Laboratory to Field Scale: Ecological Relevance of Laboratory Tests for Reliable Environmental Ecotoxicity Assessment of Polymers

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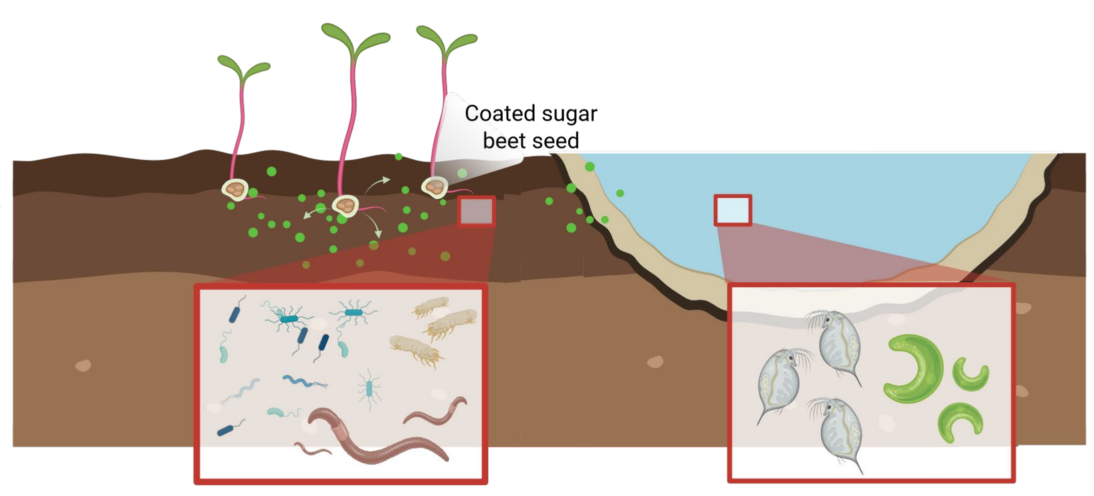
Introduction

Agrotechnical products often contain (bio-)polymers to improve crop growing conditions [1,2]. Although polymers are directly released to the environment, they are not comprehensively regulated under REACH making reliable environmental evaluation difficult. Different polymer evaluation concepts consider fate as primary hazard indicator, whereas ecotoxicity is secondary. As a result, a comprehensive ecotoxicological evaluation concept and database is missing [3].



Step 1
What is the ecotoxicological impact of (bio-)polymers?
Application and modification of standardized methods
Winter *et al.* 2025 a,b

Step 2
Are laboratory test results transferable to the field scale?
Proving the ecological reliability of the laboratory data

Materials & Methods

In order to prove the reliability of the laboratory data, a prototype of a coated sugar beet seed (*SeedPlus*) containing biopolymers and its single components were applied to the test soil. The treated soil was then incubated both under laboratory and field conditions. Ecotoxicity studies were conducted in accordance to respective guidelines.

