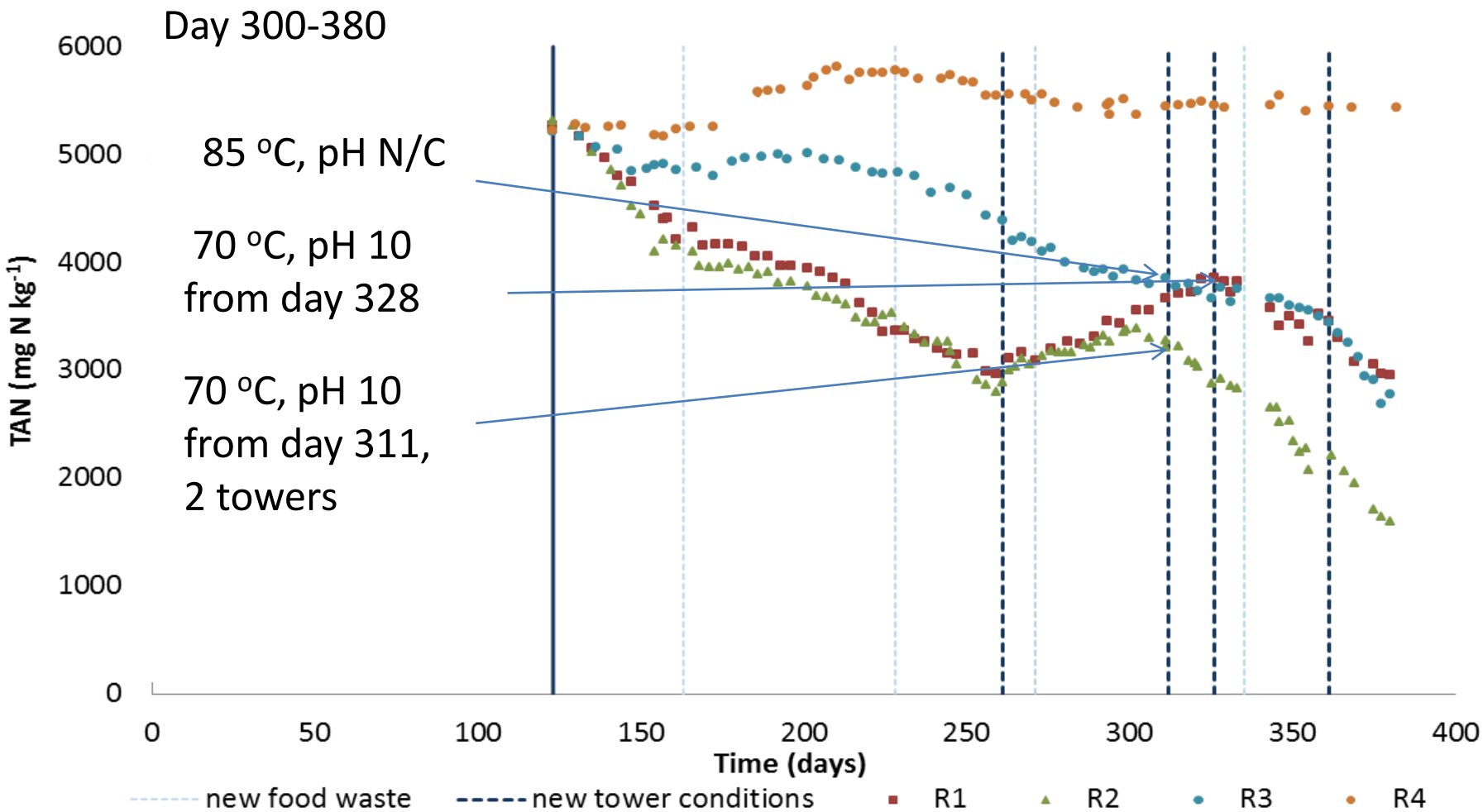

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Overall stripping performance

