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Exacerbating Soil Phosphorus Leaching: How Microplastics Impact Nutrient Dynamics in Soils

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Soil Phosphorus (P) losses through leaching is a major concern in agriculture, since high P leaching negatively impacts plant productivity and water quality. The wide use of plastics in agriculture may also increase P leaching since plastics degradation into microplastics (MPs) can alter soil properties such as water holding capacity and pore connectivity, but the linkages between MPs in soil and P leaching has not been addressed. In this study, assessed how the presence of MPs of in different size classes and concentrations in soils impacted P leaching via increased pore connectivity, and more specifically how 1) the magnitude or direction of these effects were dependent on soil texture, 2) different fertilizer application types influenced total P loss and 3) the fraction of total P leached as colloidal P. In custom-built columns (25 x 5 cm), we spiked standard LUFA soils of different textures (sandy loam, clay) with PET MP fragments (63-125µm, 125-250 µm) at different concentrations (0%, 0.1%, and 1.0%), along with organic and inorganic P fertilizers (52 kg P/ha). Water input was applied to simulate periodic rainfall for 30 days (flow rate = 18mm/h lasting 3 h) and leachates were collected at timepoints of 1, 3, 5, 7, 15, 20, 25 and 30 days. After serial filtration of the leachate, colloidal P from fine (1-220 nm) to coarse particles (450-1000 nm), organic carbon, Fe, Al, Ca, Mg and Mn were measured by ICP-MS. Our findings indicate that MPs increased vertical water transport through increased porosity and pore connectivity, and subsequently promoted more P leaching, especially at higher MPs concentrations. Collectively, this work underlines how the presence of MPs in soils can also influence biogeochemical cycles and be an important factor when considering nutrient loss and water quality, which is particularly relevant as plastics are increasingly used directly in agriculture and can have direct releases to the terrestrial ecosystem. Understanding the interactions between MPs, fertilizer application and P loss can help farmers make decisions on management practices for productive crop cycles.