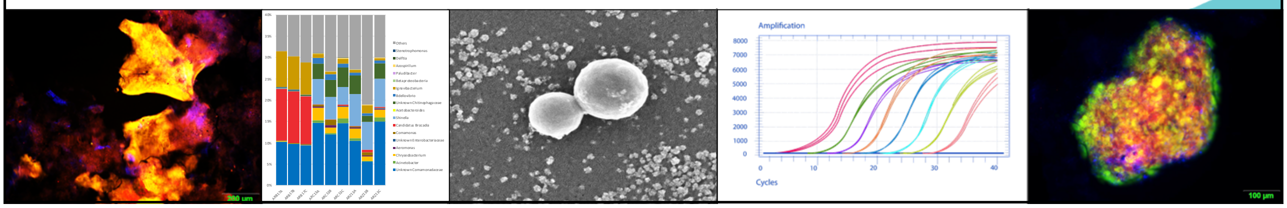
TECHNICAL SESSIONS

MOLECULAR TOOLS FOR OPTIMIZATION OF MAINSTREAM NITROGEN REMOVAL WITH ANAMMOX SELECTING MEMBRANE BIOREACTORS

ANNDEE HUFF, PAIGE NOVAK, MARC HILLMYER, MICHAEL TSAPATSIS, KIWON EUM

SEPTEMBER 25, 2019



CONVENTIONAL VS. ANAMMOX PROCESS

Nitrification — Denitrification

$$\underbrace{NH_4^+ \longrightarrow NO_2^- \longrightarrow NO_3^-}_{\uparrow\ \text{Aeration}} \;\underbrace{\longrightarrow NO_2^- \longrightarrow N_2}_{\uparrow\ \text{Carbon}}$$

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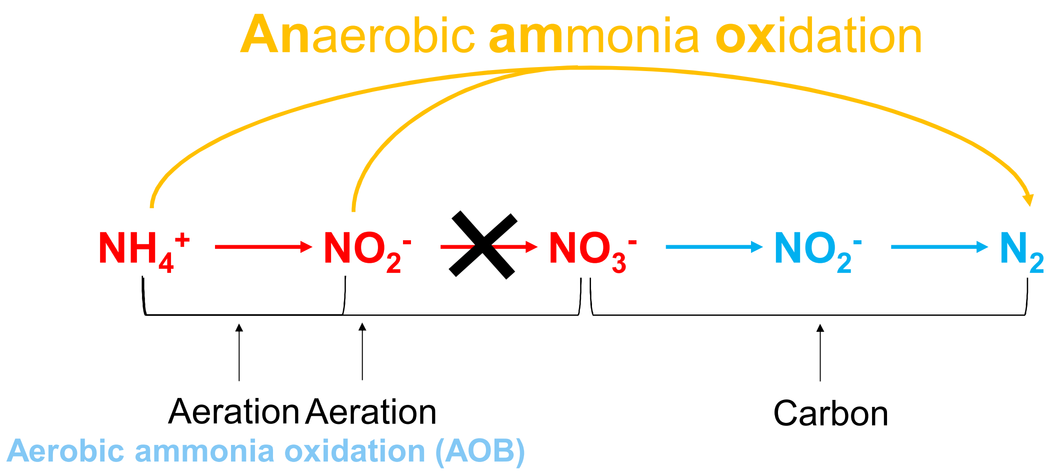
CONVENTIONAL VS. ANAMMOX PROCESS



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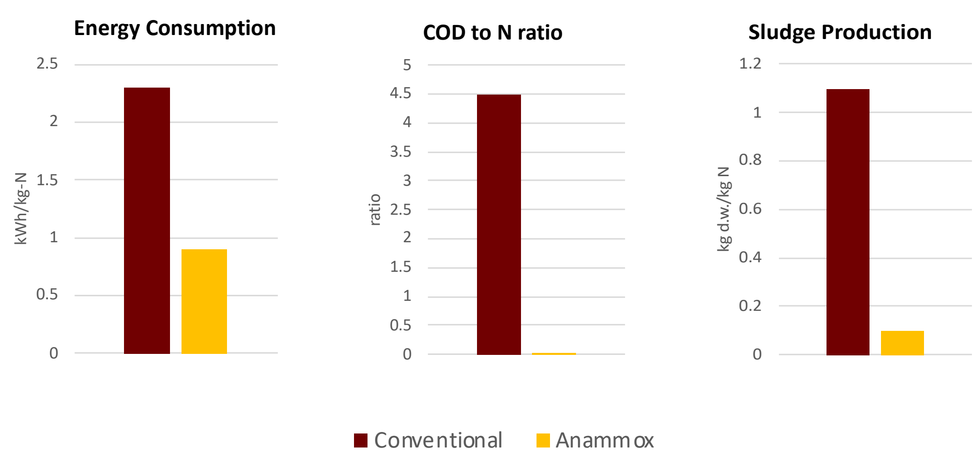
MORE COST EFFECTIVE PROCESS



