Chapter 9
Bioplastics and Their Environmental Implications

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ABSTRACT

Petroleum-based plastics generate pollution, greenhouse gas emissions, and environmental issues due to their persistence in marine and terrestrial ecosystems over their lifespan. Bioplastics represent a novel category of polymeric materials advocated as substitutes for traditional petroleum-based plastics. It is essential to evaluate the ecological impacts of bioplastic utilisation, given concerns regarding their potential to exacerbate significant issues such as detrimental land use changes and increased greenhouse gas emissions. Although extensive information exists, limited evaluations adequately assess the environmental impact of bioplastics. The primary aim of this chapter is to address this knowledge gap. This chapter aims to address the following questions: What types of bioplastics are currently being developed or utilised in the industry? Do bioplastics genuinely contribute to environmental sustainability? Further research is required to perform thorough life cycle assessments and land use change analyses to confirm the environmental sustainability of new materials.

INTRODUCTION

The widespread reliance on conventional plastics has become one of the most pressing environmental challenges of the 21st century. With over 300 million tons of plastics produced annually, a significant proportion ends up in landfills or as litter in terrestrial and marine environments, contributing to long-lasting

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ecological damage (Geyer et al., 2017). Traditional plastics, derived from non-renewable fossil fuels, are inherently non-biodegradable, taking hundreds of years to decompose, during which they fragment into microplastics that permeate the food chain and ecosystems. This escalating plastic crisis has driven global efforts to seek sustainable alternatives, with bioplastics gaining attention as a potential solution. Bioplastics are a diverse class of materials designed to either reduce the environmental impact of plastic production or address the waste and pollution associated with plastic disposal. Biodegradable plastics are materials that can decompose into natural components under certain conditions; bio-based plastics are those that originate from renewable resources like corn, sugarcane, or algae. Sometimes, both types of plastics are used. Some examples are starch blends, bio-based polyethylene (bio-PE), polylactic acid (PLA), and polyhydroxyalkanoates (PHA). Several aspects, including feedstock cultivation, production energy demands, biodegradability, and end-of-life management, impact the environmental consequences of bioplastics, which are difficult despite their promise (Ogidi et al., 2024a,b).

The increasing production and adoption of bioplastics are often touted as steps toward achieving a circular economy, a system that prioritizes resource efficiency, waste reduction, and recycling. Advocates highlight their potential to reduce greenhouse gas emissions, minimize fossil fuel dependency, and provide sustainable waste management options (Angaye et al., 2019). For example, because they are made from plant-based feedstocks that take in carbon dioxide as they grow, bio-based plastics like PLA and PHA are thought to be less carbon-intensive in manufacture (Piemonte & Gironi, 2011). Also, biodegradable bioplastics help with one-time uses, which means less plastic trash floating around. However, the reality of bioplastics' environmental benefits is far from straightforward. Questions persist regarding their large-scale viability, including the competition for arable land and freshwater resources, which are also essential for food production (Ogidi & Izah, 2024). Bioplastics derived from food crops such as corn and sugarcane have been criticized for exacerbating food insecurity and contributing to deforestation and biodiversity loss. Moreover, the claim of biodegradability often depends on specific conditions, such as industrial composting, that are unavailable in many regions, limiting their practical benefits. When improperly disposed of, bioplastics may contribute to pollution, akin to conventional plastics, or release greenhouse gases like methane during anaerobic degradation in landfills (Song et al., 2009).

In light of these complexities, understanding the environmental implications of bioplastics requires a holistic assessment of their entire lifecycle, from raw material cultivation to production, use, and disposal. This includes evaluating the trade-offs between reducing dependence on fossil fuels and the resource intensiveness of agricultural feedstocks, as well as the challenges in integrating bioplastics into existing waste management systems. For example, current recycling infrastructures often struggle to differentiate bioplastics from conventional plastics, resulting in contamination and inefficiencies in recycling processes (Haupt et al., 2018). Therefore this chapter seeks to set the stage for a comprehensive exploration of their role in addressing plastic pollution and their broader environmental implications. The growing body of research highlights both the opportunities and limitations of these materials, underscoring the need for innovations, regulatory frameworks, and consumer education to support their effective integration into sustainable practices. By addressing these aspects, this paper aims to provide a balanced perspective on bioplastics as a potential contributor to mitigating the global plastic crisis while ensuring environmental, economic, and social sustainability.

Related Content