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Microplastics in Agriculture: The Invisible Threat Beneath Our Feet

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Plastic has become an inseparable part of modern agriculture. Plastic mulch films, drip irrigation pipes, greenhouse covers, shade nets, and polymer-coated fertilizers have helped farmers conserve water, control weeds, manage nutrients, and improve crop production. However, the excessive and prolonged use of these materials has created a hidden environmental problem. Microplastics are tiny plastic particles smaller than 5 millimetres, formed either during the manufacture of plastic products or through the gradual breakdown of larger plastic materials. Even smaller particles, known as nanoplastics, can be generated during further fragmentation. Although these particles are often invisible to the naked eye, their accumulation in farmland may have long-term consequences for soil health, crop growth, and environmental quality.

Chinyo (2026) Agricultural soils receive microplastics from several direct and indirect sources. Plastic mulch films, widely used to conserve soil moisture and suppress weeds, gradually deteriorate under sunlight, temperature fluctuations, rainfall, and mechanical operations. As these films become brittle and fragment, small plastic particles remain in the soil.

Drip irrigation pipes and greenhouse plastics are additional sources. Continuous exposure to sunlight, friction, and weathering can weaken these materials and release plastic particles into agricultural fields. Microplastics can also enter farmland through polymer-coated fertilizers, contaminated compost, animal manure, sewage sludge, and wastewater used for irrigation. In addition, plastic particles released from synthetic textiles, urban waste, and airborne dust may reach agricultural land through atmospheric deposition.

These different pathways make microplastic pollution a complex problem. Even when farmers do not directly apply plastic materials to their fields, contaminated water and organic amendments may introduce these particles into the soil.

Healthy soil is the foundation of sustainable agriculture. It supports plant roots, stores water, supplies nutrients, and provides a suitable environment for beneficial microorganisms. Microplastic accumulation can interfere with these essential functions.

Changes in soil physical properties

Microplastics can modify soil bulk density, porosity, aggregation, aeration, and water-holding capacity. The extent of these changes depends on the type, size, shape, and concentration of plastic particles, as well as the texture of the soil. At higher concentrations, some particles can obstruct soil pores and interfere with the movement of water and air. Such changes may influence infiltration, drainage, and soil erosion (Bläsing and Amelung, 2018).

Disturbance of nutrient cycling

Microplastics can alter soil pH, electrical conductivity, and nutrient availability. They may also interact with soil organic matter and affect the movement of nutrients and contaminants. These changes can influence the availability of essential elements required for plant growth and may disturb the natural balance of soil fertility.

Harm to beneficial soil microorganisms

Soil microorganisms play a vital role in decomposing organic matter, mineralizing nutrients, fixing nitrogen, and supporting plant growth. Microplastic contamination may change microbial diversity, community structure, and enzyme activity. Such disturbances can affect carbon, nitrogen, and phosphorus cycling, potentially weakening important biological processes that maintain soil productivity.

Affecting Crops

Plants growing in microplastic-contaminated soils may experience changes in root development, seed germination, biomass production, and photosynthetic activity. Plastic particles can affect the physical environment around roots and may induce physiological stress. Research reviewed in the uploaded paper indicates that the effects vary according to crop species, polymer type, particle size, soil properties, and exposure concentration. Some experimental studies have reported reduced plant growth and photosynthetic performance, while responses at lower concentrations may differ (Rillig *et al*., 2017). The review also discusses evidence that certain small plastic particles, particularly nanoplastics, can enter plant tissues under experimental conditions. This raises concerns about the possible movement of plastic particles through agricultural food chains. However, the extent of this transfer under ordinary field conditions and its long-term implications require further investigation.

Microplastics and the Wider Environment

The effects of microplastics are not limited to agricultural soils. These particles can move through runoff and leaching, potentially reaching surface water and groundwater. They can also interact with heavy metals, pesticides, persistent organic pollutants, and other contaminants, influencing their movement and environmental availability. De Souza Machado *et al*. (2018) Soil organisms such as earthworms, nematodes, and other invertebrates may ingest microplastics. Experimental studies have reported effects on growth, reproduction, intestinal health, and microbial communities in some organisms. Since these organisms contribute to decomposition, soil aeration, and nutrient cycling, their disturbance may have wider consequences for ecosystem functioning. Microplastics have also been detected in food and drinking-water systems. Nevertheless, the precise extent of human health risks associated with different levels and types of exposure remains uncertain. More long-term research under realistic environmental conditions is necessary to establish these risks.

Management practices

Preventing microplastic accumulation is more effective than attempting to remove all the particles after they have entered the soil. Farmers, researchers, industries, and policymakers all have important roles to play.

- **Responsible use of agricultural plastics:** Collect, recover, and properly dispose of used mulch films, irrigation pipes, and greenhouse materials instead of leaving plastic residues in the field or burning them openly (Ng *et al*., 2018).
- **Improved irrigation management:** Inspect and replace deteriorating irrigation components and improve the management of wastewater used for agriculture.
- **Quality control of organic amendments:** Monitor compost, manure-based fertilizers, and sewage-derived materials for plastic contamination before applying them to agricultural land.
- **Development of safer alternatives:** Promote agricultural materials that have been demonstrated to be environmentally safe under actual soil conditions. Biodegradable plastics should not automatically be considered harmless, because their breakdown products and environmental behaviour also require evaluation.
- **Use of emerging remediation technologies:** Biochar, microbial degradation, enzyme-based treatments, phytoremediation, and filtration technologies show potential for reducing microplastic pollution. However, their effectiveness, cost, and suitability for large-scale agricultural use need further validation.

- **Strengthening policies and monitoring:** Improve plastic-waste collection, recycling systems, producer responsibility, and standard methods for detecting and measuring microplastics in soil and water.

Microplastic pollution represents an emerging challenge for sustainable agriculture. Although plastic technologies provide important benefits to farmers, their long-term environmental costs must be considered alongside their immediate agronomic advantages. Future research should focus on long-term field experiments, reliable monitoring methods, crop-specific responses, and the movement of microplastics through soil, plants, water, and food chains. Agricultural policies should also address the entire life cycle of plastic materials, from production and use to collection, recycling, and final disposal.

Conclusion

The presence of microplastics in agricultural soils reminds us that environmental pollution is not always visible. Tiny plastic particles can accumulate gradually, interact with soil components, and potentially affect the biological and physical processes that sustain crop production. Protecting agricultural soils therefore requires responsible plastic use, effective waste management, scientific innovation, and greater public awareness. By adopting preventive measures today, we can help safeguard soil health, sustain agricultural productivity, and protect the environment for future generations.

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