Characterization of PFAS Occurrence, Transformation, and Partitioning in New Hampshire Community Septic Systems

Alexis Eaton[1], Jennifer Harfmann[2], Stephen Roy[2], James P. Malley[1], and Paula J. Mouser[1]

[1]Civil and Environmental Engineering, University of New Hampshire, Durham

[2]New Hampshire Department of Environmental Services

Introduction

PFAS = Per- and Polyfluoroalkyl Substances

- Don't fully break down in the environment due to strength of carbon-fluorine bond
- Associated with negative health impacts including thyroid disease, cancer, and liver disease (CDC, 2024)

Figure 1: Products Containing PFAS

- PFAS are frequently detected in municipal wastewater, but little is known about the presence, concentrations, and breakdown mechanics of PFAS in septic systems

Motivation

- Because PFAS are used in many commercial products like detergents and other cleaning agents, these compounds are being detected in household septic systems
- Studies have shown that septic systems are a non-point source of PFAS and other organic wastewater contaminants (OWCs) to groundwater (Schaider et al., 2016)
- Households that rely on septic systems for the treatment of wastewater as well as groundwater as a drinking water source are common in NH and especially vulnerable, as PFAS-containing septic discharge can migrate towards drinking water wells even with lengthy setback requirements (See Figure 2)

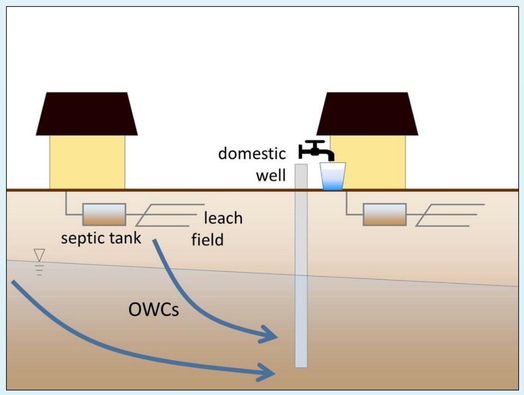

Figure 2: Septic Systems as a Non-point Source of PFAS to Drinking Water (Schaider et al., 2016)

Project Goals

The goal of this project is to identify gaps in current knowledge about PFAS in septic systems:

1) Determine the types and typical concentrations of PFAS commonly found in septic systems in comparison to municipal wastewater treatment systems
2) Understand how septic systems designed for nitrification and denitrification processes influence PFAS biochemical transformations
3) Examine how PFAS partition between solids and liquids within septic systems
4) Identify the types of microbial communities present in septic systems associated with PFAS biotransformation
5) Determine the influence that environmental conditions such as temperature, dissolved oxygen concentration, conductivity, and pH have on PFAS biotransformation

Location of Research

- Sites to be sampled include two community septic systems in coastal New Hampshire that have nitrification/ denitrification systems
  - First site utilizes a SeptiTech STAAR system (Figure 3)

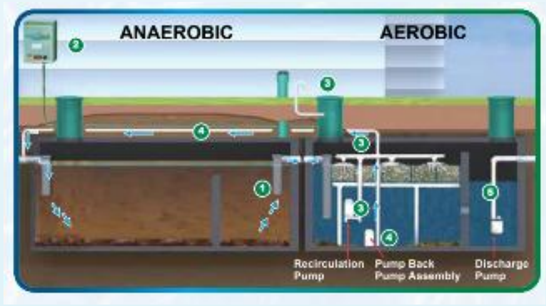

Figure 3: SeptiTech STAAR (Smart Trickling Aerobic/Anaerobic Recirculation) System

- Other site uses a Bioclere trickling filter over a clarifier (Figure 4)