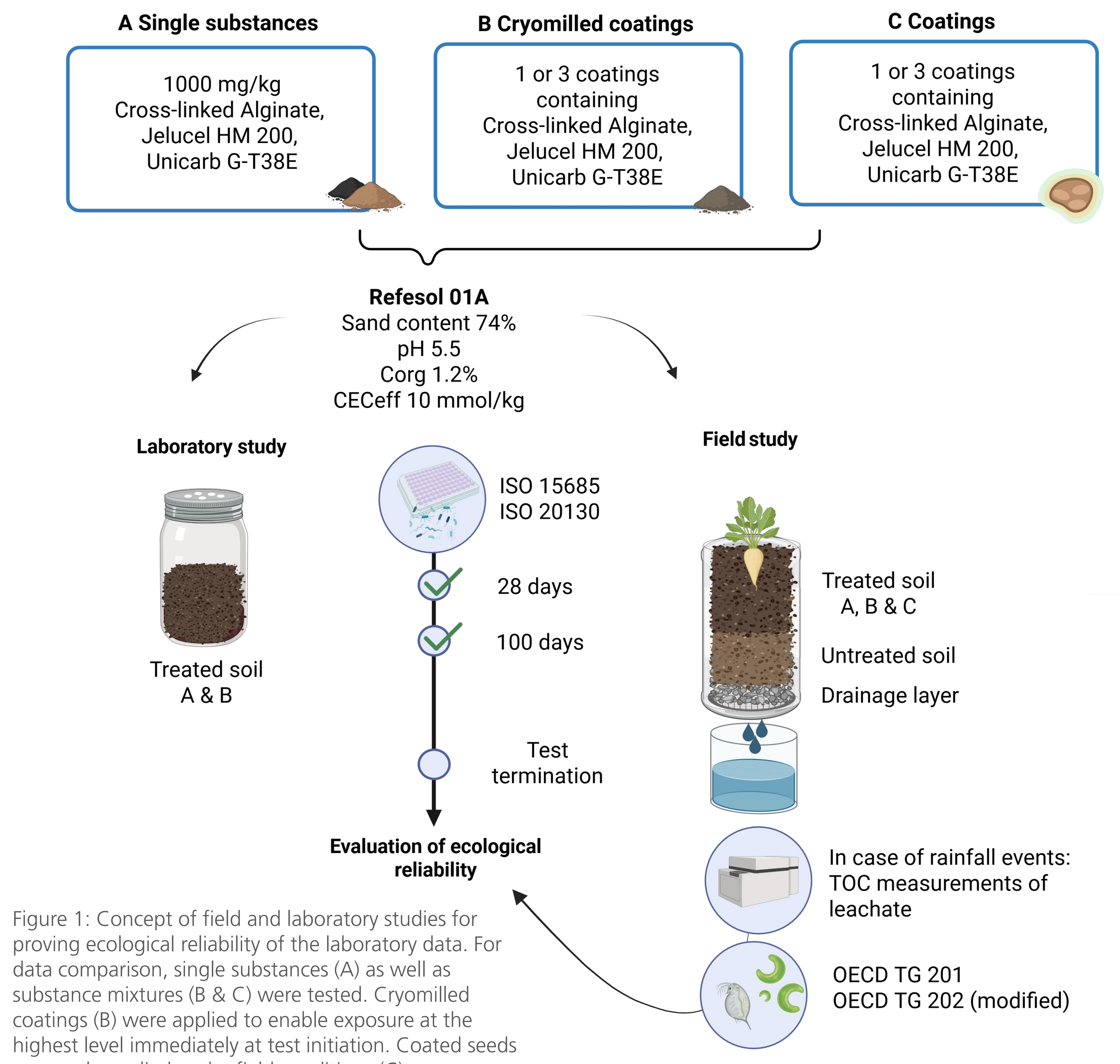


Figure 1: Concept of field and laboratory studies for proving ecological reliability of the laboratory data. For data comparison, single substances (A) as well as substance mixtures (B & C) were tested. Cryomilled coatings (B) were applied to enable exposure at the highest level immediately at test initiation. Coated seeds were only applied under field conditions (C).

