Assessing Nitrogen-removal performance of Advanced Onsite Wastewater Treatment Systems in Charlestown

Bianca Ross
University of Rhode Island
March 28, 2019
Disclaimer

Although the information in this presentation has been funded wholly or in part by the United States Environmental Protection Agency, it has not undergone the Agency’s publications review process and therefore, may not necessarily reflect the views of the Agency and no official endorsement should be inferred. The viewpoints expressed here do not necessarily represent those of the town of Charlestown or EPA, nor does mention of trade names, commercial products, or causes constitute endorsement or recommendation for use. Results discussed in this document are preliminary.
Advanced Nitrogen-removal OWTS

• Nitrogen poses a threat to coastal watersheds

• Systems consist of different zones where nitrogen cycle processes take place
  • Oxic zone $\rightarrow$ Nitrification
  • Anoxic zone $\rightarrow$ Denitrification
    • Nitrogen removed from wastewater

RI Dept. of Environmental Management has established a standard for final effluent total nitrogen concentration of 19 mg/L or less.
Advanced OWTS: Nitrogen removal treatment train

Final effluent sampling point

N$_2$O and N$_2$ have now been removed from wastewater and released to the atmosphere

Nitrification

$\text{NH}_4^+ \rightarrow \text{NO}_3^-$

Denitrification

$\text{NO}_3^- \rightarrow \text{N}_2\text{O}$

$\text{NO}_3^- \rightarrow \text{N}_2$
Project Description

- **46 study sites** in Charlestown, RI
  - **27 seasonally-occupied** – sampled 4 times throughout the summer
  - **23 year-round** – sampled quarterly throughout the year

- Field and lab analyses on final effluent to assess **system performance and N-removing effectiveness**

- Investigate rapid test accuracy for quantifying N levels (**photometer**)

- Optimize N removal
Technologies

• Orenco Advantex® AX20 and RX30

• Biomicrobics MicroFAST®

• Norweco Singulair® models TNT, 960, and DN
  • Grouped all Norweco systems for statistical analyses
Sample Collection and Processing

Arrive at field site

Collect final effluent sample

Field analysis (pH, DO, temperature, NH$_4^+$, and NO$_3^-$)

Standard lab analysis (BOD, pH, alkalinity, TN, NH$_4^+$, and NO$_3^-$)
Inorganic Nitrogen Analysis: Ammonium and Nitrate
Boxplots

- OUTLIER: Greater than 1.5 times the upper quartile
- MAXIMUM: Greatest value, outliers not included
- UPPER QUARTILE: 25% data greater than this value
- MEDIAN: Middle of the dataset
- LOWER QUARTILE: 25% data less than this value
- MINIMUM: Least value, outliers not included
- OUTLIER: Less than 1.5 times the upper quartile
Nitrate vs. Home Usage and Technology Type

Home usage: not significant

Technology type: not significant

March ’17 – August ‘18
Ammonium vs. Home Usage and Technology Type

Home usage: not significant

Technology type: significant

March ‘17 – August ‘18
Total Nitrogen Analysis
Total Nitrogen vs. Home Usage

Red line represents 19 mg/L standard

Home usage: not significant

March ’17 – August ‘18
Total Nitrogen: Seasonal Start-up Time?

Red line represents 19 mg/L standard

Sample Code Key:
- A = AX20
- R = RX30
- F = FAST
- $N_t/N_d = \text{Norweco}$

Home usage is not influencing performance
Total Nitrogen vs. Technology Type

Red line represents 19 mg/L standard

Technology type: significant

March ’17 – August ‘18
Total Nitrogen - AX20 Systems

76% of sites have median TN < 19 mg/L

March '17 – August '18
Total Nitrogen – RX30 Systems

Red line represents 19 mg/L standard

40% of sites have median TN < 19 mg/L

March ‘17 – August ‘18
Total Nitrogen – FAST Systems

100% of sites have median TN < 19 mg/L

March ‘17 – August ‘18
Total Nitrogen – Norweco Systems

Red line represents 19 mg/L standard

0% of sites have median TN < 19 mg/L

March ’17 – August ‘18
Total Nitrogen vs. Home Usage and Technology Type

Home usage: not significant

Technology type: significant

March ’17 – August ‘18
Median TN Concentration: Charlestown vs. Barnstable County Systems

Red line represents 19 mg/L standard

Monitoring makes a difference!
Rapid Test Analysis: Photometer
Rapid Test Analysis
Photometer

• Colorimetric reaction measures ammonium and nitrate concentrations

• Total Nitrogen = Ammonium + Nitrate + Organic Nitrogen

• Can the photometer estimate total nitrogen concentrations?
  • Photometer vs. Standard Methods
Rapid Test Analysis: Photometer
Sum of Ammonium and Nitrate vs. Total Nitrogen

Reliable method

**Photometer:**
- Slope = 1.01
- Y-intercept = 0.62
- \( R^2 = 0.68 \)
- \( p < 0.001 \)

**Standard methods:**
- Slope = 0.86
- Y-intercept = 5.7
- \( R^2 = 0.64 \)
- \( p < 0.001 \)
Rapid Test Analysis Photometer

• Fast method that provides nearly immediate results

• Can be used in an outdoor and indoor setting

• Cost-effective

• Reliable “triage” method for identifying underperforming systems
Summary: So far...

- Technology type does influence effluent nitrogen concentrations
  - Ammonium
  - Total nitrogen

- Home usage does not influence effluent nitrogen concentrations
  - No start-up time

- Photometer is a reliable tool for measuring effluent total nitrogen concentrations
Next steps

• Continue monthly/quarterly sampling through March 2020
  • Have service providers make adjustments to underperforming systems
  • Determine if adjustments to systems were effective

• Microbial community analyses

• Greenhouse gas flux analyses
Thanks for your attention!

Are there any questions?