The Occurrence, Mobility and Remediation of Per- and Polyfluoroalkyl Substances (PFAS) within the Soil-Groundwater System

Yanan Zhao[1], Kamryn Veith[2], Sally Klein[2], Owen Miller[2], Lisa Haas[3], David Hart[3], Justin Peschman[2], Yin Wang[1], Shangping Xu[2]

[1] Department of Civil and Environmental Engineering, University of Wisconsin – Milwaukee, Milwaukee, WI 53201
[2] Department of Geosciences, University of Wisconsin – Milwaukee, Milwaukee, WI 53201
[3] Wisconsin Geological and Natural History Survey, Madison, 53705

Initial Estimation of PFAS Flux to Lake Michigan through the Quantitative Understanding of PFAS Contamination Within Wisconsin's Connected Aquifers

Supported by Wisconsin Sea Grant

The primary goal of this research is to use the sediment repository maintained by WGNHS to provide an initial survey the spatial and temporal distribution of PFAS within Wisconsin groundwater aquifers from the 1940s when PFAS began to be manufactured in large quantities and widely used in a range of consumer, commercial and industrial applications. We then tried to re-construct the aqueous PFAS concentration at the time of the sediment collection for sites containing high PFAS concentrations through a series of carefully designed adsorption/desorption experiments. Our results showed that PFAS occurred in Wisconsin's groundwater from the 1940s and became more abundant over time.

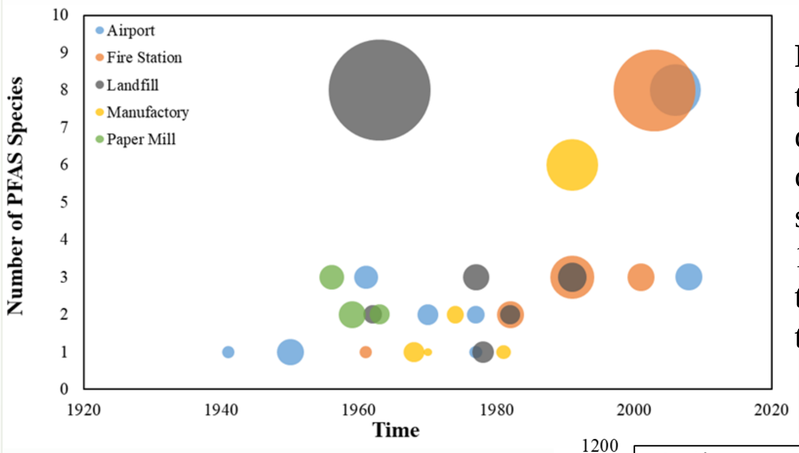


Figure 1. Temporal trend of the number of PFAS species detected and total PFAS concentrations in sediment samples collected between 1940 and 2020. The size of the symbols represents the total PFAS concentration.

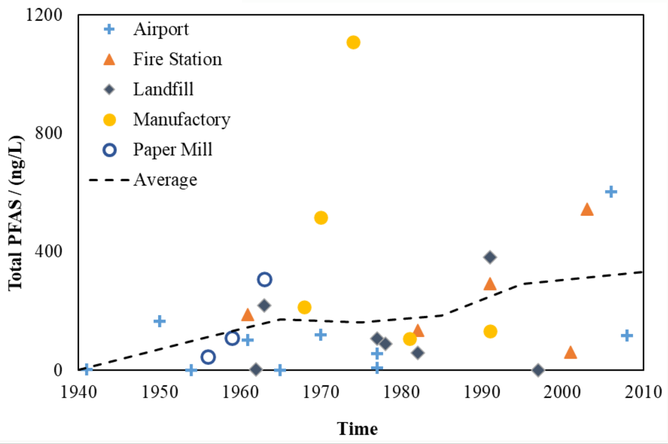


Figure 2. Estimated total PFAS concentration in groundwater at the time of sediment sample collection.

High-resolution Profiles of PFAS within the Vadose Zone of a Firefighting Test Site

Supported by Wisconsin Sea Grant, Wisconsin Groundwater Research and Wisconsin Department of Natural Resources

PFAS released into the environment via various pathways can accumulate within the soil, which in turn can play crucial roles in determining their transport, fate, as well as environmental and health impacts. In this study, we determined the vertical profiles of 12 PFAS within soil cores collected from the Truax Field located in Madison, WI, at a spatial resolution of ~ 15 cm. Our results showed that the concentrations of the PFAS within the vadose zone ranged from below detection limit to ~104 ng/g. The total mass of the PFAS within the soil cores (cross section area: 0.0046 m^2) varied from 0.08 mg for perfluorodecanoic acid (PFDA) to 51.59 mg for perfluorooctanesulfonic acid (PFOS). The overall mobilities of the PFAS were quantified using their depths of center of mass. Long-chain PFAS such as PFOS exhibited low mobility within the vadose zone thanks to the adsorption by the soil and the air-water interface. In contrast, the short chain PFAS such as PFBA and PFBS had significantly higher mobility.

