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How sustainable are biopolymers? Findings from a life cycle assessment of polyhydroxyalkanoate production from rapeseed-oil derivatives

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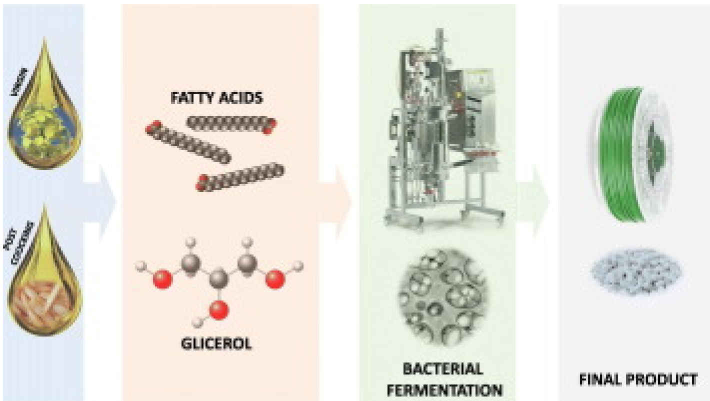
Highlights

- The study deals with application of Life Cycle Assessment in the field of biopolymers.
- Three production scenarios of two different polyhydroxyalkanoates were compared in this study.
- Primary and secondary data were inventoried for the study development.
- Polyhdroxybutyrate is more impacting than medium chain length polyhydroxyalkanoate, due to raw material production and supply.
- Biopolymers have environmental benefits, but still potentials for improvement.

Abstract

The main purpose of the article was to compare different scenarios of biopolymer production and their impacts on the environment using Life Cycle Assessment. Three alternative polyhydroxyalkanoates (PHA: amorphous PHA and poly(3-hydroxybutyrate), P(3HB)) production scenarios were considered to assess its environmental impact: Scenario A - Production of mcl-PHA/P(3HB) from crude vegetable oil; Scenario B - Production of P(3HB) with biodiesel by-product; Scenario C - Production of mcl-PHA/P(3HB) from used vegetable oil. Subject to the scenario considered, it was shown that the environmental efficiency of PHA production is highly dependent on carbon sources used, and it is strongly supporting production of mcl-PHA instead of P(3HB). As LCA study shows, due to low yield of P(3HB) in comparison to mcl-PHA production in considered processes, all the P(3HB) production scenarios have higher impacts than the production of mcl-PHA. Production processes based on bacterial fermentation had its impacts related mostly to the raw materials used and to its separation phase. Additionally, using secondary materials instead of raw ones, namely used oil instead of virgin oil, gives significant improvement with regard to environmental impact. The resource efficiency is also the identified as the key factor with sensitivity analysis that indicates the possible increase of biopolymer yield as the most beneficial factor. Biobased polymers have big environmental potential but still need significant improvement with regard to their manufacturing processes in order to become more economically benign. Preferably production of these microbial polymers should be integrated into biorefinery blocks, where such waste stream arises (e.g. biodiesel production plant).

Graphical abstract



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Keywords

Biodiesel; Life cycle assessment; Microbial fermentation; Polyhydroxyalkanoate; Rapeseed oil; ReCiPe

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