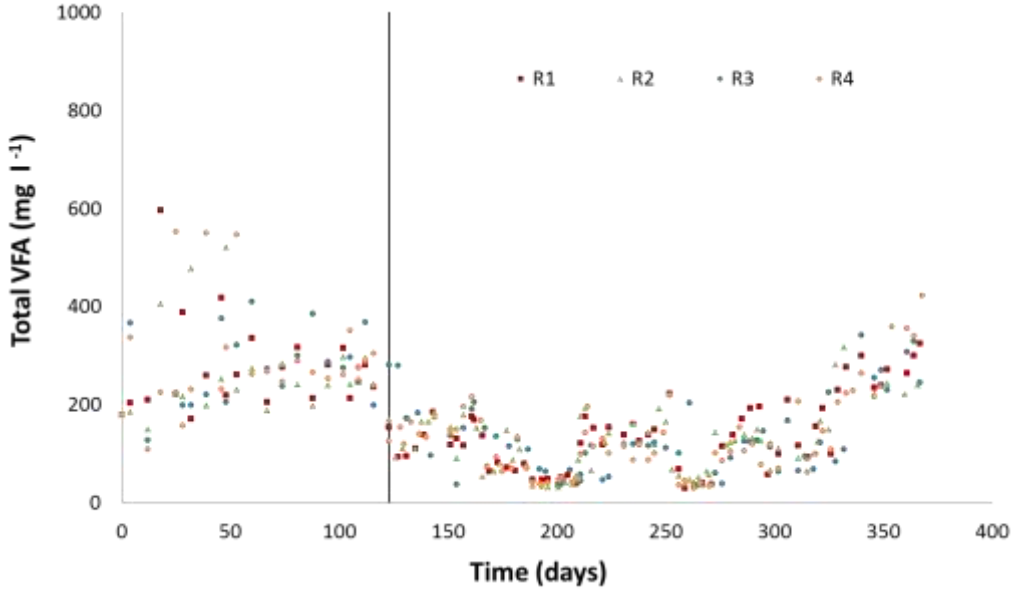
	% TAN removal day $^{-1}$
55 ^{o}C pH 10	6.8
70 ^{o}C unadjusted pH	15.3
85 ^{o}C unadjusted pH	16.4
70 ^{o}C pH 10	20.6
85 ^{o}C unadjusted pH 10	30.0

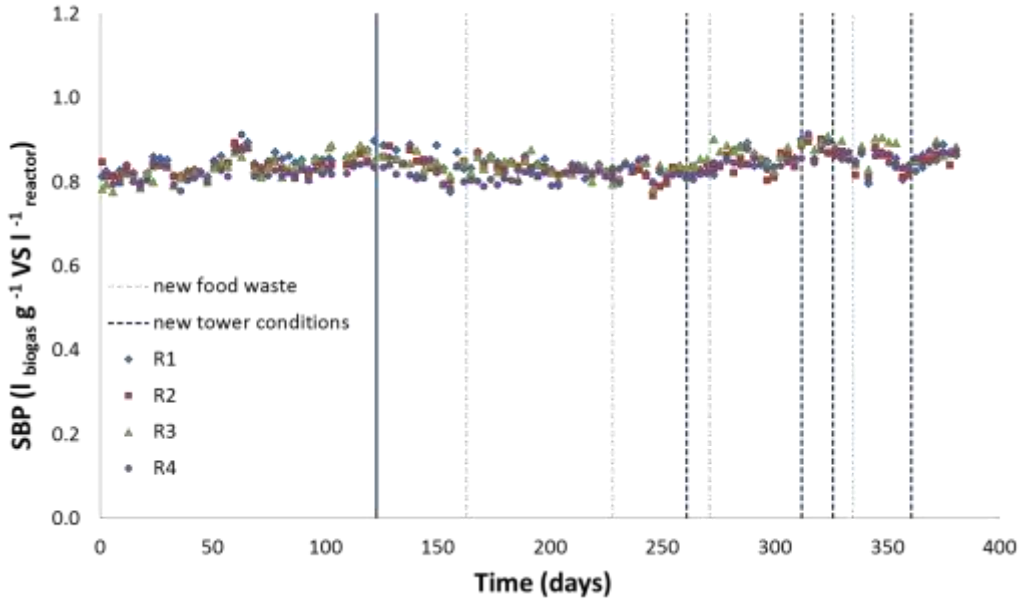
TAN removal increase

Process requires high pH and high temperature

Performance

- Total VFA below 500 mg L^{-1}
- Good specific gas production - possible slight increase?
- TAN in digesters reduced by 46-70 % → inhibition can be controlled
- No adverse effects on stability





