N-2 The Future:

Lessons Learned from Nitritation/Anammox Treatment of Swine Waste For Nitrogen Removal

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Agenda

- Research Context
- Requisites for Anaerobic Ammonium Oxidation “anammox”
- Reactor Description
- Operational Problems
- System Performance and Biomass Morphology
- Conclusions

Research Context

Swine Farms in NC

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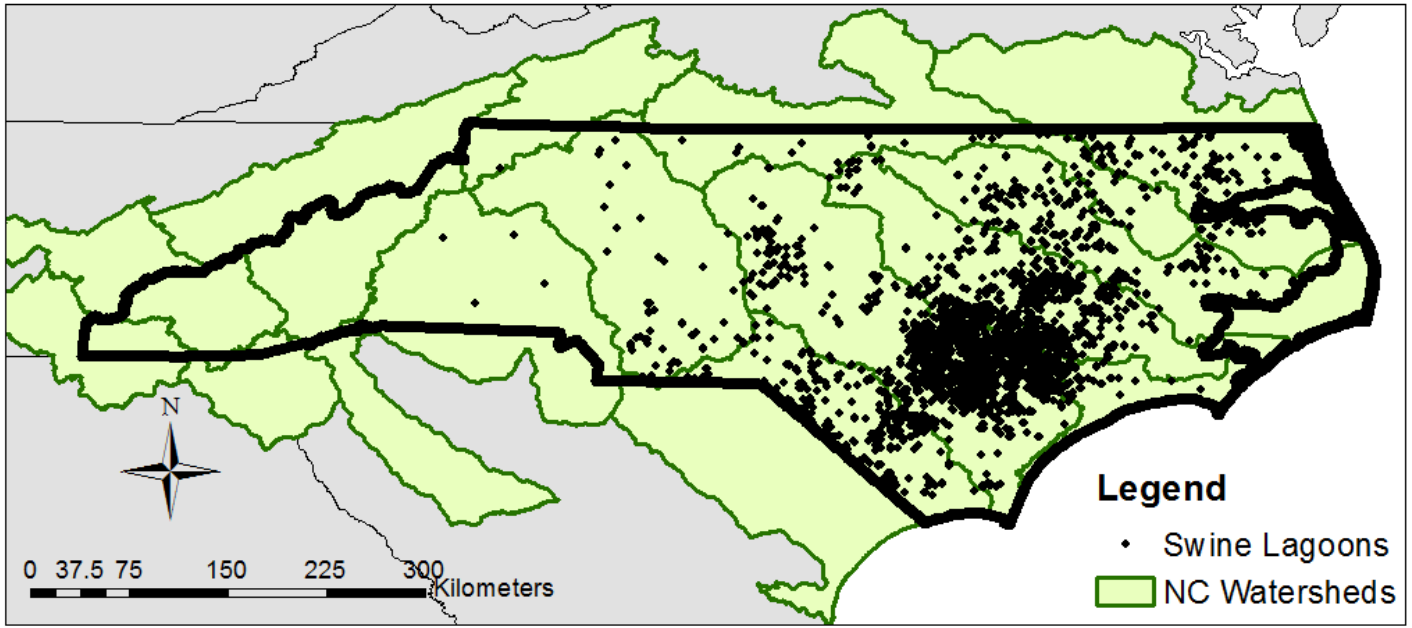
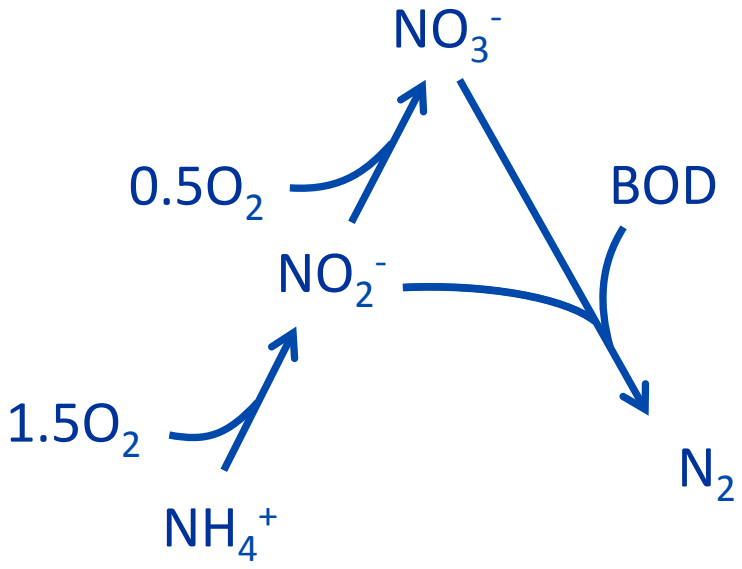


- Over 100,000 lb N/day produced collectively
- Explore coupling power generation and N removal
  - 2,500 L MLE
  - 20 L nitritation/anammox SBR

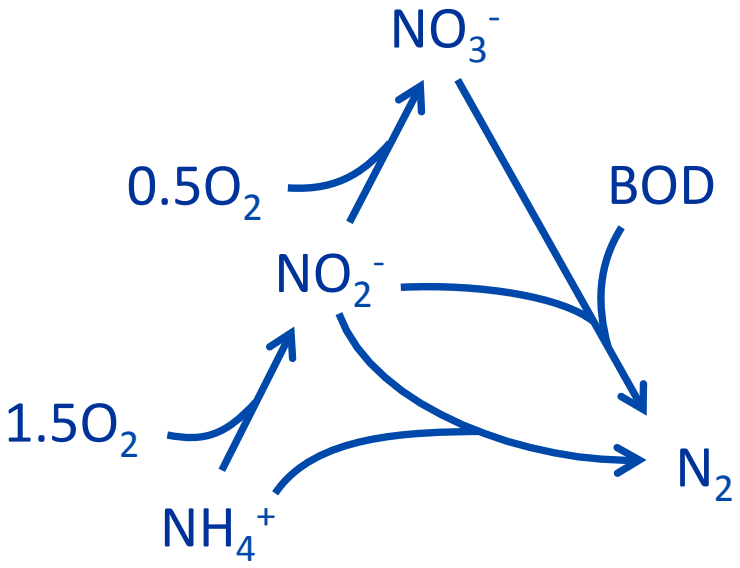
Nitrification/Denitrification



$3.00-3.50/lb N

≈1.8 kWh/lb N

Nitritation/Anammox



$3.00-3.50/lb N
≈1.8 kWh/lb N

$1.00-1.25/lb N
≈0.6 kWh/lb N

Nitritation/Anammox

$$NH\downarrow 4\uparrow + + 1.5O\downarrow 2 \rightarrow NO\downarrow 2\uparrow - + 2H\uparrow + + H\downarrow 2\ O$$
$$NH\downarrow 4\uparrow + + NO\downarrow 2\uparrow - \rightarrow N\downarrow 2 + 2H\downarrow 2\ O$$

$$NH\downarrow 4\uparrow + + 1.32NO\downarrow 2\uparrow - + 0.066HCO\downarrow 3\uparrow - + 0.13H\uparrow +$$
$$\rightarrow 1.02N\downarrow 2 + 0.26NO\downarrow 3\uparrow - + 0.066CH\downarrow 2\ O\downarrow 0.5\ N\downarrow 0.15$$
$$+ 2.03H\downarrow 2\ O$$

