Tighe&Bond

Engineers | Environmental Specialists

A GLOBAL COMMUNITY WITHIN ANAMMOX BIOREACTORS

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Ray Keren, University of California Berkeley

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PRESENTATION OVERVIEW

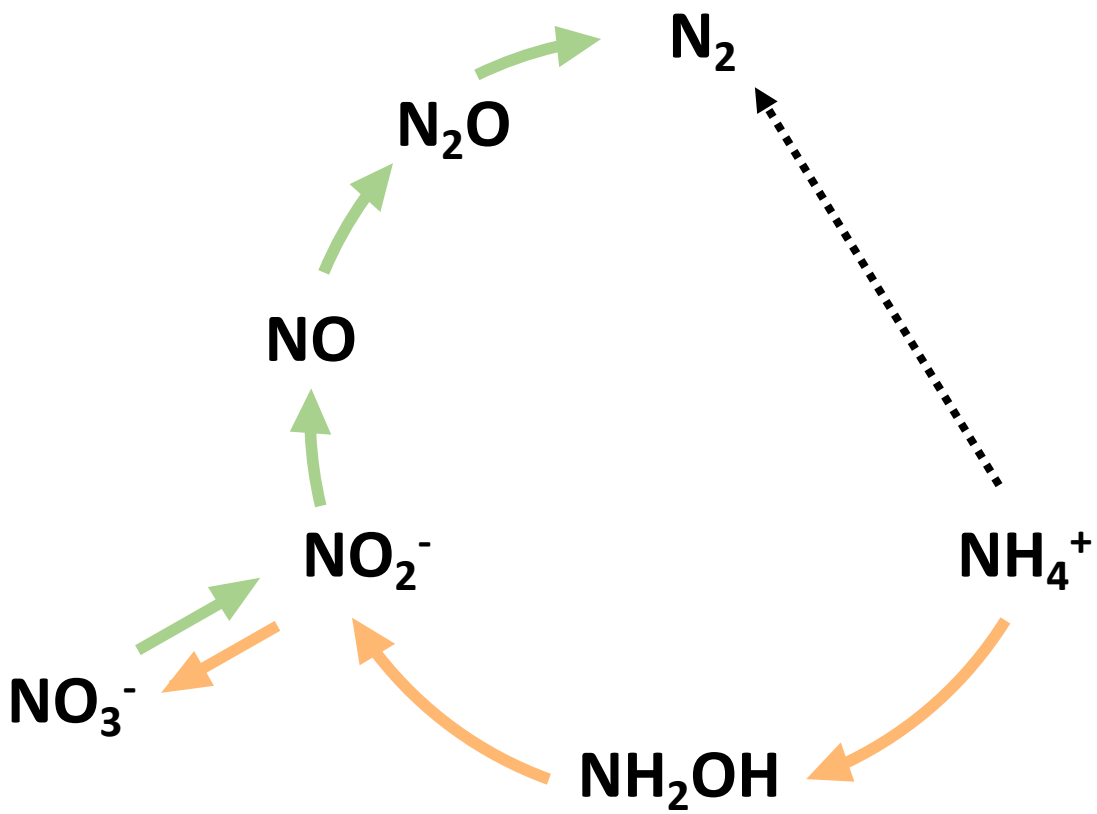
- Anaerobic Ammonium Oxidation (Anammox)
- Metagenomics
- Case Study – Application of Metagenomics to Anammox Reactors

