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Ph.D. DISSERTATION DEFENSE

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Title:	Behavior of PFAS in Wastewater Treatment Systems
Chairperson:	Dr. Dibyendu Sarkar, Department of Civil, Environmental, and Ocean Engineering, Stevens Institute of Technology
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ABSTRACT

Per- and polyfluoroalkyl substances (PFAS) pose significant challenges to wastewater treatment systems due to their persistence, mobility, and complex transformation pathways. Although wastewater treatment plants (WWTPs) are designed to protect environmental and public health, conventional treatment processes are largely ineffective at removing PFAS, potentially transforming and redistributing these contaminants into receiving waters and biosolids. This dissertation investigates PFAS occurrence, transformation, partitioning, and mitigation across wastewater systems, connecting industrial and residential contamination sources with sustainable biosolids management.

First, a full-scale WWTP co-treating municipal wastewater and industrial landfill leachate was investigated using targeted PFAS analysis, the total oxidizable precursor (TOP) assay, and extractable organic fluorine (EOF) measurements. Influent and effluent PFAS concentrations ranged from 432 to 727 and from 356 to 558 ng/L, respectively, with removal efficiencies of only 6%–25%. The TOP assay revealed substantial precursor burdens, while targeted PFAS explained merely 12%–25% of measured EOF, highlighting limitations of conventional monitoring. Significant PFAS accumulation was also observed in sludge and biosolids.

Second, three predominantly residential WWTPs were investigated to determine whether similar contamination patterns persisted without substantial industrial inputs. Effluent PFAS concentrations frequently exceeded influent levels, indicating potential precursor transformation during treatment. The TOP

assay revealed PFAS concentrations up to fourfold higher than targeted measurements. PFAS also accumulated in sludge, while incineration produced approximately 99% lower concentrations in residual ash. Finally, sustainable PFAS immobilization was evaluated using alum-based and polyaluminum chloride-based drinking water treatment residuals (WTRs), compared with granular activated carbon (GAC). Alum-based WTRs demonstrated a greater reduction in PFAS leachability, particularly at 10% amendment rates, while moderate dosages preserved appreciable plant-available phosphorus and ammonium nitrogen.

Collectively, this dissertation demonstrates that WWTPs function as critical pathways for PFAS transformation and environmental redistribution rather than sites of complete elimination. By integrating comprehensive analytical characterization, source-specific investigations, and waste-derived sorbent stabilization, this research establishes a framework for understanding PFAS behavior throughout wastewater systems. These findings support improved monitoring, sustainable biosolids management, and integrated mitigation strategies that minimize PFAS mobility while advancing circular-economy principles and protecting aquatic and terrestrial environments from persistent contamination.