Abstract

[Project Information]

Project Title :	Energy Conversion System Using Wood-derived Carbons that Contribute to Organic Waste Resource Recycling
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[Abstract]

This study examines an integrated system that couples household-scale anaerobic digestion (methane fermentation) with microbial fuel cells (MFCs) that employ biomass-derived carbon materials, with the goal of advancing sustainable local resource utilization and decentralized energy generation. By relying on locally sourced biomass—including white charcoal and biochar produced from agricultural residues and wood—the study outlines a pathway to reduce dependence on fossil-based or imported carbon materials, strengthen regional resource circularity, and mitigate environmental impacts.

Subtheme 1. Small-scale anaerobic digesters were installed across multiple households within a local community. These units convert organic wastes, primarily food waste, into biogas (methane) via microbial digestion. This study emphasized not only gas recovery but also community-based participatory operation: residents engaged directly in routine maintenance, monitoring, and incremental innovation, fostering ownership and experiential learning. The digestate by-product was used both as a soil amendment and as an experimental anode material in MFCs, thereby assessing its multifunctional potential. Although the recovered biogas does not yet meet total household energy demand, it offsets a portion of fossil gas use (e.g., for water heating) and thus provides a practical entry point for integrating decentralized renewable energy.

Subtheme 2. MFCs utilizing synthetic wastewater as the substrate and biomass-derived carbon electrodes were developed. By harnessing the metabolic activity of microorganisms, these cells generate electricity while simultaneously providing partial wastewater treatment. Despite historically low power densities in MFCs, recent advances in electrode materials—such as biochar-based cathodes and materials that enhance the oxygen reduction reaction (ORR)—show considerable

promise. This study investigates performance characteristics and the principal factors influencing power output, operational stability, and scalability under conditions approximating real-world deployment.

Beyond technological performance, the study highlights the importance of social acceptance, alignment with environmental policy, and regulatory clarity. It calls for interministerial coordination (e.g., the Ministry of the Environment; the Ministry of Agriculture, Forestry and Fisheries; and the Ministry of Land, Infrastructure, Transport and Tourism) to clarify the classification of these systems as "circular resources" and to embed them within future sustainability strategies. The findings also point to educational benefits and the accrual of social capital stemming from community engagement, indicating that the successful deployment of small-scale, locally integrated energy technologies depends not only on engineering innovation but also on social learning and cooperative practice. Collectively, the results suggest a promising model for decentralized, biomass-based energy systems aligned with Japan's broader decarbonization and regional revitalization goals.

[References]

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