Distribution and Fate of Per- and Polyfluorinated Alkyl Substances (PFAS) in Wastewater Treatment Facilities

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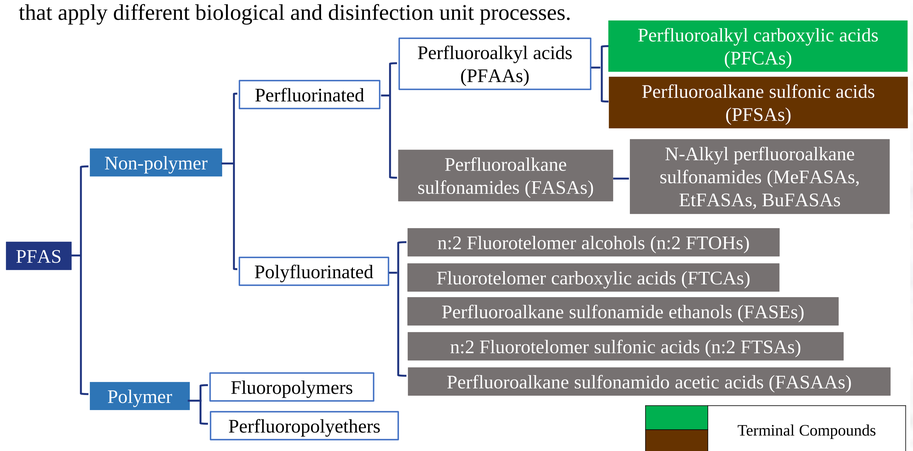
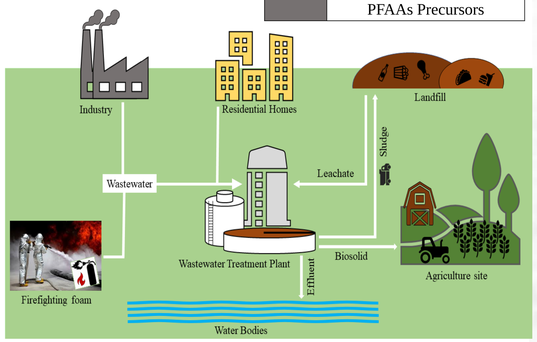
Abstract

Anthropogenic compounds known as per-and polyfluorinated alkyl substances (PFAS) represent a major class of contaminants of emerging concern (CEC). PFAS widespread use, broad environmental distribution, recalcitrance in the environment, and potential toxicity to humans and ecosystems have resulted in the considerable growing concern. PFAS are well known to be moderately toxic to marine and freshwater aquatic organisms, can bioaccumulate and pose human and ecological health concerns. Wastewater treatment Facilities (WWTFs) are a continued source of PFAS to surface waters because of their direct tie to common household products and related industrial, municipal, and firefighting wastewater discharges. This study investigated the distribution and removal efficiency of twenty-four PFAS within six New Hampshire WWTFs that apply different biological and disinfection unit processes.



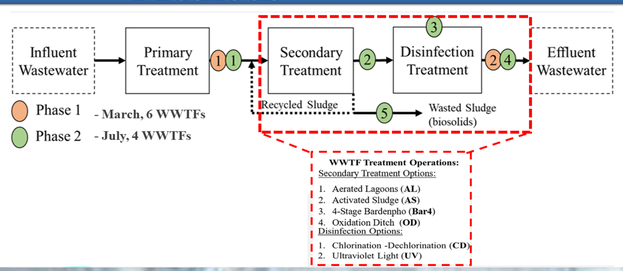
WWTFs are known to be a continued source of PFAS to surface waters. PFAS can be released to WWTFs via industrial wastewater, residential septic, landfill leachates, and frightening training area. Not only WWTFs receive a high PFAS concentrations but also, they significantly discharge PFAS in a high quantity from their effluent to water bodies due to PFAS persistency to degradation.



Goals and Hypotheses

- What portion of PFAS are being detected within local WWTFs?
- How does WWTF design and operation influence PFAS diversity and removal efficiency?
- Are PFAS concentrations influenced by seasonal variation?
- What is the distribution of PFAS in receiving water bodies (Great Bay Estuary) versus the PFAS in the WWTFs?
- What is the fate of PFAS precursors during treatment in WWTFs?

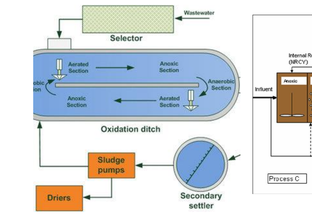
Methods



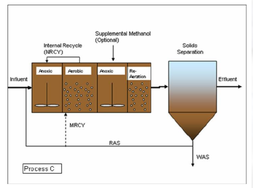
Methods

Sample Design

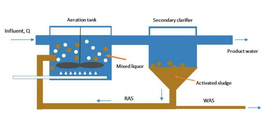
- In this study, a total of 28 wastewater, 4 sludge, and 5 surface water samples were collected from six WWTFs discharging to Great Bay estuary.
- The effect of four different biological treatment operations on PFAS degradation were investigated.



