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Transport and retention of nanoplastic particles in saturated columns packed with iron oxyhydroxide-coated sand

Taotao Lu¹, Benjamin S. Gilfedder^{1,2}, and Sven Frei¹

¹University of Bayreuth, Department of Hydrology, Germany (taotao.lu@uni-bayreuth.de)

²University of Bayreuth, Limnological Research Station, Germany

With the increasing use of nanoplastic products in our daily life, these particles will invariably enter into the subsurface environment. It is, therefore, vital to understand the transport and retention of nanoplastic particles in groundwater systems. Surface charge heterogeneity is one of the basic chemical-physical characteristics of aquifer materials, but little research has been conducted on this topic. This study aimed to understand how the interaction between the porous media, solution chemistry, and NP surface charge influences the transport and retention of PS-NPs in the subsurface. 25 mg/L polystyrene nanoplastic particles (PS-NPs) were injected into columns packed with iron oxyhydroxide-coated sand. In addition, factors such as the content of iron oxyhydroxide-coated sand (λ), pH, ionic strength (IS), and cation valence were systematically studied. DLVO theory was used to evaluate the interactions between PS-NP and the porous media. By comparing the breakthrough curves (BTCs) of PS-NPs, it was clear that all these variables exerted a significant influence on the mobility of PS-NPs in the columns. These effects could be explained by the following: Firstly, by applying the DLVO theory, it was possible to model the electrostatic interaction between quartz sand and PS-NPs. For instance, at different IS (NaCl), the maximum energy barrier (Φ_{\max}) decreased with an increase in IS, which meant PS-NPs could more easily overcome the energy barrier to deposited on the sand surface at higher IS. Secondly, the positively charged iron oxyhydroxide coating provided additional favorable deposition sites for negatively charged PS-NPs. However, when the pH of the solution exceeded the iron oxyhydroxide pH_{pzc} (\sim pH 9), the iron coating became negative and increased the mobility of PS-NPs. Finally, bridging agents, such as Ca^{2+} and Ba^{2+} , resulted in the significant deposition of PS-NPs on the sand due to the bridging effect connecting the porous media and PS-NPs through the O-containing functional groups on both plastic and mineral surfaces. This study provides a better understanding of how the charge heterogeneity on aquifer materials and groundwater hydrochemistry affect the transport of PS-NPs in aquifers.