POTENTIAL FOR GREEN ALGAE SPIRULINA TO CAPTURE CARBON DIOXIDE FROM GAS STREAM

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ABSTRACT

This study evaluated the use of green algae Spirulina microalgae as a CO2 capturing technology at different temperatures. The growth of Spirulina at 25 and 30◦C were studied in synthetic wastewater and its performance in removing nutrient were determined. Significant differences between the growth patterns of Spirulina were observed at different CO2 dosage rate and different operational temperature. Spirulina showed the highest growth at 30 C and with a CO2 injection dosage of 10%. Limited growth was observed for the systems injected with 5 and 15 % of CO2 with respect to blank solution. Ammonia and phosphorus removals for Spirulina were 69%, 75%, and 83%, and 20%, 45% and 75 % for the media injected with 0, 5 and 10% CO2. The results of this study show that simple and cost-effective microalgae-based wastewater treatment systems can be successfully employed at different temperatures as a successful CO2 capturing technology even with the small probability of inhibition at high temperatures.

Keywords: Microalgae, wastewater, treatment, carbon, nitrogen, phosphorus

1 INTRODUCTION

Scientific evidences show that the earth's climate is significantly affecting because of the continuous emissions of greenhouse gases (GHGs). The increase in CO2 level in the atmosphere leads to global warming as CO2 is one of the potential GHGs. The concentration of CO2 in atmosphere rose by 30% from pre-industrial levels of 280 ppmv to 390 ppmv today, and it is expected that the CO2 concentration of the atmosphere will increase up to 550 ppmv by the year 2050.

Physico-chemical process can be successfully employed to capture CO_2 from flue gas streams of fossil fuel based power plants (Pittman et al., 2011; Park et al., 2011; Abdel-Raouf et al., 2012). However, the efficiency and the high cost associated with these technologies limit their applicability. Micro-algae, on other hand, are among of the most productive biological systems for generating biomass and capturing carbon. Micro-algae's ability to transport bicarbonate into cells makes them well suited to capture carbon(Moheimani and Borowitzka, 2006). Moreover, microalgae is considered an inexpensive technology as it does not require aeration and the growth cycle for most algae strains range from 1 to 3 weeks. There are still knowledge gaps in understanding the use of microalgae for CO_2 capturing(Ratkowsky et al., 1983; Salvucci and Crafts-Brandner, 2004), including the capacity of CO_2 by different strains and the effect of pH, light intensity, water quality parameters and temperature on the performance of the process((Hamilton and Lewis 1990, Hamilton et al. 1997, Melo and Huszar 2000). The present study investigates the potential use of microalgae Spirulina as CO_2capturing technology under different solution pHs, temperatures, and CO_2 dosing. Algae growth was followed at different temperatures and CO_2 doses. Moreover, the potential of Spirulina in removing nutrient from synthetic wastewater was investigate

2 MATERIALS AND METHODS

2.1 Cultivation of microalgae

The microalgae strain Spirulina that was used in this study was purchased from UTEX The Culture Collection of Algae (Texas, USA). Algae growth experiments were carried out in 1.00 mL-Erlenmeyer flasks specific temperature. The growth experiments were performed using a temperature-controlled incubator equipped with a thermostat. The incubator consisted of an insulated chamber with dimensions of 60 cm (width), 50 cm (depth) and 70 cm (height). Three fluorescent daylight lamps, 1120 lux-each, were used as the light source.

For each batch experiment, a volume of 750 mL of synthetic growth media wastewater was mixed with algal culture and incubated at 30 and 25 °C. As a result of the low light intensity produced by the light sources, experiments were carried out under continuous lighting for a period of 21 days. CO2 was supplied on a daily baes for 10 min to the samples at different concentrations (0, 5 and 10v/v%). The flasks were stirred by the continuous aeration supplied to the flasks. To monitor algal growth, samples were taken from the flasks every day and optical density at 680 nm (OD680) was measured using a spectrophotometer.

2.2 Chemical analyses

Wastewater samples with microalgae were analyzed for ammonia (NH_4^+-N), TSS, TS, dissolved total phosphorus, dissolved oxygen, and pH on a daily basis to evaluate the treatment efficiency. Each test was performed in duplicate and reported as an average value.

NH_4^+-N was measured according to Standard Methods, Method 4500–NH3 B and C (APHA 1995) using a HACH spectrophotometer at 425 nm (DR2700 HACH, CO, USA). Total dissolved phosphorus was measured using HACH Molybdovanadate Method with Acid Persulfate Digestion (Method #10127). Dissolved oxygen (DO) was measured using Orion 5 star® (Thermo scientific®) portable dissolved oxygen meter.

