Innovative valorization of food processing residues: Sustainable digestate treatment for fertilizers and soil amendments

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Food processing residues (FPRs) from diverse food industries, particularly those generated by dairy and other production sectors, pose a notable environmental challenge. These residues, rich in nutrients and organic carbon, necessitate efficient treatment strategies to minimize waste and promote sustainability. One viable solution involves transforming these residues into fertilizers and soil amendments, creating valuable resources for agriculture. Anaerobic digestion (AD) emerges as an effective method for managing FPRs, simultaneously generating biogas and digestate. The digestate, a nutrient-rich byproduct of AD, is highly suitable for further processing into valuable agricultural products such as fertilizers and soil enhancers.

Advanced valorization techniques, including selective electrodialysis (SED) for the liquid fraction and composting for the solid fraction, can significantly improve digestate quality and maximize nutrient recovery. SED, a membrane-based technology, employs an electric field to selectively separate ions from the liquid digestate fraction. Using membranes that differentiate ions by charge and valence, this process produces distinct ion streams, which can be converted into fertilizers like ammonium sulfate and phosphorus salts. The treated liquid fraction can then serve as a nutrient-rich solution for agricultural use.

For the solid fraction, composting stabilizes the organic matter, transforming it into a high-quality, pathogen-free compost. This compost can be directly applied to soil, enhancing fertility and health. Together, these methods align with circular economy principles, turning waste into products that reintegrate into the agricultural system.

Living Labs play a pivotal role in this transformation by fostering collaboration among stakeholders across the food value chain. These platforms for real-world experimentation engage food producers, researchers, policymakers, and farmers in testing and validating sustainable practices for FPR treatment and valorization. Through active participation, Living Labs drive innovation, encourage stakeholder involvement, and ensure that solutions are scalable and adaptable. Farmers, as end-users of the resulting fertilizers and compost, provide critical feedback on their performance and benefits in agricultural settings.

This study focuses on treating digestate derived from FPRs to produce fertilizers and compost through SED and composting, all within a Living Lab framework. By implementing real-time experimentation, the study aims to optimize these processes, assess the quality and efficacy of the products, and demonstrate their feasibility for sustainable agriculture. This approach represents a promising avenue for enhancing nutrient recovery from FPRs while advancing sustainable food production practices.

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