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Water flow and MP transport in sandy soils imaged with neutron radiography and X-ray CT

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Microplastic (MP, □ < 5 mm) can be found worldwide. Besides aquatic environments, terrestrial ecosystems are reported to contain large amounts of MP of different origin, polymer type, shape, size, and state of degradation. Furthermore, soil is considered the largest sink of MP in terrestrial ecosystems. Though, little is known about the effects of MP on soil and its interaction with water flow. Since MP is inherently hydrophobic, the transport of MP and the flow of water interact with each other. However, the extent of MP transport in soils and the interactions with water flow remain largely unexplored.

To approach these questions, neutron and x-ray imaging methods were applied. Simultaneous neutron and x-ray CT at the beamline ICON (Paul-Scherrer-Institute) during wetting and drying cycles of a model porous media mixed with MP in different contents were used to monitor MP in different contents (size between 20-75 µm) and water distribution during repeated wetting and drying cycle of a sandy substrate (particle size between 700-1200 µm). Here, the initial MP configuration as well as the configuration after each wetting and drying cycle were captured in three dimensions. During the wetting process, time-series neutron radiographies imaged the water infiltration patterns.

MP reduced water infiltration in soils. High MP contents caused local water reppellency and were by-passed by perculating water. MP impacted the verticle distribution of water, reducing the local soil water content and driving water to deeper soil layers. Significant transport of MP were not visible during the wetting and drying cycles, plausibly because water by-passed the pore space containing MP. Rapid and preferential infiltration into deeper areas of the sample as well as low local volumetric water contents during the course of infiltration are evident. The extent seems to be MP content dependent.

In conclusion, MP-water interactions in soils have a strong impact on water flow and MP transport and fate in soils. Transport processes like advection, which are significant for wettable particles, play only a minor role in transporting low wettability particles like MP under unsaturated conditions. Though, MP seems to be spatially re-configured. This might be due to hydrophobic interactions between water and MP. Hydrophobic MP has an affinity towards adsorbing to the air-

water interface rather than being dispersed in water when in contact.