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Tracing the transport of organic colloids in porous media using tailored poly(ethylene glycol)

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A large fraction of organic matter in natural aqueous soil solutions is given by molecules in sizes above one nanometer, which classifies them as colloids according to the IUPAC definition. Such colloids feature discernable mobility in soils and their transport is decisive for the cycling of carbon as well as the migration of nutrients or contaminants. Yet, their size-dependent hydrodynamics and functional diversity result in transport phenomena that are specific to colloids and, thus, largely differ from those observed for smaller substances. Still, tracers that appropriately represent small organic colloids are not available and the investigation of their transport in laboratory column experiments, in dependence of size and chemistry, remains difficult. To overcome this limitation, we tested if well-defined synthetic polymers in the colloidal size range are suitable as non-conventional tracers of colloidal transport. As polymer backbone, we selected poly(ethylene glycol) (PEG) due to its high water-solubility and established pathway of synthesis that permits tailoring of functional moieties to the fullest extent. An easy and sensitive detection in the aqueous phase became possible by using a fluorophore as starting group. After full characterization, we studied PEG adsorption to quartz, illite, goethite, and their mixtures in batch and column transport experiments. In numerical simulations, we successfully reconstructed and predicted PEG transport based on its physicochemical as well as hydrodynamic properties and, thus, show that PEG transport can be comprehensively and quantitatively studied. Considering also its low adverse effect on the environment, functional PEG therefore presents as promising candidate to be used as organic tracer, designable in the size range of natural organic (macro-)molecules (Ritschel et al., 2021).

References

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