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Nanoparticles at the interface between atmosphere and hydrosphere

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In the light of increasing use of engineered nanoparticles and reports of reports of adverse effects of nanoparticles on aquatic ecosystems and possible health issues, assessment of the transport of nanoparticles is of high importance. In this study we address the transport of airborne nanoparticles through the unsaturated zone in an urban environment.

Aquifers and soils are the primary filter systems to remove engineered nanoparticles. These effects are used e.g., for bank filtration. Recent flooding events, on the other hand, show the limited capacity of this filter. While engineered nanoparticles are tailored to specific applications, one has to assume that they nonetheless interact with dissolved organic matter (DOM) present in surface water and top soil in larger quantities. A coating with DOM has a stabilizing effect on most nanoparticles. Thus, a transport of engineered nanoparticles through the soil seems likely.

A monitoring program was performed at the Munich vadose zone field laboratory, a shaft reaching from the top soil to the groundwater table at 10 m below the ground surface. Wet and dry deposition were collected and analyzed to assess the input function. Seepage water was collected and analyzed in nine depths to assess the transport of nanoparticles. For all samples the size distribution and the elemental composition of the particles was measured using ultrafiltration, AF^4, and ICP/MS.

Nanoparticles deposited during dry periods may accumulate on the plant leaves and on the top soil. Here a first interaction with organic matter occurs. Heavy rainfall after a dry period will mobilize the nanoparticles. Through cracks in the top soil, preferential flow can transport the surface modified particles to the groundwater. During winter, particles are deposited on the snow cover. Sublimation of snow may lead to relatively high concentrations in the remaining snow. Cracks in the top soil caused by freezing ease the transport of nanoparticles together with the melting snow. During winter, however, aging and masking of the nanoparticles should be different.

Laboratory experiments in undisturbed soil columns indicate that the transport of unaltered, dispersed nanoparticles (TiO_2, SiO_2) is very limited. Filtration efficiency is on the order of 98.5 % for a sand column which was 10 cm long. This is in contradiction to field observations and underlines the importance of preferential flow and masking for nanoparticle transport.