Characterizing PFAS Transport in Unsaturated Glacial Sediments Using Meter-Scale Column Experiments

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Background

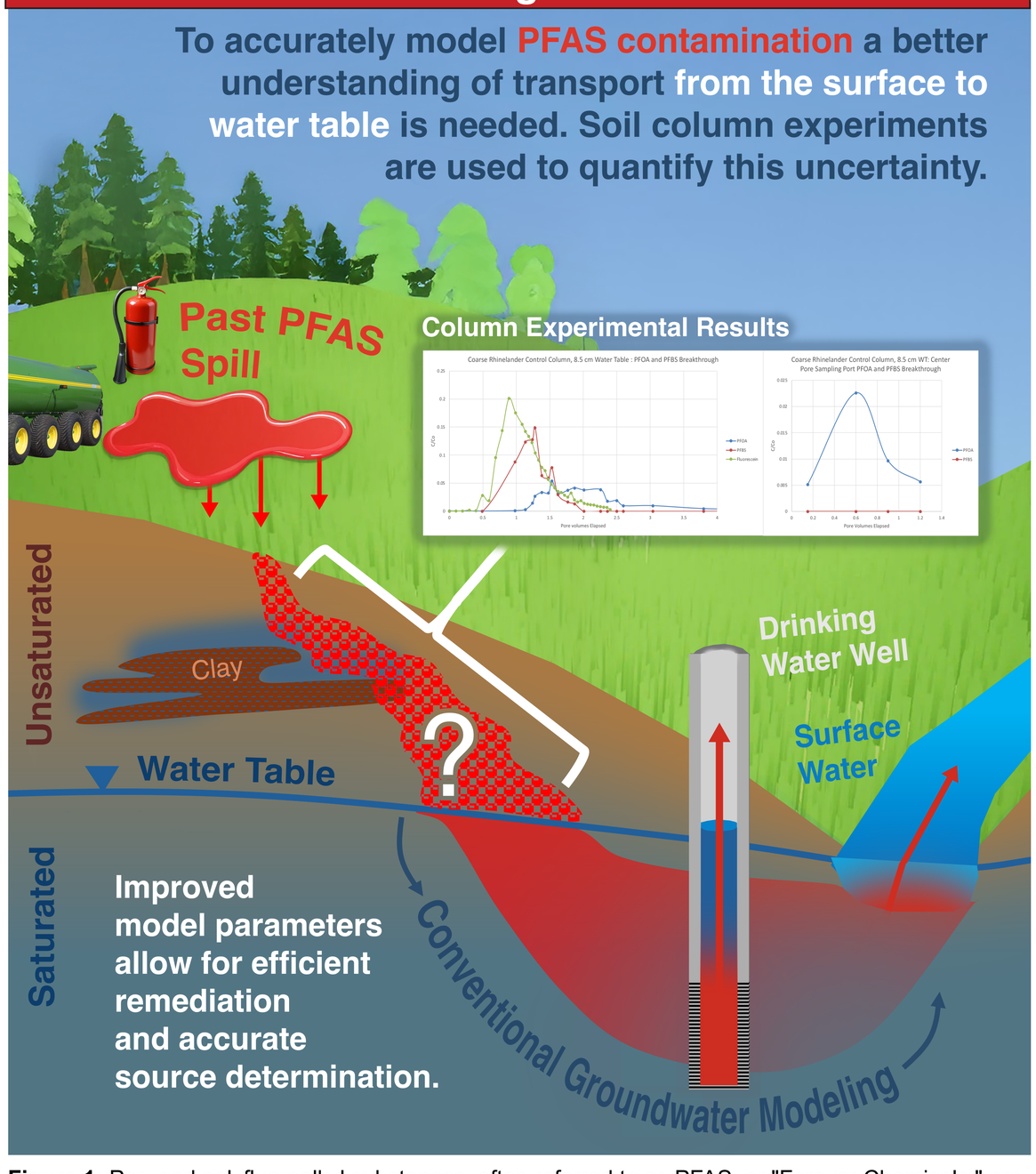

Figure 1: Per- and polyfluoroalkyl substances, often referred to as PFAS, or "Forever Chemicals," are widespread because of their unique polar properties that repel chemicals, resist fire, among other uses. However, these characteristics also make PFAS resistant to degradation and a potent drinking water contaminant, with health implications at low part-per-trillion concentrations. PFAS transport is slow in the unsaturated zone, making contamination from past events potentially long lasting and difficult to remediate.
Areas with shallow fluctuating water tables, such as Rhinelander Wisconsin, are especially impacted by PFAS contamination, with the greatest challenges being determining the age and location of the contamination source zone.

