

Valorization strategies for manure-based digestate



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SEMPRE-BIO Project

SEMPRE-BIO aims to demonstrate **novel and cost-effective biomethane production solutions** and pathways, deemed essential to achieve the European Green Deal and climate and energy targets for 2030 and the net zero greenhouse gas emissions by 2050, and to increase the market uptake of biomethane related technologies.

Objective

Manure-based digestate constitutes a valuable secondary resource within circular bioeconomy systems. Instead of being regarded solely as a waste by-product, digestate can be valorized through multiple pathways, including nutrient recovery technologies for **agronomic use**, **thermochemical conversion**, and a range of **biochemical and biotechnological processes**. In addition, it shows potential for **material reuse** and as a **low-cost growth medium** for plants, microalgae, bacteria, and fungi. This study presents a comprehensive assessment of the strengths, weaknesses, opportunities, and threats (SWOT) associated with various manure-based digestate valorization strategies.



Fig. 1. Valorization strategies and challenges for manure-based digestate.

SWOT Analysis

The primary strengths of manure-based digestate lie in its **nutrient-rich composition** and **functional versatility**, enabling a wide range of valorization pathways, from direct agronomic use to advanced biochemical, thermochemical, and material-based applications. Its alignment with EU circular economy objectives provides a strong policy framework to support market uptake. However, **compositional variability**, **high water content**, and the presence of **potential contaminants** pose **challenges to product standardization and market confidence**, while elevated processing costs limit economic feasibility, particularly for small- to medium-scale biogas plants. Opportunities are driven by the expanding markets for biobased products and nutrient recovery technologies that can reduce dependence on imported mineral fertilizers. In addition, carbon-rich materials such as biochar and hydrochar present opportunities within carbon credit schemes, especially when integrated into **biorefinery models** that combine energy, nutrient, and material recovery.

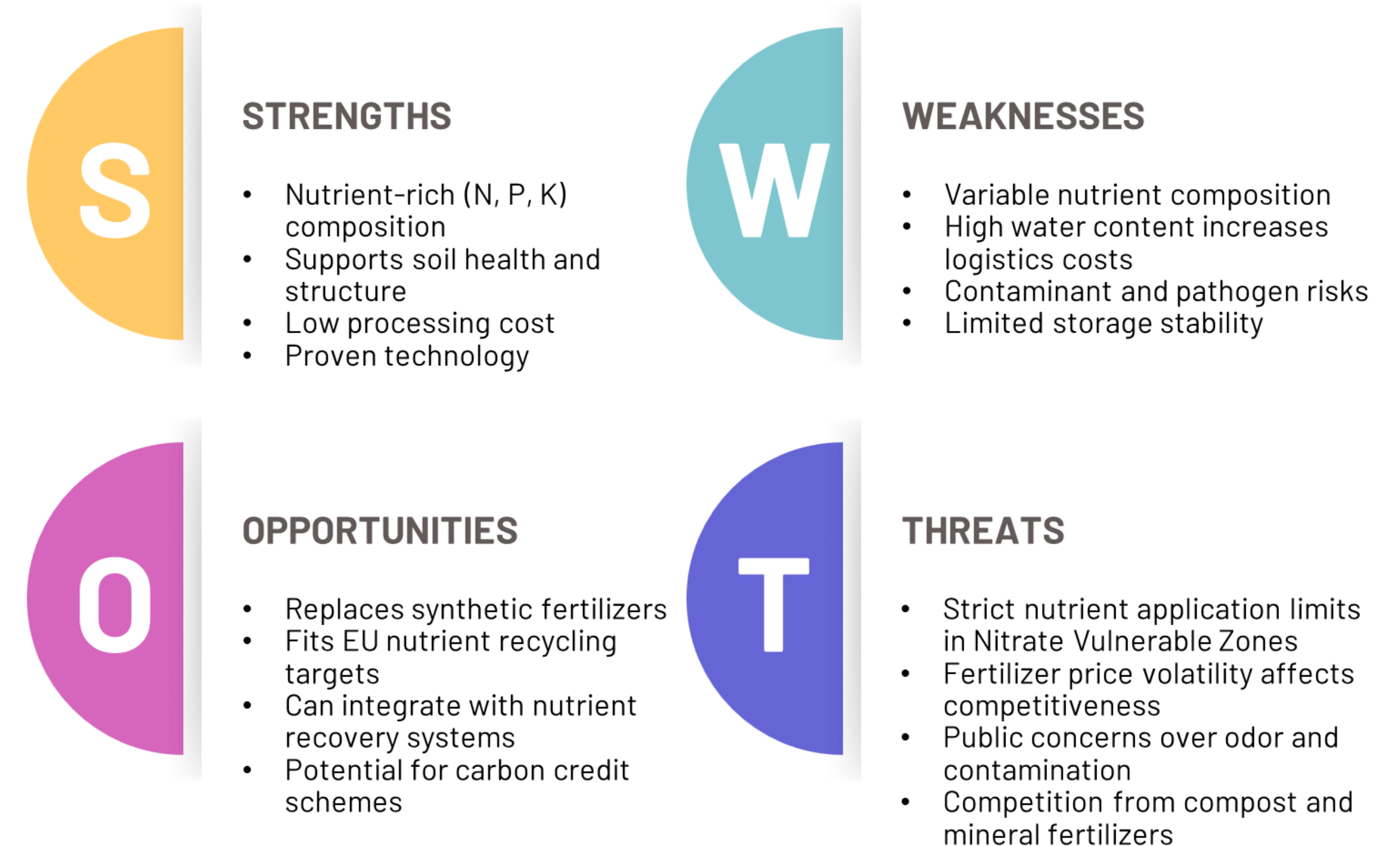


Fig. 2. SWOT analysis of manure-based digestate valorization for agronomic use.

Nonetheless, **regulatory barriers**, **competition** from established products, and **public perception** issues remain significant threats to broader adoption. Overall, while the technical feasibility of digestate valorization is well established, its commercial viability depends on improving **feedstock consistency**, developing **robust and scalable processing** technologies, and strengthening **product quality** assurance. Nutrient recovery pathways, which are less sensitive to input variability, represent a particularly promising route toward standardized, high-value digestate-derived products.

Recommendations

- Standardization and quality assurance:** Develop and harmonize EU-wide quality standards for digestate-derived products to improve market confidence and facilitate cross-border trade.
- Policy support and incentives:** Expand support under the CAP and national programs for nutrient recycling, carbon sequestration, and peat substitution, alongside targeted subsidies and green public procurement initiatives.
- Technology integration:** Promote multi-valorization biorefinery models that combine nutrient recovery, thermochemical conversion, and biotechnological production within single operational frameworks.
- Market development:** Invest in demonstration projects, product labeling, and public awareness campaigns to expand demand for digestate-based fertilizers, soil improvers, and bio-based materials.
- Research and innovation:** Support R&D into cost-effective pretreatment, contaminant removal, and upscaling of promising technologies such as purple non-sulfur bacteria cultivation, hydrochar functionalization, and digestate-based composites.
- Stakeholder collaboration:** Strengthen cooperation between AD operators, farmers, industry, policymakers, and research institutions to accelerate adoption of best practices and reduce transaction costs.



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