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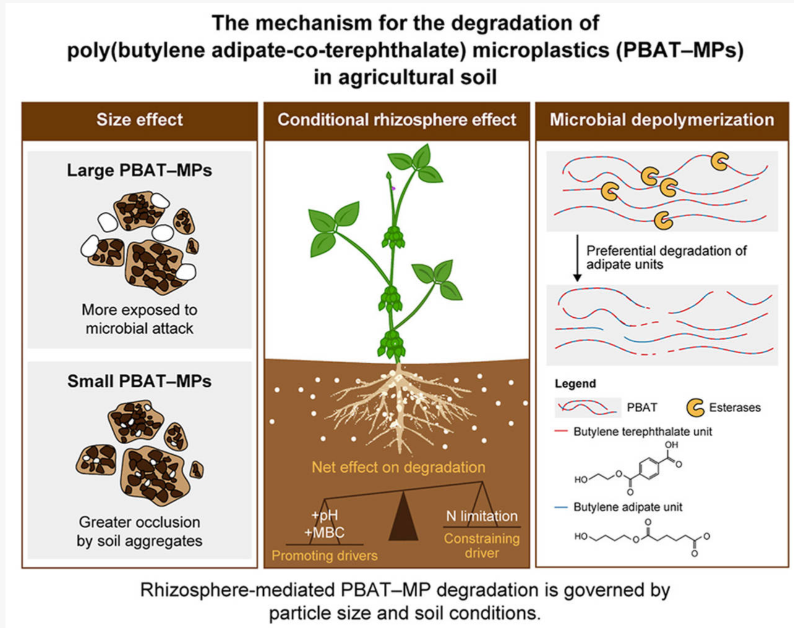
Biodegradable mulch isn't disappearing as expected, new study warns

GA, UNITED STATES, March 10, 2026 /EINPresswire.com/ -- Biodegradable mulch films are widely promoted as a sustainable alternative to conventional agricultural plastics, yet their breakdown in soil remains poorly understood. A new study reveals that plant roots can selectively accelerate the degradation of large biodegradable microplastic particles in soil—but this process also leads to the accumulation of potentially phytotoxic byproducts directly in the root zone. Using advanced molecular and microbial analyses, researchers show that degradation rates depend strongly on particle size and soil conditions. While larger particles degrade more rapidly in the rhizosphere, smaller particles remain protected within soil aggregates. These findings challenge assumptions that biodegradable plastics harmlessly disappear in agricultural soils.



Size-dependent and conditional rhizosphere effects on PBAT microplastic degradation.

The global shift toward biodegradable mulch films aims to reduce persistent plastic contamination in farmland. Materials such as poly (butylene adipate-co-terephthalate) (PBAT) are designed to mineralize in soil after use. However, incomplete degradation can generate biodegradable microplastics whose environmental fate is uncertain. Previous research has focused mainly on temperature, moisture, and soil chemistry, with limited attention to the rhizosphere—the biologically active soil region influenced by plant roots. Roots alter microbial communities, nutrient dynamics, and enzyme activities, all of which may affect plastic breakdown. Yet it remains unclear whether root activity accelerates or inhibits degradation, and whether degradation products accumulate near crops. Based on these challenges, in-depth investigation of rhizosphere-mediated degradation is urgently needed.

In a study (DOI: 10.1016/j.ese.2026.100678) published on February 22, 2026, in Environmental Science and Ecotechnology, researchers from East China University of Science and Technology and collaborating institutions investigated how soybean roots influence the degradation of PBAT microplastics in soil. By combining quantitative proton nuclear magnetic resonance (q-^{1}H NMR), microbial sequencing, soil metabolomics, and aggregate analysis, the team tracked both polymer loss and monomer accumulation over a full 70-day plant growth cycle, revealing size-dependent and condition-specific rhizosphere effects.

The researchers conducted a controlled pot experiment using two PBAT microplastic sizes—approximately 1 millimeter ("large") and 150 micrometers ("small")—at environmentally relevant and elevated concentrations. A mesh barrier separated rhizosphere soil from bulk soil, allowing precise comparison under identical growth conditions. After 70 days, overall degradation in bulk soil was limited, with only 1.4–3.7% polymer loss. However, in the rhizosphere, large particles at high concentration degraded significantly faster than in bulk soil. In contrast, small particles showed little degradation, likely because they became physically protected within microaggregates, limiting microbial access. Advanced q-^{1}H NMR analysis confirmed preferential hydrolysis of aliphatic adipate units within the PBAT polymer. Correspondingly, degradation monomers—particularly adipic acid and terephthalic acid—accumulated at higher concentrations in rhizosphere soil than in bulk soil. Microbial sequencing revealed enrichment of Proteobacteria, especially Bradyrhizobium and Ramlibacter, genera associated with ester hydrolysis and terephthalate metabolism. Soil enzyme assays further showed elevated esterase activity on microplastic surfaces, indicating the formation of specialized plastisphere communities.

Together, the results suggest a surface-erosion mechanism driven by root-modified microbial activity, but one that may simultaneously concentrate degradation byproducts in the root zone.

"Our findings show that the rhizosphere is not simply a degradation accelerator," said the study's corresponding author. "It is a conditional hotspot where particle size, soil aggregation, nutrient availability, and microbial communities interact in complex ways. While roots can stimulate microbial breakdown of larger biodegradable microplastics, they may also promote localized accumulation of monomers that could affect plant health over time. This challenges the assumption that biodegradability automatically equates to ecological safety."

The study carries important implications for agricultural sustainability and plastic policy. Current biodegradability certifications typically assess bulk soil mineralization under standardized laboratory conditions, without accounting for rhizosphere-specific dynamics or byproduct accumulation. The findings suggest that biodegradable plastics may persist longer than expected, especially in smaller particle forms that become physically protected within soil aggregates. Moreover, accelerated degradation near roots could increase plant exposure to phytotoxic intermediates. The researchers call for revised testing standards that include rhizosphere-relevant evaluation criteria and monitoring of monomer accumulation. Without such safeguards, biodegradable plastics risk becoming a chronic source of soil contamination rather than a definitive solution to agricultural plastic pollution.

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