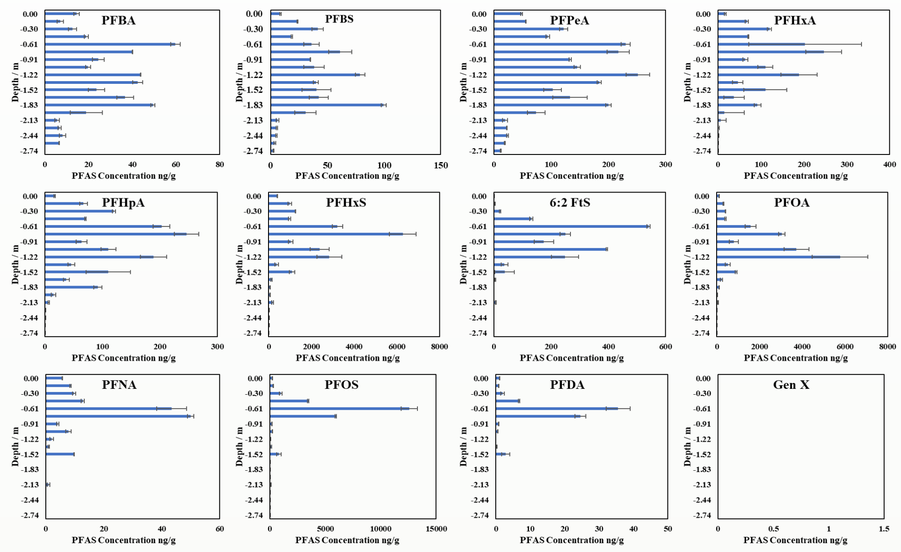


Figure 6. Profiles of 12 PFAS within soil core A.

Assessing the Effectiveness of Injectable Particulate Carbon (IPC) on PFAS Immobilization in Groundwater

Supported by Wisconsin Department of Natural Resources

To the best of our knowledge, very few studies have examined the potential use of IPC in the remediation of groundwater PFAS contamination within the state of Wisconsin. The primary goal of this research is to experimentally evaluate the retention of representative PFAS by commercial IPC within selected Wisconsin groundwater aquifer sediments. Our results showed that the effectiveness of IPS varied based on properties of sediments.

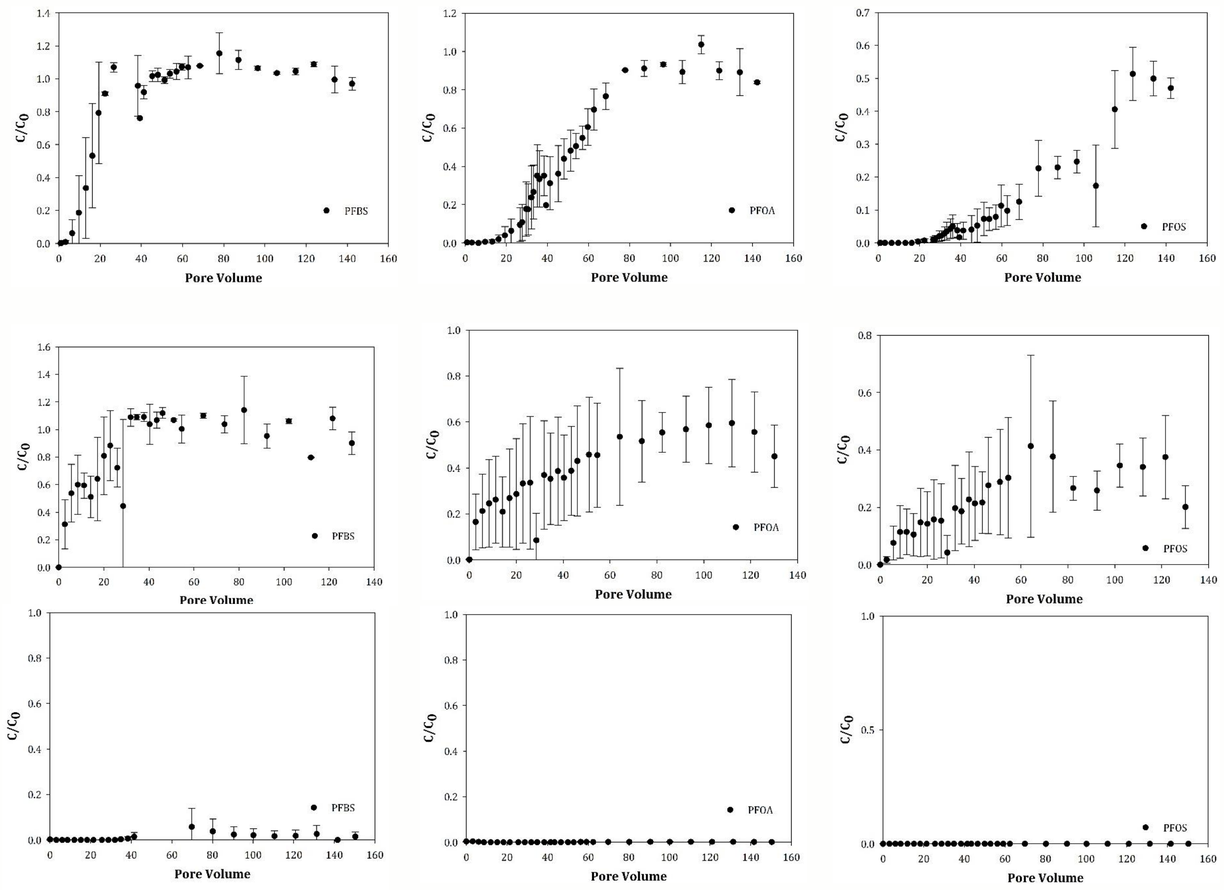
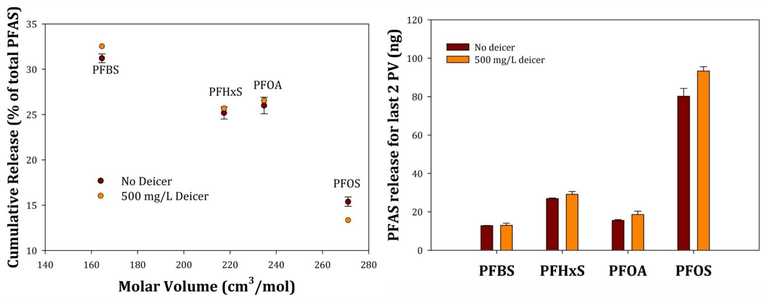