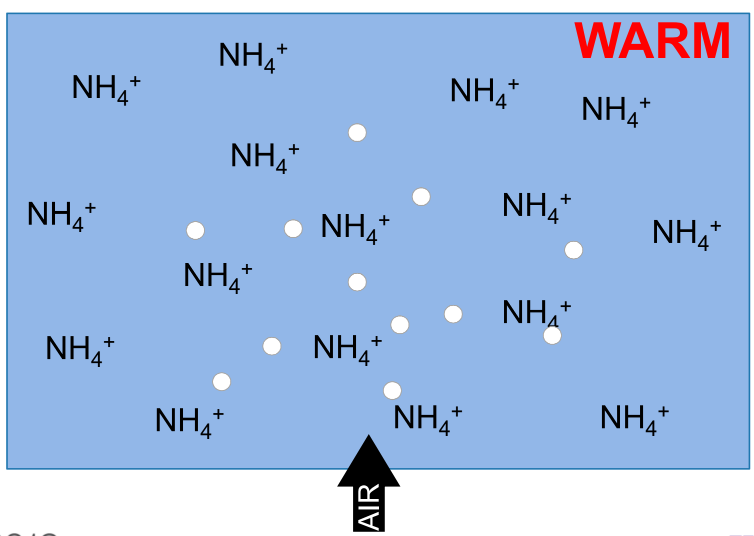
Source: Crawford and Sandino 2010

TECHNICAL SESSIONS

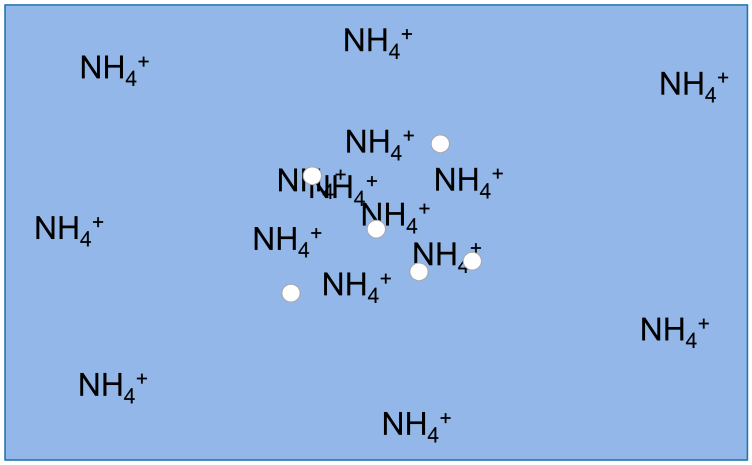
MAINSTREAM IMPLEMENTATION CHALLENGES

- Anammox microorganisms are **limited** by:
  - Slow growth rate
  - Temperatures below 30 ºc
  - High carbon concentrations
  - Dissolved oxygen concentrations over 1%
- Require high levels of influent NH_4^+
- Hard to stop nitrification at NO_2^-

SIDESTREAM SUCCESS



IDEAL ANAMMOX MICRO-ENVIRONMENT



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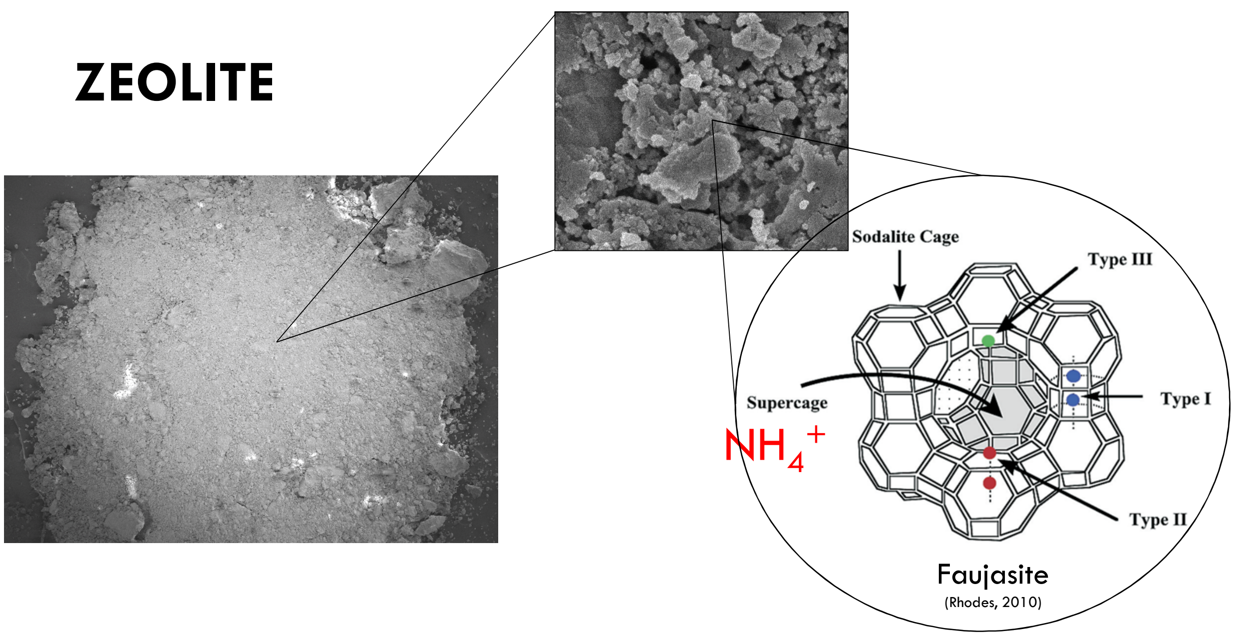
TECHNICAL SESSIONS