Results & Discussion

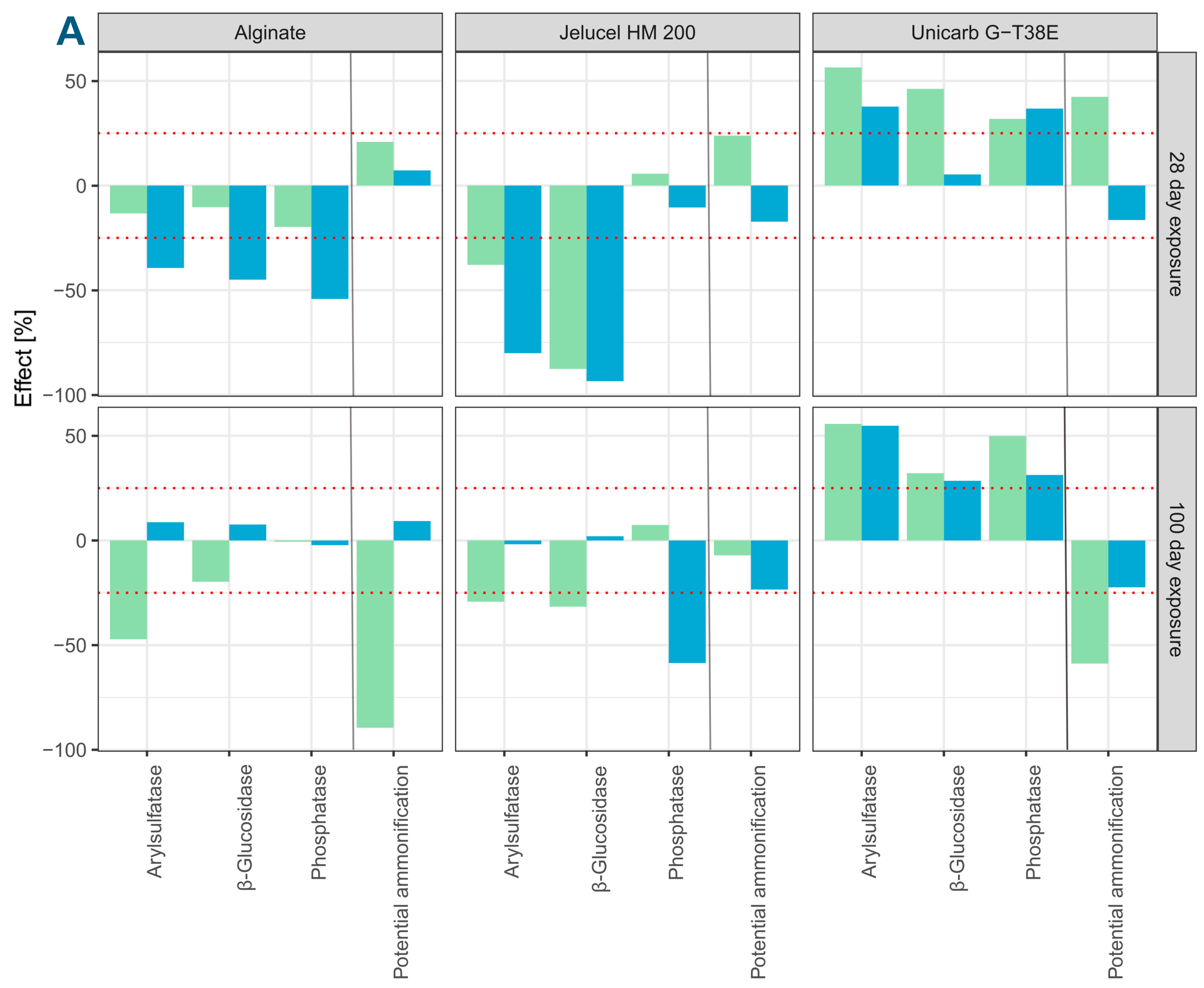
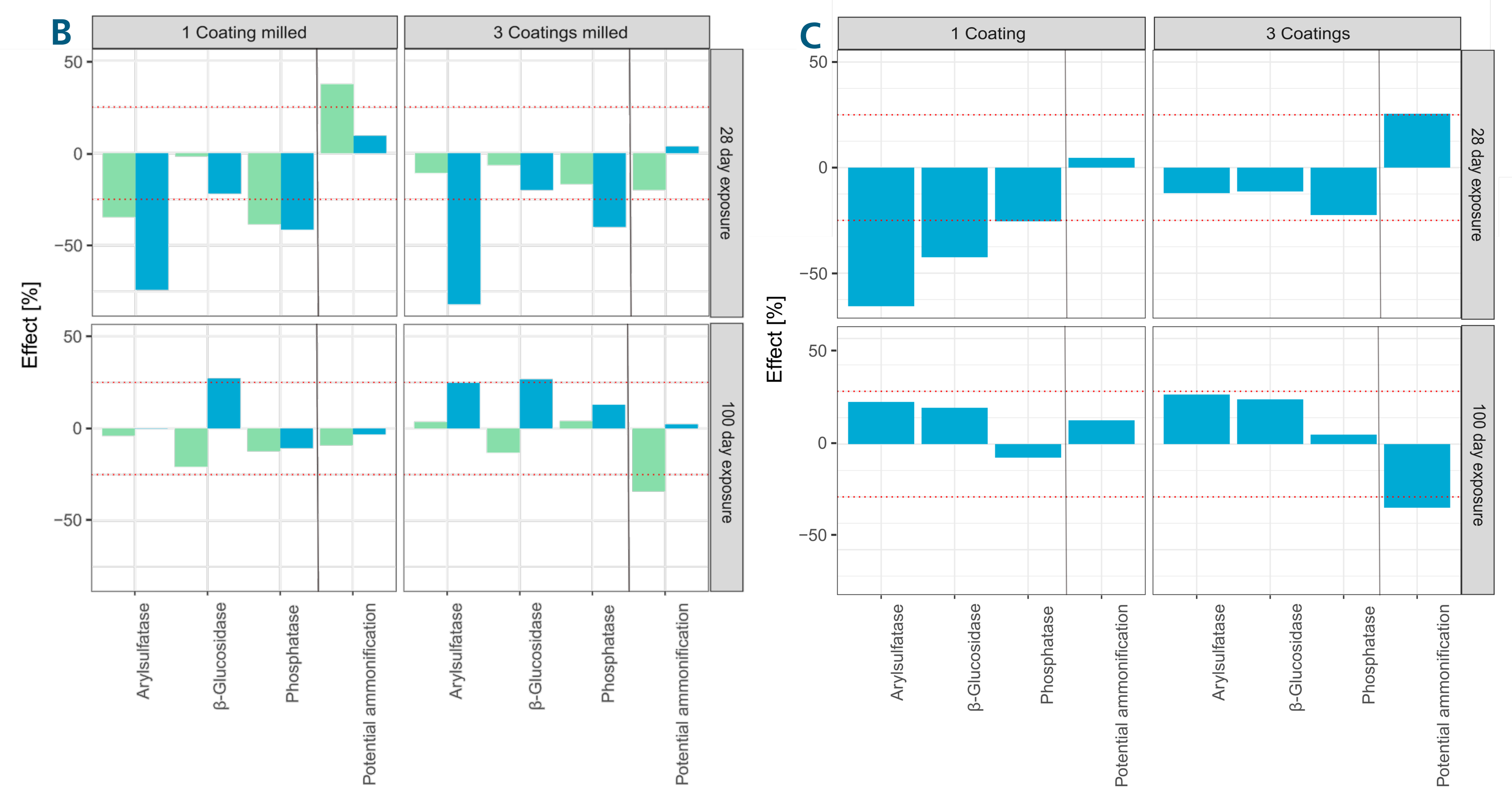


