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Sustainable Biofertilizer Production via Anaerobic Digestion

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Introduction

The increasing demand for sustainable agriculture has driven eco-friendly alternatives to synthetic fertilizers. Anaerobic digestion converts animal manure and agricultural residues into two valuable products: biogas, a renewable energy source, and a nutrient-rich digestate used as biofertilizer. A single process treats waste, recovers energy and returns nutrients to the soil.

Objectives

- Operate a 90 L laboratory-scale digester under mesophilic conditions.
- Evaluate biogas generation and its energy recovery potential.
- Characterize the digestate and apply it as biofertilizer to a degraded soil site.

Methodology

A homemade laboratory-scale anaerobic digester (90 L working volume) was fed with animal manure and agricultural residues and operated under mesophilic conditions. Biogas was evaluated by gasometrical analysis and a flare combustion test; the digestate was characterized for nutrient content and applied to a degraded soil site, monitored daily.

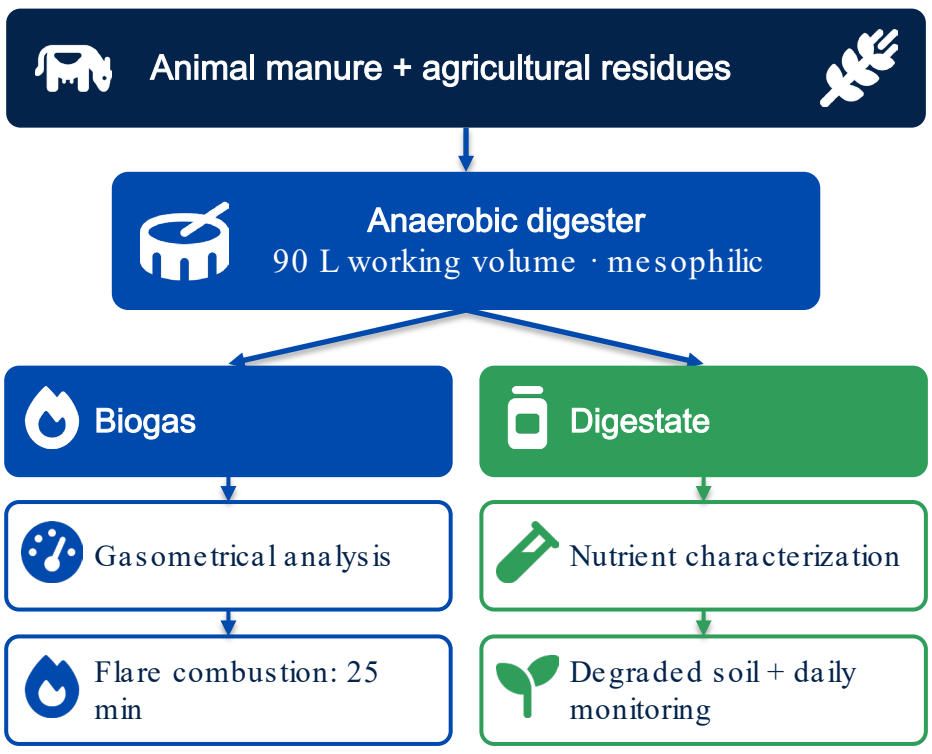


Figure 1. Flowchart of the integrated system: energy route (biogas) and agricultural route (digestate).

Results and Discussion

Gasometrical analysis demonstrated sustained biogas production, and the stored gas maintained combustion in the flare for 25 minutes, indicating successful methanogenesis and energy recovery potential. Daily monitoring of the area treated with digestate revealed progressive soil rehabilitation, with plant emergence where vegetation was previously absent, suggesting enhanced nutrient availability, improved soil structure and restored biological activity.