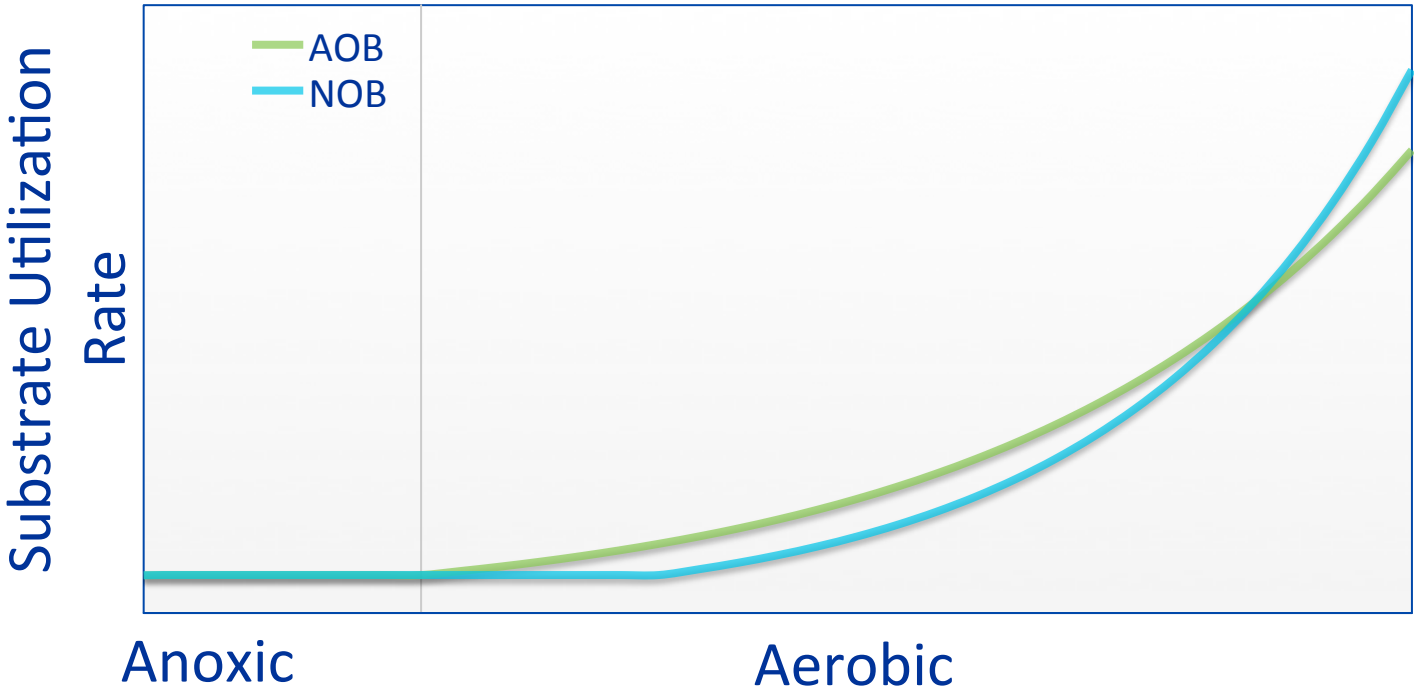
$$NH\downarrow 4\uparrow + + 0.85O\downarrow 2 \rightarrow 0.45N\downarrow 2 + 0.1NO\downarrow 3\uparrow - + 1.1H\uparrow +$$