ANAMMOX

ANAMMOX

Conventional Nitrogen Removal

- Nitrification
- Denitrification



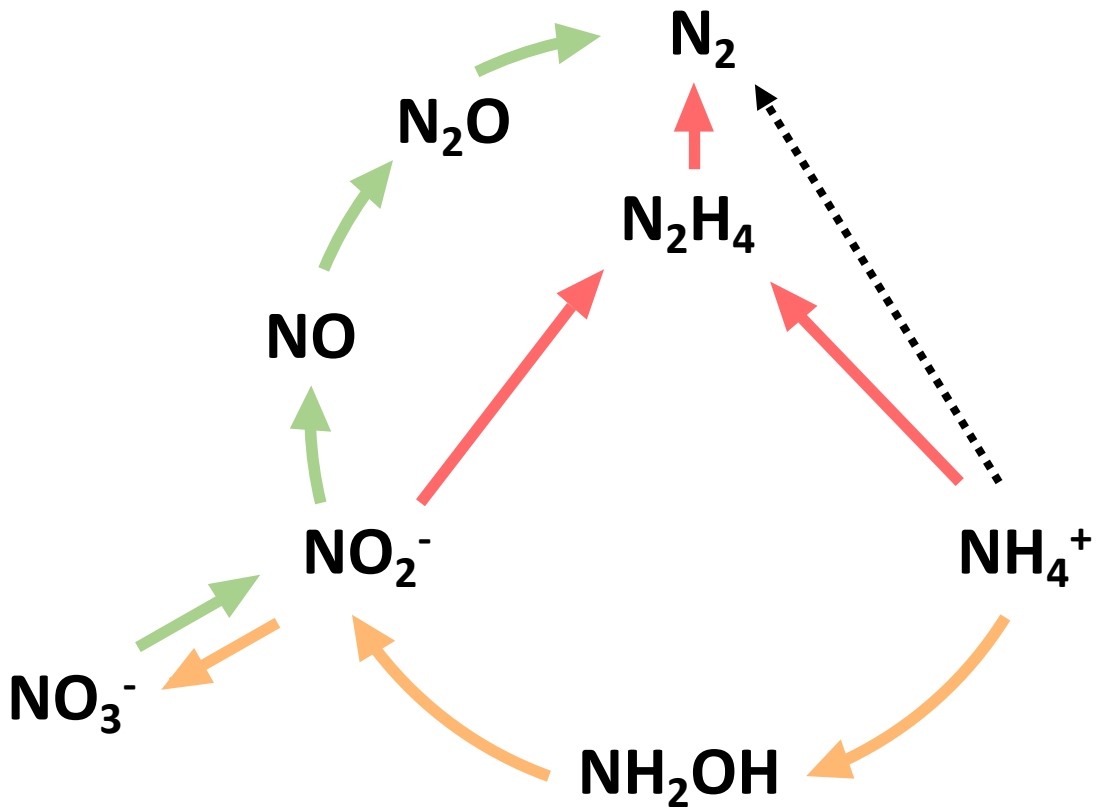
ANAMMOX

Conventional Nitrogen Removal

- Nitrification
- Denitrification

Anammox / Deammonification

- Partial nitritation
- Anaerobic ammonium oxidation (anammox)



ANAMMOX

Denver, CO

Alexandria, VA

ANAMMOX

Strengths:

- Decreased aeration demands
  - 60% reduction in energy consumption
- Decreased organic carbon demands
  - 90% reduction in waste biomass
  - Reduction in CO_2 emissions
- Reduction in N_2O emissions

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  - Instability
  - Periodic Failures
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What are these bugs doing?

METAGENOMICS

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GENE

- Unit of DNA that controls the development of one or more traits, and is the basic unit by which genetic information is passed from parent to offspring

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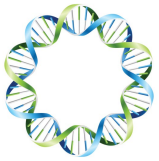

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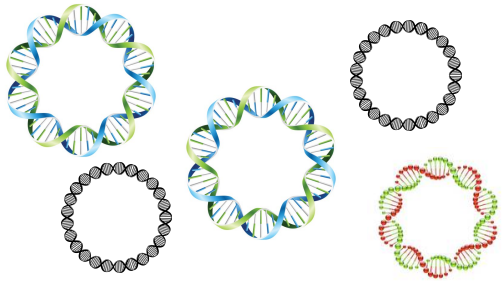
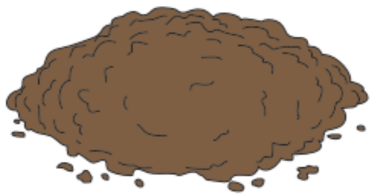
METAGENOMICS



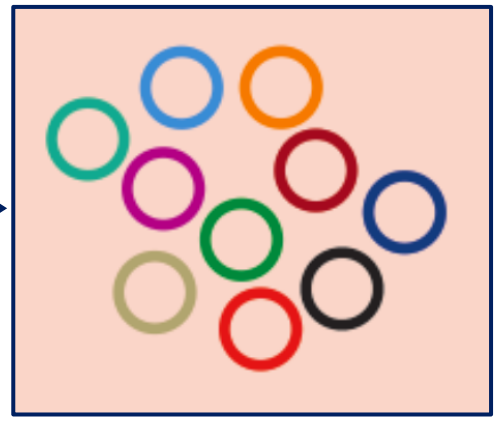
- The study of genetic material recovered directly from environmental samples

METAGENOMICS

1 g soil / biomass → **10^{12} genes** → **10^{9} genomes**



~10^{9} cells (genomes)
~10^{12} genes



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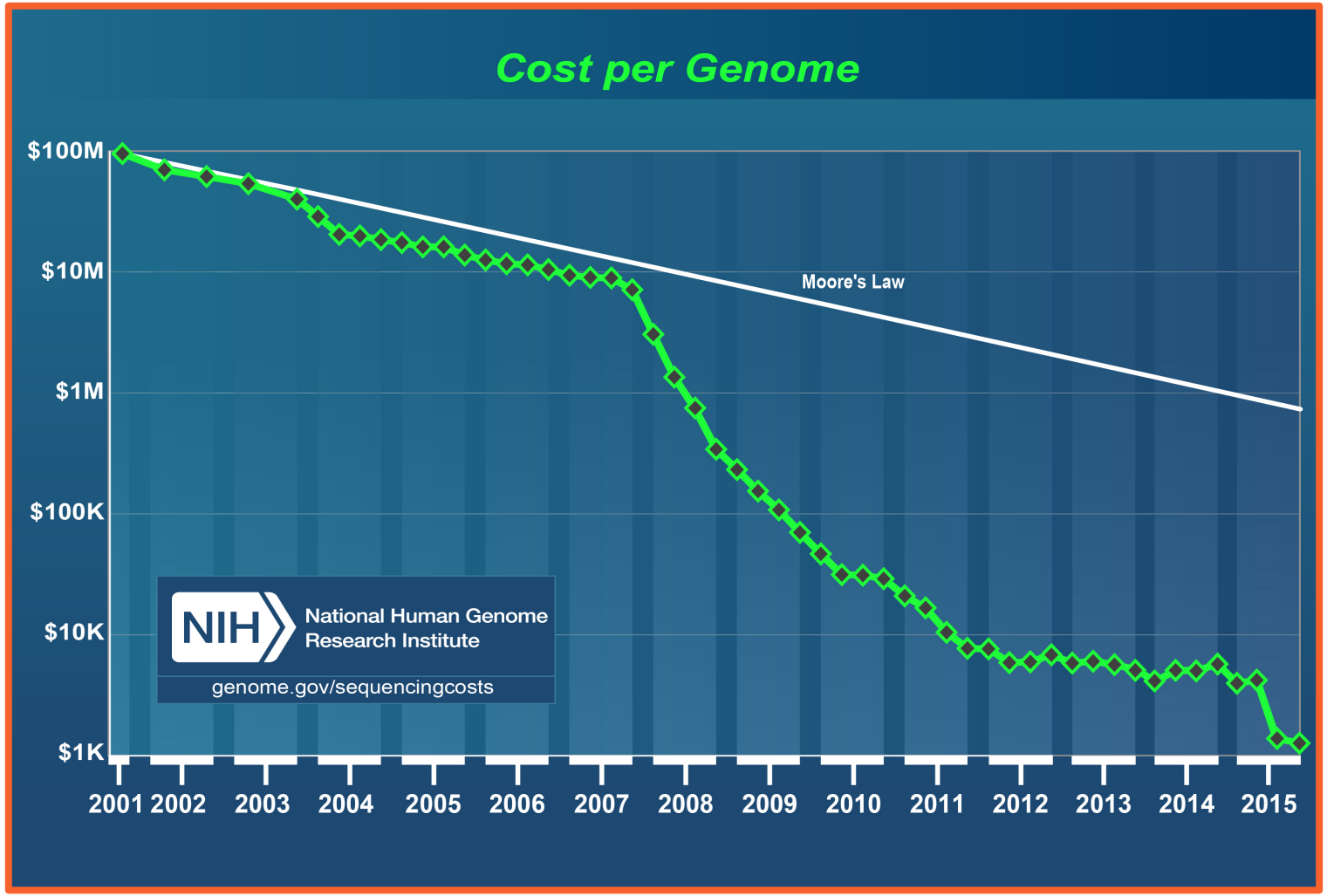

