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# Environmental Assessment and Ecotoxicity of Paper Coated with PHBV and Cellulose: Uncovering Hidden Risks in "Sustainable" Packaging †

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The growing demand for sustainable packaging has accelerated the development of biodegradable, bio-based alternatives to traditional plastics. Among these, poly (hydroxybutyrate-co-hydroxyvalerate) (PHBV) and cellulose-coated paper are promising due to their compostability and renewable origin. However, their environmental safety remains uncertain, especially considering the possible release of chemical additives—such as organophosphate esters (OPEs), phthalates, and alternative plasticisers—during degradation. These substances may pose ecotoxicological risks to soil organisms and ecosystems. This study evaluates the environmental performance of a commercial PHBV–cellulose coated paper (BIOFUNPAPER) by assessing its degradation and ecotoxicity under composting conditions.

Four composting reactors were operated at 58 °C for 90 days with 1.7 kg of compost each. At 30, 60, and 90 days, 25 g samples were collected and analysed by HPLC-MS to quantify 20 OPEs, 11 phthalates, and four alternative plasticisers. Parallel bioassays were conducted on earthworms (*Eisenia fetida*), oat and tomato plants, and soil microbes. Parameters included germination, biomass, worm survival, reproduction, and nitrification inhibition.

The results showed 60% biodegradation of the BIOFUNPAPER material. Acute toxicity in worms was negligible; however, chronic exposure resulted in a 50% reduction in reproduction and a 33% reduction in biomass. Plant germination exceeded 90%, yet tomato biomass fell to 68% of control levels. Microbial nitrification activity dropped to 79.8%, just below the ISO 15685 safety threshold [1]. Most additive concentrations decreased over time but were detectable throughout.

The findings indicate that, despite effective degradation and low acute toxicity, chronic ecological effects persist. These outcomes highlight the need to go beyond biodegradability

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assessments and integrate ecotoxicological evaluations of additives and by-products. Ensuring the environmental compatibility of new bio-based packaging materials requires a holistic, lifecycle-based approach to support a truly circular and safe packaging system.

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## Reference

1. *ISO 15685:2012*; Soil Quality—Determination of Potential Nitrification and Inhibition of Nitrification—Rapid Test by Ammonium Oxidation. International Organization for Standardization: Geneva, Switzerland, 2012. Available online: https://www.iso.org/standard/53530.html (accessed on 6 March 2025).

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