


ESR 10

Project title and research strand:	LCA of biodegradation of bioplastics. Strand 4: Methodology.	
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Abstract

The growing concern over plastic emissions has increased interest in biodegradable plastics and circular economy strategies as potential solutions. However, evaluating their overall sustainability remains complex. This study explores two main areas of applications: highly abrasive use cases in textiles and facilitating organic waste treatment with compostable plastics. The research was based on examining three case studies. Integrating microplastic emissions into Life Cycle Assessments (LCAs) emerges as a critical aspect for comprehensive environmental evaluation of plastic products. The case studies focus on textiles and tea bags, showcasing the environmental implications of biodegradable polymers and circularity approaches. Current findings suggest that while these materials offer some benefits, their overall environmental impact reduction is limited. Comprehensive data and advanced modeling of Fate Factors are identified as crucial for accurately assessing their environmental performance. This research underscores the necessity for integrated approaches that consider not only production but also use phases and end-of-life scenarios. Future advancements in biodegradable polymer research must prioritize robust data collection and transparent modeling techniques to refine our understanding and optimize their environmental benefits. By addressing these challenges, stakeholders can effectively navigate the complexities of holistic plastic product design and advance sustainable practices in diverse industrial sectors.

Visual Summary – Poster



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Biodegradable Plastics – A Win for the Environment?



Why do we need to assess biodegradable plastic solutions?



Each of us consumes **one credit card of microplastics per week**⁴

“In which cases is **biodegradability environmentally beneficial?**”

Two cases for biodegradability

1 Highly abrasive applications



Problem:

- **Microfiber emissions** from textiles are a major environmental concern
- Characterization Factors (CFs) are needed to include the impact of microplastic emissions:

Environmental impact = CF × Emission
CF = Fate Factor × Exposure Effect Factor

- Fate Factors (FF) depend on datasets from literature^{2,5}

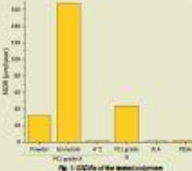
Aim:

- Understanding implications and validating assumptions taken in former research, by performing degradation experiments
- Extending datasets of biodegradable polymers for CF modeling
- Testing new CFs in case study LCA of a sports shirt

ASTM D 5887 – 06
• CO₂ evolution
• Cell count
• pH
• Dissolved organic carbon

Approach:

- Performing degradation experiments in seawater under different conditions (pH, salinity, 20 °C, 4 °C)
- Deriving CFs from results and performing a prospective **cradle-to-grave LCA of a sports shirt**



Results and learnings:

- Specific surface degradation rate (SSDR) derived from experiments: five times higher for granulate compared to powder
- Almost no degradation after six months in 4 °C sea water
- Effect of **bulk degradation** and applicability of results taken at **higher temperatures** need to be considered

- Worst case of a non-degrading polymer (PLA*) leads to a contribution of **5.8%** to overall impact on ecosystem quality of a sports shirt
- Switching to a **degradable polymer (PCL**)** can reduce the impact by one third

* Polylactide (PLA) not biodegradable in seawater
** Polybutyrate (PCL) biodegradable in seawater

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2 Facilitating organic waste management



Problem:

- **Commingling of polymeric and organic material** hinders waste management in composting
- Case study of (home)compostable polymeric fibers for tea bags, including plastic emissions to water

Aim:

- Identifying the potential of novel biobased and biodegradable material by facilitating alternative waste management in industrial and home composting

Approach:

- Collection of primary data through collaboration with fiber spinning company
- In-depth analysis of **industrial and home composting for the commingled waste of a tea bag**

Results and learnings:

- **End-of-life (EoL) has significant climate change impact** (if case plastic is recycled)
- **Industrial composting does not result in benefits** compared to incineration
- **Greener energy mix: lower credit for incineration**
- Current approach shows **home composting for PBS-based teabags as slightly more beneficial EoL**
- Credits for composting highly depend on **long-term sequestration of carbon in compost** and the assumed **substituted product** (e.g., peat, fertilizer, etc.)
- Outlook: Impacts from **microplastic pollution by tea bags** in water could be reduced by biodegradable materials (assessment following)

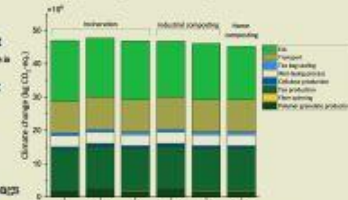


Fig. 2 Climate change impact based on the best case for composting in the Netherlands

Conclusions and outlook

- **Three years of the BBVC project → 156 credit cards of microplastics consumed per person**
- → **Accounting for microplastics in LCA studies is pressing**
- Currently: leakage models and CFs based on limited number of studies
- **End-of-life modeling of plastics lacking accuracy, hence clear recommendations are not possible**
- Closer **collaboration** between **material science research** and **LCA research** needed to enhance the quality of datasets
- Further development of **Characterization Factors** to include potential **toxicity**
- Closer **collaboration** between **industry** and **LCA research** to improve the data availability and representativeness of LCA results



References and acknowledgements

Wang, Y., Li, J., et al. (2021) Accounting for microplastic emissions in life cycle assessment using a Swelling Thermal Analysis. Sci Rep 11(1): 1-10. <https://doi.org/10.1038/s41598-021-02024-0>

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