ZEOLITE



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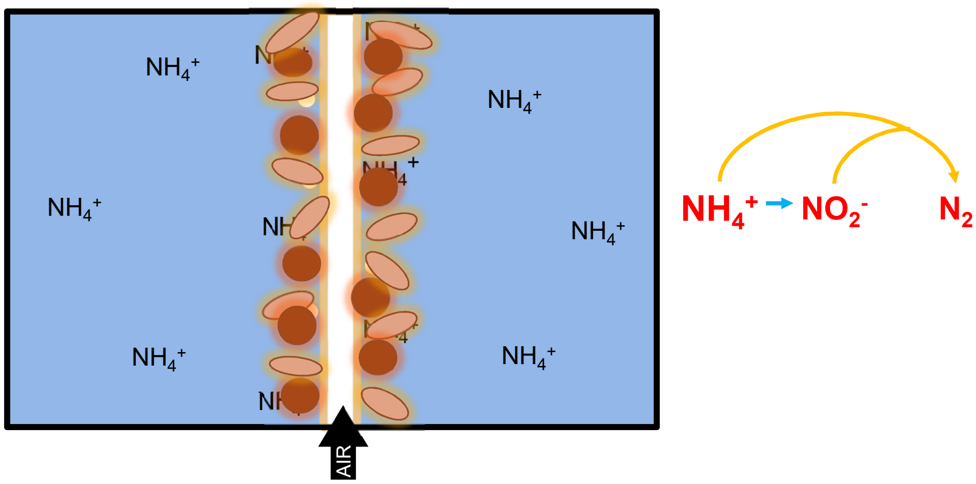
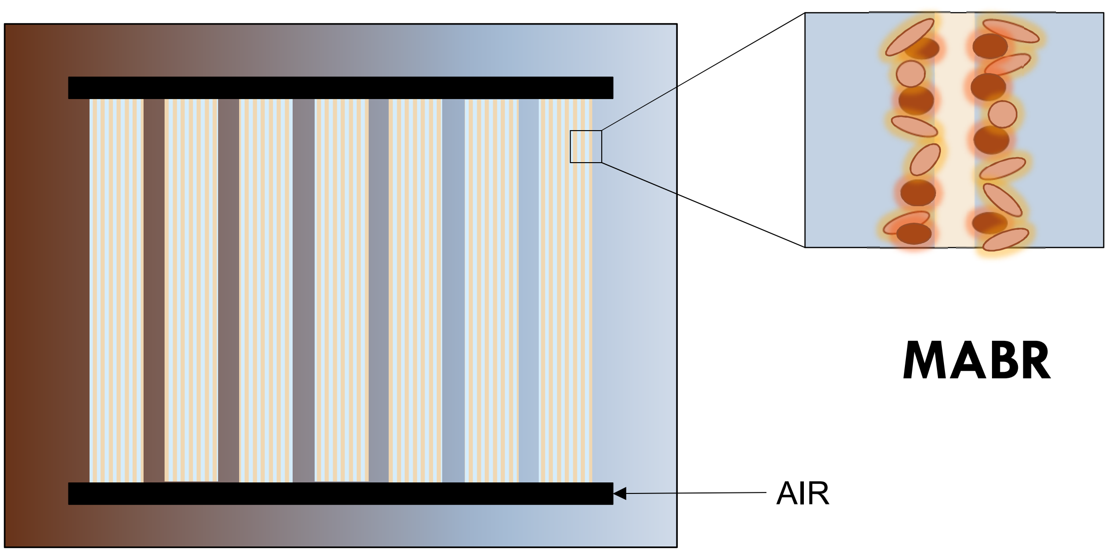
ZEOLITE MEMBRANE AERATED BIOREACTOR





MABR

HOW WOULD WE USE MOLECULAR METHODS TO DESIGN AND OPERATE THIS SYSTEM?

- Sequencing – who's there, untargeted
- qPCR – how many, genes (dead and alive)
- FISH – spatial and physical, genes
- RT-qPCR – how many are active, genes (alive)