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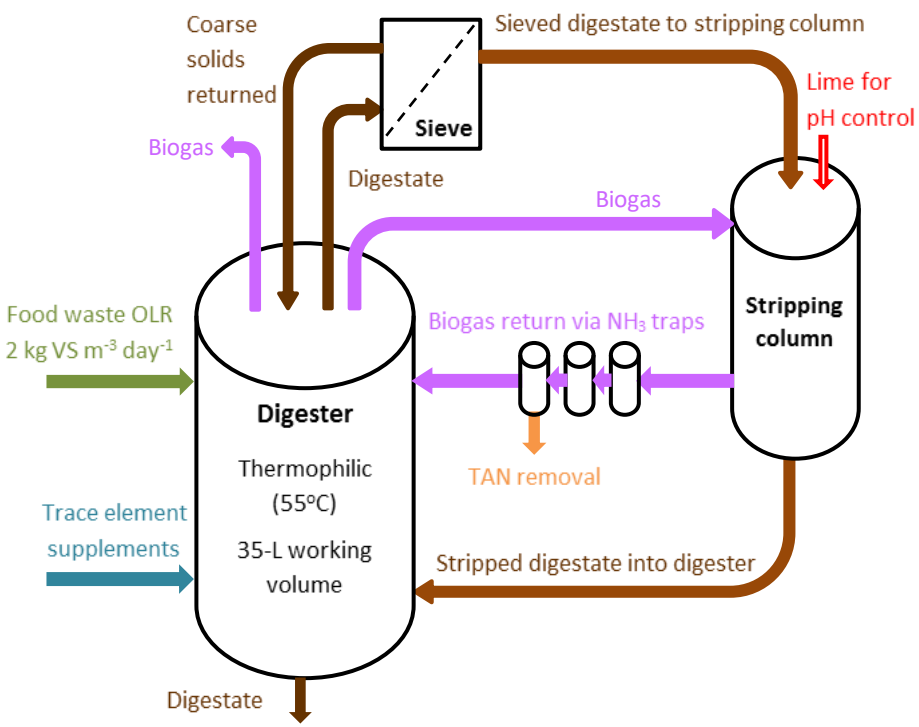
Thermophilic stripping

- Same process configuration
- Natural TAN concentration toxic, so must maintain low concentrations from the start



- Inoculum from a mesophilic digester treating sewage sludge
  - adapted to thermo conditions
- Work carried out by Wei Zhang