Figure 3-5. Effects of colloidal carbon injection on the transport of PFBS, PFOA and PFOS within Truax Field sediments.

Impacts of Deicers on FPAS Transport in Groundwater

This study investigates the potential impact of airplane deicer solution, which is commonly used in large quantities in airports, on the transport of PFAS through groundwater systems. A series of column experiments were conducted using soil collected from a firefighting test area (FTA) located in Dane County, Wisconsin. The columns were wet packed with prepared soils and groundwater (with and without type IV deicer) was injected into the packed columns. Our results showed that airplane deicer at environmentally relevant concentrations could enhance the release of PFAS from contaminated soils collected from AFFF sites, likely due to competitive adsorption.



Figures 7-8. Show that the release of PFAS was dependent on PFAS properties (hydrophobicity, as reflected in molar volume), and the impact of deicer on PFAS release was slow (more pronounced for last 2 PV)

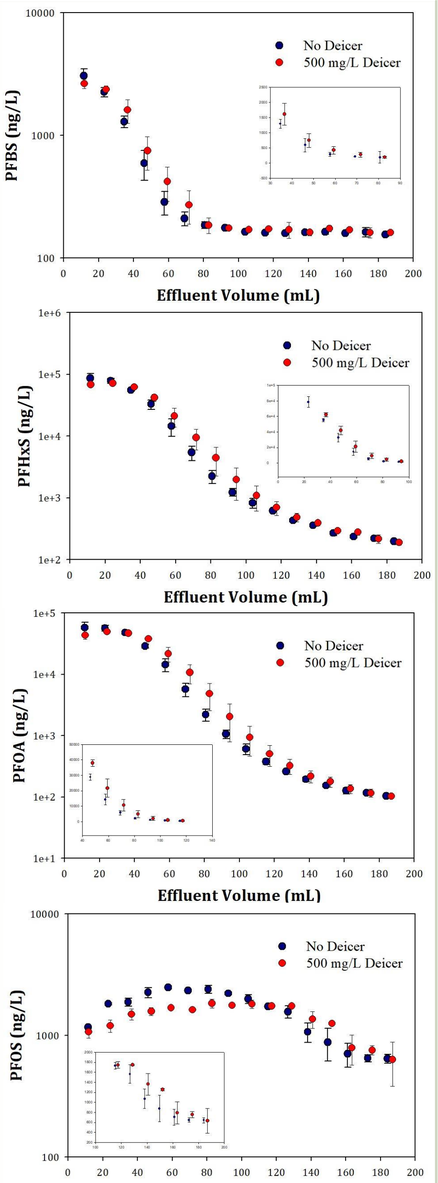


Figure 9. Effluent PFAS concentrations.