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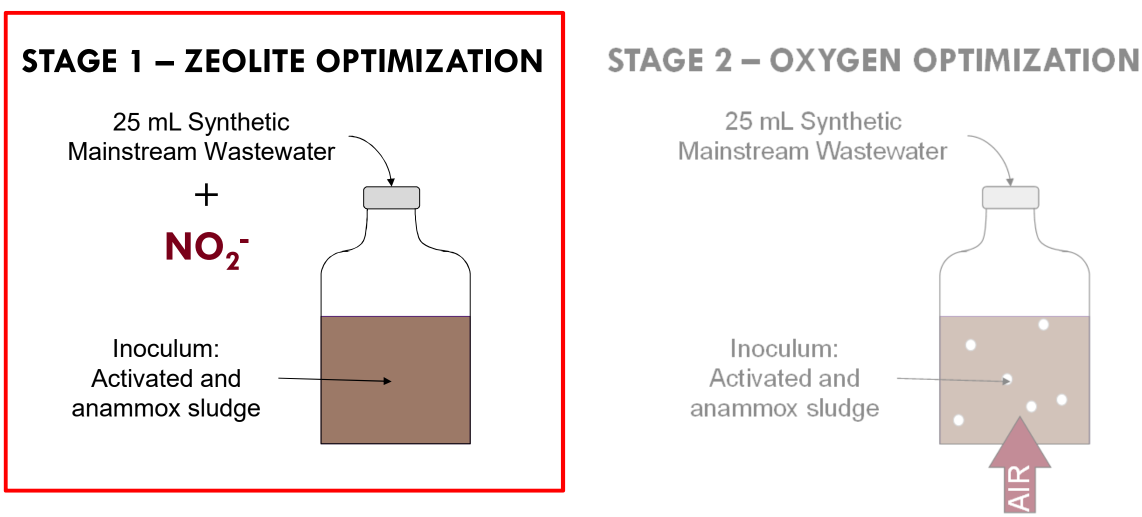
EXPERIMENTAL STAGES



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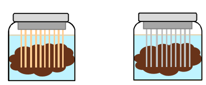
STAGE 1 – ZEOLITE OPTIMIZATION

1. ZEOLITE PARTICLES VS. GLASS PARTICLES

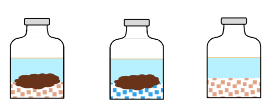
2. VARYING ZEOLITE MASS

3. ZEOLITE COATED VS. UNCOATED MEMBRANES



STAGE 1 – ZEOLITE OPTIMIZATION

1. **ZEOLITE PARTICLES VS. GLASS PARTICLES**

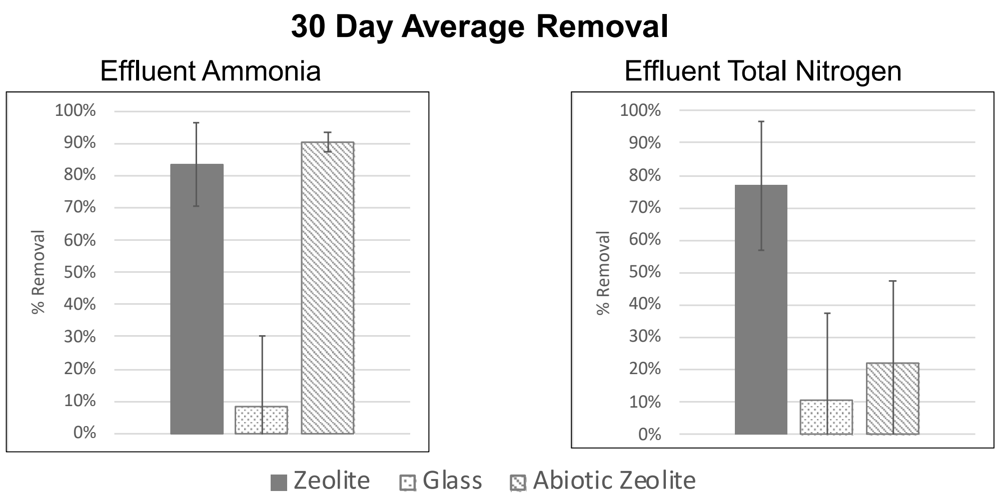


x4 (3 g each)

2. VARYING ZEOLITE MASS

3. ZEOLITE COATED VS. UNCOATED MEMBRANES

ZEOLITE VS. GLASS PARTICLES



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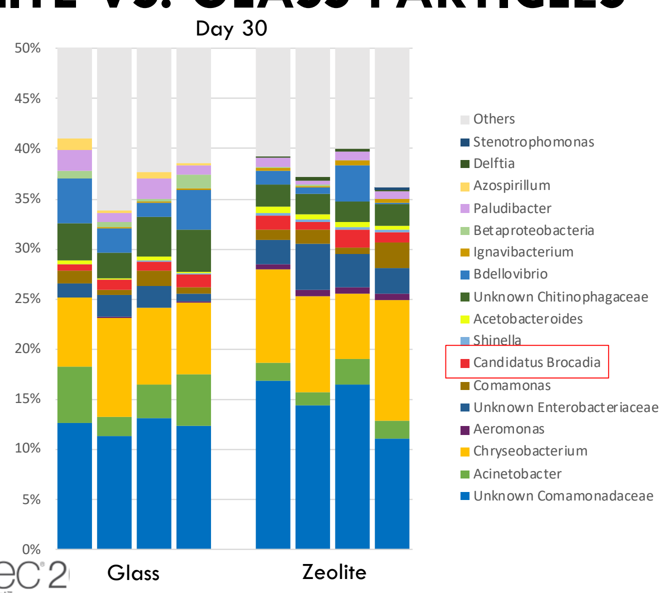
ZEOLITE VS. GLASS PARTICLES - SEQUENCING



Sequencing hits:

- *Candidatus Brocadia*
- *Candidatus Anammoximicrobium*
- *Uncultured Planctomycetes*
- *Unknown Planctomycetes*