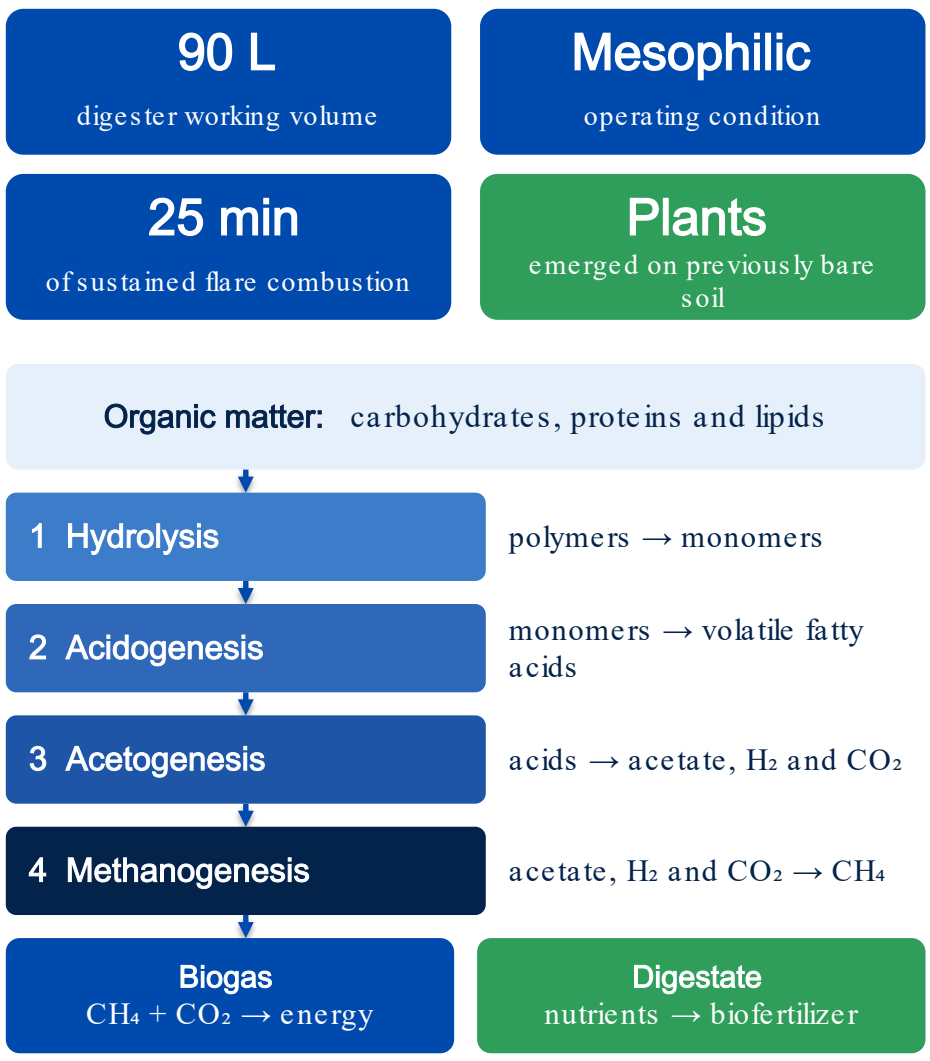


Figure 2. Stages of anaerobic digestion (conceptual scheme) and process products.

Conclusions

Anaerobic digestion effectively converted organic waste streams into valuable agricultural inputs, reducing the environmental burden and the reliance on chemical fertilizers. The biofertilizer showed significant potential for soil recovery, promoting sustainable nutrient cycling within a circular economy.

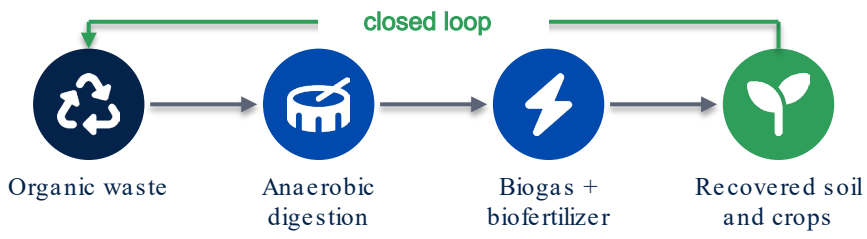


Figure 3. Waste-to-resource integration in the circular economy.

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