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Biodiesel production potential of microalgae, cultivated in acid mine drainage and livestock wastewater

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ABSTRACT

The adaptability and biofuel production potential of two strains of microalgae isolated and cultivated in livestock wastewater effluent (LWE) with acid mine drainage (AMD) were investigated. The isolated strains of microalgae from samples obtained from LWE and AMD, two microalgal strains (*Nephroselmis* sp. KGE2 and *Autodesmus obliquus* KGE17) were selected based on their growth rate and lipid productivity. The dry cell weight of *Nephroselmis* sp. KGE2 and *Autodesmus obliquus* KGE17 after 20 days of cultivation in AMD increased from 0.05 to 0.59 g/L and from 0.05 to 0.55 g/L, respectively. These findings revealed a significant accumulation of fatty acids with increasing AMD content. *Nephroselmis* sp. KGE2 in LWE with 5% AMD demonstrated a higher growth rate (0.59 ± 0.03 g/L) and fatty acid production (401.5 ± 47.3 mg/L) than *Autodesmus obliquus* KGE17 with 5% AMD. Additionally, *Nephroselmis* sp. KGE2 had C16–C18 fatty acid content (92.4%) in LWE with AMD. Biodiesel produced from *Nephroselmis* sp. KGE2 had a higher cetane number (52.31) and iodine value (88.26 g I_2/100 g oil). Consequently, *Nephroselmis* sp. KGE2 can be considered a potential candidate for biodiesel production using AMD as an iron source.

1. Introduction

Cultivation of microalgae combined with an environmentally and economically sustainable wastewater treatment (WWT) strategy is recommended for bioenergy production (Dang and Lee, 2018). The global biodiesel market was estimated at $46.8 billion in 2021 and is expected to reach $51.5 billion by 2026. Demand for biodiesel is driven by transport vehicles replacing fossil fuels and is expected to grow at an annual growth rate of approximately 5.9% by 2026 (Market Data Forecast, 2022). Microalgae cultivation technologies using wastewater are related to resource recovery, biofuels production, and bioremediation in a circular carbon economy (Bhatia et al., 2021). Cultivation is considered an expensive step during the biodiesel production due to the enormous consumption of nutrients, including carbon, nitrogen, phosphate, and trace elements (Han et al., 2019). Wastewater treatment using microalgae can be considered an alternative to the traditional wastewater treatment process because microalgae effectively utilize nutrients in different wastewaters (Han et al., 2019). Membrane bioreactor (MBR) processes have been widely used in the treatment of urban and industrial wastewater because of their higher organic load, high efficiency, lower area requirement, and sludge yield (Kampouris et al., 2018). Wastewater after secondary treatment by MBR can be utilized for the microalgal growth.

Iron species in aqueous solution are mostly present in the form of insoluble oxides or hydroxides due to thermodynamic instability and low solubility (Kuma et al., 1995). Thus, iron is considered a major limiting factor in algae cultivation (Paz et al., 2007). Iron is an essential micronutrient for microalgae growth and is used in photosynthesis, nitrogen consumption, chlorophyll synthesis, respiration, and in the cellular and metabolic activities of microalgae. In particular, iron plays an important role in the electron transport system and assists in light harvesting and carbon fixation (Hutchins and Bruland, 1998; Rana and Prajapati, 2021). The low concentration of iron in wastewater leads to low biomass production and lipid productivity (Rana and Prajapati, 2021). This makes microalgae cultivation in MBR effluent unfeasible for practical application (Ding et al., 2020; Rana and Prajapati, 2021; Wang

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