Review of advanced biowaste-to-hydrogen technologies: Their role in modern waste management and environmental impact.

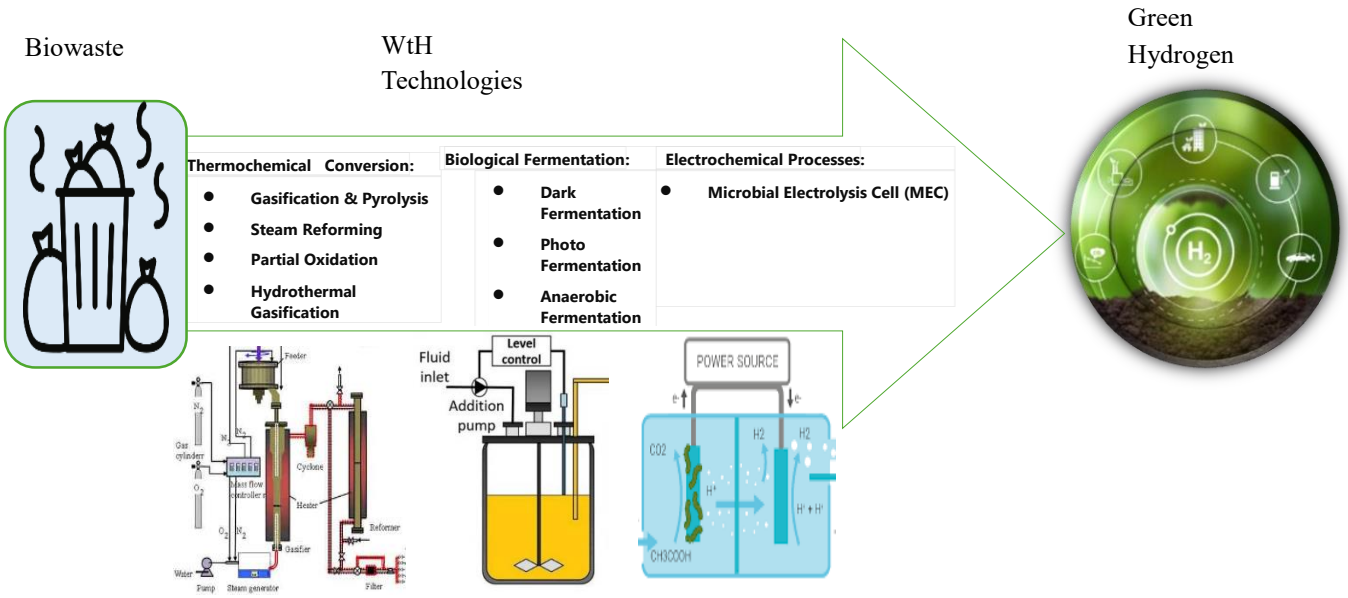
Krzysztof Pikoń , Mamo Abawalo,* Marcin Landrat , Waldemar Ścierski

Department of Technologies and Installation for Waste Management, Silesian University of Technology, Gliwice, Silesia, Konarskiego 18, 44-100, Poland

Keywords: biowaste, waste management, hydrogen, environmental impact, technologies, clean energy, efficiency, thermochemical, biological fermentation, electrochemical processes

Presenting author email: krzysztof.pikon@polsl.pl

Graphical Abstract



The increase in solid waste production and its environmental impacts worldwide has sparked significant interest in waste valorization through various waste-to-energy (WtE) methods, intending to generate renewable energy sources and reduce reliance on fossil fuels and chemicals. These technologies play a crucial role in implementing the envisioned global "bioeconomy" through biorefineries. The utilization of waste-to-hydrogen technologies within solid waste management practices has emerged as a promising avenue with significant environmental implications. In light of this, this review provides the role of waste-to-hydrogen technologies and their environmental impact in modern solid waste management. By converting diverse waste streams, including municipal solid waste, agricultural residues, biomass, and sewage sludge, into hydrogen gas through thermochemical, biological fermentation, or electrochemical processes, these technologies offer a dual benefit of energy production and waste reduction. Thermochemical conversion routes, including gasification and pyrolysis, demonstrate significant potential for hydrogen production, albeit with operational complexities and reactor costs. Biological fermentation methods, explored extensively in recent research, offer a sustainable approach for biohydrogen production from various biowastes. Studies emphasize the efficacy of dark fermentation and photo fermentation pathways, albeit with differences in production rates and yields. Electrochemical processes, while offering promising avenues for hydrogen generation, require further optimization and exploration. The present studies explore the environmental benefits and challenges associated with waste-to-hydrogen technologies, highlighting their potential to mitigate greenhouse gas emissions, reduce landfill waste, and foster a circular economy. Challenges, including varying hydrogen production rates and yields among different waste types, necessitate optimization of operational parameters for enhanced efficiency and viability. Furthermore, it discusses ongoing research efforts aimed at improving the efficiency, scalability, and environmental performance of waste-

to-hydrogen processes. Efforts to improve the efficiency and scalability of waste-to-hydrogen technologies through innovations in catalysts, reactor designs, and process optimization are ongoing, aiming to make these technologies more cost-effective and commercially viable. In this review, existing knowledge is critically analyzed and synthesized to provide insight into waste-to-hydrogen technologies' role in modern solid waste management practices and their contribution to environmental sustainability. In addition to contributing to H_2 production capacity, these options need to be improved for larger competitive quantities to be produced.