ANAMMOX & METAGENOMES

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- **Research Goal: Utilize insights from metagenomes to understand and improve the functionality of the anammox bioreactor**

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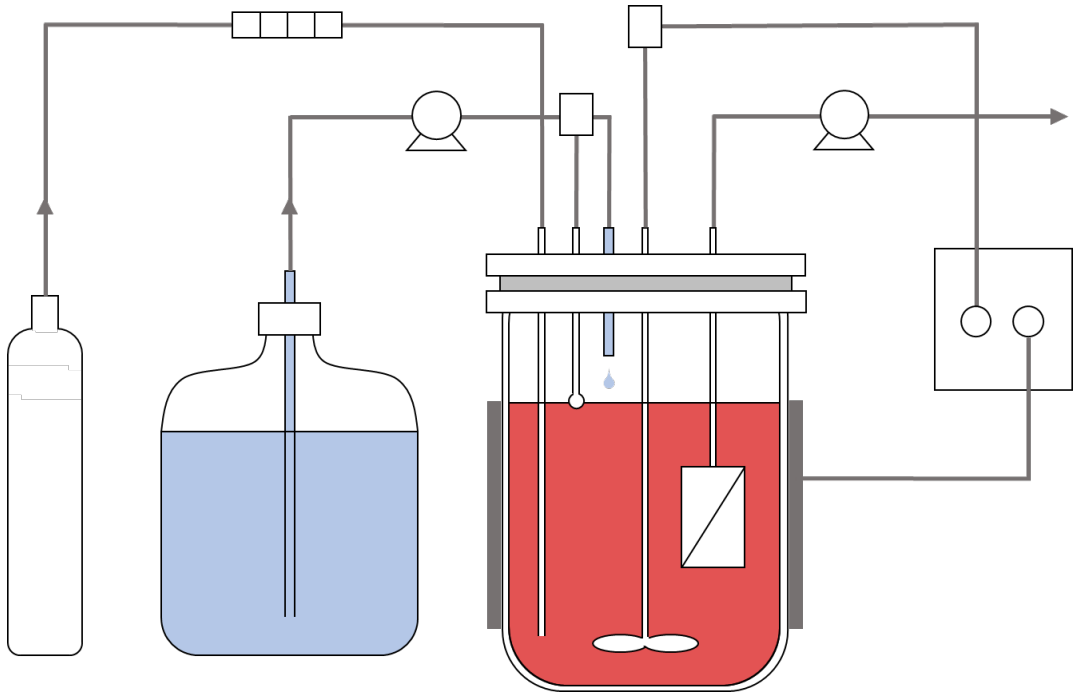
Bioreactor Setup:



Operating Conditions:

- Reactor:
  - Volume: 1L
  - Temperature: 37°C
  - HRT: 48-12 hours
  - SRT: ∞-50 days
- Influent:
  - Synthetic wastewater
  - $ArCO_2$

