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Effect of polymer recycling towards multi-functional agro-ecosystems promoting climate-resilient futures

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Abstract

Plastic polymers have become indispensable in modern agriculture, yet their unplanned consequences are increasingly disturbing. From degraded mulch films to discarded irrigation components, persistent plastic residues accumulate in soils, fragment into microplastics and now infiltrate into food systems. These pollutants disrupt soil microbial balance, reduce fertility, inhibit yield and pose emerging risks to public health through ingestion, bioaccumulation, pollution and toxicological effects such as endocrine disruption. In several regions, improper disposal practices including open burning further release hazardous emissions, compounding environmental and respiratory health burdens.

This study critically examines the dual challenge of polymer-induced degradation in agro-ecosystems and its consequences for sustainable food production. Evidence indicates that plastic contamination impairs water infiltration, pose danger to aquatics, alters nutrient cycling and diminishes long-term agricultural productivity. At the same time, human exposure pathways are expanding, raising urgent concerns about food safety and ecosystem integrity under climate stress. The paper highlights how systematic recovery and reuse of agricultural plastics can significantly minimise environmental leakage and health risks. By converting waste polymers into durable, value-added agricultural inputs, recycling supports circular economy principles while lowering greenhouse gas emissions associated with virgin plastic production. Integrating policy support, technological innovation and farmer engagement is critical to scale these solutions effectively.

By addressing these gaps, recycling can enhance nutrient cycling, problems management, and soil regeneration, offering a viable path toward sustainable agriculture. This will eventually support the development of context-specific, circular, and resilient enhanced farming systems that align with global sustainability goals.

Ultimately, advancing polymer recycling offers a practical pathway to restore agro-ecosystem functionality, safeguard public health and build climate-resilient agricultural futures

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