DOI: http://doi.org/10.21698/simi.2026.ab41

SERVICE LIFE AND ENVIRONMENTAL SAFETY OF BIOMASS-FILLED SBS THERMOPLASTIC COMPOSITES

Cristina-Mihaela Nicolescu[1], Marius Bumbac[1,*], Gabriela Zinca[1], Daniela Cristiana Alexandrescu[1], Costel Bumbac[2], Lidia Kim[2], Cosmin Stefan Gherghinoiu[3], Germano Craia[3], Bogdan Catalin Serban[4], Octavian Buiu[4]

[1]Valahia University of Targoviste, Aleea Sinaia Street, 13, 130004 Targoviste, Dambovita, cristina.nicolescu@valahia.ro, Romania
[2]National Research and Development Institute for Industrial Ecology-ECOIND, 57-73 Drumul Podu Dambovitei, district 6, 060652, Bucharest, costel.bumbac@incdecoind.ro, Romania
[3]KIK Compounds SRL, Boerescu Zaharia Street, 6, 130059, Targoviste, Dambovita, Romania
[4]National Institute for Research and Development in Microtechnologies - IMT Bucharest, 126A, Erou Iancu Nicolae Street, 077190, Bucharest, Romania

**corresponding author: marius.bumbac@valahia.ro*

Keywords: *biomass fillers, ecotoxicity, life cycle assessment, life cycle costing, SBS*

Introduction

Low-polarity thermoplastic elastomers filled with biomass can reduce fossil-polymer demand, but their sustainability also depends on durability, additive release and recoverability. Styrene–butadiene–styrene (SBS) is the thermoplastic representative considered here. Published SBS/*Arthrospira platensis* experiments show that composting changes composite morphology and melt flow [1], highlighting the need to evaluate retained processing performance alongside degradation. This communication develops an assessment framework combining life cycle assessment (LCA), environmental life cycle costing (E-LCC) and ecotoxicity for SBS composites containing biomass fillers.

Materials and methods

A prospective scenario framework compares an unfilled SBS formulation with biomass-filled alternatives, with and without interfacial modification. Cellulosic residues and microalgal biomass are candidate fillers. Oil, antioxidant and compatibilizer contents are required inventory entries. The functional unit is a specified flexible-component function delivered over a defined service period, subject to matched hardness, strength and abrasion requirements. System boundaries encompass biomass preparation, polymer production, compounding, use, collection and recovery or disposal.

E-LCC follows the same boundaries [2], accounting for sourcing, drying, grinding, additives, energy, quality control, replacements and waste treatment. Sensitivity variables include filler loading, electricity demand, service-life retention and recycling yield. The assessment is prospective: numerical SBS rankings require formulation-specific inventories, costs and ecotoxicity measurements. The framework tests whether biomass substitution improves performance per unit of service.

Results and conclusions

The framework identifies interfacial stability as a link between resource substitution and service life. Poor bonding can allow water access and filler debonding, while compatibilization may improve retention at additional processing and material cost. These formulation-dependent mechanisms define the evidence priorities in Table 1.

Table 1 - Evidence needed for the SBS/biomass assessment

Assessment	Priority measurements
Service durability	Aged strength, abrasion and water uptake
Environmental release	Leachate composition and released particle size/mass
Material recovery	Reprocessing yield, melt flow and retained properties

An illustrative sensitivity calculation makes the durability tradeoff explicit: a 20% reduction in impact per component combined with a 25% shorter service life gives approximately 7% higher impact per unit of service (0.80/0.75 = 1.067). This hypothetical example assumes constant function, replacement proportional to use time and negligible use-phase impacts; it is not an SBS measurement. E-LCC requires the corresponding replacement costs.

Identified chemical emissions can be characterized with USEtox [3]. Whole leachates and abrasion particles require separate bioassays, controlling for biomass-derived nutrients, turbidity and oxygen depletion. Biomass loss or pore formation does not by itself establish mineralization of the SBS matrix. Reprocessing must also be checked after ageing, as the published composting study found reduced melt flow [1]. The framework therefore tests environmental and economic gains against retained service life, release behavior and feasible recovery.

Acknowledgement

The research was funded by the Ministry of Education and Research – UEFISCDI, project PN-IV-P7.1-PTE-2024-0653 – contract no. 38PTE/2025.

References

[1] Bumbac, M.; et al. Biodegradation Study of Styrene–Butadiene Composites with Incorporated Arthrospira platensis Biomass. *Polymers 16* (2024), 1218. https://doi.org/10.3390/polym16091218.

[2] Swarr, T. E.; et al. Environmental life-cycle costing: A code of practice. *The International Journal of Life Cycle Assessment* 16 (2011), 389–391. https://doi.org/10.1007/s11367-011-0287-5.

[3] Rosenbaum, R. K.; et al. USEtox—the UNEP-SETAC toxicity model: Recommended characterisation factors for human toxicity and freshwater ecotoxicity in life cycle impact assessment. *The International Journal of Life Cycle* Assessment 13 (2008), 532–546. https://doi.org/10.1007/s11367-008-0038-4.