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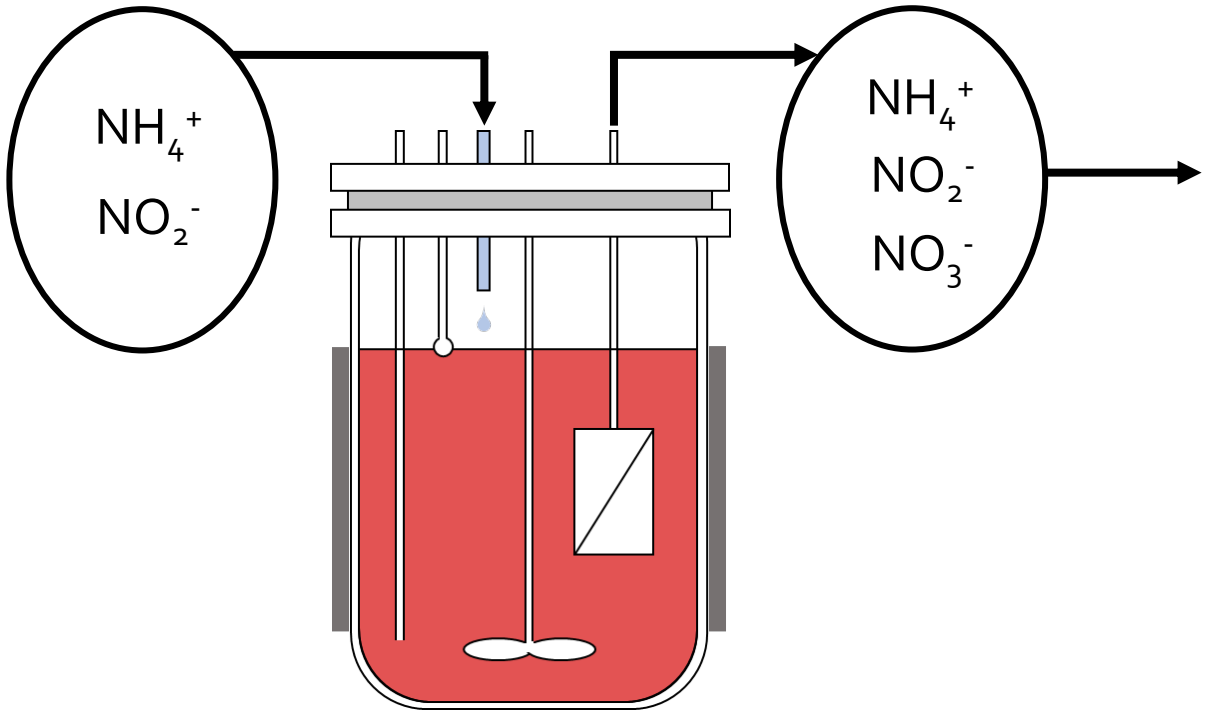
ANAMMOX & METAGENOMES

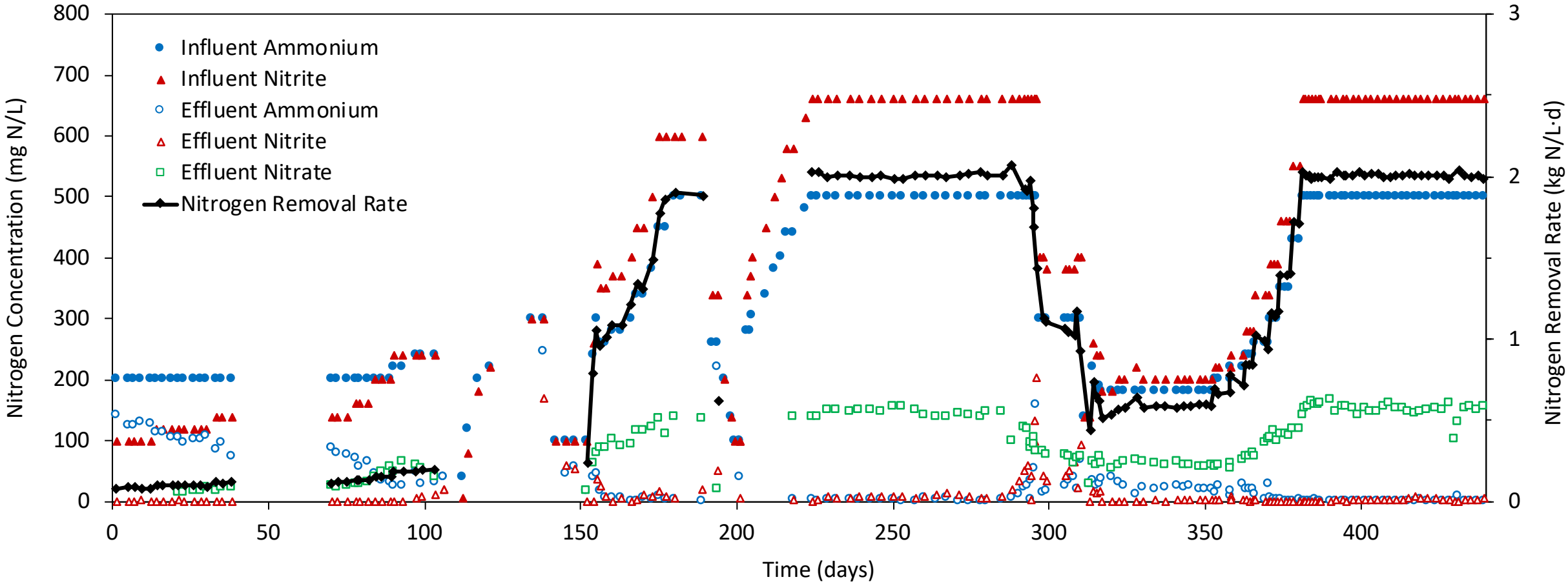
- **Performance: Tracked for over 400 days**

$$NH_4^+ + 1.32\ NO_2^- + \text{bicarbonate} \longrightarrow N_2 + 0.26\ NO_3^- + \text{biomass}$$