Anammox Requisites

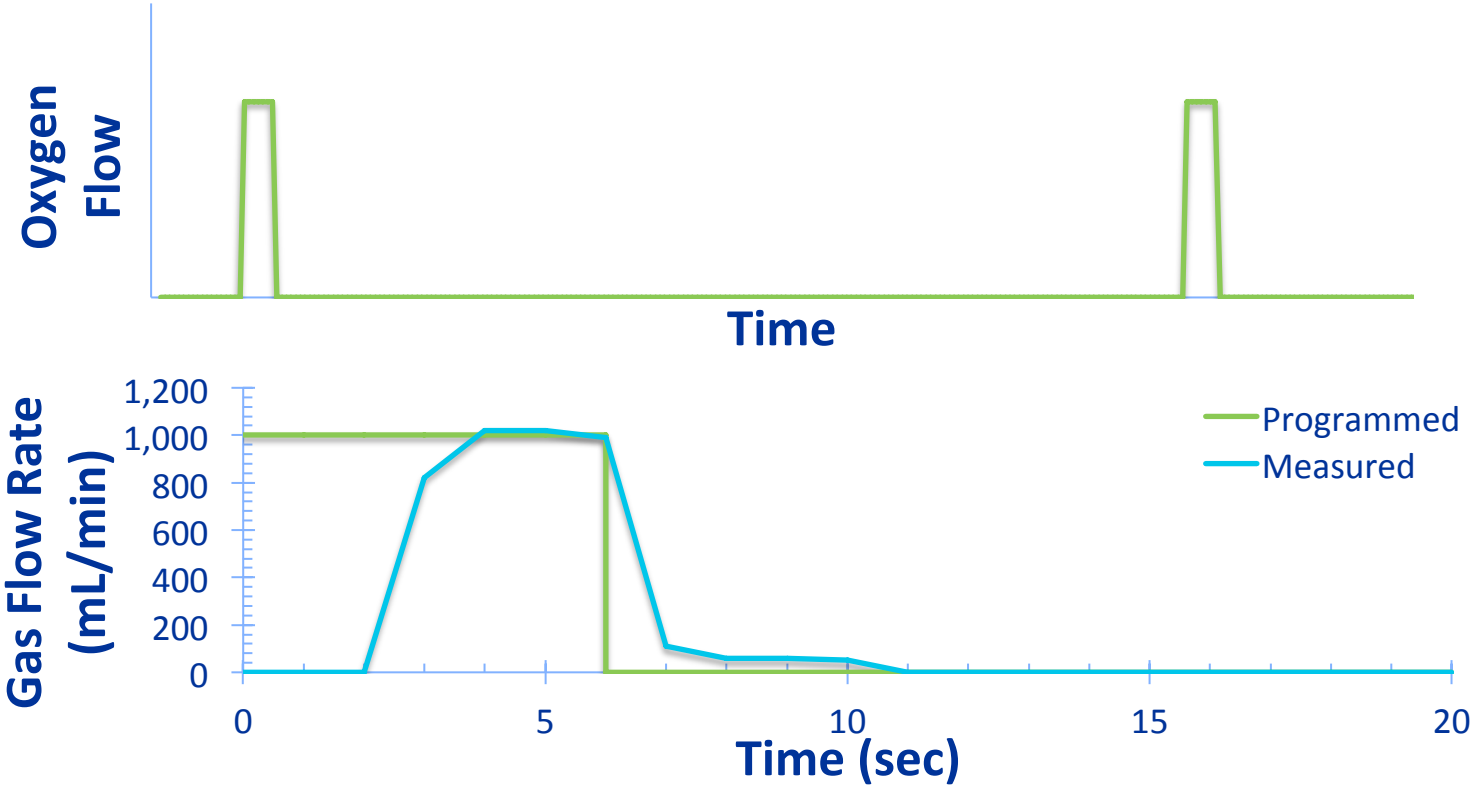
Anammox Requisites

1. Ammonium and nitrite
2. Low BOD/N ratio
3. NOB inhibition
4. Nitrite control
5. Efficient (≈100%) solids retention
   - Granules?
   - Biofilm?