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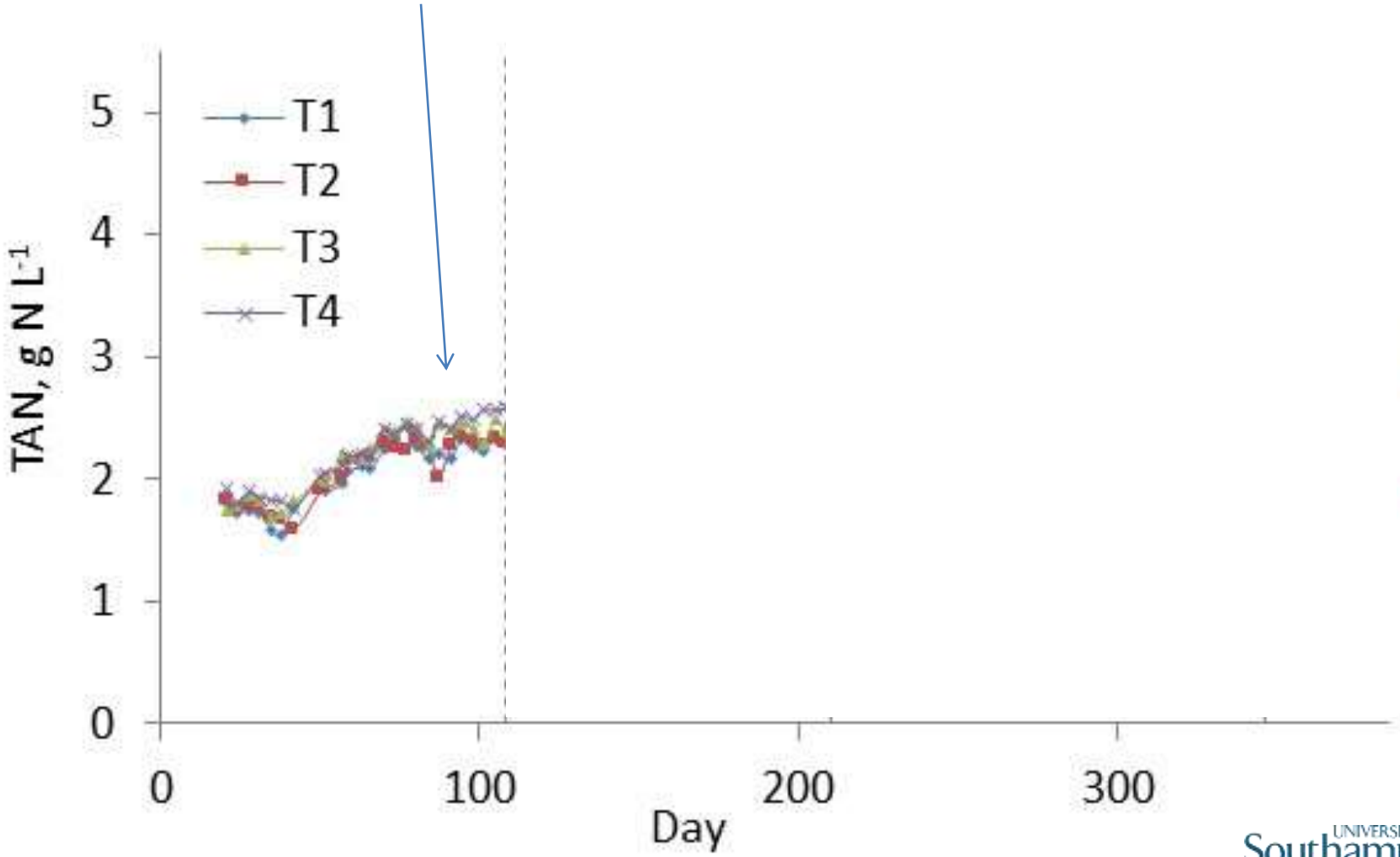
Thermophilic stripping

All digesters same conditions: pH 10, 2.1 kg digestate stripped at 70 °C 2 x a week



