

# Point-of-Generation Nitrogen Recovery from Wastewater

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The logo for the American Academy of Environmental Engineers and Scientists (AET), consisting of the letters 'AET' in a bold, black, sans-serif font.

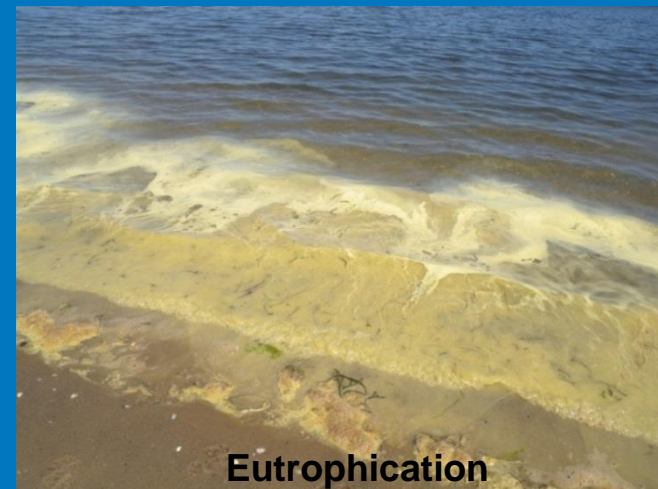
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# Acknowledgements

- US Environmental Protection Agency
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- Nathaniel Smith, Civil & Environmental Engineering, UC Davis
- Mayo Water Reclamation Facility, Anne Arundel County, Maryland

# Distributed Wastewater Systems

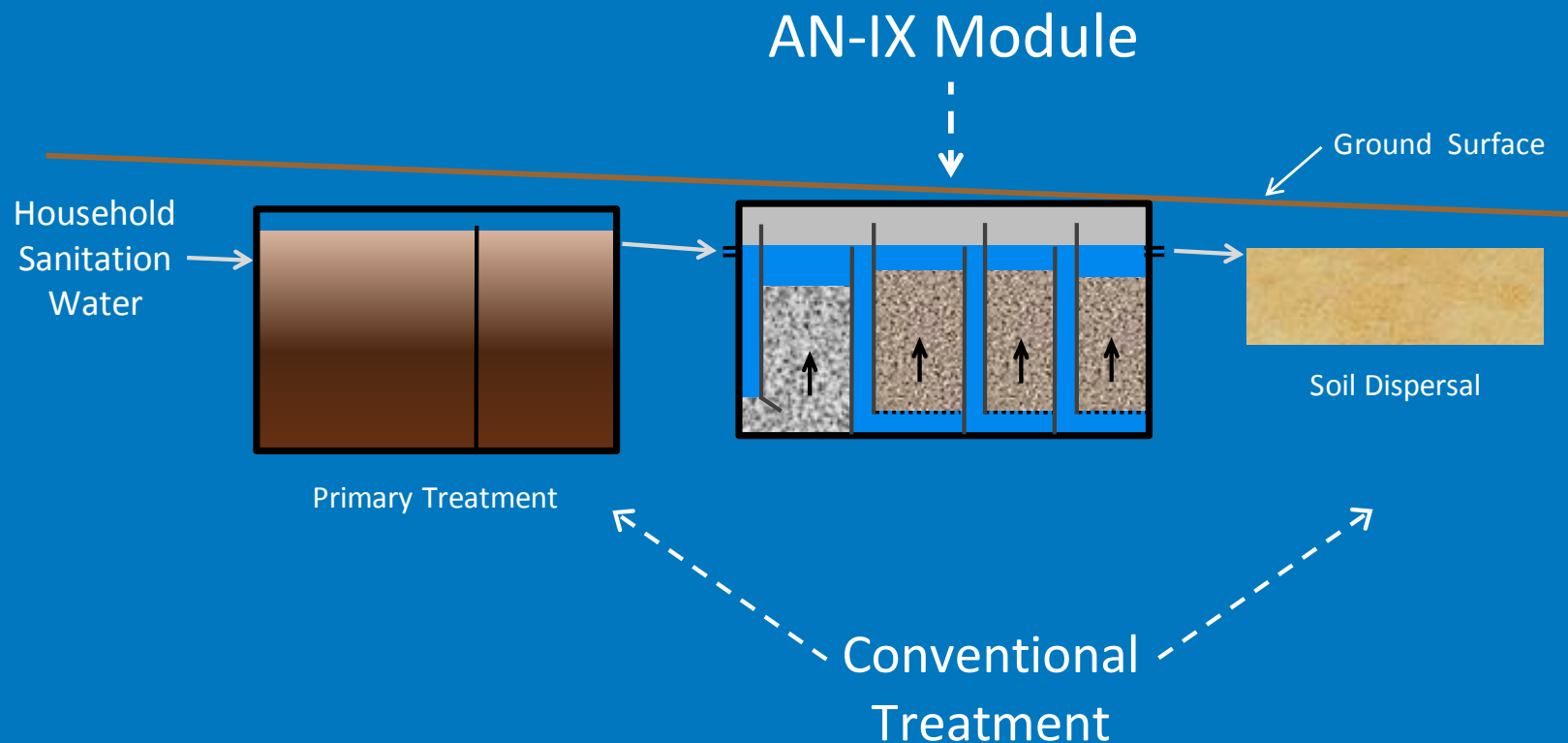
- > 25 million in U.S. (EPA/625/R-00/008)
- 25% of households
- 500 - 1,900 L/day (125 -500 gpd)
- 40 - 80 mg/L TN



