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Investigation into the Vertical Migration of Microplastic in Agricultural Soil

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The prevalence of microplastic (MP), typically characterised as polymeric materials of particle (1 µm - 5 mm) are an increasing concern in our marine and freshwater systems. International research efforts have mainly focused on the abundance, characteristics and implications of plastic pollution in marine settings, with the transport and fate of plastics in terrestrial and freshwater systems being less well understood. The pathway from land to sea is significant in the Irish context given the widespread use of MP rich biosolids for soil conditioning in agricultural lands. Biosolids represent the treated sewage sludge produced in the wastewater treatment process, ~80% of which nationally is used in land treatment. Given the combined nature (storm and foul water conveyed and treated together) of the drainage network in many parts of Ireland, coupled with evidence that 90% of MPs in influent waters are retained in these sewage sludges, the application of sludges to agricultural lands represents a considerable MP input on these land systems. MPs can potentially be moved or transported from these terrestrial systems through atmospheric escape, and in hydrological pathways through the soil matrix and/ or in direct overland runoff.

Here we report on an experimental investigation exploring the transport potential of biosolid MPs through infiltration and percolation processes in agricultural fields. A drainage experiment was initially undertaken in loosely packed vertical sand columns. Polymers of different type (PVC, PET and LDPE), size (<150 µm, 150-300 µm) and in both virgin and weathered states were seeded on the surface of saturated sand columns and subjected to simulated rainfall of varying intensity for different durations (up to 20 hours). Each test was conducted in triplicate with columns draining under gravity and water samples were collected from their base. The results indicate limited MP mobility given all seeded MPs were recovered in the surface layers (top 5 cm). To confirm these findings, a further investigation involving the extraction of 2 m deep cores from a down-slope transect of an agricultural field was undertaken. This field had been treated with thermally dried wastewater treatment plant sludge annually for ~20 years. The dispersion and depth of MPs were observed through laboratory testing and through Itrax core scanning. Results indicated that the majority of MPs (mostly fibers) were retained in the upper c. 30 cm (plough zone) of each core with penetration of biosolid MPs to depths below this being considerably more limited. Concentrations of MPs found within the plough zone were lower than expected (0.14 to 0.03 MP per gram of soil),

suggesting that vertical migration through the soil matrix of biosolid MPs is not a significant hydrological transport pathway.