

From emissions to feed: Quantifying the GHG emission avoidance potential of microbial protein production with hybrid living materials.

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Global food systems account for one-third of total greenhouse gas (GHG) emissions and are simultaneously challenged by future food insecurity and significant plastic pollution. In the European Union (EU), 66% of protein-rich animal feed is imported, resulting in vulnerable supply chains, plastic recycling rates remain low at 16%, and agriculture contributes to 11% of EU GHG emissions, with methane (CH₄) identified as a major and high-impact pollutant.

The REPLACER project addresses these challenges by developing a GHG capture approach for biomass production using Hybrid Living Materials (HLMs). This system, inspired by nature, integrates biofilm-based methanotrophic and phototrophic microbial consortia cultivation on porous scaffolds made from recycled PET or viscose, directly sequestering CH₄ and CO₂ to produce microbial protein suitable for animal feed. Preliminary Life Cycle Assessment (LCA) confirms the sustainability potential of HLMs, notably outperforming conventional fishmeal and soymeal feeds in land and water use efficiency. However, while LCA effectively maps relative environmental impacts and hotspots, it does not answer a critical policy question: **what is the absolute volume of GHG emissions avoided?**

This study aims to quantify the absolute and relative GHG emission avoidance for HLM-based microbial protein production following the EU Innovation Fund (InnovFund v5.1) methodology for energy intensive industries. The assessment adopts a modified cradle-to-gate system boundary with an end-of-life phase over a 10 year operational cycle (upstream feedstock, production, excluding capital goods) and aligns with ISO 14067 and IPCC AR5 GWP 100 guidelines. To model long-term impacts, the methodology assumes 1) a decarbonized 2050 electricity grid factor (0.00 tCO₂eq/MWh), 2) biogenic input compliance with the Renewable Energy Directive II (RED II, Directive 2018/2001/EU) sustainability criteria and 3) benchmarks the Project Scenario against a proposed reference scenario for carbon-intensive conventional feeds.

At technology readiness level (TRL) 3, this assessment relies on lab-scale data, and proactively aims to estimate GHG emission mitigation potential before physical scale-up. The obtained results will be compared against broader-scale GHG mitigation targets to estimate the platform's actual capacity to drive the transition toward carbon neutrality, or even carbon negativity, within the EU agriculture system.

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