# Type 1 Value Proposition

## Nitrogen *Removal*

### Anaerobic-Ion Exchange Process



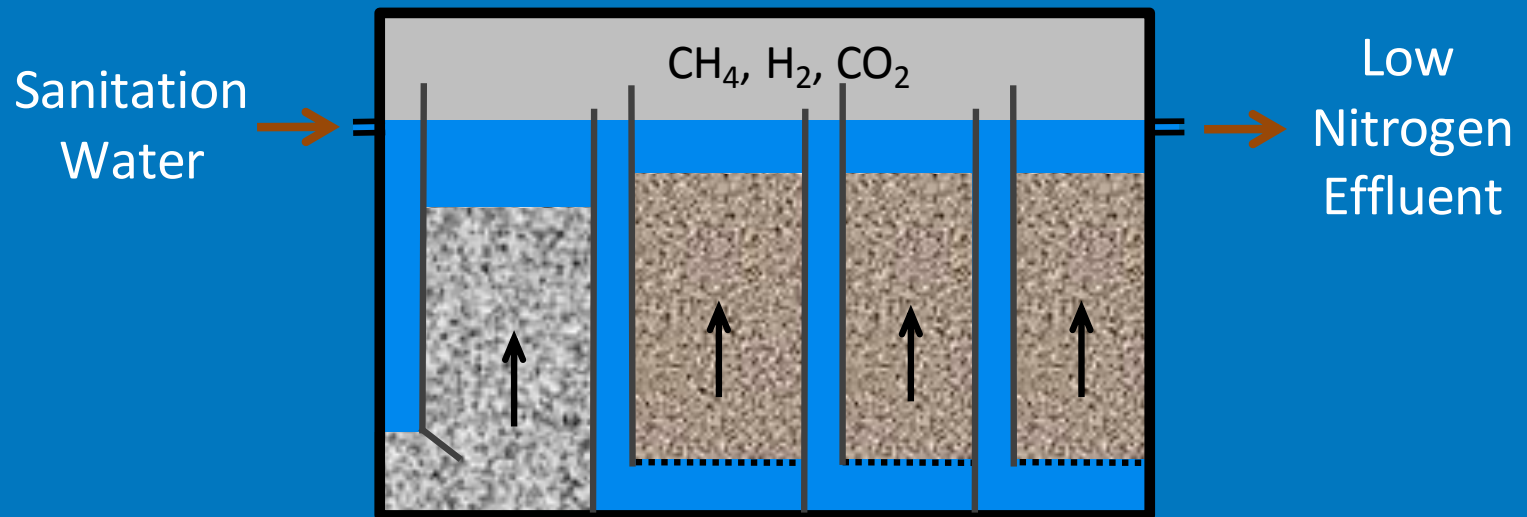
# AN/IX Prototype

Anaerobic Solids Blanket

ammonification

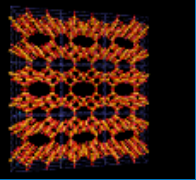
3 Ion Exchange Chambers

porous granular media



# Anaerobic Upflow Solids Blanket

- Pre-treatment
- Ammonify Organic N to  $\text{NH}_4^+$
- Reduce suspended & colloidal solids
- Increase biological stability
- Biogas maintains lowoxic headspace