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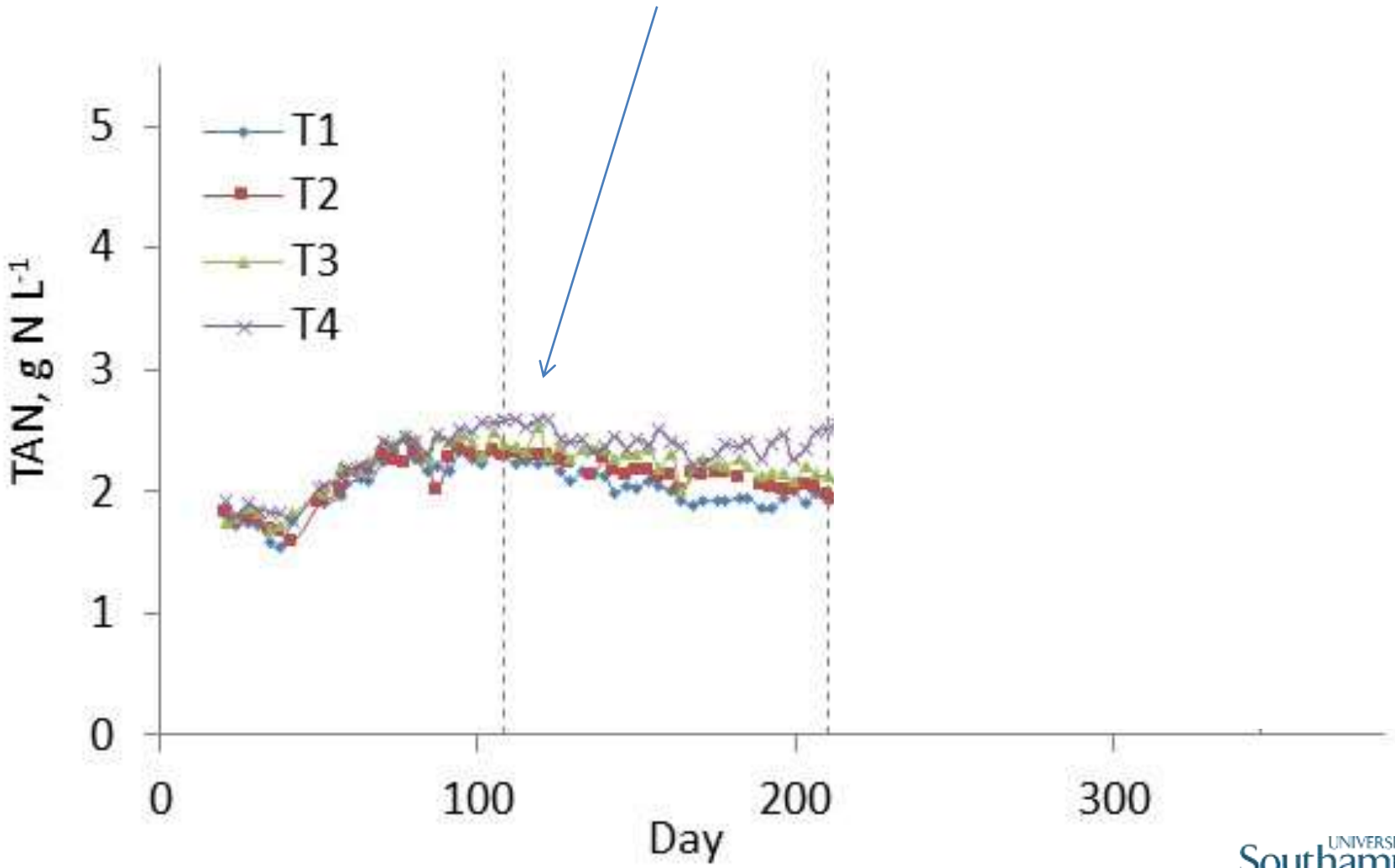
Thermophilic stripping