$$NRR = \frac{[N]_{inf} - [N]_{eff}}{HRT}$$

ANAMMOX & METAGENOMES



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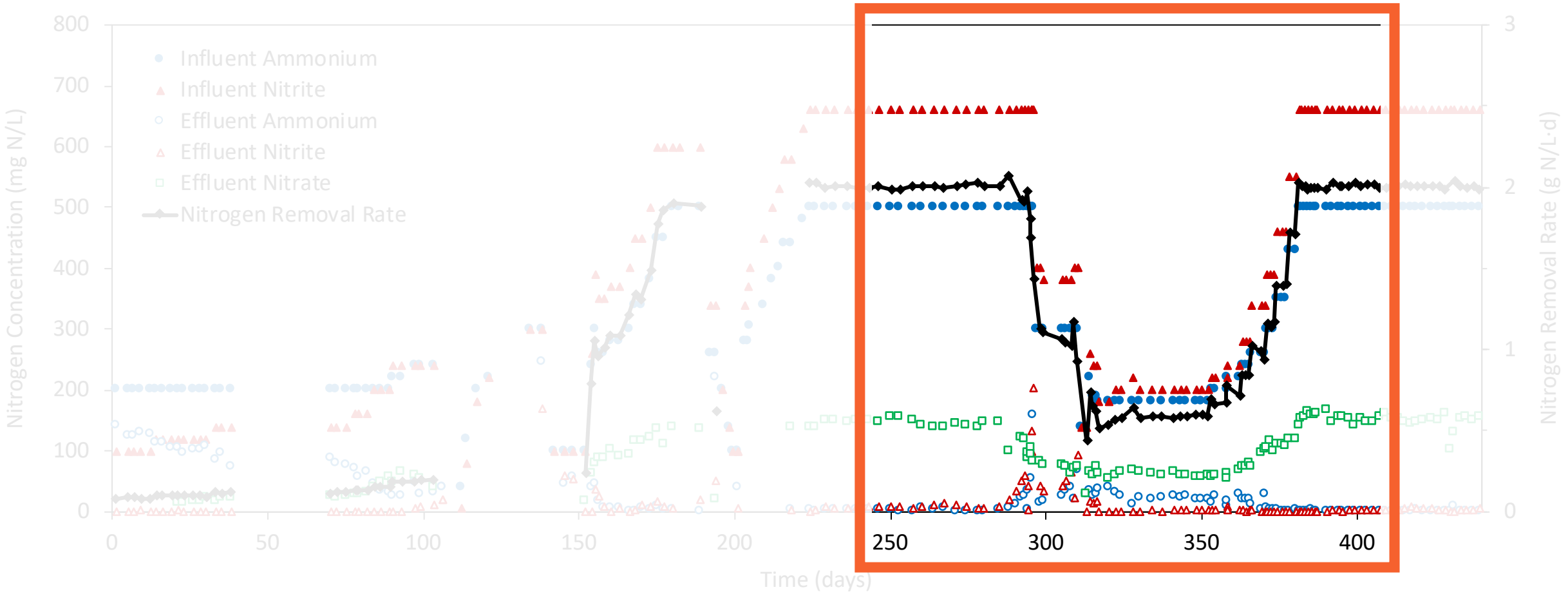