Growth of AOB/NOB After Anoxic Exposure

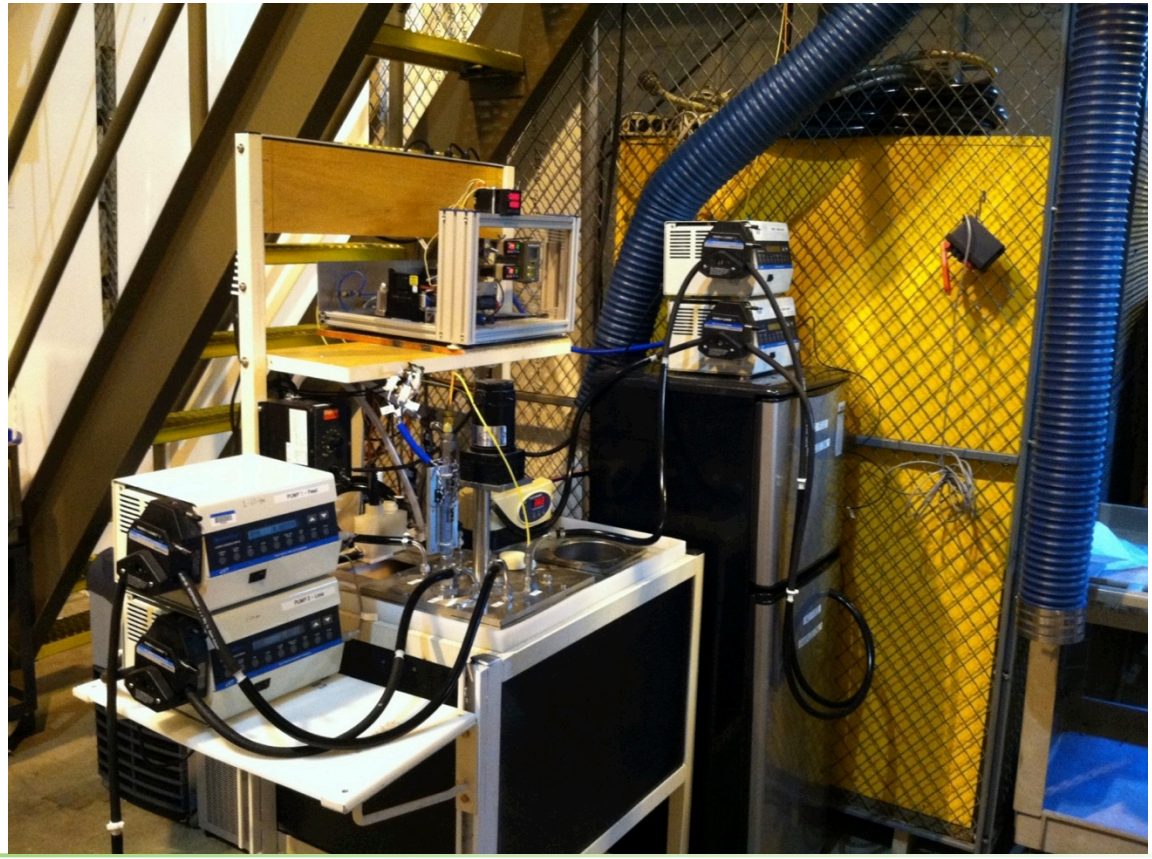


Transient Oxic Conditions

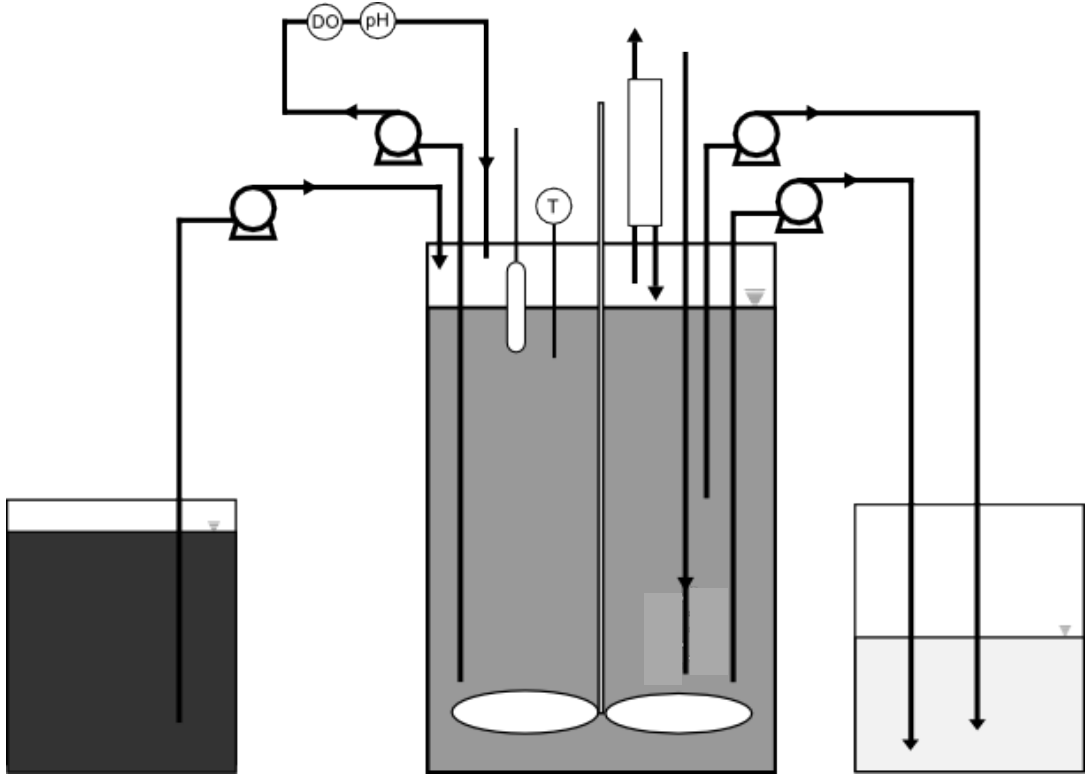


Reactor Description

Anammox SBR



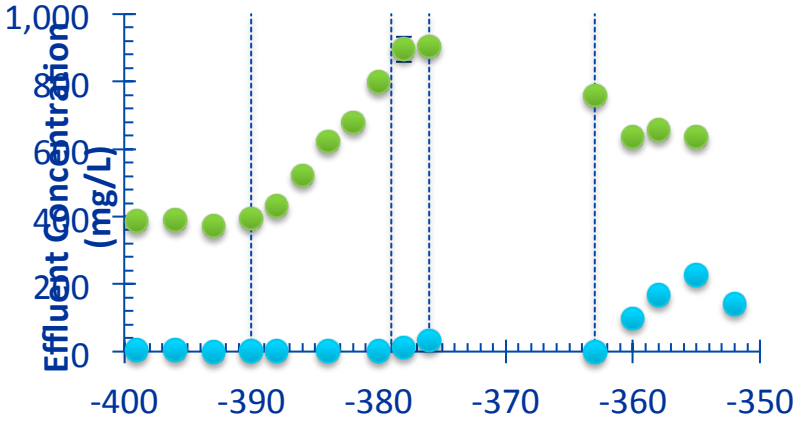
Anammox SBR

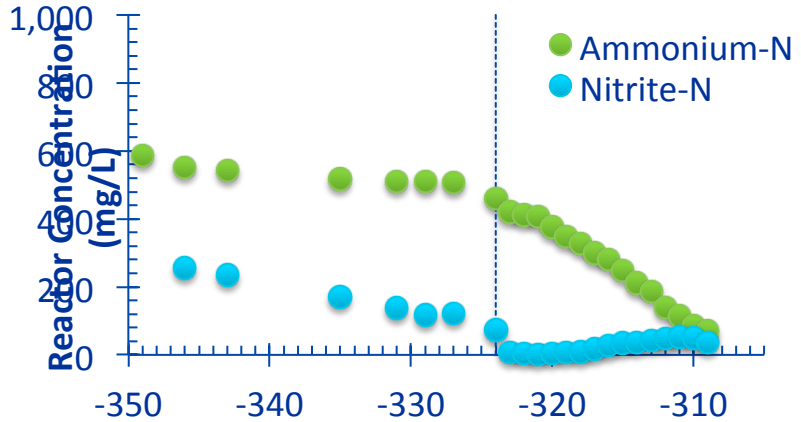


Anammox SBR

REACTOR UPSETS

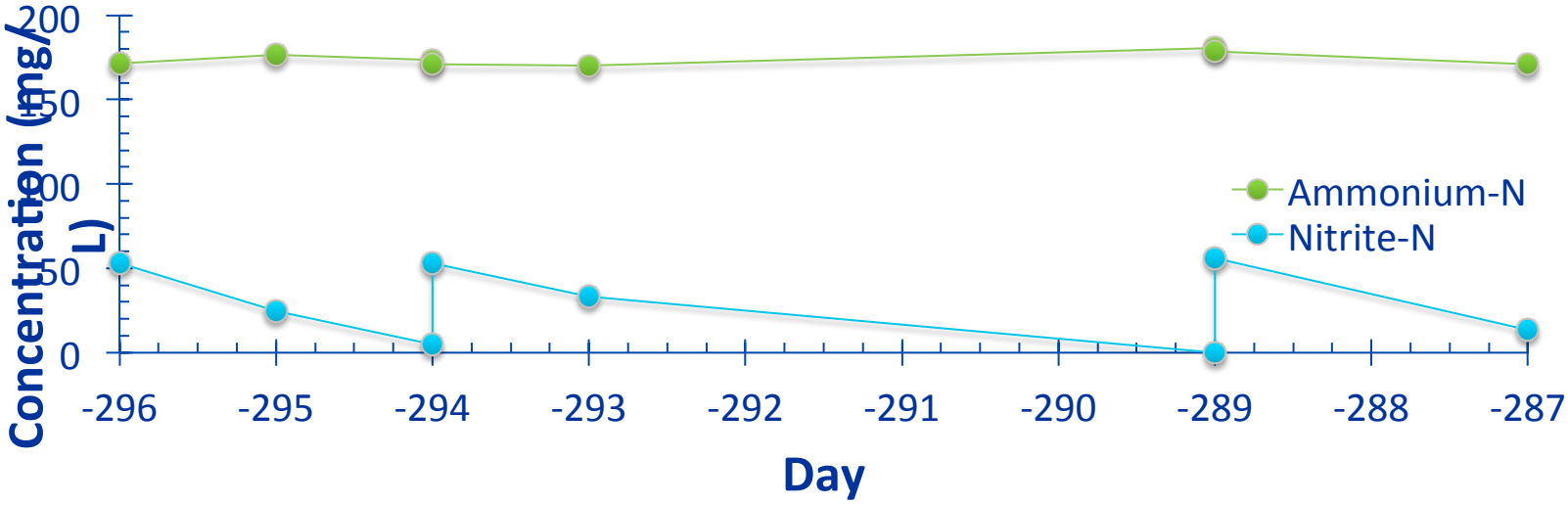
Reactor Upsets





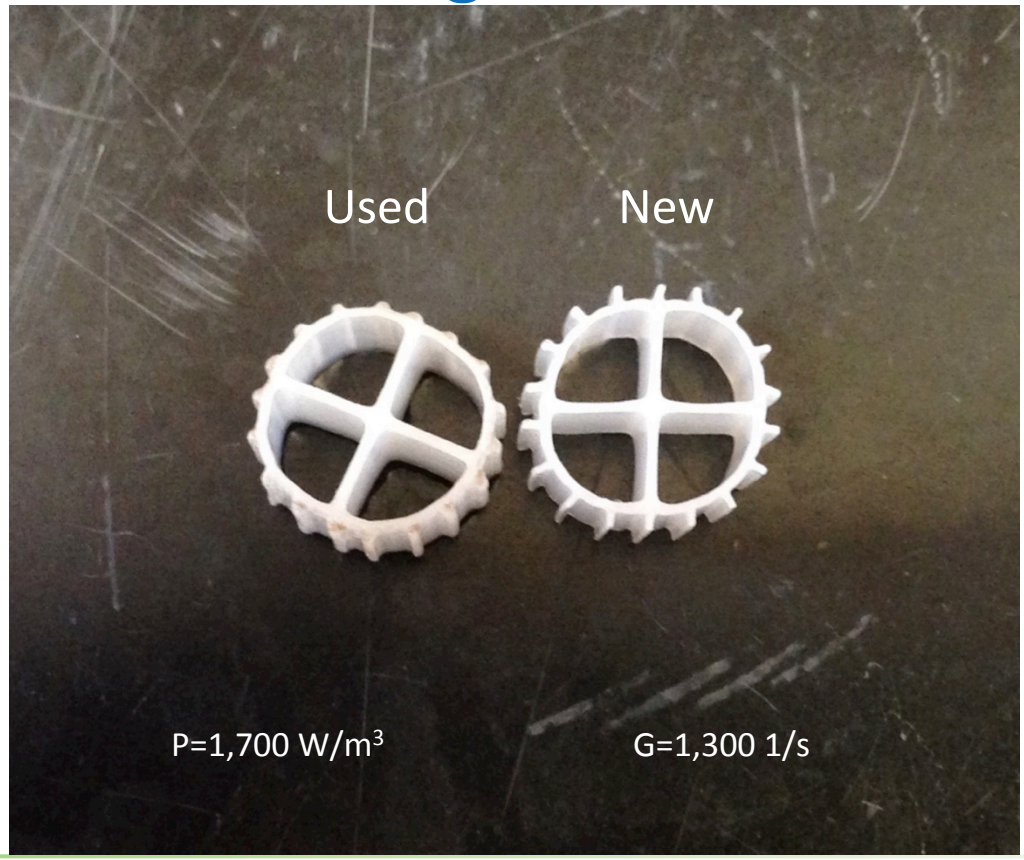
