Treatment of domestic wastewater in microalgae-system: effect of adding NaO_2CCH_3 and NaHCO3

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Highlights:

- The addition of NaO_2CCH_3 and $NaHCO_3$ did not significantly affect the removal of pathogens in batch microalgae systems;
- The addition of different sources of carbon can improve the productivity of microalgae-based systems;
- The combined addition of NaO_2CCH_3 and $NaHCO_3$ has an impact on the pH of microalgae-based systems.

Keywords: Photobioreactor; Mixotrophic Microalgae; Pathogen Removal.

INTRODUCTION

Anaerobic digestion is widely used for treating domestic and agro-industrial wastewater due to its low energy consumption, low installation and operating costs, high tolerance to organic loads, and biogas production (Chernicharo, 2007). However, it is not effective in removing nitrogen, phosphorus, and pathogens, requiring post-treatment processes (Chernicharo, 2007).

Microalgae-based systems have gained attention as an option for digestate post-treatment due to their ability to remove nutrients and pathogens while producing biomass with potential commercial, energy, and agricultural applications (Arias et al., 2018; Ruas et al., 2021). However, the efficiency of these systems is limited by the low carbon content in anaerobic effluents, requiring external carbon supplementation to enhance both biomass productivity and pollutant removal (Ruas et al., 2018). Gaseous CO_2 is commonly used as a carbon source, but its high cost poses a challenge to the economic viability of microalgae-based systems.

Therefore, exploring alternative, cost-effective carbon sources is essential to improving the performance of these systems. Organic and inorganic carbon sources such as sodium acetate (NaO_2CCH_3) and sodium bicarbonate ($NaHCO_3$) are promising alternatives that could improve treatment efficiency and reduce costs.

This study aims to investigate the effects of these alternative carbon sources on microalgae biomass productivity, nutrient, and pathogen removal from domestic wastewater, contributing to more sustainable and cost-effective wastewater treatment solutions.

METHODOLOGY

The experimental setup consisted of seven batch assays conducted in 2-liter reactors with a working volume of 1.5 L, each containing different concentrations of NaO_2CCH_3 and $NaHCO_3$. A control condition (no addition of inoculum or carbon sources) was included, alongside condition A, which received only a microalgae inoculum. Conditions B, C, D, E and F involved both the microalgae inoculum and varying concentrations of NaO_2CCH_3 (0.07, 0.15, 0.25, 0.04 and 0.7 g/L, respectively) and $NaHCO_3$ (0.7, 1.5, 2.5, 4.0 and 7.0 g/L, respectively) (Figure 1).

The cultivation conditions were maintained with a light intensity of 175 μmol m^{-2} s^{-1}, a 12:12 h photoperiod of light:dark, and a temperature of 25.0 ± 0.4 °C. The microalgae consortium was isolated from anaerobically digested domestic wastewater, following the method described by Serejo et al. (2015). The domestic wastewater, collected post-anaerobic treatment, had the following characteristics: pH 7.14 ± 0.10, turbidity 217.41 ± 28.58 NTU, total alkalinity 195.92 ± 33.95 mg $CaCO_3$ L^{-1}, total phosphorus 9.99±3.27 mg $P\text{-}PO_4^{3-}$ L^{-1}, total ammonia 73.84±10.76 mg $N\text{-}NH_4^+$ L^{-1}, *Escherichia coli* (1.86 ±1.01) x10^4 UFC (100 mL) $^{-1}$ and total coliforms (TC) (4.97±0.27) x10^4 UFC (100 mL)$^{-1}$. *E. coli* and TC were monitored using Chromocult® Coliform Agar (Merk Cat.No.1.10426). All analyses were conducted according to Standard Methods for the Examination of Water and Wastewater (APHA, 2012).

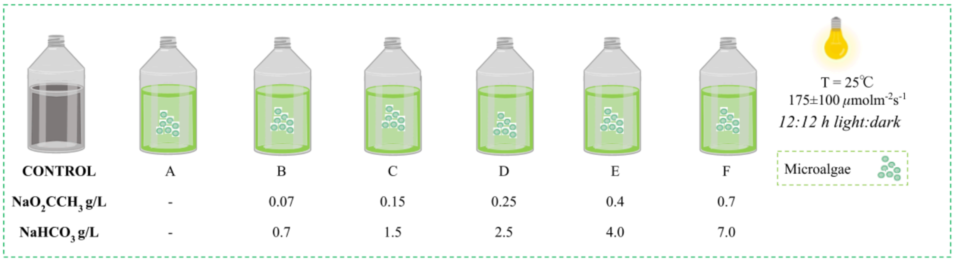

Figure 1: Schematic representation and operating conditions of the Lab-scale tests where different concentrations of NaO_2CCH_3 and $NaHCO_3$ were tested.

RESULTS AND CONCLUSIONS

The pH across the tested conditions ranged from 8.55 to 10.18, which is higher than values typically observed in crops where gaseous CO_2 is added (Ruas et al. 2018). Ammonium removal efficiency (NH_4^+-RE) was significantly lower only in the control condition, while all other conditions (A, B, C, D, E and F) exhibited statistically similar removals, ranging from 95 to 99% . Total phosphorus removal efficiency (TP-RE) ranged from 65.8 to 85.8%, with condition F showing the lowest removal and conditions B and C displaying the highest removals. These conditions showed statistically significant differences when compared to each other. Phosphate removal efficiency ($P\text{-}PO_4^{3-}$-RE) was lowest in condition A (approximately 75%), with significant differences observed only when compared to conditions C (≈ 88%) and D (≈ 89%).

For pathogen removal, the Kruskal-Wallis test (used due to non-normal data distribution) yielded p-values of 0.995 for *E. coli* and 0.91 for TC removals. These results indicate that the addition of alternative carbon sources did not significantly affect pathogen removal mechanisms in microalgae systems. The highest biomass productivity was observed in condition D (0.35 ± 0.20 g d^{-1}).

Under laboratory conditions, with controlled light, temperature and photoperiod, the addition of both organic (NaO_2CCH_3) and inorganic ($NaHCO_3$) carbon sources did not significantly impact the removal of the indicator organisms studied (*E. coli* and TC). However, the carbon sources did influence biomass production, with condition D (0.25 g L^{-1} NaO_2CCH_3 and 2.5 g L^{-1} $NaHCO_3$) showing the highest productivity.

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