Observations

PFAS chemicals are more difficult to model and understand than traditional contaminants because they adsorb to air-water interfaces found in the unsaturated portions of the subsurface. These interfacial interactions were observed by injecting PFAS through partially saturated soil columns packed with glacial soil from a known PFAS contamination site, Rhinelander, WI.
Fine soils increased water retention in the unsaturated zone, resulting in overall higher saturation due to capillary pressure. However, potential surface interactions with the finer soil particles led to persistent, low-concentration contaminant plume leaching over time.
Ongoing research is exploring the impact of fluctuating water tables on the mobilization of PFAS adsorbed to fine soils and air-water interfaces within the vadose zone.

Column Experimental Design

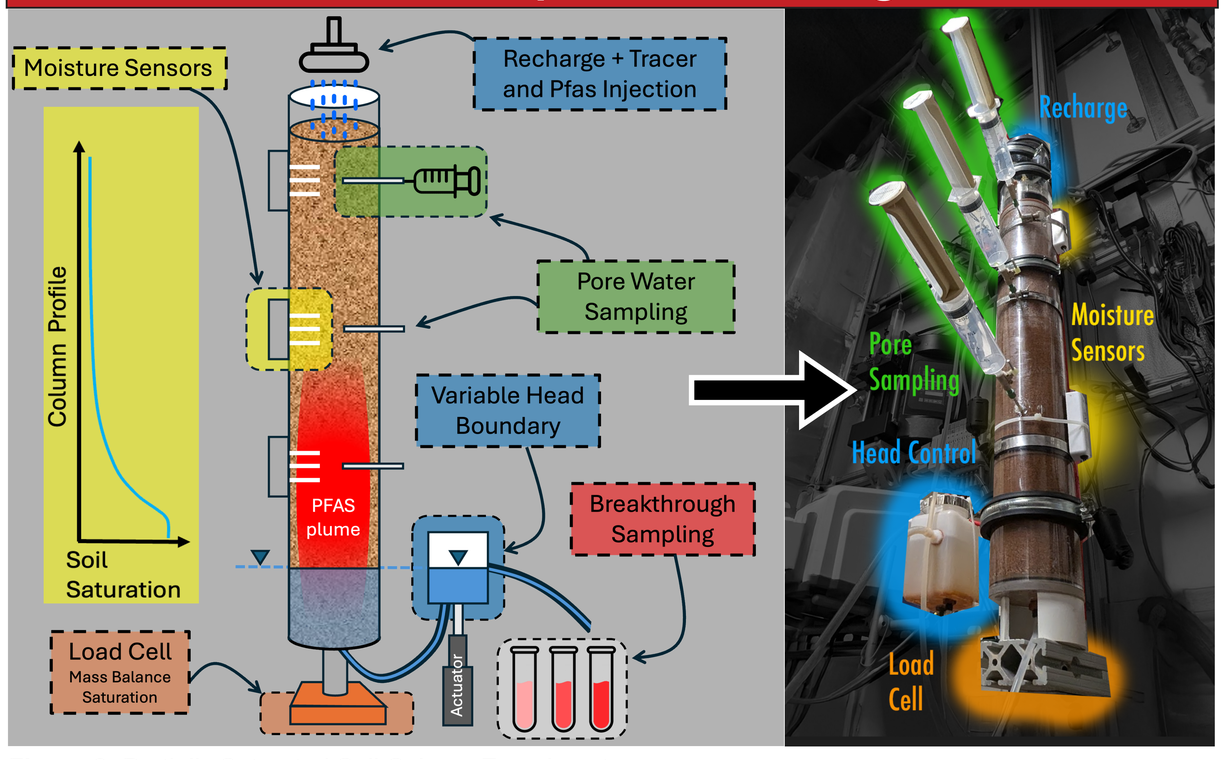

Figure 2: Partially Saturated Soil Column Experiment
- Glacial soil is sieved to size, fired to remove contaminants, and partially saturated.
- Water is introduced into the top of the column to simulate recharge-driven groundwater flow.
- PFAS and a conservative tracer are injected, simulating a contaminant spill.
- An actuator controls the water table, while moisture sensors monitor soil saturation and a load cell tracks the mass balance within the system.
- Pore water sampling track the PFAS plume mid-transport through the unsaturated zone, while an autosampler collects data to construct a PFAS breakthrough curve.
- PFAS is analyzed in-house via LC-MS with help from Water Science Engineering Laboratory.

Acknowledgements and References

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References: *Gnesda, W. R., Draxler, E. F., Tinjum, J., & Zahasky, C. (2022). Adsorption of PFAAs in the vadose zone and implications for long-term groundwater contamination. Environmental Science & Technology, 56(23), 16748-16758.*