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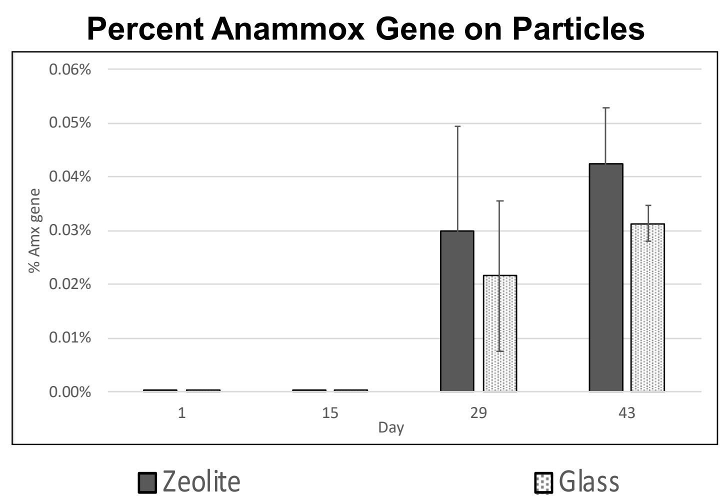
ZEOLITE VS. GLASS PARTICLES - qPCR

$$\frac{\#\ \text{Amx copies}}{\#\ \text{16S copies}}$$



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TECHNICAL SESSIONS

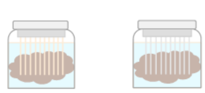
STAGE 1 – ZEOLITE OPTIMIZATION

1. ZEOLITE PARTICLES VS. GLASS PARTICLES

2. **VARYING ZEOLITE MASS**

x3 (1g, 0.5g, 0.1g, 0.05g)

3. ZEOLITE COATED VS. UNCOATED MEMBRANES



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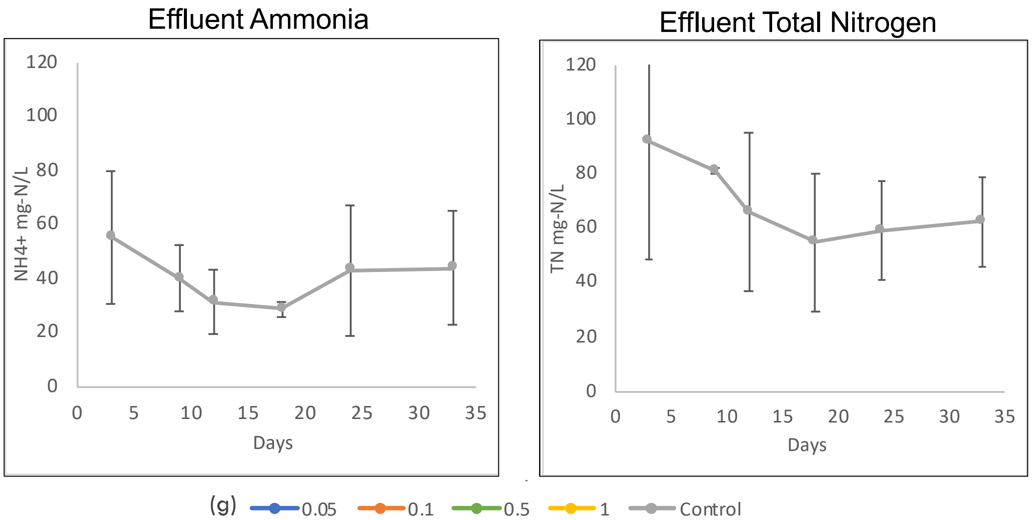
VARYING ZEOLITE MASS



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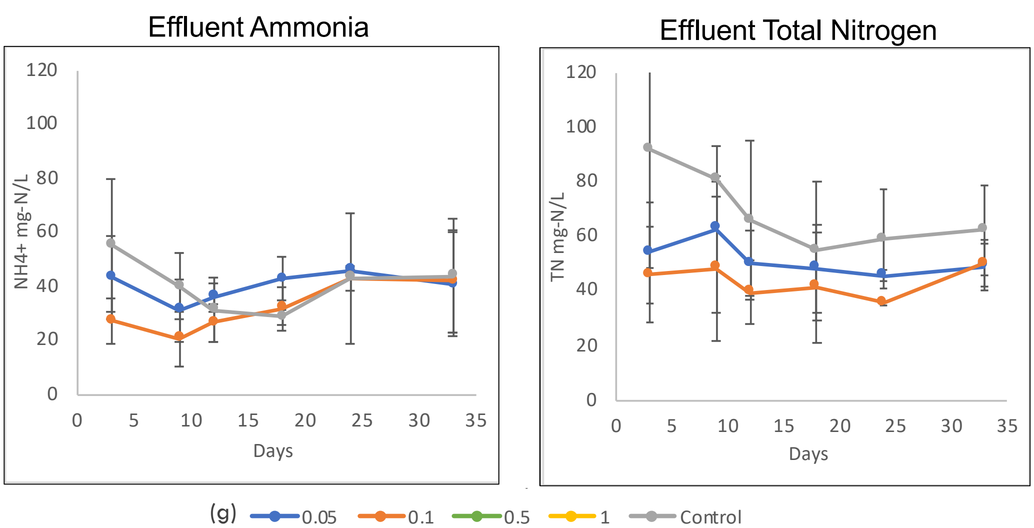
VARYING ZEOLITE MASS



