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How to account for environmental consequences of plastics recycling in the future?

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Chemical recycling allows types of plastics, potentially mixed or degraded, to be recycled when mechanical recycling cannot. Plastics from chemical recycling can be used in direct food contact, toys and in pharmaceutical applications. However, it requires more energy and resources while its technological readiness level is relatively low. In the future, fossil resource use will be strongly reduced, and recycling technology will result in complete closed-loop recycling. A quantitative environmental assessment of new technologies in a new context is required to map future trade-offs for feedstock options, end-of-life options, market changes, etc. The presented prospective consequential approach demonstrates how this could be done.The functional unit is recycling 1 kg of HDPE. System boundaries include the end-of-life stage of the plastic, the recycling activities and avoided incineration and virgin plastic production. Six scenarios were defined to assess the effects of global warming, land use and fossil resource depletion of chemical recycling for plastics from different feedstocks. 1) Fossil HDPE, 2) Sugarcane HDPE and 3) Sugarcane HDPE with an expanded land use change assessment were assessed for 2020. 4) Sugarcane HDPE, 5) Sugarbeet HDPE and 6) Sugarbeet molasses HDPE were assessed for 2050. Data on the recycling process was taken from two approaches from literature (process modelling and theoretical). Cropping activities were modelled from literature, AgriFootprint and ecoinvent. Land use change (LUC) assessment was expanded by calculating land transformations with the model MAGNET, general equilibrium model of the global economy that describes the development of prices, production and trade.The results show counteracting contributions which influence the environmental effects of recycling in 2020 and 2050. Recycling instead of incinerating sugarcane HDPE seems to have an adverse effect (+1 kg CO2eq global warming potential (GWP)). However, beneficial effects are observed under the MAGNET based LUC approach (e.g. -11 kg CO2eq GWP). The increased recycling efficiency in 2050 yields net beneficial effects of recycling HDPE from sugarcane, sugar beet and sugar beet molasses (resp. -4, -1 and -2 kg CO2eq GWP). In contrast to sugarcane, effects of global land transformation are negligible and the effects of feed market substitutions are larger for sugarbeet feedstocks.The mentioned land and market effects strongly affect results for global warming and land use, and the methodology should be further harmonized. The type of electricity and heat supply in 2020 and 2050 strongly determine results and are a topic of further research too. Concluding, impacts due to cultivation and land expansion on land use and global warming indicate the need to recycle biobased HDPE from any feedstock. The current research approach enables a prospective consequential perspective, among others, thanks to the novel MAGNET based LUC approach.

Key words:

Consequential LCA, Prospective LCA, plastics, recycling, HDPE