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Polystyrene Nanoplastics-enhanced Contaminant Transport in Saturated Soil

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Nanoplastics (NPs) are becoming an emerging pollutant of global concern. A potential risk is that NPs may serve as carriers to increase the spreading of co-existing contaminants. In this study, we examined the effects of polystyrene nanoplastics (PSNPs, 100 nm), used as a model NP, on the transport of five organic contaminants of different polarity in saturated soil. The presence of low concentrations of PSNPs significantly enhanced the transport of nonpolar (pyrene) and weakly polar (2,2',4,4'-tetrabromodiphenyl ether) compounds, but had essentially no effects on the transport of three polar compounds (bisphenol A, bisphenol F and 4-nonylphenol). The strikingly different effects of NPs on the transport of nonpolar/weakly polar versus polar contaminants could not be explained with different adsorption affinities, but was consistent with the polarity-dependent extents of desorption hysteresis. Notably, desorption hysteresis was only observed for nonpolar/weakly polar contaminants, likely because nonpolar compounds tended to adsorb in the inner matrices of glassy polymeric structure of polystyrene (resulting in physical entrapment of adsorbates), whereas polar compounds favored surface adsorption. This hypothesis was verified with supplemental adsorption and desorption experiments of pyrene and 4-nonylphenol using a dense, glassy polystyrene polymer and a flexible, rubbery polyethylene polymer. Overall, the findings of this study underscore the potentially significant environmental implication of NPs as contaminant carriers.