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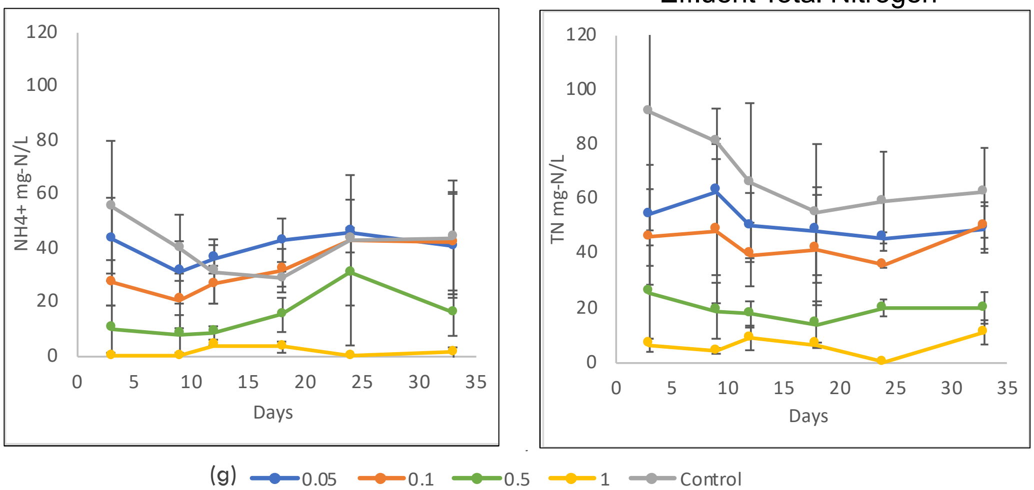
TECHNICAL SESSIONS