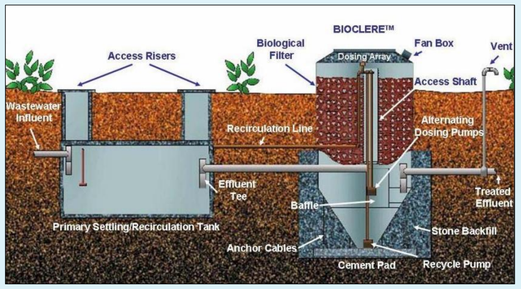

Figure 4: Bioclere Trickling Filter

Study Design

- Influent and effluent (liquid) samples collected monthly
- Post-nitrification and post-denitrification samples collected semiannually from both sites
- Solids samples from Site 1 settling tank were already collected in summer of 2024 during routine pump out
- Biofilm present on the trickling filter media (Figure 5) will be collected from both sites in January 2025 and June 2025 and analyzed using EPA Method 1633
  - DNA extraction will also be performed to identify the microbial communities associated with biotransformations occurring in each septic system
    - Biofilm removed via sonication and vortexing

Figure 5: Biofilm Present on the Trickling Filter Media at Site 2 and Sonication Process

- Measurements of temperature, dissolved oxygen concentration, conductivity, and pH will be collected with each sampling event

Preliminary Findings

Table 1: Detection Frequency of PFAS in WWTP and Septic System Influent

Compound	WWTP Detection Frequency	Septic System Detection Frequency
PFBA	81%	50%
PFBS	69%	83%
PFPeA	86%	83%
PFHxA	98%	67%
PFHxS	62%	50%
PFHpA	69%	83%
PFOA	81%	67%
PFOS	50%	50%

Table 2: Detection Frequency of PFAS in WWTP and Septic System Effluent

Compound	WWTP Detection Frequency	Septic System Detection Frequency
PFBA	83%	46%
PFBS	86%	67%
PFPeA	100%	83%
PFHxA	100%	100%
PFHxS	60%	25%
PFHpA	88%	75%
PFOA	95%	75%
PFOS	85%	58%

Preliminary Findings

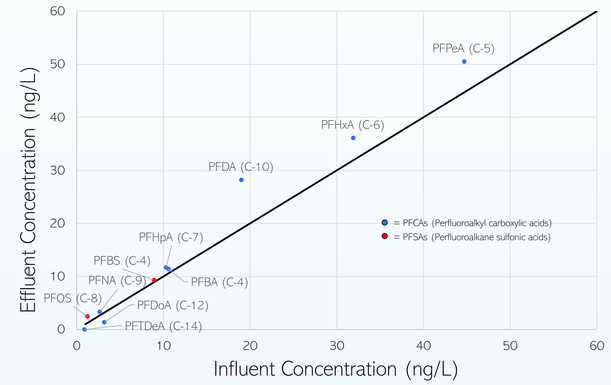

Figure 7: Detected End Products: Influent versus Effluent Concentrations

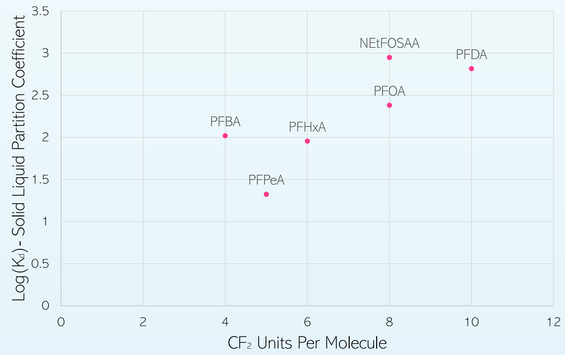

Figure 8: Solid-Liquid Partitioning in a Household Septic Tank

Main Takeaways:

- Similar compounds present in municipal WWTFs are present in community septic systems
- Septic systems appear to be sources of short chain PFAS compounds and sinks for long chain compounds
  - Higher concentrations of short chain PFAS in effluent than influent could be attributed to biotransformation
  - It is likely that long chain PFAS are sorbing to the solids

Future Plans

- Determine if preliminary findings and trends continue to be evident
- Perform DNA extraction of biofilm on media at both sites to characterize microbial communities associated with PFAS concentrations and biotransformation
- Examine how changes in environmental conditions over time influence PFAS concentrations (pH, temperature, etc.)
- Obtain post-nitrification and post-denitrification samples to understand how these processes influence PFAS transformation