# Clinoptilolite ZS403H

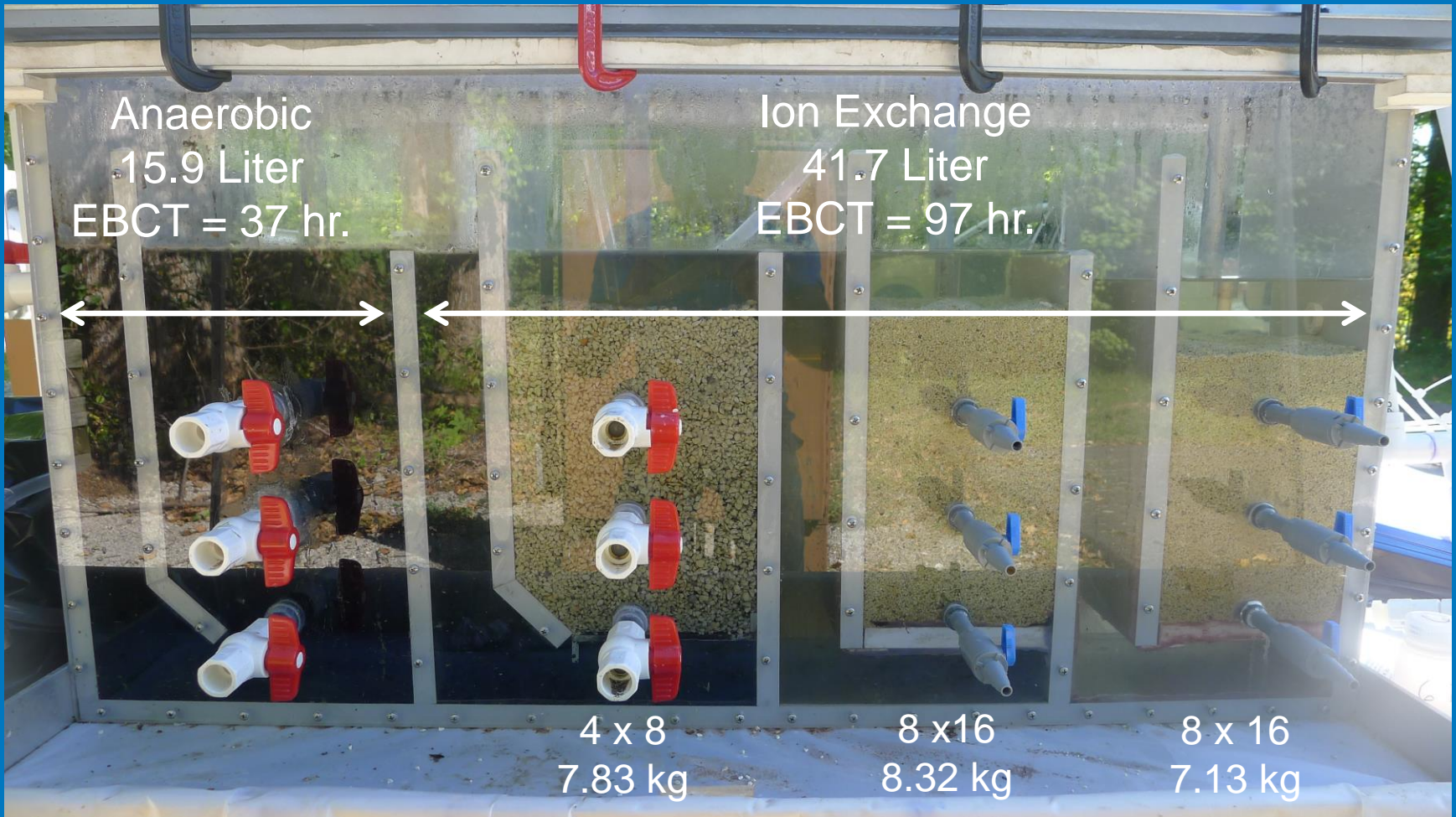
- Natural zeolite
- Hydrated aluminosilicate
- Granular, crystalline
- 1.85 meq./gram CEC





# 4 Chamber Prototype

57.6 L Liquid Empty Bed





# Prototype Field Test

Mayo Water Treatment Plant, Anne Arundel County, Maryland

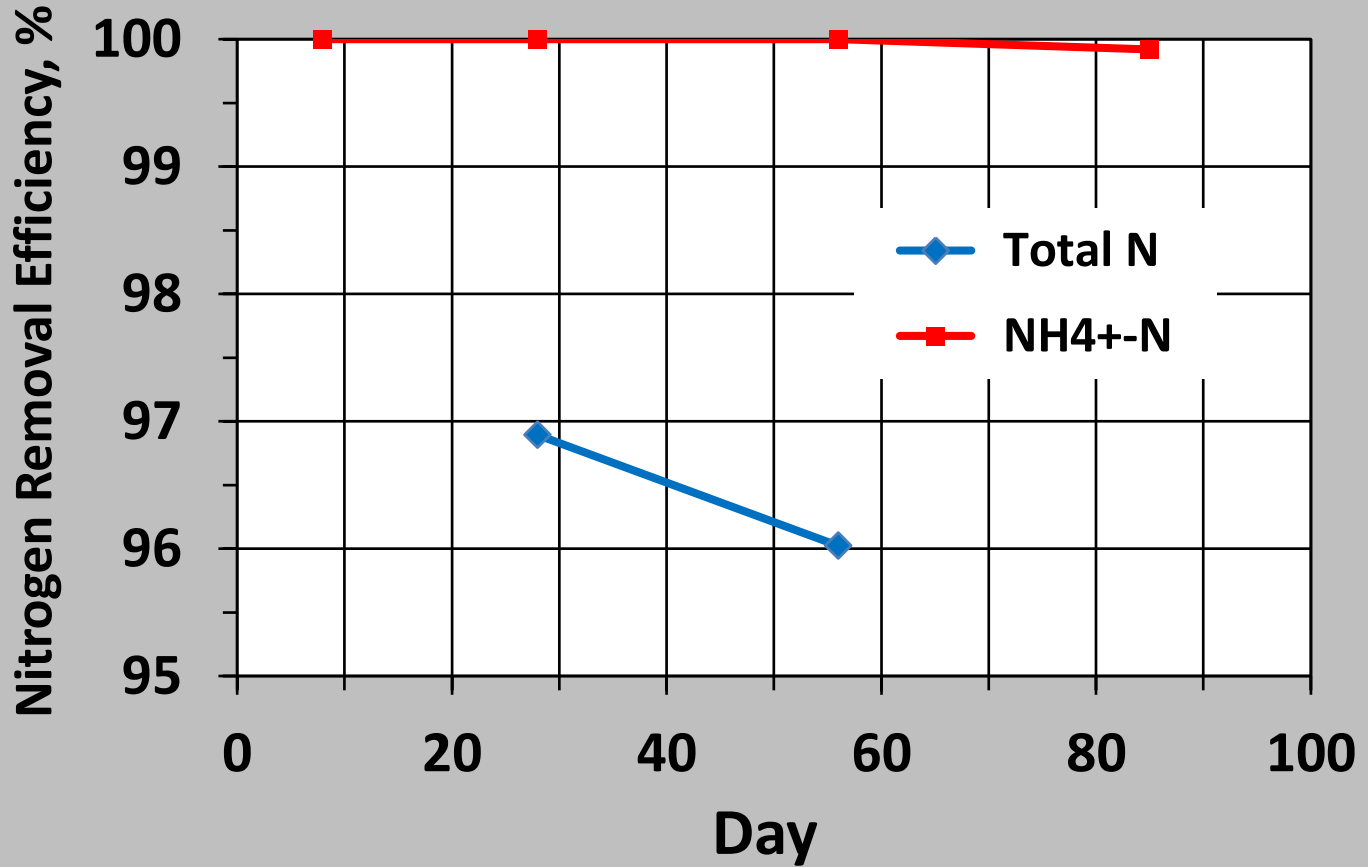
- $Q = 10.2 \text{ L/day @ 1/hour dose cycle}$
- 7 to 24 C



