Microplastics, polymer-based particles of less than five millimetres in size, have become an archetypal sign of anthropogenic waste and environmental pollution. This German study explores how microplastics in soil affect plants, screening the potential effects of six different microplastics on the soil environment, plant traits and function using a terrestrial plant-soil model based on the spring onion (Allium fistulosum). The researchers find that plants react strongly to microplastic exposure, with significant changes observed in the physical parameters of soil, plant root and leaf traits and plant biomass.

Discarded microplastics interact with and accumulate in their environments; most of the plastic ever produced — an immense 12 000 megatonnes by 2050 — will find its way into environmental systems, with agricultural soils potentially storing more microplastic than oceanic basins. Soils can store over 40 000 microplastic particles per kilogram, with the vast majority of these being secondary particles — fibres (92%) or fragments (4.1%) resulting from the degradation of larger plastics.

This study explored how six different microplastics affected a plant-soil model of the spring onion. The test soil comprised a loamy, sandy soil collected from the centre of Berlin, Germany on 4 April 2017, sieved to remove roots and gravel larger than five millimetres in size. This soil was then exposed to six types of microplastic — polyamide beads, and fragments of polyethylene, polyester terephthalate, polypropylene and polystyrene — over roughly two months at levels relevant to highly polluted environmental soils, before being planted with spring onion seedlings and left for an additional 1.5 months.

Various properties were used as proxies for soil health — these were measured and then subjected to statistical analysis. To assess soil in terms of evapotranspiration, the researchers saturated it with distilled water and then tracked soil weight over 72 hours, subsequently converting this into water loss (1 g = 1 ml).

For bulk soil density, the researchers measured soil volume when harvesting the plants, also assessing microbial activity via hydrolysis and examining soil structure by pushing the soil through a set of stacked sieves. For the plants, above- and below-ground organs were removed — which were initially weighed fresh (aerial, bulbs, leaves), then dried for 48 hours at 60°C and reweighed. Roots were washed, scanned and characterised in terms of length, diameter, surface area and volume. Finally, the researchers used elemental analysis to measure the carbon and nitrogen content of photosynthetic leaves.

The results show that microplastics change a) the physical parameters of the soil environment; b) plant root traits; and c) plant leaf traits and total biomass. Specifically, plant biomass (total organic matter), tissue composition, root traits and microbial activity within the soil changed significantly, reflecting that both plant and soil responded strongly to microplastic exposure. The magnitude of this response depended on the type of microplastic — particles that differed most in size, shape or composition to natural soil particles elicited the most noticeable effects.

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The researchers suggest, via a proposed causal model (a diagram of the relationships between independent, control and dependent variables), that microplastics affect plant-soil systems in a way that triggers a cascade of events that alter the soil's biophysical environment. For instance, changes in soil structure and composition affect pore space and connectivity, which also affect water holding capacity and permeability. Increased water evaporation decreases the amount of water available in the soil (impacting biological processes such as root growth and microbial activity), thereby affecting the frequency and intensity of wet-dry cycles within the soils. These cycles regulate the expansion and contraction of soil particles — something linked to soil structure. The plants, in turn, adjust their traits to the soil's new biophysical condition, changing in both form and function.

This demonstrates that pervasive microplastic contamination in soil can have significant consequences for plant performance, say the researchers, and may thus trigger environmental change that threatens agroecosystems and terrestrial biodiversity. They suggest that further study is needed to improve understanding of how various microplastics affect different soils, plants and environments.