

EGU22-10808

<https://doi.org/10.5194/egusphere-egu22-10808>

EGU General Assembly 2022

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Sorption of Per- and Polyfluoroalkyl Substances (PFAS) by Porous Media in Saturated Zone: A Review Study

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PFAS are of emerging concern due to their high environmental persistence, human health effects, and bioaccumulation attributed to their chemical properties. These chemical properties make them preferable for many industrial and domestic purposes. In turn, PFAS are emitted from a vast amount of sources and eventually reach the surface water and groundwater environments. The most critical pathways for groundwater are infiltration via the unsaturated zone and riverbank filtration. Natural filtration of PFAS reduces the risk of PFAS contamination, and sorption is considered the most crucial removal mechanism of PFAS from saturated porous media. This study aims to better understand the sorption processes and factors affecting the affinity of soil to sorb different types of PFAS. A thorough understanding of these processes is needed to model PFAS fate and transport in groundwater and estimate human health's impact. To meet this aim, we conducted a literature survey involving PFAS sorption behavior to soil and external sorbents in batch and column experimental studies and monitoring studies in the field.

PFAS tail group are hydrophobic organic chemicals. Hydrophobic interactions are thus one of the main sorption mechanisms in groundwater, especially when the soil has a higher organic carbon content. Several studies have found that the retention of PFAS is increased with the increase in PFAS hydrophobicity and the amount of organic matter in the soil. Another important forces affecting the interaction of PFAS with soil are the electrostatic forces. Many PFAS are present in the environment in their anion form and bond to positively charged soil surfaces. Soils with a negative charge surface can repel PFAS and reduce retention. Other minor processes such as the hydrogen bond and PFAS functional group forming complexes can increase the sorption to soil. Soil properties and solution chemistry significantly affect these forces and bonds and can either reduce or increase the affinity of PFAS sorption to soil. The presence of co-contaminants and nonaqueous phase liquids in groundwater further affects these processes.

Difficulties in degrading PFAS compounds led to alternative ways of remediation, such as stabilizing PFAS in soil by employing sorption processes. With the gained knowledge, external sorption enhancers can be used to increase the PFAS sorption besides altering the solution

chemistry to maximize the retention and stabilization of PFAS in soil.

The dynamics of the sorption process are affected by preferential flow and intra-sorbent diffusion, leading to rate-limited sorption effects. These dynamics are essential for the model selection and estimating the time needed for the clean-up during remediation.