# Mayo influent: typical dilute wastewater

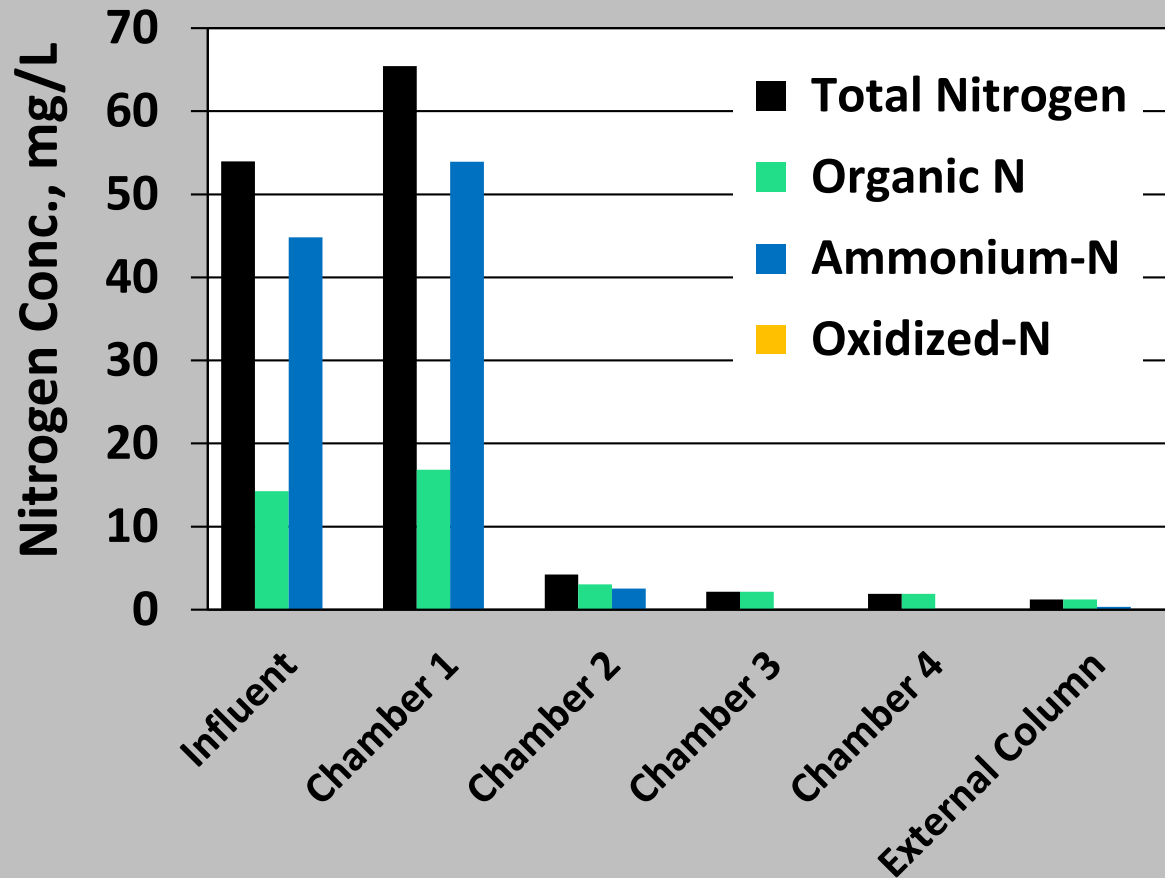
Parameter	Mean
Temp, C	19.3
pH	7.0
Alkalinity, mg/L as CaCO <sub>3</sub>	317
Dissolved Oxygen, mg/L	0
Chemical Oxygen Demand, mg/L	227
Total Suspended Solids, mg/L	89.2
Oxidation Reduction Potential, mV	-243
Nitrogen	
Total	54.0
Total Kjeldahl	54.0
Organic	14.3
Ammonia	44.8
Nitrate+nitrite	0.02