- Day -390 — Disrupt biofilm
- Day -379 — Increase oxygen supply
- Day -376 — Incubate anaerobically
- Day -363 — Resume aeration
- Day -349 — Stop feeding/incubate anaerobic
- Day -324 — Add fresh anammox granules

Mixed Liquor Activity

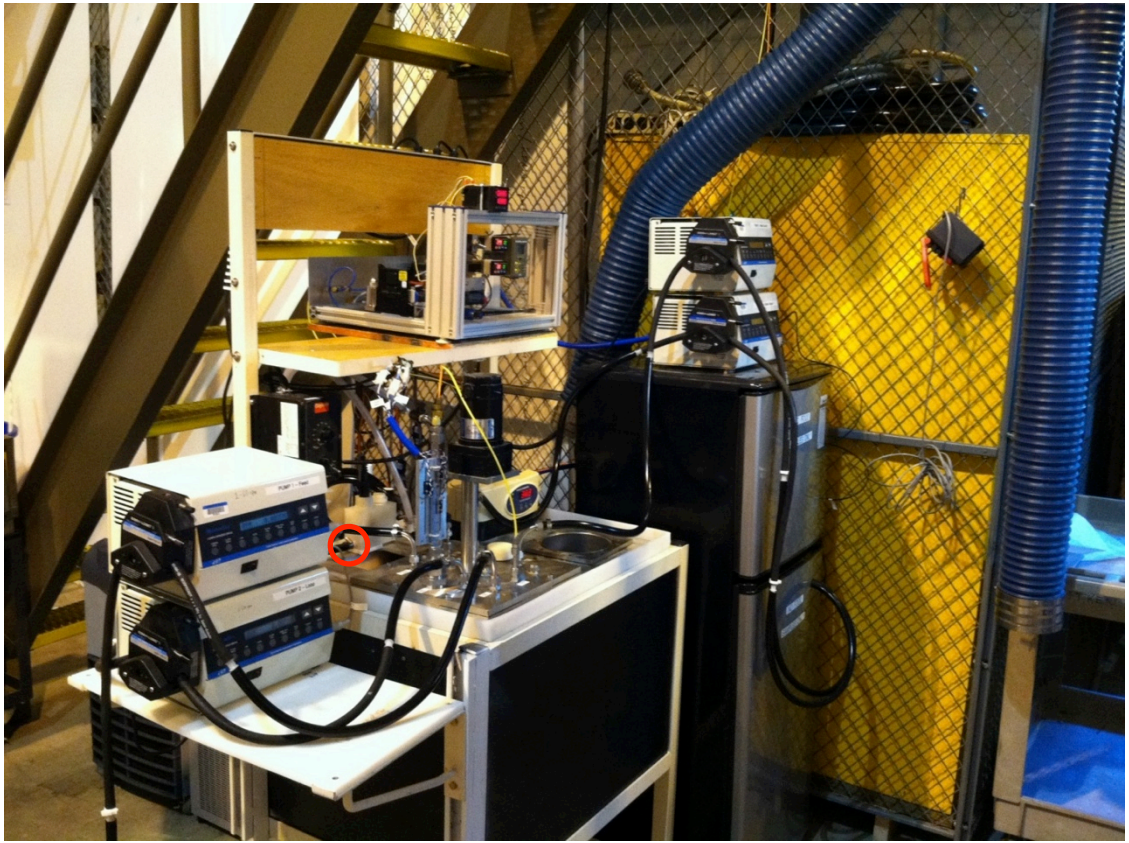


- Subsample sample of mixed liquor
- Nitrite consumption without ammonium consumption
  - Likely endogenous decay
- Transition to biofilm based system