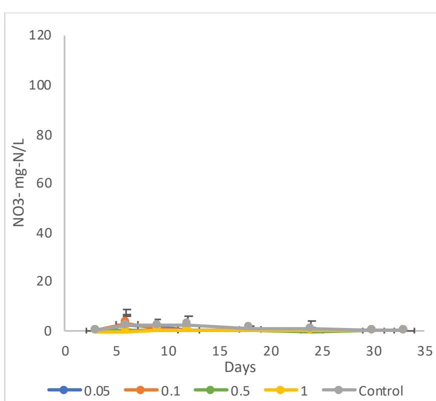
VARYING ZEOLITE MASS

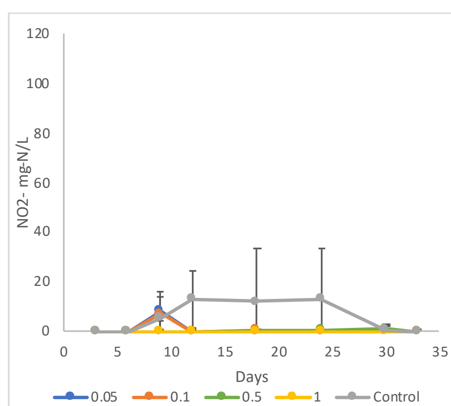
Effluent Ammonia

Effluent Total Nitrogen



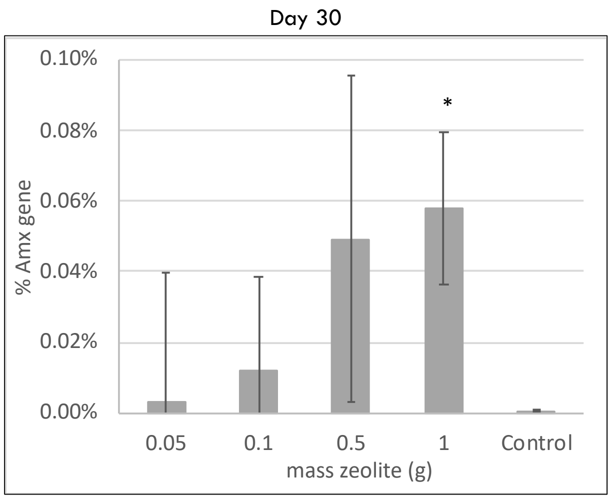
NITRITE AND NITRATE EFFLUENT





VARYING ZEOLITE MASS - qPCR

Amx copies
16S copies



* Indicates p-value < 0.05

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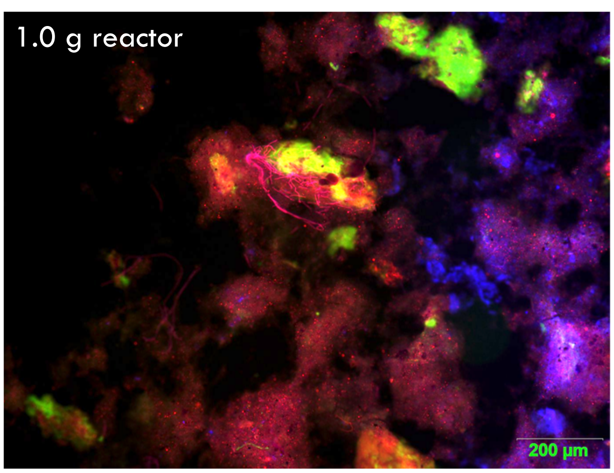
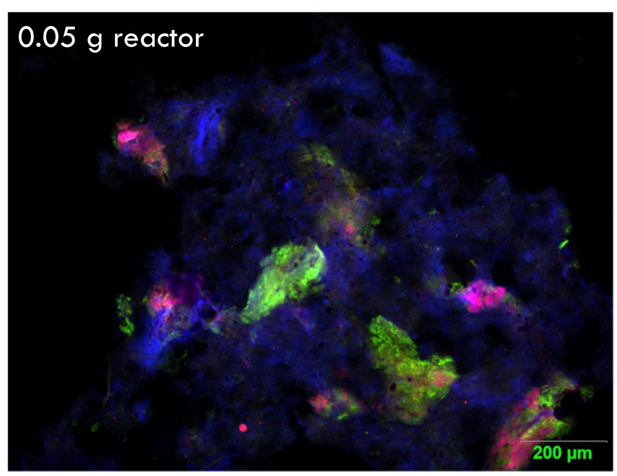
VARYING ZEOLITE MASS - FISH

All bacteria
Anammox
NOB





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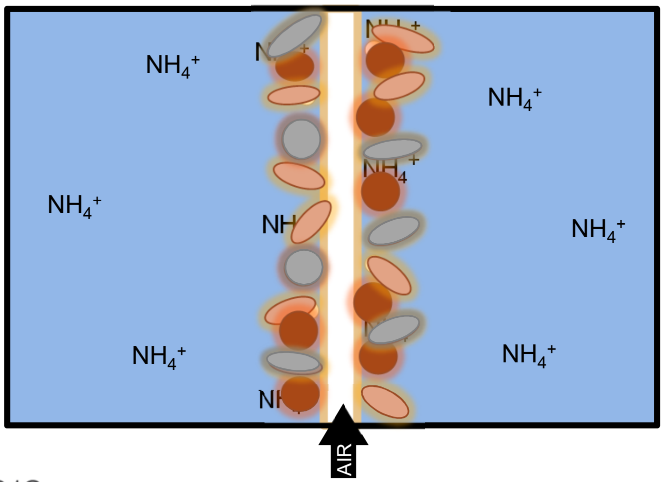
ACTIVITY MEASUREMENTS

RNA ANALYSIS (RT-qPCR)



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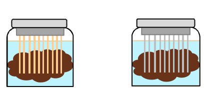
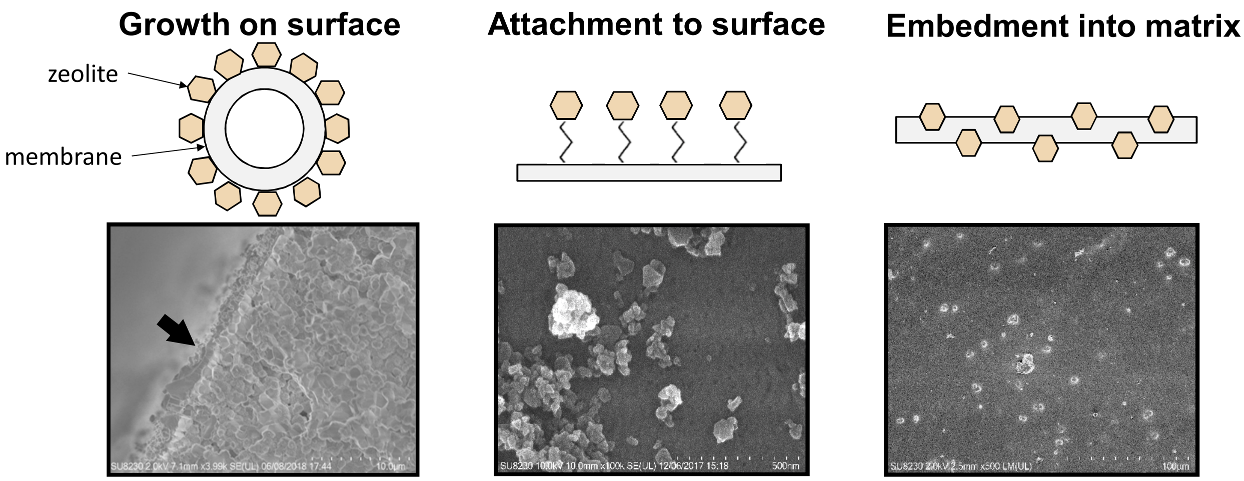


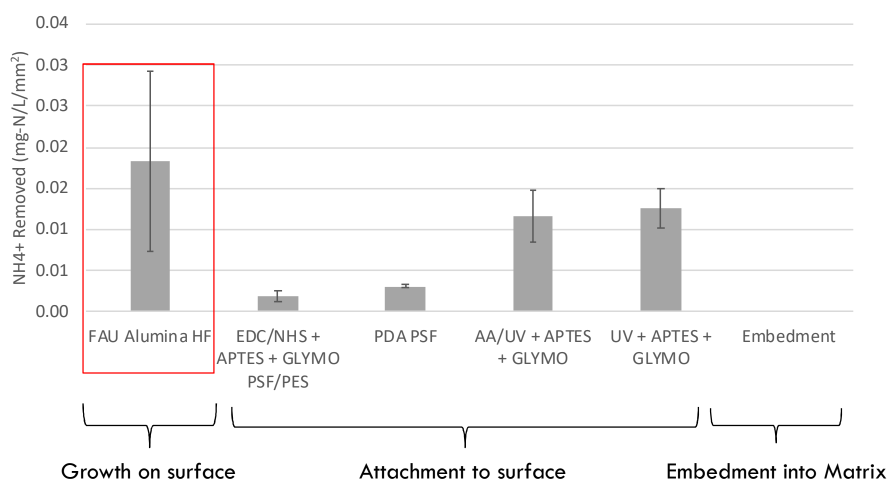
x3 (Equivalent to 0.5 g of zeolite)