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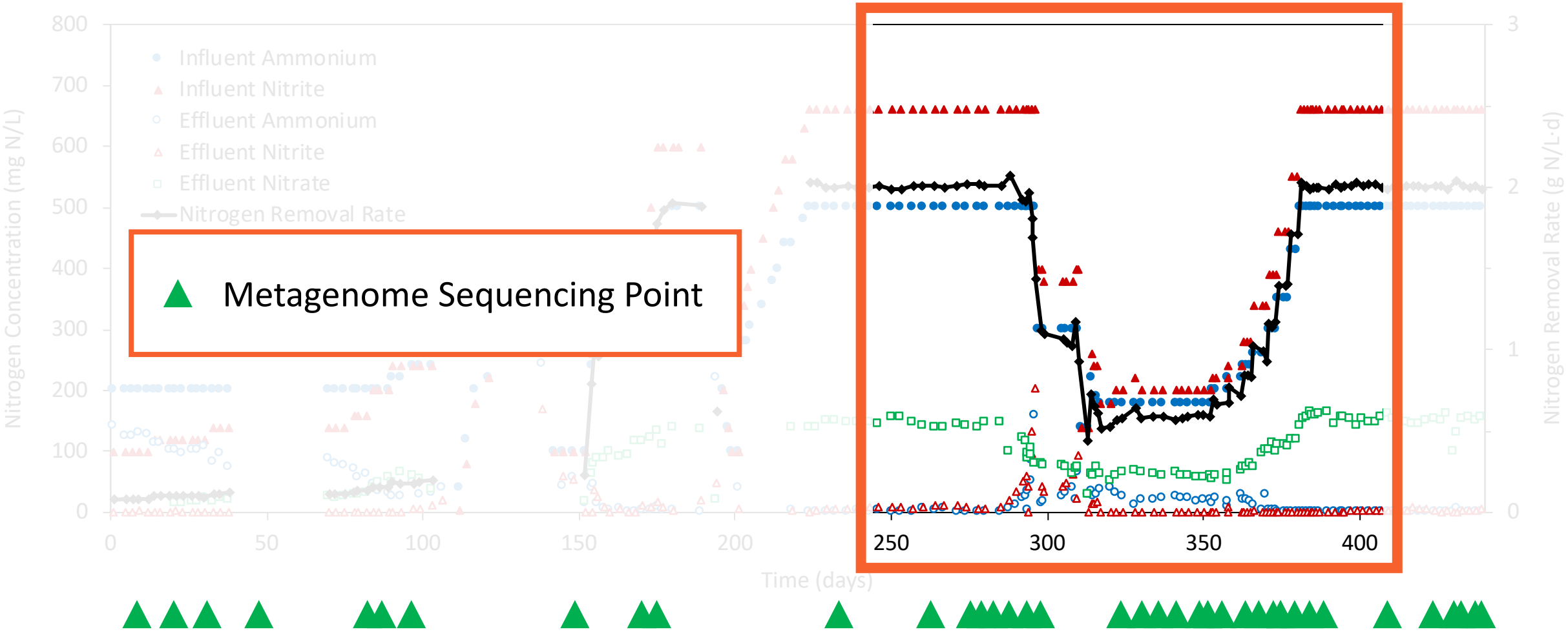
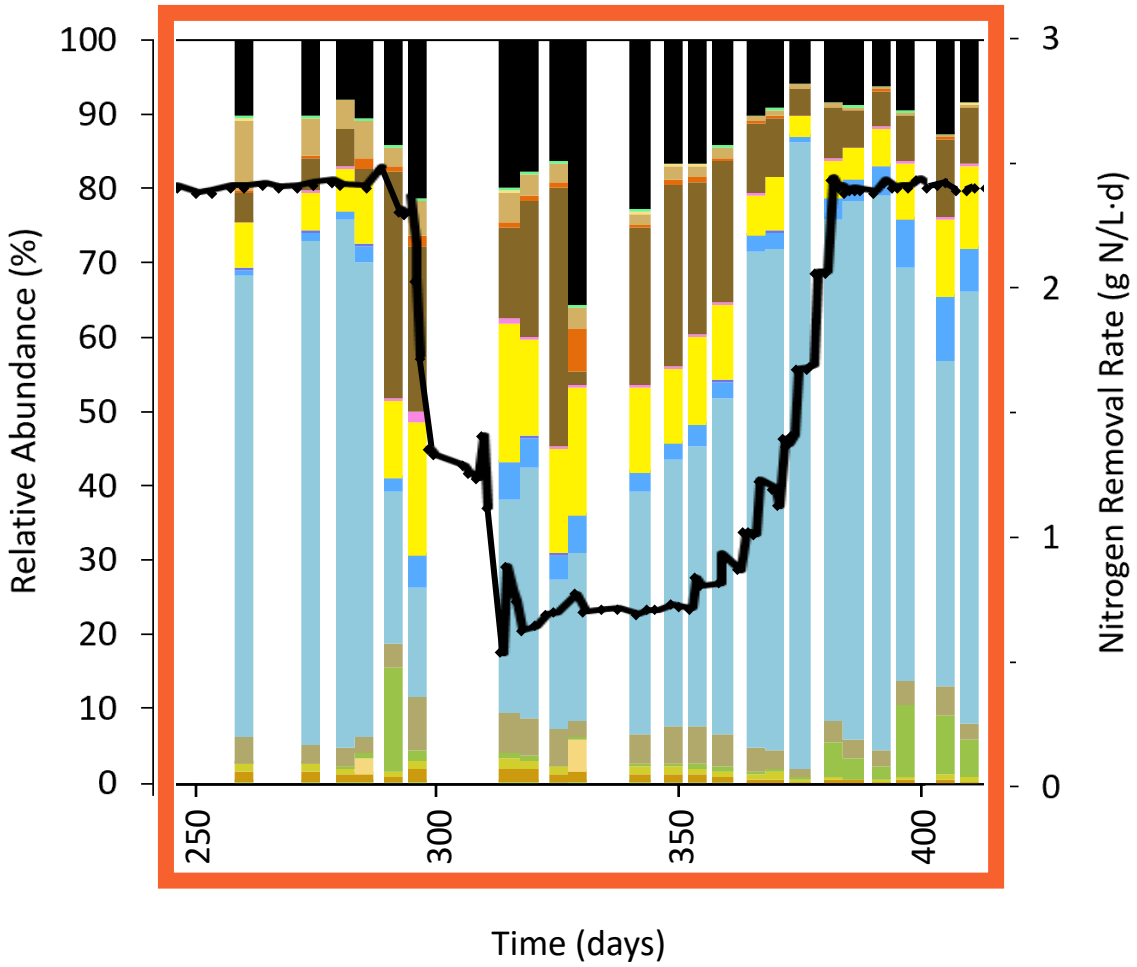


ANAMMOX & METAGENOMES

Phylum	Classification
Unmatched	
Acidobacteria	-
Bacteroidetes	-
Bacteroidetes	Sphingobacteria; Sphingobacteriales
Chloroflexi	-
Chloroflexi	Anaerolineae
Deinococcus-Thermus	Deinococci; Deinococcales; Truepera
Ignavibacteriae	Ignavibacteria
Nitrospirae	Nitrospira; Nitrospirales; Nitrospira
Planctomycetes	-
Planctomycetes	Planctomycetia; Brocadiales; Brocadia
Proteobacteria	-
Proteobacteria	Alphaproteobacteria
Proteobacteria	Betaproteobacteria; Burkholderiales
Proteobacteria	Betaproteobacteria; Rhodocyclales
Proteobacteria	Gammaproteobacteria
Proteobacteria	Gammaproteobacteria; Xanthomonadales
Verrucomicrobia	-