Moving Bed Media



Loss of Reactor Contents



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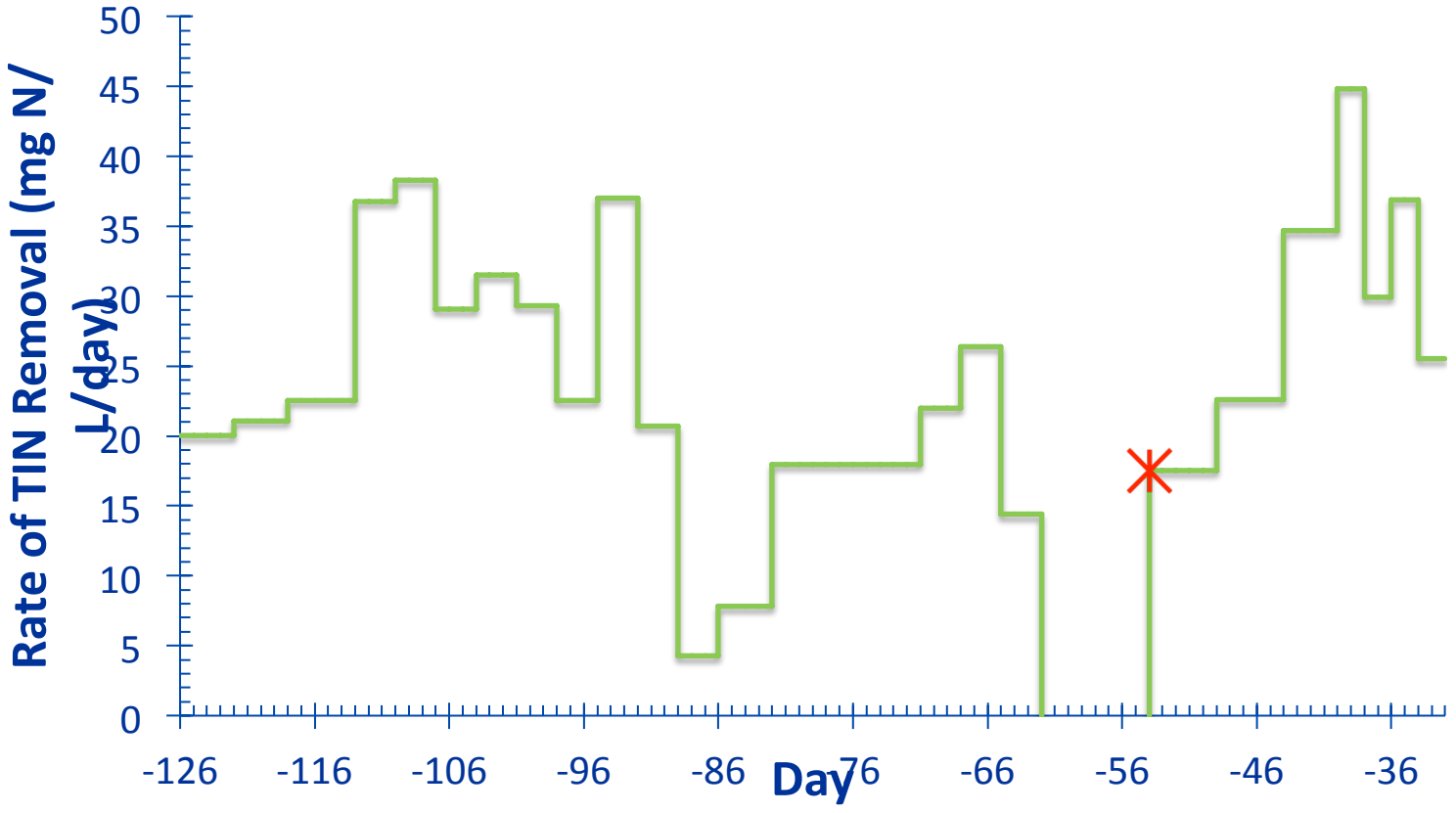
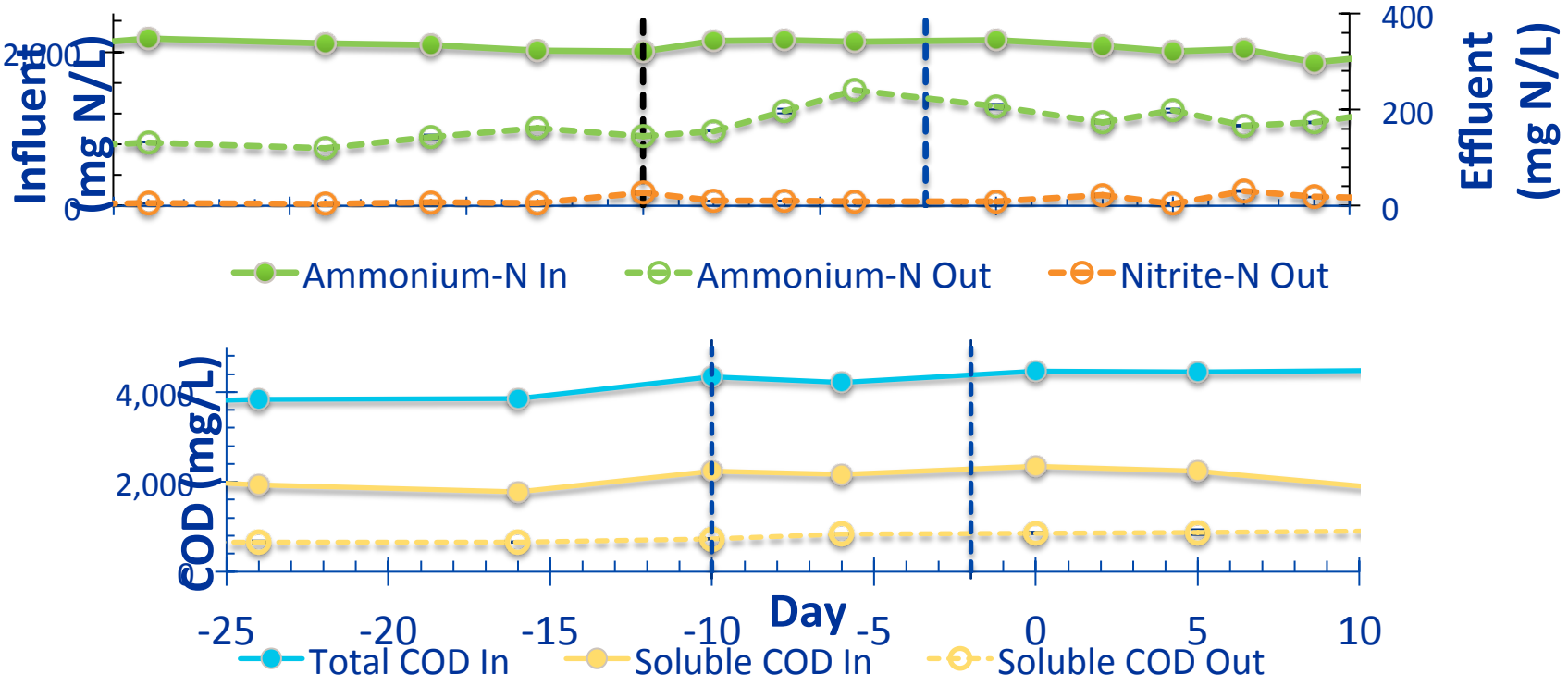
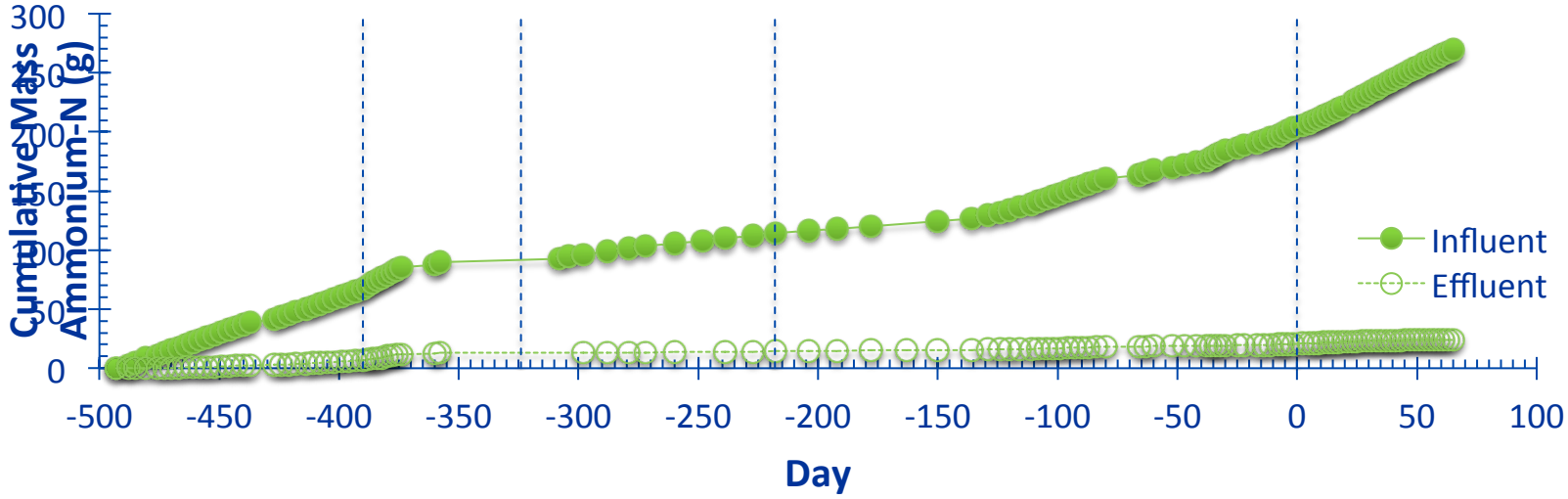