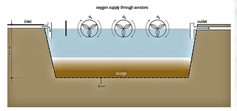
Liu et al., 2016



Wilner et al., 2010



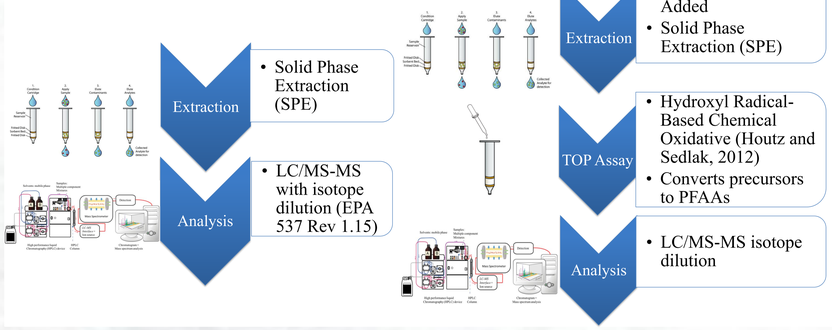
Genesis Water Technologies. 2018



TILLEY et al. (2014)

Sample Analysis

- PFAS quantification was conducted using two approaches: (1) direct LC-MS/MS analysis of 24 known compounds and (2) a total oxidizable precursor assay (TOP Assay) followed by LC-MS/MS to determine the total potential PFAS concentration. The TOP Assay uses a strong chemical oxidizing agent to convert larger fluorinated precursor compounds (for which no analytical standards exist) into their terminal end products that can be quantified by LC-MS/MS method. Therefore, TOP Assay expands our limited compound specific analytical techniques by providing an overall quantifiable estimate of all likely PFAS present.



Results

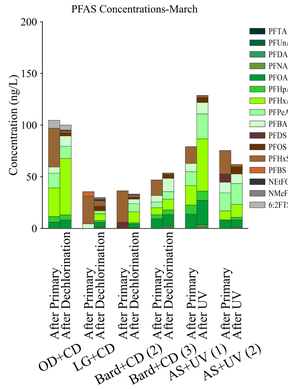
Detections

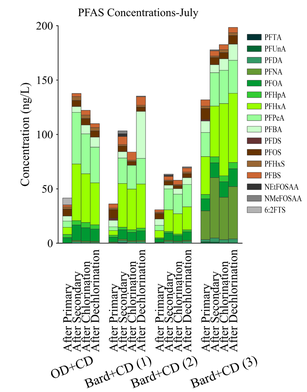
		WWTP#	1				2				3				4				5	6	Surface water Samples				
		Treatment	OD+CD				AL+CD		Bard+CD (1)		Bard+CD(2)				Bard+CD(3)				AS+UV (1)	AS+UV (2)					
			Influent		Effluent		Influent		Effluent		Influent		Effluent		Influent		Effluent		March	March					
Group		Compound	Mar	July	Mar	July	Mar	July	Mar	July	Mar	July	Mar	July	Mar	July	Mar	July	Inf	Effl	Inf	Eff	Hilton Park	Mill Pond	Adams Point	Great Bay	Squam -Scott
24 PFAS	PFCA(11)	PFBA																									
		PFPeA																									
		PFHxA																									
		PFHpA																									
		PFOA																									
		PFNA																									
		PFDA																									
		PFUnA																									
		PFDoA																									
		PFTrDA																									
		PFTA																									
	PFSA(7)	PFBS																									
		PFHxS																									
		PFOS																									
		PFDS																									
		PFPeS																									
		PFHpS																									
		PFNS																									
	PRECURSOR(6)	6:2FTS																									
		8:2FTS																									
		NMeFOSAA																									
		NEtFOSAA																									
		4:2FTS																									
		FOSA																									

Non-Detected | Detected | Inf>Eff | Eff>Inf

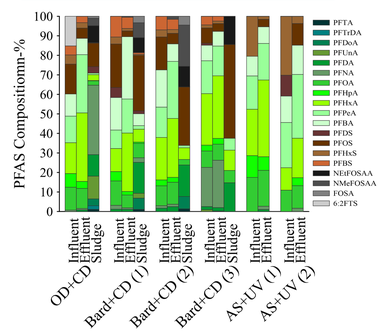
Results

Aqueous Distribution

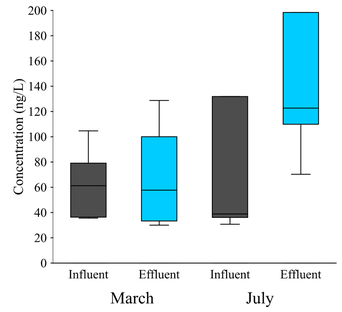




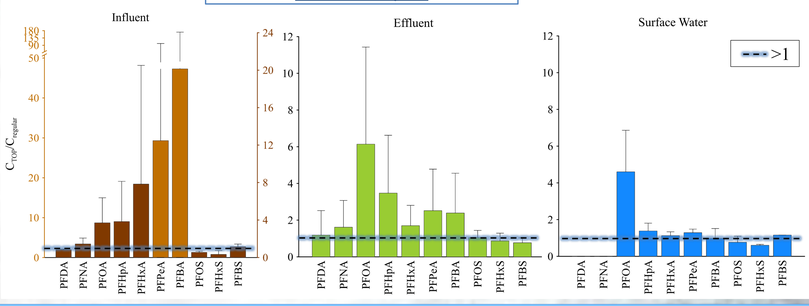
Sludge Distribution



Seasonal Differences



TOP Analysis



Summary of Findings

- 8PFCAs, 4PFSAs, and 4 Precursors detected in influent and effluent .
- Total PFAS concentrations increased after treatment in effluent of WWTFs.
- Higher effluent PFAS concentrations were detected in second season, it may due to higher temperature.
- Long-chain compounds were detected more in sludge due to higher hydrophobicity
- Short-chain compounds were detected more in aqueous phase, due to their hydrophilicity
- Higher PFAS precursors were indirectly detected in influent compared to effluent and surface water through TOP Assay analysis.

Acknowledgement

- We would like to thank all wastewater facilities for their collaboration
- Thank New Hampshire Sea Grant and UNH STAF fellowship program for supporting our research study