Journal of Environmental Management 370 (2024) 122760

Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: www.elsevier.com/locate/jenvman

Research article

Municipal and industrial wastewater blending: Effect of the carbon/nitrogen ratio on microalgae productivity and biocompound accumulation

Alexia Saleme Aona de Paula Pereira [a,*], Iara Barbosa Magalhães [a], Thiago Abrantes Silva [a], Alberto Jose Delgado dos Reis [b], Eduardo de Aguiar do Couto [c], Maria Lucia Calijuri [a]

[a] Civil Engineering Department, Federal University of Viçosa, Campus Universitário, Viçosa, Minas Gerais, Brazil
[b] Bioenergy and Biorefineries Unit, National Laboratory of Energy and Geology, Lisbon, Portugal
[c] Institute of Pure and Applied Sciences, Federal University of Itajuba, Itabira, Minas Gerais, Brazil

ARTICLE INFO

Keywords:
Microalgae
Biomass
Nutrients removal
Resource recovery
Wastewater treatment
C/N ratio

ABSTRACT

Municipal wastewater (MW) and industrial wastewater from juice processing (IWJ) were blended in different proportions to assess the effect of the carbon/nitrogen (C/N) ratio on pollutant removal, microalgal biomass (MB) cultivation, and the accumulation of carotenoids and biocompounds. MB development was not observed in treatments with higher C/N ratios (>30.67). The wastewater mixture favored the removal of dissolved organic carbon (75.61 and 81.90%) and soluble chemical oxygen demand (66.78–88.85%), compared to the treatment composed exclusively of MW (T7). Treatments T3 and T6 (C/N ratio equal to 30.67 and 7.52, respectively) showed higher Chlorophyll-*a* concentrations, 1.47 and 1.54 times higher than T7 (C/N ratio 1.75). It was also observed that the C/N ratio of 30.67 favored the accumulation of carbohydrates and lipids (30.07% and 26.39%, respectively), while the C/N ratio of 7.52 improved protein accumulation (33.00%). The fatty acids C16:0, C18:1, C18:2, and C18:3 had the highest concentrations. Additionally, increasing the C/N ratio can be an efficient strategy to improve the production of fatty acids for biofuels, mainly due to the increased concentration of shorter-chain fatty acids (C16:0). These findings suggest that blending wastewater not only enhances treatment performance but also increases the accumulation of valuable carbohydrates and lipids in MB, and optimizes fatty acid production for biofuel applications. This research represents significant progress towards feasibility of using MB produced from wastewater.

1. Introduction

Microalgal biomass (MB) production can be effectively integrated into wastewater treatment due to the abundance of nutrients and organic matter, which is crucial for the symbiotic interactions between microalgae and bacteria. Moreover, the MB produced at the end of this process can be utilized in biofertilizer and biofuel production pathways (Castro et al., 2023; Pereira et al., 2024), enhancing the valorization of sanitation resources (Liyanaarachchi et al., 2021; Pereira et al., 2023). However, several challenges can impact MB production performance, such as carbon (C) limitation, which is commonly reported in municipal wastewater (MW) (Moreno-Garcia et al., 2019; Xie et al., 2019a). A viable alternative is to co-treat MW with other types of wastewater that have a higher carbon concentration. This approach can provide a medium with a more favorable carbon/nitrogen (C/N) ratio, enhancing MB cultivation performance.

The interaction between algae and bacteria improves the efficiency of biological nitrogen (N) and phosphorus (P) removal and effectively reduces aeration energy consumption (Yu et al., 2024). However, the availability of C, N, and P can vary between different types of wastewater and, consequently, influence microalgae development (Xie et al., 2019b) and biocompound accumulation (Ferreira et al., 2024; Liang et al., 2023). Wastewater from different sources has been used as a cultivation medium for MB, including MW (Assis et al., 2017; Gao et al., 2022; Khan et al., 2022), swine wastewater (Cheng et al., 2017; Oliveira et al., 2023a, 2023b; Qu et al., 2019), agro-industrial sector (Pereira et al., 2021; Silva et al., 2021; Wu et al., 2019), and brewery industry (Gama et al., 2023; Zheng et al., 2018). However, the composition of the culture medium plays a fundamental role in biomass production and

* Corresponding author. Department of Civil Engineering, Federal University of Viçosa (Universidade Federal de Viçosa/UFV), Av. Peter Henry Rolfs, s/n, Campus Universitário, Viçosa, Minas Gerais, 36570-900, Brazil.
E-mail addresses: alexia.aona94@gmail.com, alexia.pereira@ufv.br (A.S.A.P. Pereira), iara.barbosa@ufv.br (I.B. Magalhães), thiago.abrantes@ufv.br (T.A. Silva), alberto.reis@lneg.pt (A.J.D. Reis), eduardo.couto@ufla.br (E.A. Couto), calijuri@ufv.br (M.L. Calijuri).

https://doi.org/10.1016/j.jenvman.2024.122760
Received 15 July 2024; Received in revised form 3 September 2024; Accepted 29 September 2024
Available online 9 October 2024