Modeling the Transport of Microplastics Through the Floridan Aquifer System

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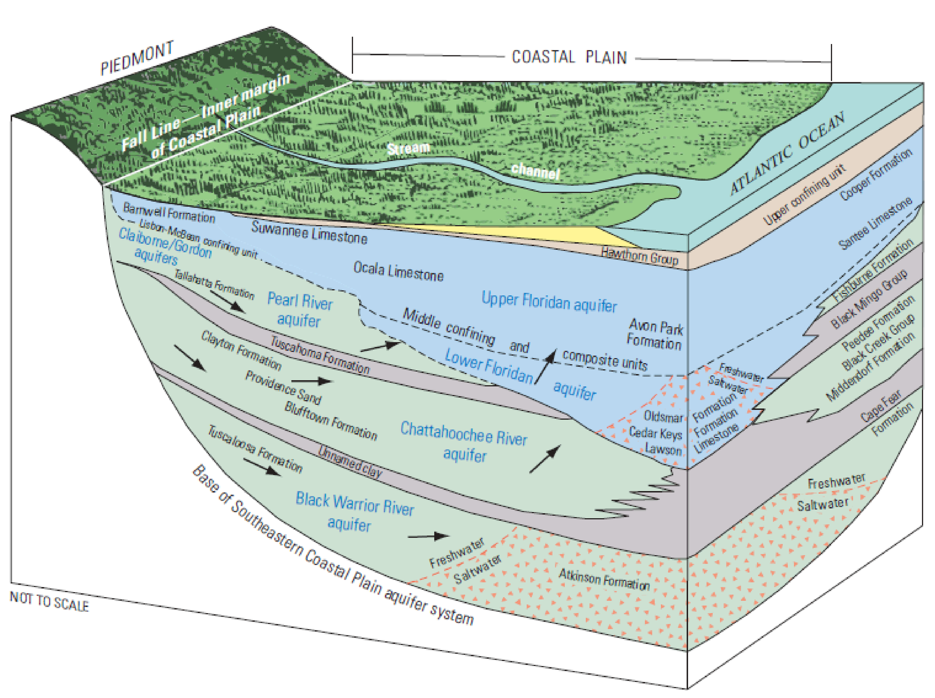
Background

Due to the Floridan Aquifer System's geographical location and its proximity to populous areas, it is extremely vulnerable to contaminants, including microplastics. Microplastics are particles smaller than 5 millimeters that result from the degradation of synthetic polymers. In this experiment, we investigated whether we can effectively and consistently model the sediment filtration of microplastics as they travel through Florida's aquifers. By understanding their transport behavior, we can better assess the long-term risks to the state's primary water source.



Study Distinction

Although the process for measuring the concentration of solutes is well developed, there is a gap in our ability to model the behavior of nanoplastics in "environmentally realistic" settings, making it so variables such as flow rate and particle adherence have not been thoroughly studied. By contrasting the stable breakthrough of tracers with the erratic movement of nanoplastics, this experiment addresses the failure of current models to account for the unique risks microplastics pose to the Floridan Aquifer System

