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Toward meaningful evaluation of climate change impacts in sustainability assessment of bioplastics

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Assessing environmental sustainability of bio-based materials, such as bioplastics, plays a key role in supporting decision making in the transition towards a more resource-efficient and environmentally sound bio-based economy. Life Cycle Assessment (LCA) has been largely used to assess environmental impacts and benefits resulting from the entire life cycle of bioplastics and compare their environmental performance with conventional fossil-based plastics. Although the current methodology for assessing climate change impacts based on global warming potentials (GWP) is well established, there are some challenges when it comes to evaluate impacts of biopolymers. Based on these challenges, we propose three possible methodological improvements for better assessing climate change impacts of bioplastics. **First**, currently utilized and recommended methodologies do not consider the contribution of a greenhouse gas (GHG) emission to crossing of climatic tipping points, that is, levels of pressure on the climate system beyond which adverse and irreversible changes may occur. Bioplastics are sourced from biomass feedstocks and hence store atmospheric CO_2 which gives them the potential to mitigate climate change by delaying GHG emissions beyond the time when climatic tipping points are expected to be crossed. Earlier efforts to include a climatic target level into assessment of climate change impacts in LCA are limited to the climate tipping potential (CTP) indicator, which considers the tipping point related to melting of Arctic summer sea-ice, representing the cumulative contribution of a GHG emission to fill the remaining capacity left before reaching the predefined target level of atmospheric GHG concentration of 450 ppm CO_2 equivalents. However, impacts occurring after this target level is crossed are disregarded. We suggest to include other tipping points in the CTP method to allow quantifying the contribution of bioplastics to delaying exceeding of several critical levels. **Second**, the CTP method does not support modelling of the damage on human health and ecosystems resulting from climate change, such as loss of biodiversity. Accounting for impacts on these categories in the CTP methodology would be important to provide easily interpretable information on the actual damage caused if the use of bioplastics affects the crossing of climatic tipping points. **Finally**, including the effects of surface albedo changes on climate dynamics in the CTP indicator is relevant for bioplastics, as biomass farming for fermentation feedstock leads to changes in land use and surface reflectivity, which could cause significant perturbations of the Earth energy balance. We elaborate on the importance of these mechanisms and give recommendations for future research to better reflect climate change impacts in environmental sustainability assessment of bioplastics.

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