Same pH, temp: quantity stripped in T1 & T2 increased to 2.5 kg twice a week



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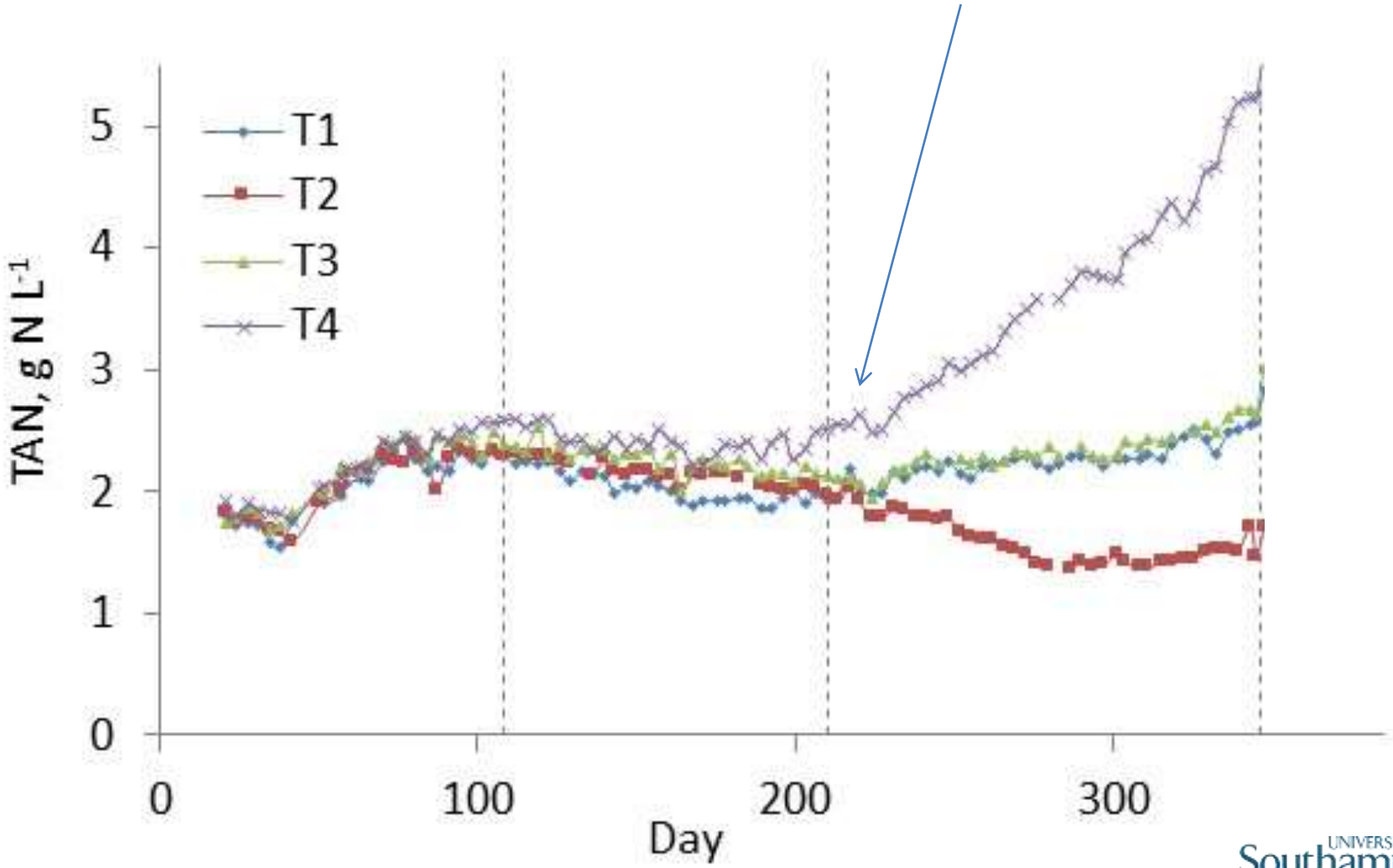
Thermophilic stripping

