Early Careers Environmental Brief **(ECGECEB No 7)**

Microplastics in soil: an important issue

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Whilst the intrusion and subsequent impacts of microplastics on the hydrosphere are widely realised, less is known about their effects within the pedosphere. This environmental brief focuses on the sources and impacts of microplastics in soil.

Microplastics, along with larger plastics, have become an integral tool for the efficient functioning of 21st Century society. Commonly defined as a synthetic, chemically stable material smaller in length than 5 mm, microplastics can be a variety of different shapes and sizes, but the most frequently used microplastic polymers are polystyrene, polyethylene and polypropylene, all of which contain carbon (*1*, *2*). Their resistance to decomposition, along with the length of the chains that polymers form, explains why most microplastics last for so long in the environment (*1*).

Microplastic contamination of soils is a significant issue, as soils are a vital global resource. Among other things, they are essential for carbon sequestration, flood prevention and food production. Any contamination of soil must be studied in order to understand the effects this contamination may have as well as how to prevent further contamination.

Sources

If soil microplastic pollution is to be reduced, their sources must first be identified (**Figure 1**). The formation of microplastics falls into two distinct categories – primary microplastics, those which have been intentionally manufactured to the size they are, and secondary microplastics, which form from the breakdown of larger plastic particles (*1*).

Whilst agriculture depends heavily on healthy soil, it is one of the major sources of soil microplastic pollution – studies estimate that annually, 63,000-430,000 tonnes of microplastic pollution is deposited in European agricultural soils (*3*). Water treatment plants remove nearly 90% of plastics from wastewater, concentrating microplastics in the sewage sludge that remains (*4*). Sewage sludge, containing both primary and secondary microplastics, is widely used as a soil amendment to improve crop yields, with as much as 50% of the total sewage sludge produced in North America and Europe later applied to fields (*3*).

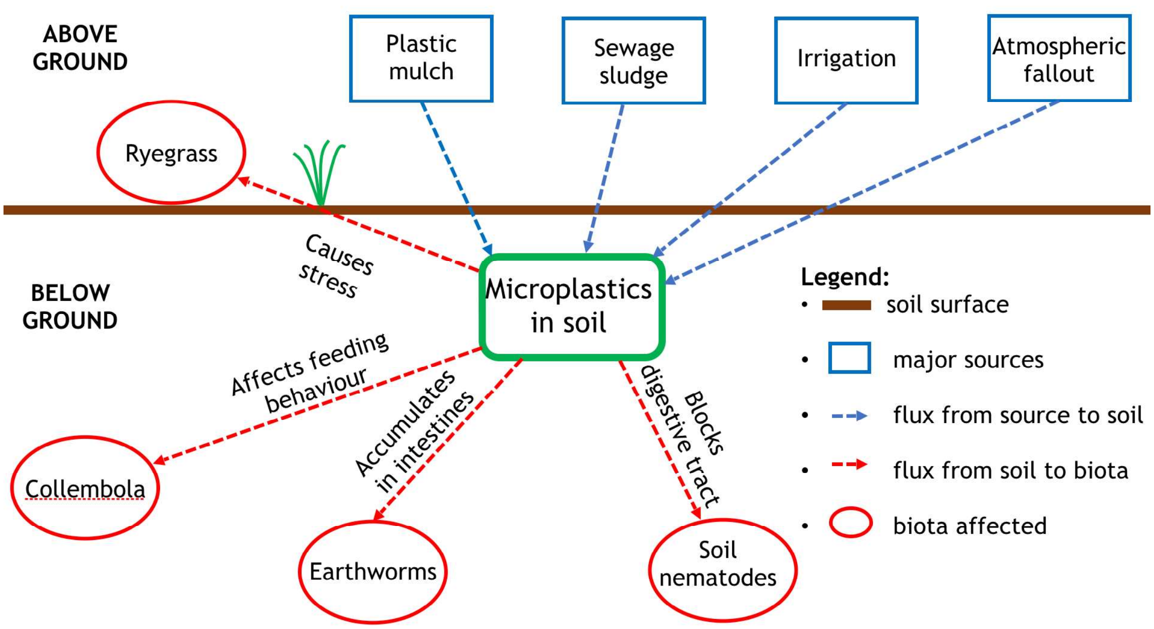

Figure 1. Sources of microplastics in soil and some effects on biota.

Other major agricultural sources of microplastic pollution in soils stem from the use of plastic mulch (*3*). Used to conserve soil moisture and prevent competition from weeds, China is the largest plastic mulch user, swathing over 20 million hectares of land in plastic film (*1*).

Irrigation is utilised on 18% of the world's agricultural land – 7% is irrigated with untreated wastewater (*4*). This attempt to provide water to facilitate optimal plant growth inadvertently creates an unregulated flux of plastic pollution into soils.

Outside of agriculture, microplastic fallout from the atmosphere can enter even remote soils far from a large populace. Tire abrasion on road surfaces generates tire dust, which can be washed off into soil by rain; in Sweden, anual tire dust emissions total nearly 1000 tonnes (*4*).

Impacts – biota

Microplastics can have impacts both on belowground soil organisms and on plants (**Figure 1**). The presence of microplastics in soil has been shown to cause significant stress in perennial ryegrass (*5*). Seed germination decreased, whilst increases in root biomass and chlorophyll a/b ratios were observed (*5*). Whilst no directly toxic effects were observed, these responses demonstrate that ryegrass behaviour is forcibly changed by the presence of microplastics.

Furthermore, a decrease in earthworm biomass was observed when microplastics were present (*5*). Since earthworms consume soil, they unintentionally swallow microplastics (*5*). Any microplastics that pass through the digestive system are expelled in casts, distributing microplastics further down the soil profile where they can be consumed by other organisms. If they remain inside the worm, microplastics can obstruct the digestive tract, causing decreased nutrient adsorption, weight loss and death (*5*). As a keystone species, a reduction in earthworm populations can have devastating knock on effects to the entire soil ecosystem, as well as plants.

Impacts – soil properties

As well as the indirect effects that microplastic pollution may have on soil properties through reducing earthworm biomass, there are several direct impacts.

For example, a lowered soil pH was observed when microplastic particles were present (*5*). Soil microbial communities are particularly sensitive to pH; these are essential for various biogeochemical cycles, including the nitrogen cycle. Nitrogen is converted to plant available nitrates by soil microbes, the optimal pH range of which lies between 6.6-8.5 – any change outside of these limits could be detrimental to plant growth (*7*)

Plastic films in soil have also been shown to create channels, which aid water movement, resulting in increased evaporation (*6*). This causes soil drying, an effect that may be most prevalent in water scarce areas (*6*). With global temperatures expected to rise by 1.8 °C, widespread soil drying could be worsened further by the presence of microplastics hindering crop production (*8*).

Conclusions/further research

The pathways through which microplastics enter soil are numerous (**Figure 1**). However, many of the sources, particularly in agriculture, are essential for crop production. Microplastics in soil have been shown to have several detrimental effects and so, where possible, sources should be reduced. Further research should continue to assess the damage inflicted by microplastics upon the pedosphere, as well as researching whether alternative, less damaging materials can be used instead of microplastics to carry out the same function.

References

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