# Total Nitrogen Removal Efficiency

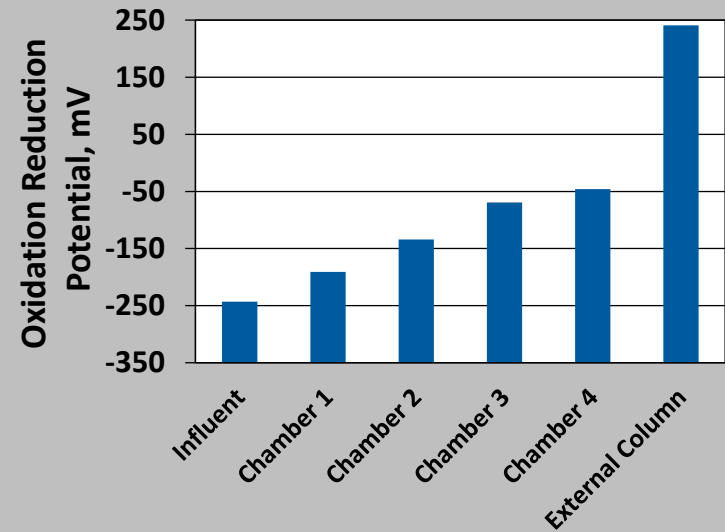
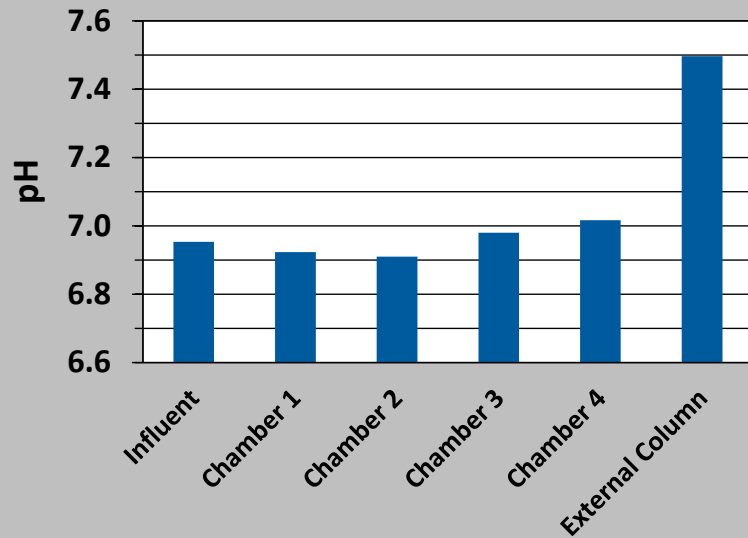


# Nitrogen Species Profile

(Mean Day 1 - 100)