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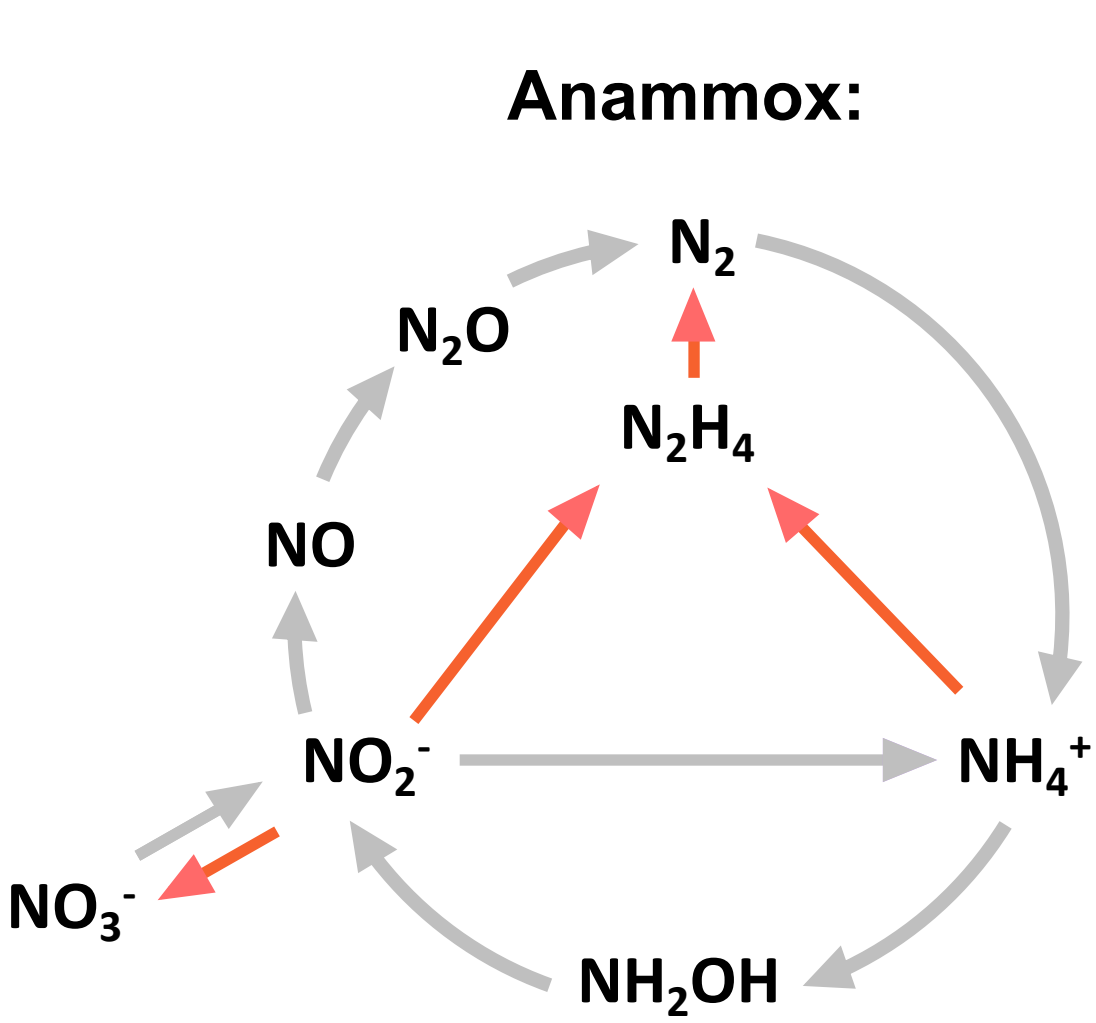