Stopped stripping in T4, doubled the amount stripped in T1 to 5 kg twice a week



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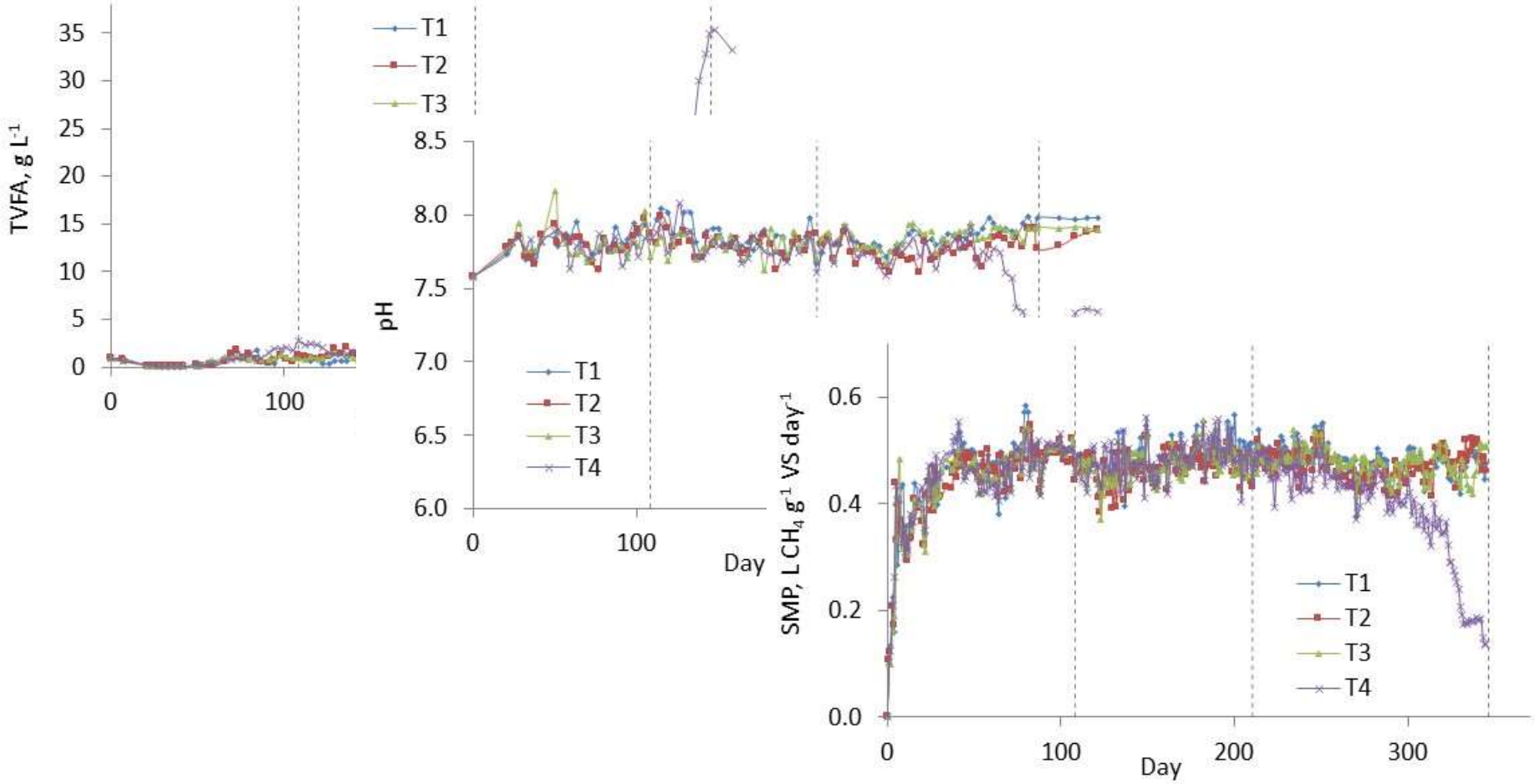
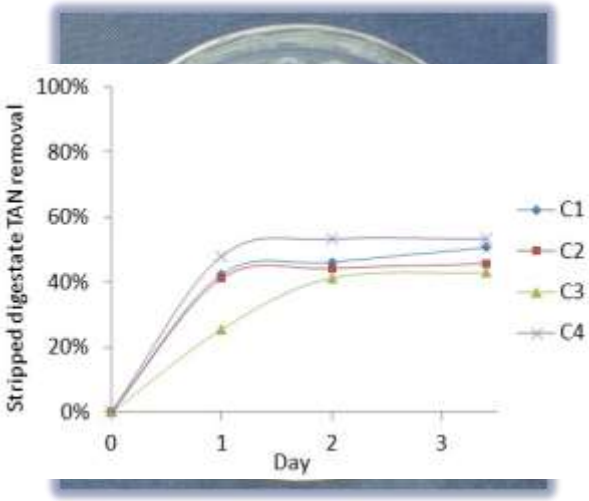


What are other people doing?

- Pedizzi et al. (2017) using air stripping rather than biogas
  - highly effective, no pH adjustment needed, but much larger volumes stripped (21% of digester volume 3 - 5 x a week)
- Bousek et al. (2016) looked at effect of different stripping gases
  - Flue gas might be more efficient than biogas
- Many others

What would we like to do next?

- Many aspects we can optimise
  - Type of gas and flow rate
  - pH control (in this study, Lime addition 14 g kg^{-1} digestate)
  - use of recovered ammonia (in this study 3.5 g N kg^{-1} digestate)
  - Continuous sidestream stripping



What does all this mean?

- Sidestream stripping shown to reduce TAN to low values → NH_3 inhibition can be controlled
  - makes digestion or co-digestion of high N feedstocks like slaughterhouse wastes a real possibility
  - makes thermophilic digestion an option for high N feedstocks
- TAN recovery as high value product possible, though economic feasibility may depend on scale
- Can control TAN concentration by modifying stripping conditions → 'designer' digestates possible to meet specific soil requirements
- Above all, we have a process that **works** and is ready for demonstration

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Thank you!

Work kindly supported by

wrap Material change for a better environment

SEVENTH FRAMEWORK PROGRAMME VALORGAS

AD NETWORK Harnessing Anaerobic Digestion

PERMASTORE TANKS & SILOS

References

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