

The effect of transformation on plastic transport in and from agricultural soils

Jeongyeon Yun

Plastics have become an essential part of modern life, but also persistent in the environment. Their slow degradation leads to the accumulation of small fragments, known as microplastics (MPs, particles <5 mm). Although research has mainly focused on marine environments, growing evidence shows that soils are a major sink for plastic debris. Agricultural soils receive continuous inputs through sewage sludge, compost, and the degradation of agricultural plastics such as mulching films. These particles can remain in soils for decades with potential implications for soil health and soil biota.

Once introduced to soils, MPs are subject to physical, chemical, and biological processes that can redistribute them vertically. In addition, they are gradually transformed by sunlight, oxidation, and microbial activity. These transformations modify their surface chemistry and may influence how they attach to soil particles or leach into groundwater. However, most experimental studies on MP mobility have been carried out with pristine spherical particles in simplified media, which do not reflect the irregular, weathered plastics and heterogeneous structures of natural soils. Consequently, our understanding of microplastic behaviour under realistic soil conditions remains limited.

Therefore, this PhD project addresses this gap by investigating the vertical transport and transformation of microplastics in structured agricultural soils by combining rainfall simulation, X-ray computed tomography (CT), and advanced surface analysis to get closer to realistic understanding of MPs mobility. The first study quantifies rainfall-induced transport of indium-doped PET MPs in intact soil cores of contrasting textures (clay and sandy), providing insight into how soil structure and macropores influence mobility. The second study examines long-term field-aged MPs collected from Swedish sludge application trials (Lanna and Pettersborg), using Time-of-Flight Secondary Ion Mass Spectrometry (ToF-SIMS) to compare their surface chemistry with pristine and reference materials. This work evaluates whether laboratory weathering reproduces environmental transformation and how these differences affect MPs mobility. The third study integrates these insights within outdoor mesocosms, where hydrological processes, biological activity, and natural aging jointly control MP transformation and redistribution over time. Together, these studies aim to establish a mechanistic understanding of how microplastics move and evolve in real soils.