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Editorial: Microbial communities for bioenergy recovery from wastes and waste streams

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Editorial on the Research Topic
Editorial: Microbial communities for bioenergy recovery from wastes and waste streams

Introduction

As we navigate the challenges posed by a rapidly growing global population, resulting in a surge in waste generation, coupled with an ongoing energy crisis, natural or synthetic microbial communities emerge as a promising solution to tackle two critical issues—waste management and sustainable energy production. Aligned with the UN Sustainable Development Goal 7 (SDG7), which envisions "affordable, reliable, sustainable, and modern energy for all" by 2030, the biotransformation of organic compounds present in wastes and waste streams into diverse energy carriers emerges as a viable and sustainable pathway. This transformative process contributes to realising a circular economy, diminishing our reliance on fossil fuels, mitigating environmental pollution, reducing net carbon emissions, and preserving both public and ecological health. The Research Topic explores recent advances in innovative technologies that leverage microbial communities to produce green energy from wastes and waste streams, offering a glimpse into the promising future of sustainable energy solutions.

Published papers

This Research Topic accepted three research articles and one review paper following peer review and editing.

Tesfaw presented a comprehensive review paper on the recent advancements in bioethanol production from cheese whey using yeasts. The paper explores emerging methods to enhance bioethanol production, such as co-culturing ethanol-producing yeasts with lactose-utilising microbes, yeast immobilization using nanoparticles, and

employing electro-fermentation. The review provides insights from both biological and economic perspectives.

Lang et al. investigated the changes in the spatial pattern of biomass energy supply across 31 provinces in China from 2000 to 2020. They accomplished this by constructing a comprehensive biowaste inventory, incorporating crop straw, livestock manure, forest residues, and organic fraction of municipal solid waste. The results indicated that the amount of biomass energy converted into tons of coal equivalent (tce) in China exhibited fluctuations, increasing from $139{,}141.73 \times 10^4$ tce in 2000 to $146{,}133.20 \times 10^4$ tce in 2020, with an average annual growth rate of 0.24%. Biomass energy demonstrated high potential for future energy supply and decarbonisation of the energy sector.

Pivato et al. utilised microbial communities involved in aerobic biodegradation of organic waste to develop a compost heat recovery system. The system recovered heat from the biodegradation of pruning residues supplemented with woodchips-derived biochar. The heat generated during microbial respiration was extracted through a hydraulic circuit. The researchers conducted a comprehensive analysis of factors influencing the process and optimised heat recovery. Microbial community analysis was performed to identify key microbes contributing to the process, their impact on ecological benefits, antibiotic-resistant genes, and heat recovery efficiency. The heat extraction flux was improved by the presence of biochar and the microbial communities also changed.

The synthesis of neutral lipids in the form of triacylglycerol (considered as potential precursors for the manufacture of biodiesel) during stress by different species is another process for energy recovery from wastewater. Alkhamis et al. investigated the enhancing effect of pH-induced stress on autotrophic (induced during the starvation phase) and mixotrophic (during the growth phase) microalgae's lipid accumulation during wastewater treatment and CO_2 sequestration. The researchers applied fluorescent staining to detect intracellular lipid bodies and conducted gas chromatography analysis of fatty acid methyl esters to quantify substantial amounts of saturated and unsaturated fatty acids.

Outlook

This Research Topic of articles demonstrated the feasibility of different approaches for energy recovery from organic waste through a biotechnological approach, with a special focus on comprehension and improvement of the feedstock properties and microorganisms' role and performance. The biotechnological approach includes, but is not limited to, recovery of heat from composting, production of bioethanol and lipids from waste, and analysis of the potential of biomass as a renewable energy source. The manipulation of microbial communities, either simple (co-culture) or complex (enriched mixed culture), is essential in waste-to-energy systems. Commonly used approaches, such as managing the physicochemical and process parameters, have shown success to some extent in improving energy recovery. However, approaches for manipulating the microbial community more directly should be explored, e.g., bioaugmentation, designed community, and mixed cultures consisting of genetically modified strains.

Author contributions

RR: Writing–original draft, Writing–review and editing. BG: Writing–original draft, Writing–review and editing. WP: Writing–original draft, Writing–review and editing. RP: Writing–original draft, Writing–review and editing.

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In memory of our esteemed co-author, Professor Alberto Pivato, whose untimely passing has left an indelible void, we, the co-author and the Editorial board, dedicate this work to honoring the enduring legacy of a respected colleague and friend.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The author(s) declared that they were an editorial board member of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

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