Chapter 9
Environmental Assessment of Microalgal Biomass Fermentation for Green Hydrogen Production

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ABSTRACT

Hydrogen is an environmentally friendly energy source that is crucial in addressing global climate change and energy shortages. Microalgae are a highly appealing method for generating biohydrogen, which is a clean and environmentally friendly energy source. This strategy can help reach carbon neutrality and ensure the sustainability of bioenergy. The production of biohydrogen by dark fermentation is seen as a promising way of using clean, renewable energy. Microbial fermentation activities produce the majority of hydrogen in the biosphere. The biological synthesis of hydrogen is an attractive approach to renewable energy production, utilizing both photosynthesis and fermentation processes. Certain types of green algae, blue-green algae (cyanobacteria), fermentative and photosynthetic bacteria, and archaea can produce hydrogen by using light energy and/or various organic substances. Our work aims to study

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the role and influence of biohydrogen production by dark fermentation using microalgae, as well as improve the production yield, with a view to wider application in the future

1. INTRODUCTION

The conventional techniques used to produce hydrogen, however, are linked to environmental pollution around the world (Benchrifa et al. 2024). For this reason, the energy and environment sectors are working to develop more sustainable ways of producing hydrogen from renewable resources (Abanades et Rodat 2022; Qureshi et al. 2023). The production of green hydrogen is widely acknowledged to be environmentally friendly and sustainable, as it utilizes a renewable source (Machhirake et al. 2024). Provided that the electricity utilized is derived from a renewable energy source such as hydroelectricity, wind or solar power, or biomass, all aspects of the manufacturing cycle have a minimal carbon impact (El-Moustaqim, Mabrouki, Azrour, et al. 2024). The hydrogen generated is referred to as green hydrogen (El-Moustaqim, Mabrouki, et Hmouni 2024b). This manufacturing process produces minute amounts of greenhouse gas emissions (El-Moustaqim, Mohammed, Mabrouki, et al. 2024; El-Moustaqim, Rachiq, Mabrouki, et al. 2024). Green hydrogen constitutes around 2% of the total worldwide output. The present production costs of this substance exceed those of grey hydrogen (Jarosz et al. 2024). Policymakers and researchers are paying more attention to biohydrogen since it is seen as an environmentally benign energy source that may play a major part in global sustainability efforts (El-Moustaqim et al. 2024; El-Moustaqim, Mabrouki, et Hmouni 2024a; Leong et al. 2024). It is also regarded as a green carbon-free energy source because it emits no products that include carbon dioxide (Sankir et Sankir 2024; Sarkar, Katakojwala, et Mohan 2021). The potential of biomass, including substrates such as food waste, wastewater, sludge, algae, and lignocellulosic materials, for biohydrogen production with reduced carbon emissions is considerable (Buffi, Prussi, et Scarlat 2022). From the circular economy perspective, using microalgae in wastewater treatment offers an ecologically friendly and potentially economically viable substitute for conventional treatment techniques (Udaypal, Goswami, et Verma 2024). However, the general adoption of this technology still needs more study and advancement to surmount the obstacles of enhancing prices and adjusting to various environmental situations (Akram et al. 2024). Most hydrogen supply is now derived from the reforming or gasifying of hydrocarbons (Jain et al. 2024). Water electrolysis is expected to emerge as the predominant technique for hydrogen generation due to its clean nature (eliminating carbon emissions when combined with a renewable energy source) and ability to provide hydrogen of exceptional purity (El-Moustaqim et al. 2024; Omer et al. 2024; Oraby et Shawqi 2024). The production of biohydrogen by dark fermentation is seen as a promising way of using clean, renewable energy (Suastes-Rivas et al. 2024; Sun et al. 2022; Yarkent et al. 2024). Dark fermentation is a widely recognized technique that functions without light (Montiel-Corona et Buitrón 2024). As one of the metabolic byproducts, hydrogen is produced here when anaerobic microbes break down a range of organic substances, including biomass and organic waste (Jung et al. 2013; Kucharska et al. 2021; Xia et al. 2016). This technique is very adaptable and may make use of a broad spectrum of raw materials (Haruna et al. 2024).

Our work plays a role in analyzing methods for producing biohydrogen by dark fermentation using microalgae, as well as improving production yields, highlighting factors affecting its productivity and key strategies to enhance its productivity, and also emphasizing the economic assessment of microalgal biohydrogen production with present challenges. with a view to wider application in the future.

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