Figure 2: Comparison of the field and laboratory study results on different microbial endpoints after 28 and 100 days of exposure. Different substances (A) and coatings (B & C) were tested. The dotted lines indicate the greater than or equal to ± 25% threshold according to OECD TG 216 for evaluation of the ecotoxicological impact.
Arylsulfatase, ß-glucosidase as well as phosphatase activity were derived with ISO 20130 and potential ammonification with ISO 15685.

Study
Laboratory study
Lysimeter study
25% Threshold



Aquatic tests were not conducted as TOC measurements indicated no significant carbon peak in the leachate after rainfall events.

Terrestrial tests indicated after 28 days of exposure comparable trends in activity deviation while after 100 days of exposure trends were not visible anymore for alginate and Jelucel HM 200.

→ The biopolymers alginate and Jelucel HM 200 may have been metabolized leading to observed stimulations after 28 days of exposure.

→ Substrates may have been adsorbed on the surface of Unicarb G-T38E triggering the observed effects.

Conclusion

Laboratory results overestimated the adverse effects observed under field exposure, indicating that the laboratory approach is a conservative and protective tool for risk evaluation.

Outlook

- Performance of tests after one year of exposure
- Performance of gene expression analysis (archaeal and bacterial amoA) to combine functional and molecular biological test results

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Figures created with BioRender and RStudio.

Winter et al. 2025a:
Natural but threatening? (I) A systematic aquatic ecotoxicity evaluation of biopolymers and modified natural polymers

Winter et al. 2025b:
Natural but threatening? (II) A systematic terrestrial ecotoxicity evaluation of biopolymers and modified natural polymers

Portable Poster

[1] Chang, L., Xu, L., Liu, Y., & Qiu, D. (2021): Superabsorbent polymers used for agricultural water retention. In: Polymer Testing, 94: 107021. [2] Ostrand, M. S., De Sutter, T. M., Daigh, A. L. M., Limb, R. F., & Steele, D. D. (2020): Superabsorbent polymer characteristics, properties, and applications. In: Agrosystems, Geosciences & Environment, 3(1): 1. [3] ECETOC (2019): The ECETOC Conceptual Framework for Polymer Risk Assessment (CF4Polymers). Technical Report No. 133-1. Edited by European Centre for Ecotoxicology and Toxicology of Chemicals. Brussels.