COD Degradation



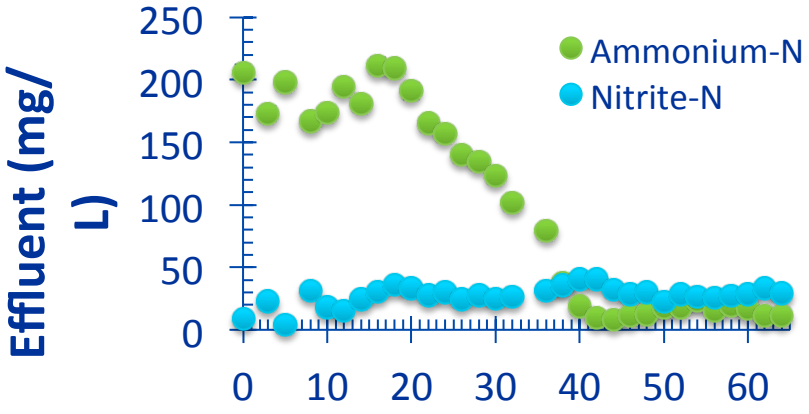
System Performance

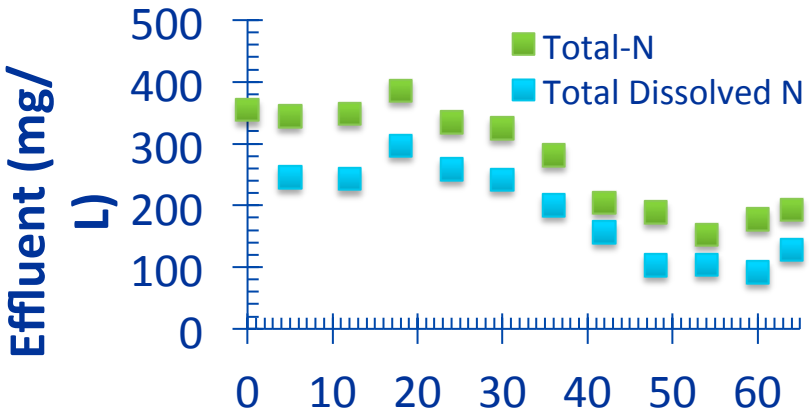
System Performance Overview



- Day -390 Clean Biofilm
- Day -324 Add HRSD Granules
- Day -218 Add Biofilm Media
- Day 0 Begin System Assessment