# pH & ORP (Mean 1<sup>st</sup> 100 day)

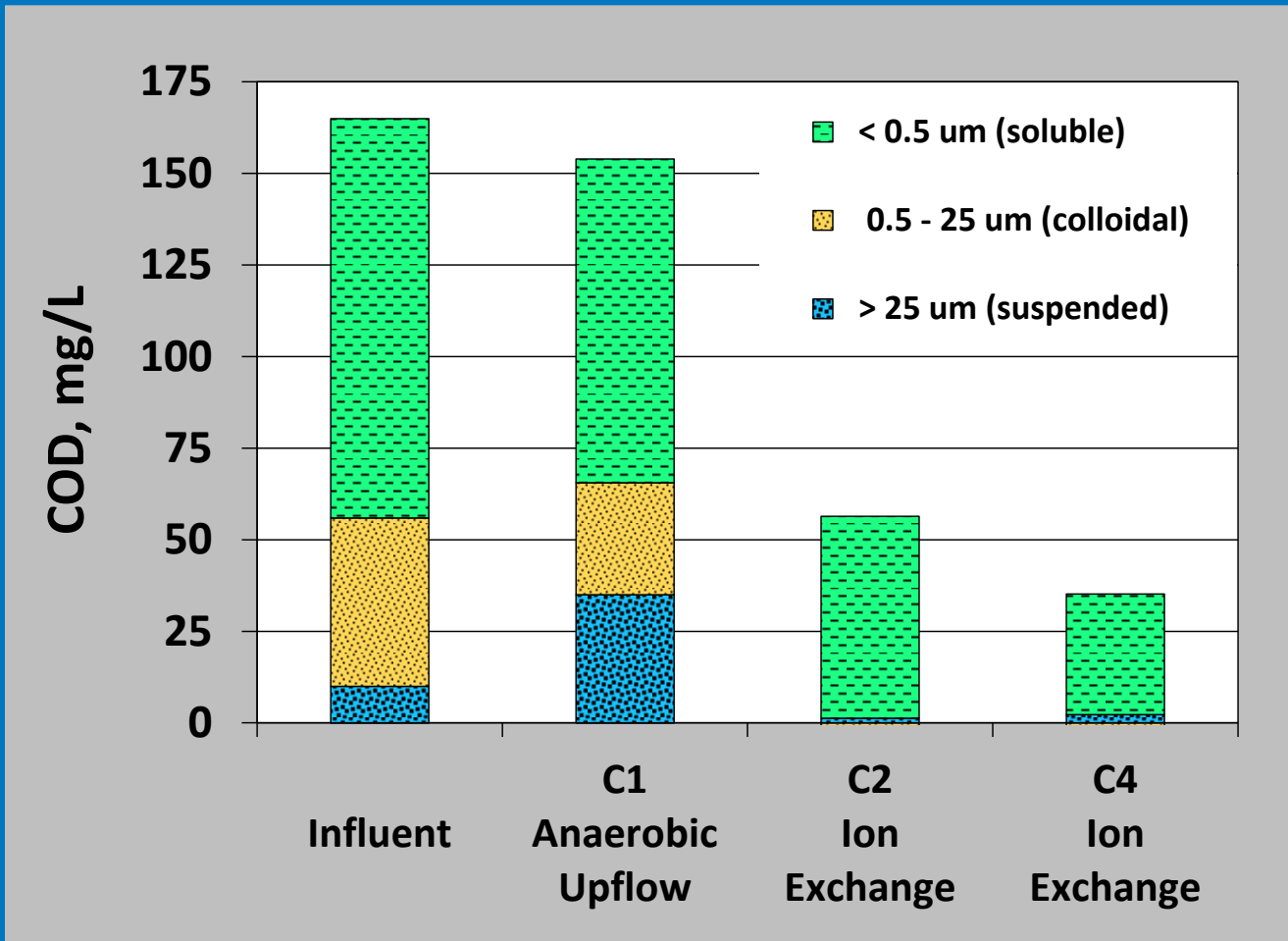




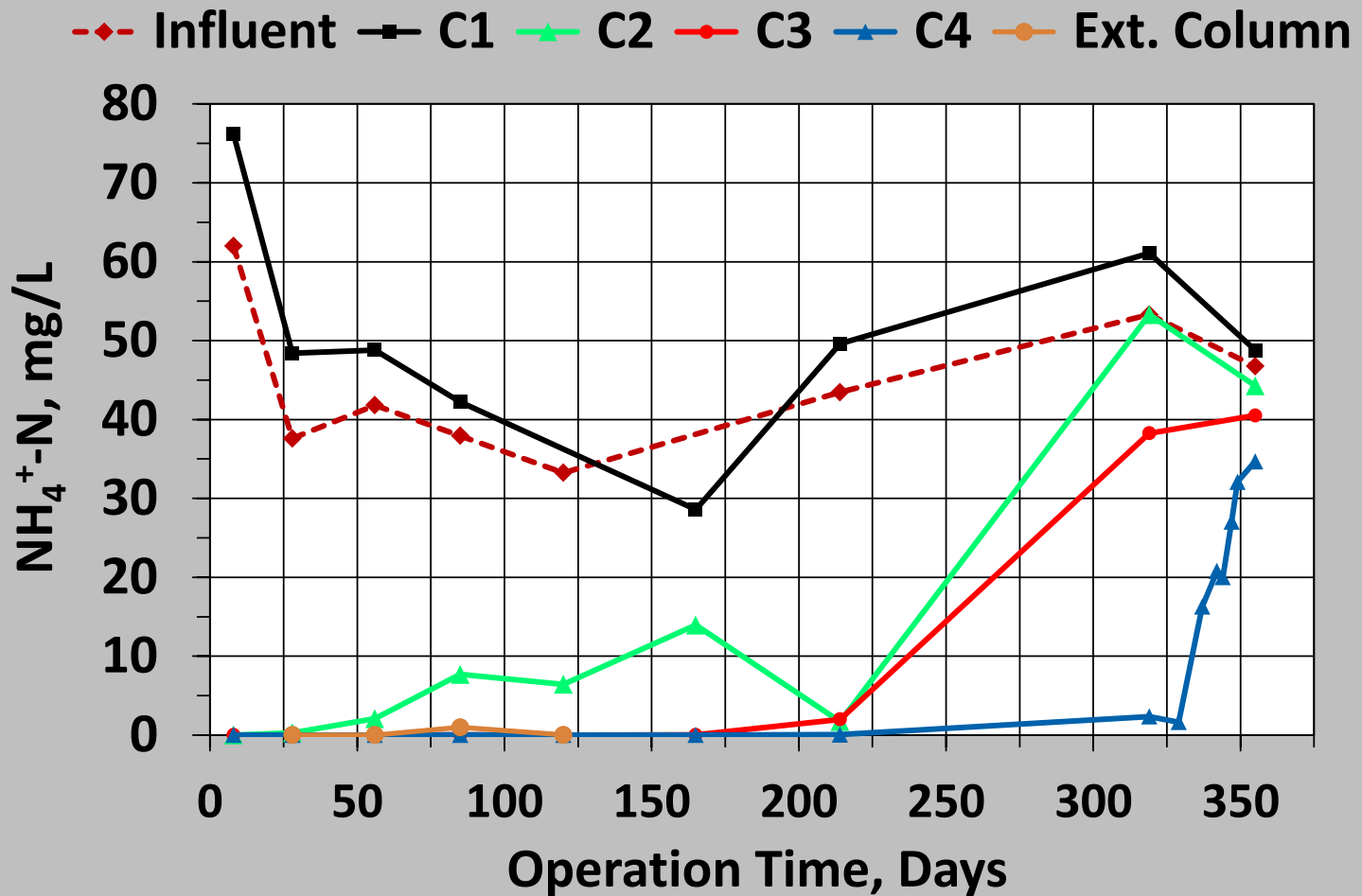
# Typical AN-IX Effluent

- DON < 2
- Ammonia, nitrate, nitrate ND
- C-BOD<sub>5</sub> < 5
- TSS < 5
- pH 7.1 – 7.4
- ORP < 50