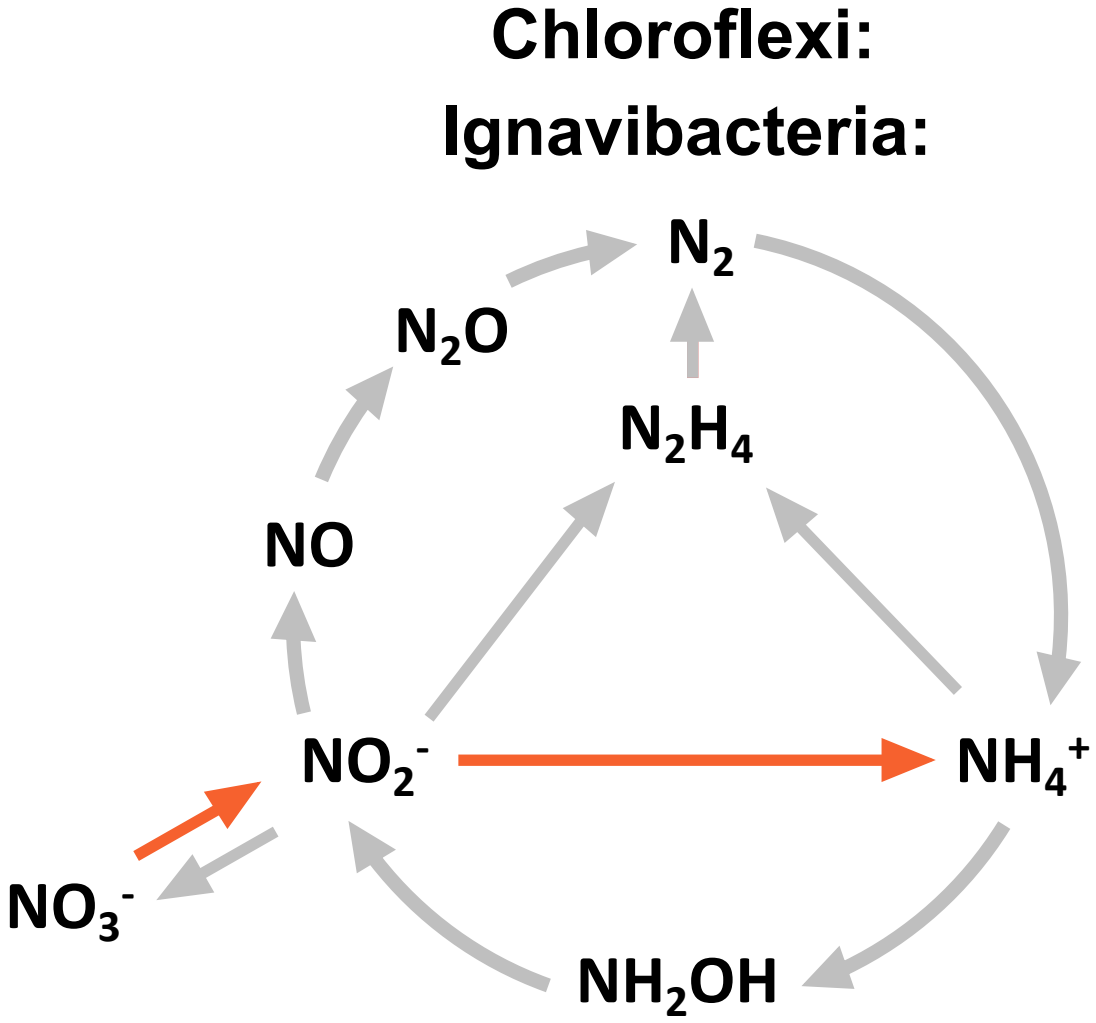

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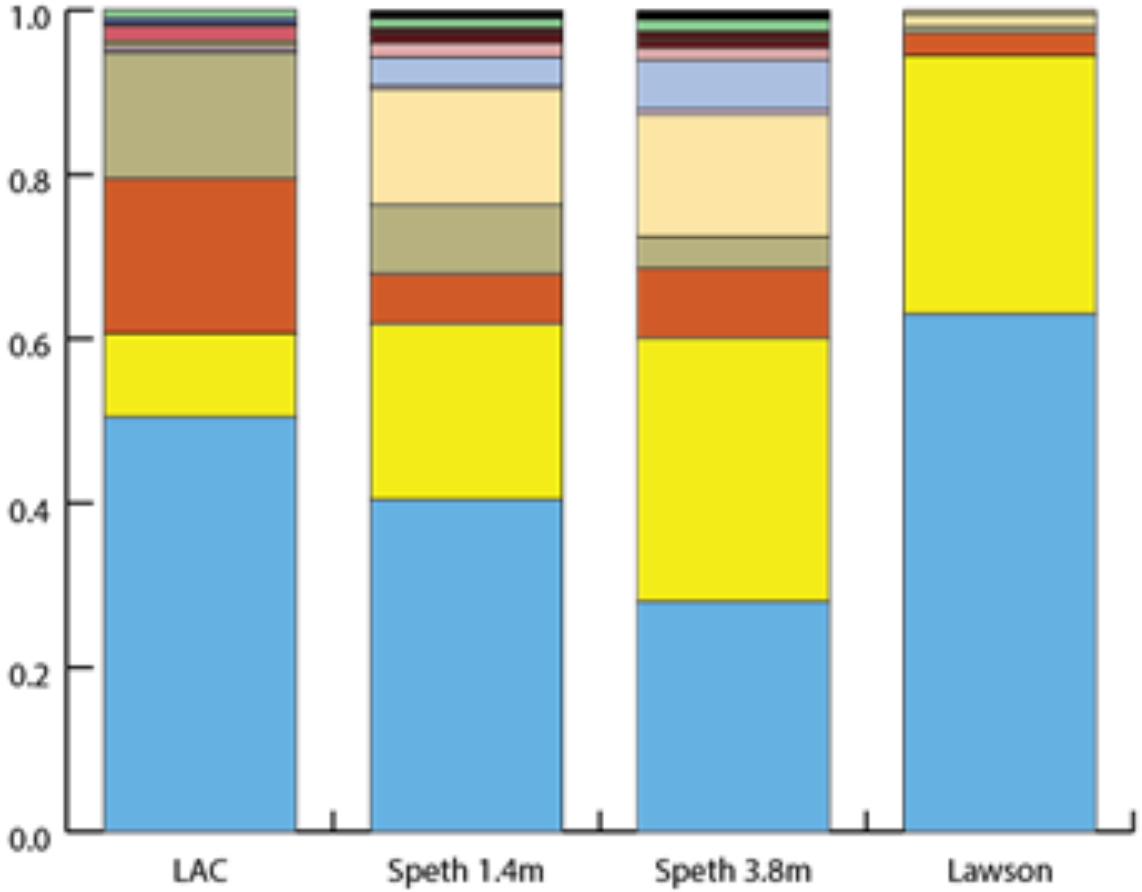

Chloroflexi

Ignavibacteria

Anammox

ANAMMOX & METAGENOMES

What we know:

Chloroflexi and Ignavibacteria increased before the performance crash

- Both are capable of DNRA

Chloroflexi and Ignavibacteria are uniquely ubiquitous in anammox bioreactors.

What this means:

Competing anaerobic nitrogen cycling pathways may have caused the anammox performance crash.

A strategy must be devised to manage their presence in anammox bioreactors.

ANAMMOX & METAGENOMES

Next Steps:

Identify operational or biological strategies to manage microbial interactions in an anammox reactor

- Real-time nitrogen amendments
- Microbe-specific inhibitors

THANK YOU

Ray Keren, **Jennifer Lawrence**, Weiqin Zhuang, David Jenkins, Jill Banfield, Lisa Alvarez-Cohen, Lijie Zhou, Ke Yu “Increased Replication Rates of Dissimilatory Nitrate-Reducing Bacteria Lead to Decreased Anammox Bioreactor Performance.” *In Submission.*

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ADDITIONAL SLIDES

TEXT AND IMAGE SAMPLE

- **Text first level bullet may be orange, dark grey, or blue (from theme color menu)**
  - **Embedded photos** should have green or yellow border
  - xxx
    - xxx
    - xxx

TABLE SAMPLE

Title	Description	Xxx	Xxx	xxx
Blue text	ewewq	wqeqeq	12	15