

Biodegradable Polymers for Soil Health Improvement and Sustainable Agriculture

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Abstract: Soil degradation, declining soil fertility, excessive use of synthetic agricultural inputs, and the accumulation of persistent plastic residues are major challenges to sustainable agriculture. Biodegradable polymers have attracted increasing attention as alternative materials for agricultural applications because they can be designed to break down through biological and environmental processes under suitable conditions. These materials include naturally occurring polymers, such as starch, cellulose, chitosan, alginate, and other polysaccharides, as well as biodegradable synthetic polymers, including polylactic acid (PLA), polyhydroxyalkanoates (PHAs), and polybutylene succinate (PBS). Their applications include biodegradable mulch films, controlled-release fertilizers, seed coatings, soil conditioners, water-retention materials, and carriers for beneficial microorganisms. This review examines the role of biodegradable polymers in soil health improvement and sustainable agriculture, focusing on research published up to December 2020. The major mechanisms of polymer degradation, interactions with soil microorganisms, effects on soil physical and chemical properties, and potential contributions to crop productivity are discussed. Biodegradable polymer materials may help conserve soil moisture, regulate soil temperature, reduce weed growth, improve nutrient-use efficiency, and limit the accumulation of persistent agricultural plastics. However, their environmental performance depends on polymer composition, formulation, degradation conditions, agricultural practices, and the nature of the degradation products. Biodegradability does not automatically guarantee complete degradation or environmental safety. Further research is therefore required to establish standardized testing methods, assess long-term soil effects, and verify the economic and environmental benefits of these materials under field conditions.

Keywords: Biodegradable polymers, soil health, sustainable agriculture, biodegradable mulch films, controlled-release fertilizers, soil microorganisms, nutrient management, biopolymers, environmental sustainability..