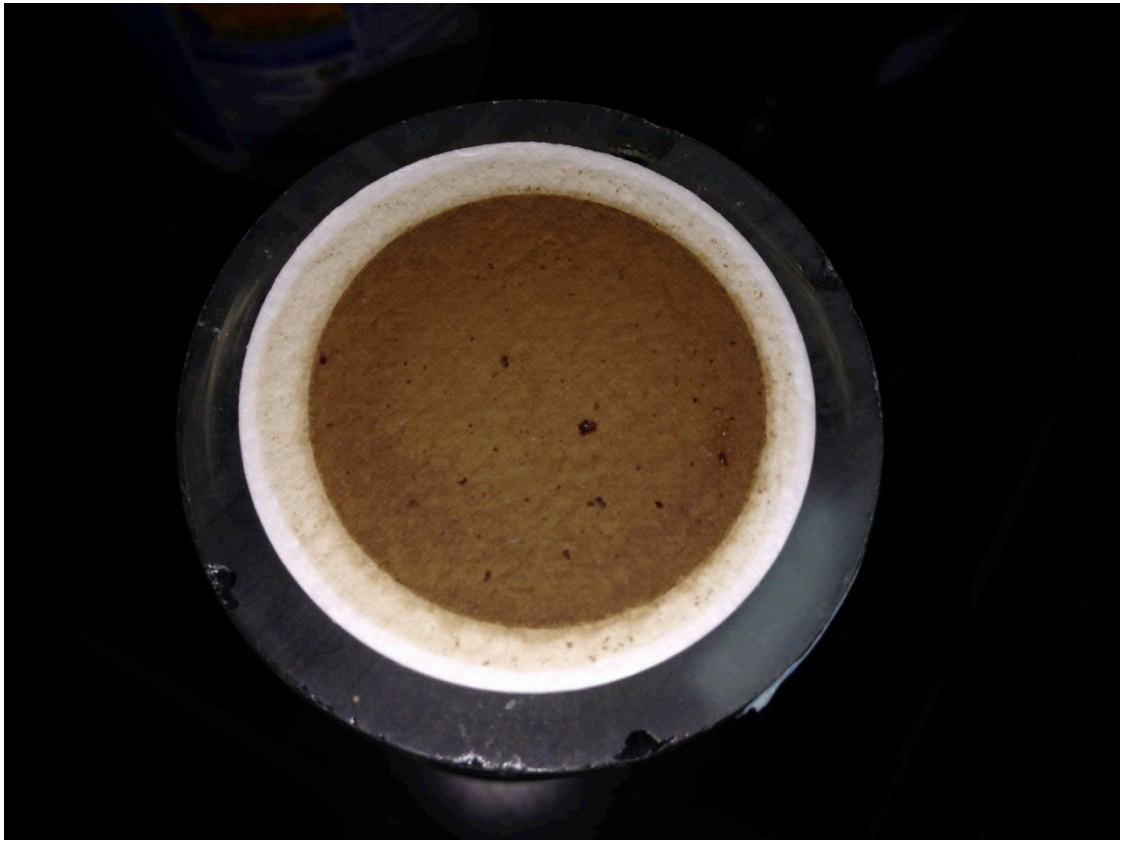
System Performance



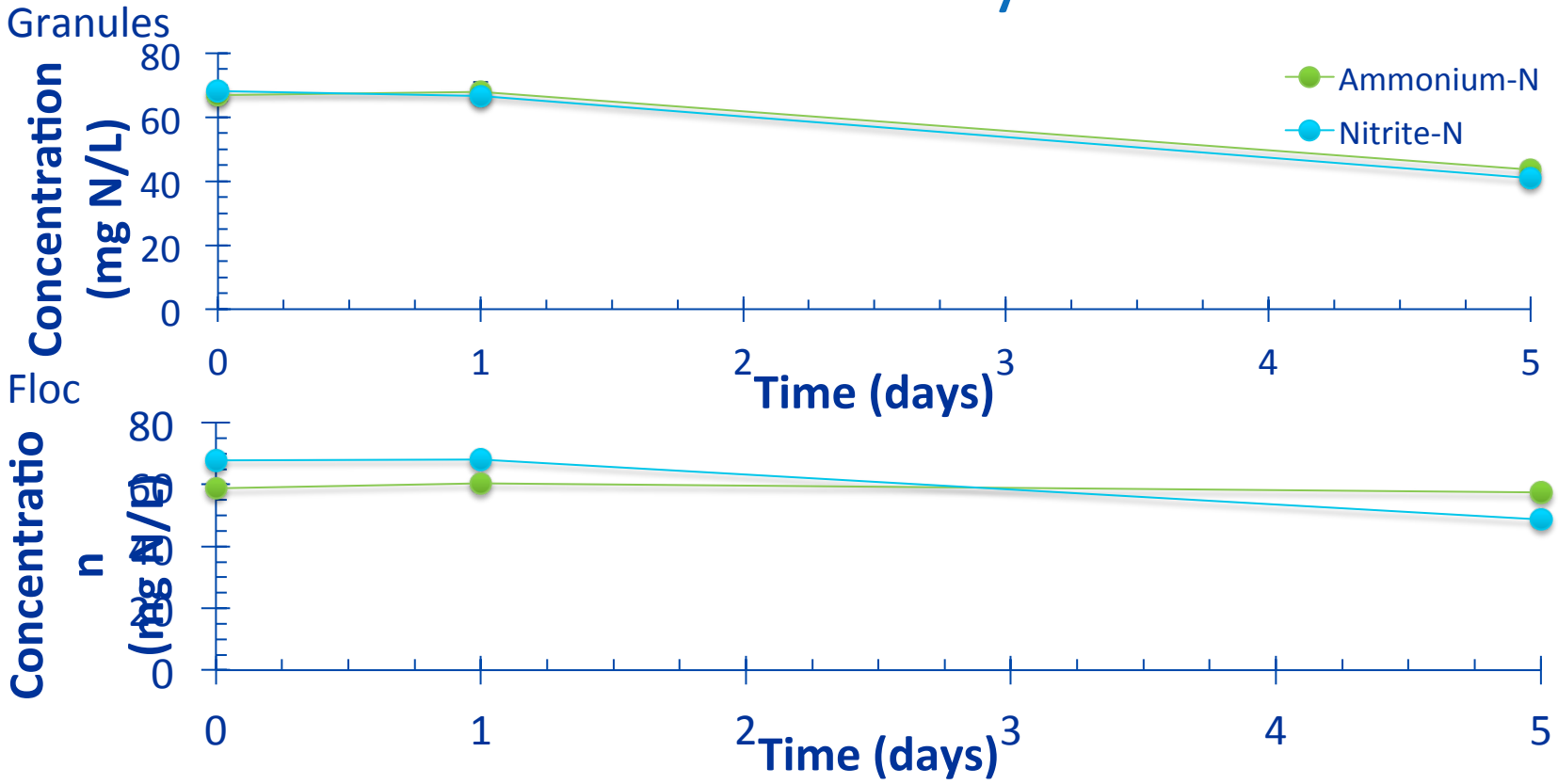


Consumed	
NH_4^+-N	99%
TN	93%
tCOD	45%
tCOD/TN	1.8 g/g
O_2/TN	1.5-2.3 g/g
NO_2^--N/NH_4^+-N	0.8-2.1 g/g

Granules



Biomass Activity



Conclusions

Conclusions

- Maintain a low concentration of nitrite
- Transient oxygen addition can inhibit NOB
- Anammox bacteria only active in large aggregates
- Beware of mixing power in an MBBR
- Little difference between anammox and conventional systems
  - Establish environments for the desired activity
  - Balance loading rates to system capacity

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QUESTIONS?
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