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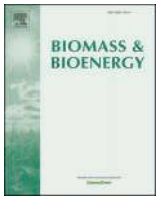

Biohydrogen production for sustainable energy transition: A bibliometric and systematic review of the reaction mechanisms, challenges, knowledge gaps and emerging trends

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ABSTRACT

Biological hydrogen production is seen as one of the solutions to achieve a sustainable energy transition and net-zero emission by 2050. The underlying mechanisms of biological hydrogen production methods are still tenuous in literature. This study uses bibliometric and systematic literature review methodologies to examine the recent and emerging techniques on biological hydrogen production methods and their reaction mechanisms by evaluating 705 articles in Scopus® database from 2000 to May 2024. Scientific visuals were developed for subject areas, top journals, productive nations, top institutions, leading authors, most cited articles, emerging themes, research areas, and reaction mechanisms. The analysis revealed substantial growth in this research area over the past two decades, with notable shifts observed between 2016 and 2019, indicating strong interest from the scientific community. Exploration of the author's keywords reveals that hydrolysis, acidogenesis, carbon fixation, absorption, and nitrogen fixation are the dominant reaction mechanisms of biohydrogen (bio-H_2) production methods. Emerging themes in Bio-H_2 production research from Scopus® database query shows four clusters with dark fermentation as the most published bio-H_2 production method. Keywords co-occurrence analysis identified hydrogen production, hydrogen, biohydrogen, and fermentation, as the most prevalent. Bioenergy, biofuels, biohydrogen production, fermentation process, wastewater treatment technologies, microbial and biochemical aspects of anaerobic fermentation are the emerging trends for the future. This review acts as a useful resource for researchers, scholars, and practitioners interested in advancing their knowledge of biological hydrogen production. Results obtained from this study can provide valuable information for researchers to identify future hotspots in biological hydrogen production.

1. Introduction

Energy demands are projected to increase by 50 % over the next 30 years due to population growth and industrialization [1–4]. Presently, fossil fuels account for approximately 80 % of the world's energy supply, but their combustion releases significant amounts of greenhouse gases like carbon dioxide (CO_2) and methane, contributing to global warming [5–11]. Consequently, renewable energy sources such as solar, wind, and geothermal power are being pursued as sustainable alternatives to achieve a CO_2-free global economy and balance energy supply and demand [12]. However, these sources, such as wind and sunlight, are subject to seasonal variability. As a result, there is a growing focus on exploring other energy streams [12]. Hydrogen is emerging as a promising alternative energy source for industries due to its high energy density per unit weight [13,14]. It is a colorless energy carrier that produces only water upon combustion. Various methods for hydrogen production have been investigated, including water electrolysis, thermocatalytic reforming, biological processes, and electrochemical and thermochemical approaches. However, many of these methods require harsh conditions, are energy-intensive, or involve the use or production

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