MEMBRANE TECHNOLOGY

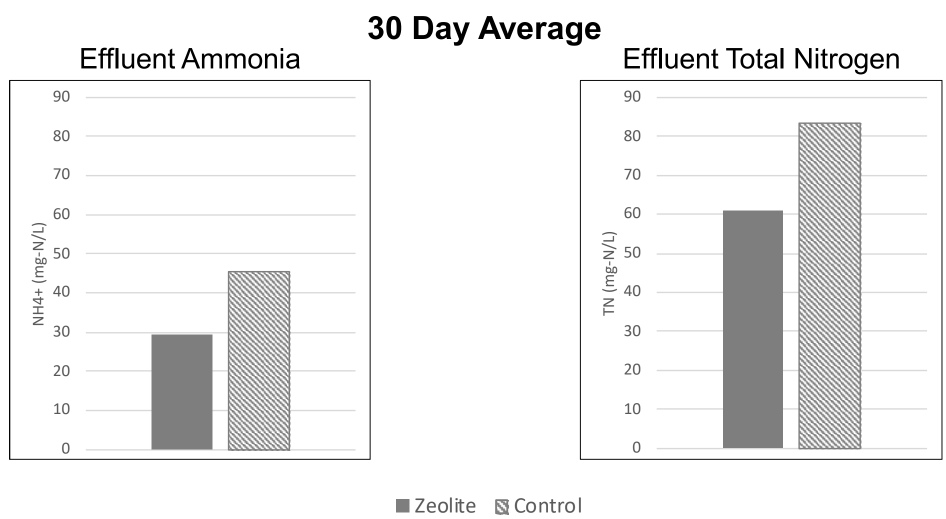


Patent: Novak, P., Romero-Vargas Castrillón, S., Huff, A., Hillmyer, M. and Tsapatsis, M. U.S. Patent 16/433,915. 2019.

SORPTION DATA



MEMBRANES – ZEOLITE VS. PLAIN



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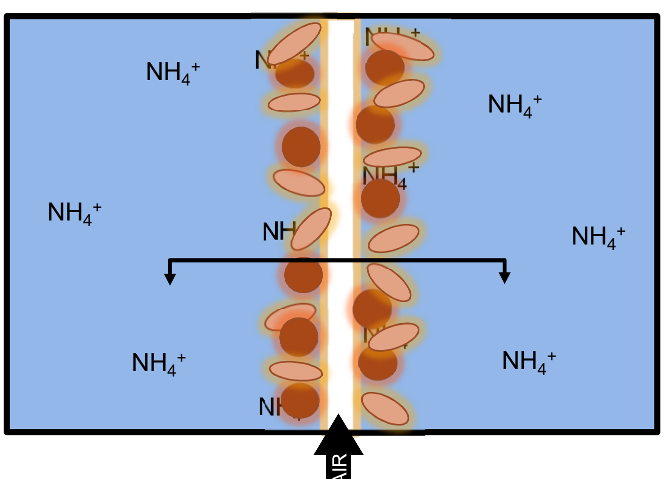
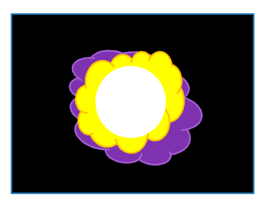
FISH FOR MEMBRANES





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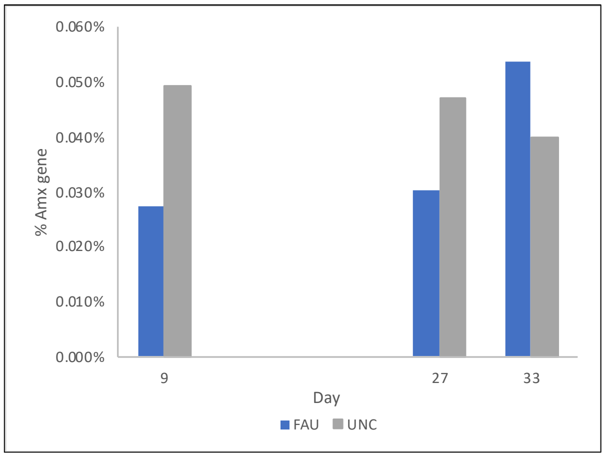
MEMBRANES - QPCR



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TECHNICAL SESSIONS

CONCLUSIONS

- Zeolite increased ammonia and TN removal
- Amx gene quantities are not always greater
- Molecular techniques allow us to better understand what microbial processes are occurring and why

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TECHNICAL SESSIONS

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QUESTIONS?

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND

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