Methodology

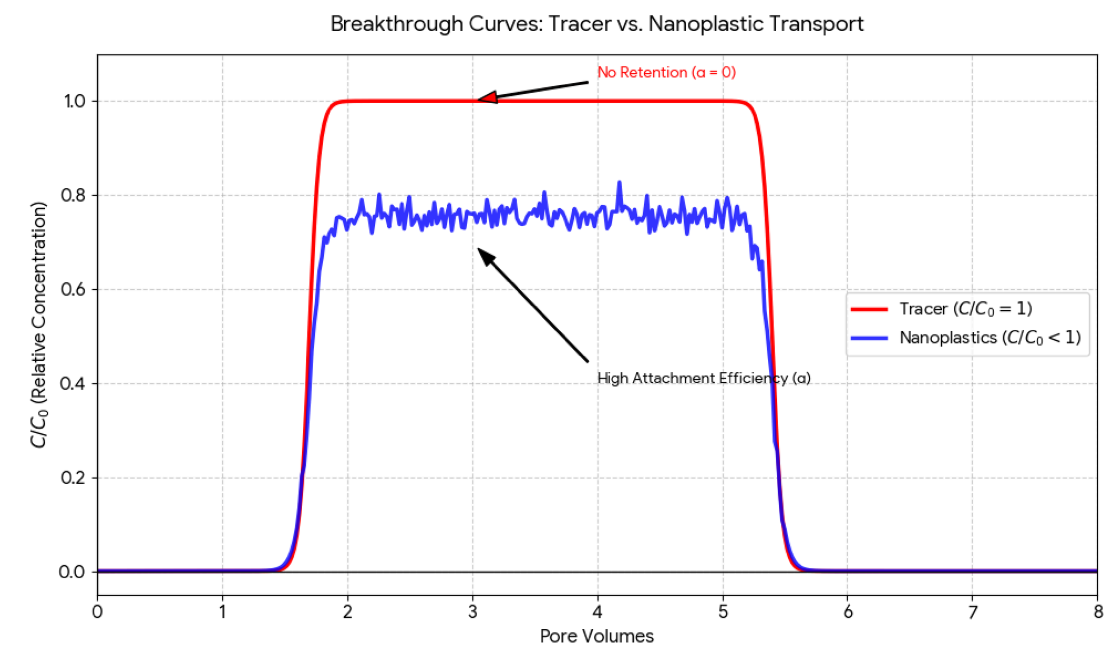
We conducted two distinct column experiments: one utilizing a standard chemical tracer and another utilizing a tracer containing synthetic nanoplastics.The experiment consisted of a column packed with acid-washed sand. To mimic aquifer conditions the sediment was compacted using mechanical vibration. A syringe pump pushed the liquid tracers at a constant flow rate of 0.9 mL/min. As the tracers migrated through the sediment-packed column, the effluent was analyzed in real-time using a UV-Visible Spectrophotometer. By monitoring the absorbance we quantified the concentration of particles that successfully passed through the sediment. This data allowed us to identify specific physical variables that interfere with the movement of nanoplastics

Refrences

Tufenkji, N., & Elimelech, M. (2004). Correlation equation for predicting single-collector efficiency in physicochemical filtration in saturated porous media. Environmental Science & Technology

Yacoob, U., & Farner, J. M. (2020). Column Experiments Standard Operating Procedure. Tufenkji Lab, Updated February 2020.

Results



The standard chemical tracer trials yielded consistent breakthrough curves, establishing a reliable baseline for one pore volume at a flow rate of 0.9 mL/min. However, Experiments using synthetic polymer particles showed high variability in concentration recovery.

These results allowed us to identify particle accumulation at tubing junctions and tight bends, as well as significant fluctuations in absorbance readings due to minor adjustments to the syringe pump flow rate, such as those that appeared when we utilized the four-way connector or switched between sources.

The adhesion to tubing and the fluctuating concentrations caused by small adjustments in flow rate suggest that calculated amounts of microplastics in water sources may be representative of temporary conditions rather than the consistent levels humans regularly ingest. Furthermore, the fluctuations in our results likely mimic the "pulses" that occur during weather events or other natural forces of change, which can suddenly mobilize particles that were previously adhered to the environment.

Disscussion

Our findings show that nanoplastics introduce a level of "hypersensitivity" not seen in standard tracers. There is a lack of knowledge of the movement of nanoplastics once they enter the environment, as they do not follow predictable flow paths. This makes it so they pose a significant threat to the Floridan Aquifer system and citizens' drinking water. We recommend the development of "plastic-specific" transport models that account for the electrostatic interactions that cause them to adhere to surfaces and react to flow rate changes.

Significance

These findings are significant because they demonstrate that nanoplastics do not behave like traditional solutes. The varying movement observed suggests that current water quality models may be underestimating how quickly or inconsistently these pollutants move through landscapes like Florida's aquifers.

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