# COD Fractionation



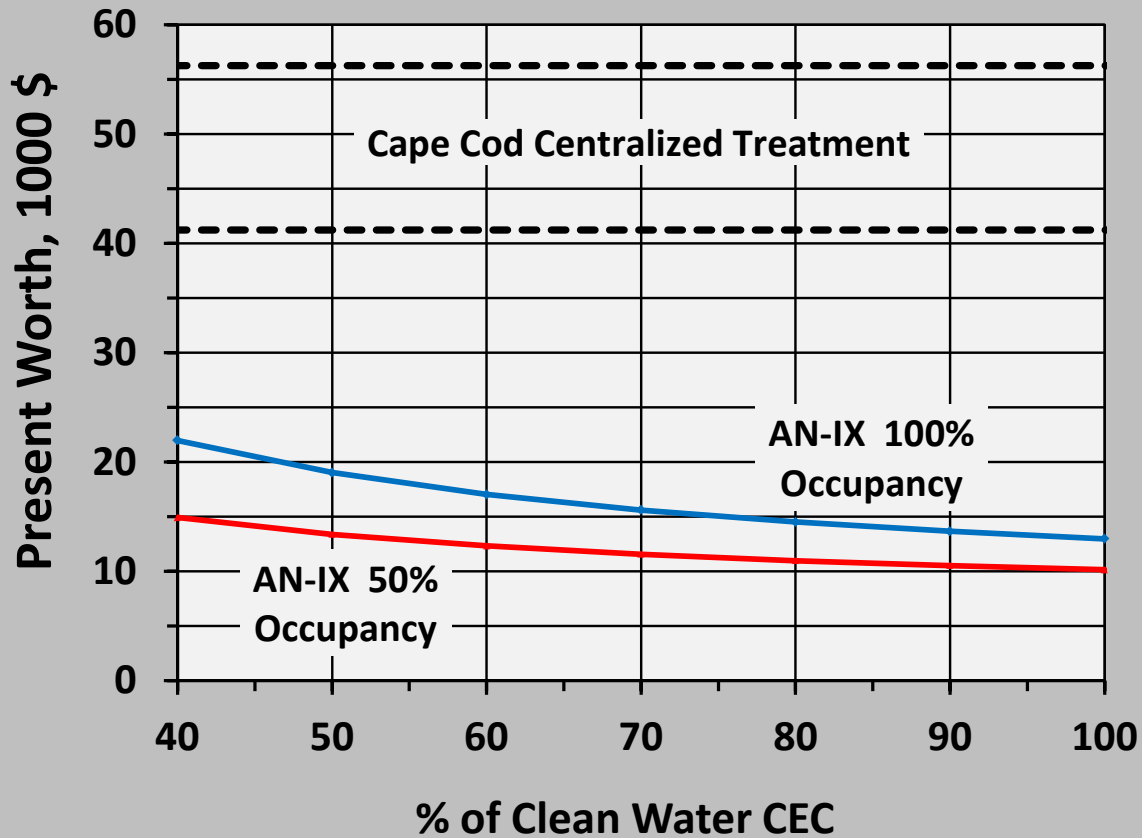
# NH<sub>4</sub><sup>+</sup> Time Profiles



# Effective $\text{NH}_4^+$ Exchange Capacity

- 11.3 mg  $\text{NH}_4^+$ -N/gram
- Factors: water matrix: competing cations, organic matter
- $\text{NH}_4^+$  concentration
- Short circuiting

