

## The Influence of Microbial Diversity on the Energy Efficiency of Anaerobic Digestion of Biodegradable Waste

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### INTRODUCTION & AIM

Anaerobic digestion is a key technology for the circular economy that transforms biodegradable waste into biogas. The efficiency of the process depends on the delicate balance between the four stages of hydrolysis and acidogenesis as well as acetogenesis and methanogenesis.

Research purpose - Analyzing the correlation between microbial community structure and energy yield in terms of methane production.

Objective - Highlighting the biological mechanisms that ensure system resilience under variable operational conditions.

### METHOD

This study utilizes a systematic review of recent scientific literature published between 2020 and 2026.

Data sources - Google Scholar and Web of Science as well as PubMed.

Analyzed indicators - The Shannon diversity index and taxonomic composition via 16S rRNA sequencing along with methane production rates and volatile fatty acid accumulation.

### RESULTS & DISCUSSION

#### A. Main Microbial Groups

- Hydrolytic and Acidogenic Bacteria such as *Firmicutes* and *Bacteroidetes* transform complex polymers into monomers and subsequently into volatile fatty acids. High diversity in this stage prevents bottlenecks during the initial phase.

- Methanogenic Archaea such as *Methanosarcina* and *Methanosaeta* represent the group most sensitive to pH variations. The diversity between hydrogenotrophic and acetoclastic species ensures the stability of biogas production.

#### B. Diversity versus Energy Efficiency

- Functional Stability Systems with high microbial diversity exhibit functional redundancy. If one species is inhibited by temperature or pH shocks other species can occupy the ecological niche.

- Energy Yield Research indicates that a diverse community reduces the accumulation of intermediate metabolites such as propionate which can inhibit the process. This leads to a 15 to 25 % increase in biogas yield.

#### C. System Resilience

- Increased diversity allows for rapid adaptation to feedstock changes. This maintains constant energy production even under environmental stress conditions.

### CONCLUSION

Microbiology as the primary engine - Microbial community composition and diversity serve as more accurate predictors of energy performance than purely chemical parameters.

Optimization - Incorporating microbial monitoring into the operation of biogas facilities can prevent process collapse and optimize the conversion of biomass into green energy.

Sustainability - A robust microbial diversity contributes directly to climate neutrality goals by reducing greenhouse gas emissions associated with organic waste management.

### FUTURE WORK / REFERENCES

- Kostopoulou, E., Chioti, A. G., Tsioni, V., & Sfetsas, T. (2023). Microbial dynamics in anaerobic digestion: A review of operational and environmental factors affecting microbiome composition and function.
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- Zou, J., Shi, Z., Peng, W., Zhang, H., Lü, F., & He, P. (2025). Long-term microbial community dynamics in full-scale dry and wet anaerobic digesters for food waste. Waste Disposal & Sustainable Energy, 7(3), 393-407.