3. RESULTS AND DISCUSSION

3.1 Microalgae growth

Figure 1 shows the growth of Spirulina at different CO2 dosing at 25 and 30°C, respectively. for both studied temperatures, it can be seen that Spirulina experienced a typical growth curves consisting of lag phase, extended exponential growth phase and stationary phase reached after 27 days of cultivation. The length of the lag phases was observed to change by changing the temperature. In addition, it can be seen in the figure that the OD of the mirco-algae strain is related to the amount of CO2 injected to the growth media. For experiments carried out at 25°C the maximum growth was observed for media injected with 0 and 10% of CO2. In other hand, experiment carried out at 30 °C showed the highest growth rate for the media injected by 10% CO2 followed by 5% and 0%, respectively. Moreover, experimental results show the effect of temperature on the growth rate of Spirulina with a general trend showing an increase in the growth rate by increasing the growth temperature.

Another set of experiment were carried out by CO2 dosing of 15% CO2 and showed limited growth with respect to blank solution

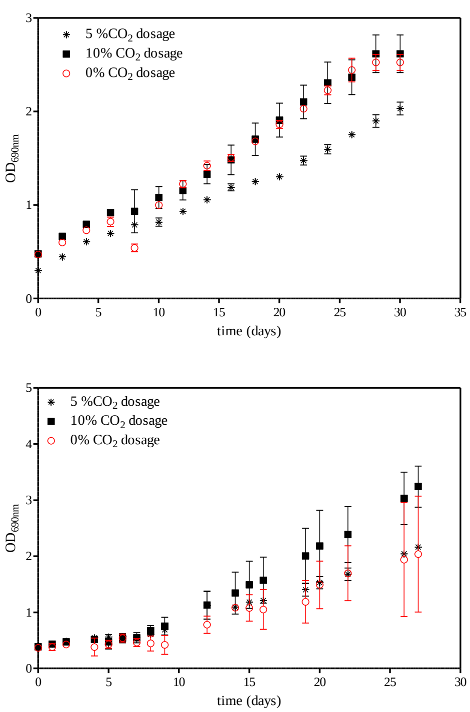

Figure 1: The change in optical density of Spirulina as a function of CO2 doing (a) temperature= 25°C and, (b) temperature= 30°C

The change in pH changes that occurred in the media during the cultivation of Spirulina are reported in Figure 2. The pH of the solution injected with 5 % CO2 showed a very small variation in comparison with experiments carried out with 10%. Blank solution slow showed a good variation in solution pH. The increases in the solution pH are expected due to the uptake of CO2 and H+ by microalgae during microalgae growth, however should be controlled if needed in order not to inhibit the microalgae growth. Higher pH values can also contribute to natural disinfection of wastewater as well as volatilisation of ammonia and precipitation of phosphorus . In this study, pH changes were in the expected range and the highest pH increase was 1.1 when the initial and final pH values of samples were compared. .

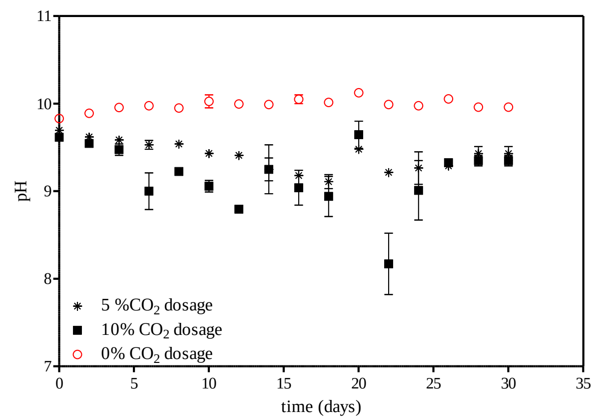

Figure 2: pH changes in wastewater samples during the 30 days cultivation of Spirulina at different CO2.

3.2 Removal of nutrient (ammonia & phosphorus)

Spirulina was effective in removing ammonia and phosphorus from the synthetic wastewater samples at both studied temperatures. the percent of ammonia removal for the medi injected with 0, 5 and 10% CO2 were 69%, 75%, and 83%, respectively. The lag phase for ammonia removal appeared to be shorter for media injected with 10% CO2 in comparison with other dosage. The removals of phosphorus for the same pervious media were found to be 20%, 45% and 75 % , respectively.

Conclusion:

ammonia and phosphorus from wastewater at 25 and 30°C. This simple and cost-effective microalgae-based wastewater treatment systems can be successfully employed in hot regions in spite of some potential inhibition to microalgae due to high temperatures. Spirulina showed a maximum growth for media injected with 10% of CO2 at both temperatures. More than 70% of ammonia and 75 % of Phosphorous was removed by Spirulina in the temperature range of 20-30°C. Growth rates of microalgae were different not only between the two temperatures but also for the same microalgae injected with different CO2, which indicates that the operational condition play an important role in determining the dominant algae species and this knowledge can be used to optimize the microalgae based treatment systems in hot regions.

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