# Life Cycle Cost Analysis





# Anaerobic Ion Exchange Proof of Concept

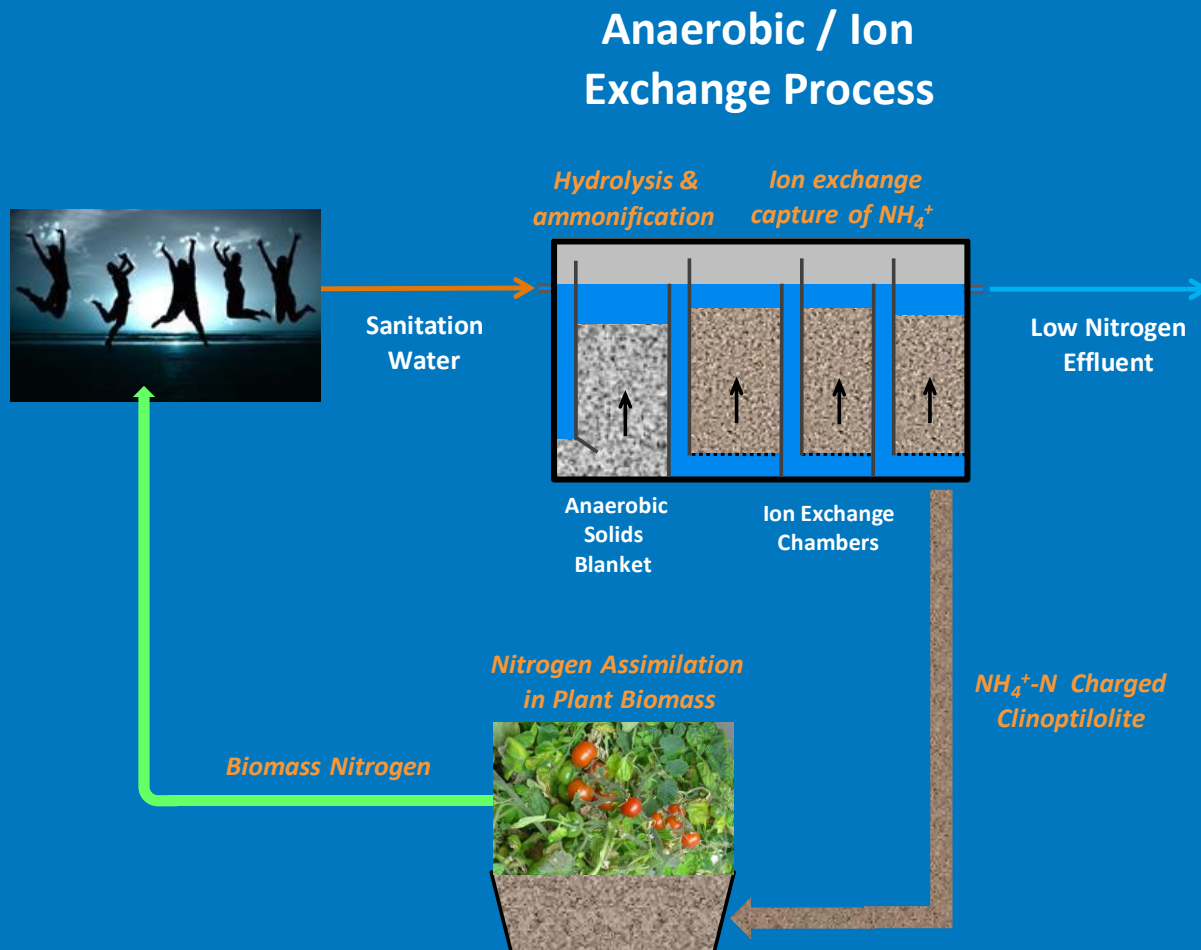
- Point-of-origin N recovery
- > 95% TN reduction
- Reliable performance ~1 year
- Passive, unattended operation
- No aeration or mechanical components

# AN-IX Advantages

- Simple with limited maintenance
- Reliable
- High % nitrogen removal
- Small footprint
- Not affected by groundwater table
- Seasonal operation

# Type 2 Value Proposition

## *Nitrogen Recovery & Reuse*



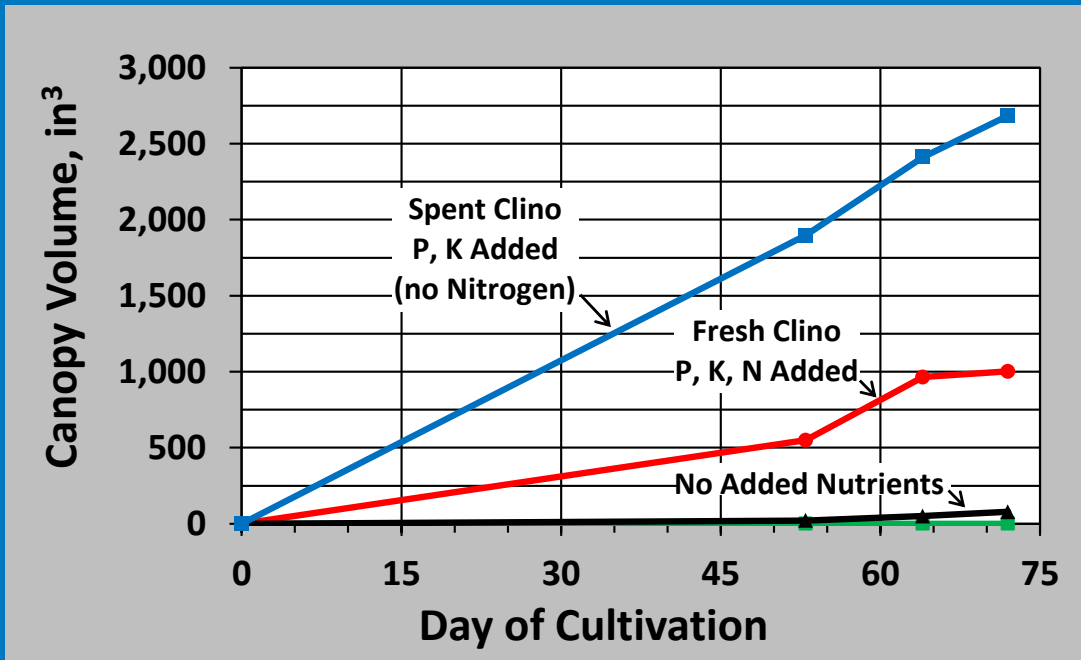
# Nitrogen & Zeolite Recycling

- Agricultural soil- direct application
- Controlled plant cultivation



# Clinoponics

Plant growth in granular clinoptilolite containing wastewater nitrogen



*Solanum lycopersicum* (cherry tomato)  
All nitrogen extracted from spent clinoptilolite  
250  $\mu\text{mol}/\text{m}^2\text{-sec}$  Photosynthetic Photon Flux  
12 hour on/off cycle



# Coniunctio



# END

