Selection of Optimal Algae Species for CO_2 Capture and Water Purification

Introduction

This report aims to identify the most suitable *Chlorella* species for use in algae-based bioreactors by analyzing parameters such as CO_2 capture efficiency, biomass productivity, and environmental conditions like temperature and CO_2 concentration.

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Table 3. Comparison of the main results of the experiment.

Type of Algae	Biomass Productivity, mg/Ld	CO_2 Content, mg/Ld	Temperature, °C	The Capture CO_2, mg/Ld
Nannochloris sp.	350	15	25	658
Nannochloropsis sp.	300	15	25	564
Chlorella sp.	950	50	35	1790
Chlorella sp.	700	20	40	1316
Chlorella sp.	386	50	25	725
Chlorella sp.	1000	15	25	1880
Chlorella sp.	500	50	25	940
Chlorogleopsis sp.	40	5	50	20.45
Hot spring algae	266.7	15	50	501.3
Chlorocuccum littorale	44	50	22	82

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Table Relevance and Significance

A detailed study was carried out to compare different parameters for various *Chlorella* species. With different types of algae presents, the initial focus was on understanding the conditions under which these algae perform best. *Chlorella sp.* showed the highest biomass productivity of 1000 mg/Ld and CO_2 capture of 1880 mg/Ld when the CO_2 concentration was at 15 mg/Ld and the temperature was 25 degrees Celsius. When compared to other rows of this species (row 3), it is visible that with an increase in CO_2

content to 50 mg/Ld and a temperature increase to 35 degrees Celsius, there is a decrease in biomass productivity and CO_2 capture.

The data show that increasing both the temperature (from 25°C to 35°C) and the CO_2 concentration (from 15 mg/Ld to 50 mg/Ld) results in a decrease in biomass productivity and CO_2 capture by *Chlorella sp.* This suggests that *Chlorella sp.* thrives better under moderate temperature and lower CO_2 levels, and higher levels of either factor may inhibit its growth and carbon absorption capacity.

Lack of Specific Strain Information and Comparative Analysis

The data source from the research paper does not specify the exact species or strain of *Chlorella* used, referring to it only as *Chlorella* sp. There are three main strains of *Chlorella* sp. commonly used in photobioreactors that exhibit similarly high biomass yield and carbon capture capacity: *Chlorella vulgaris*, *Chlorella pyrenoidosa*, and *Chlorella sorokiniana*. However, regardless of the strain, *Chlorella* sp. shows optimal CO_2 absorption and high biomass yield at moderate temperatures and low CO_2 concentrations, making it a strong candidate.

Researching Water Treatment Properties of Chlorella Species

The genus Chlorella can show significant potential in treating various wastewater pollutants by using mechanisms like biosorption, bioaccumulation, biodegrading, and photooxidation.

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Microalgae species	Targeted pollutants	Mechanism	Wastewater source	Removal efficiency	Ref.
Chlorella vulgaris	TN, TP, COD	–	Aquaculture wastewater	100 %, 100 %, >96 %	[46]
Chlorella vulgaris	Ciprofloxacin	Biosorption	Real hospital wastewater	100 %	[50]
Chlorella vulgaris	Clomipramine, trihexyphenidyl, flecainide, orphenadrine, memantine, biperiden, bupropion, diphenhydramine, hydroxyzine	Biosorption, bioaccumulation, biodegradation	Synthetic wastewater	100 %, 100 %, 100 %, 100 %, 100 %, 93 %, 82 %, 98 %, 93 %	[36]
Chlorella vulgaris	Motor oil	Biodegradation	Synthetic wastewater	99.2 %	[54]
Chlorella vulgaris	Chlorpyrifos, cypermethrin pestecides	Biosorption and biodegradation	Synthetic wastewater	88.8 %, 93.1 %	[56]
Chlorella sp. *G-9*	TN, TP, TOC	Biodegradation	Wastewater treatment plant	99.61 %, 99.79 %, 93.1 %	[60]
Chlorella sp. *HL*	Zn, Mn	Biosorption and bioaccumulation	Swine wastewater	97.2 %, 42.7 %	[61]
Chlorella sp.	Tetracycline, chlortetracycline, doxycycline, oxytetracycline	Biosorption	Swine wastewater	100 %, 100 %, 91 %, 83 %	[63]
Chlorella sp.	Malachite Green dye	Biosorption	Non-domestic wastewater	91 %	[68]
Chlorella sp.	Propanil, acetamiprid pesticides	Biodegradation	Synthetic wastewater	99 %, 71 %	[69]
Chlorella sorokiniana Pa*.91*	NH_3, NO_3^-, PO_4^{3-}, COD	–	Municipal wastewater	91 %, 99 %, 97 %, 93 %	[73]
Chlorella sorokiniana	Cu, Pb	Biosorption	Industrial wastewater	> 90 %	[78]
Chlorella sorokiniana	Oseltamivir	Biosorption, biodegradation	Synthetic municipal wastewater	100 %	[76]
Chlorella sorokiniana	Hydroxytyrosol	Bioaccumulation	Real OMW	69 %	[81]
Chlorella sorokiniana	Crystal violet, methylene blue, eosin Y, rhodamine B dyes	Biosorption and biodegradation	Synthetic wastewater	97.04 %, 95.75 %, 94.90 %, 56.05 %	[79]
Chlorella pyrenoidosa FACHB-9	COD, TN, TP	Biosorption	Starch wastewater	92.1 %, 83.6 %, 96.6 %	[85]
Chlorella pyrenoidosa	Fe, Cu, Pb, Cd	Biosorption and bioaccumulation	Oilfield wastewater	76.74 %, 73.39 %, 72.86 %, 48.42 %	[88]
Chlorella pyrenoidosa	Tetracycline	Biosorption, bioaccumulation, biodegradation	Synthetic wastewater	99 %	[91]
Chlorella pyrenoidosa	TN, TP, TOC	Biosorption	Municipal wastewater	96.7 %, 98.0 %, 95.9 %	[87]
Chlorella pyrenoidosa	*Escherichia coli*, total bacterial count, *Enterobacteriaceae, Salmonella* sp.	Photooxidation	High-strength synthetic municipal wastewater and real sewage wastewater	99.9 %, 92 %, 98 %, 96 %	[93]

Abuhasheesh, Y., Ghazal, A., Tang, D. Y. Y., Banat, F., Hasan, S. W., & Show, P. L. (2025). Advances in chlorella microalgae for sustainable wastewater treatment and bioproduction. *Chemical Engineering Journal Advances*, 100715. https://doi.org/10.1016/j.ceja.2025.100715

Specifically, *Chlorella vulgaris* has demonstrated nearly 100% removal efficiency of key nutrients—including total nitrogen (TN), total phosphorus (TP), and chemical oxygen demand (COD)—in various wastewater types, such as aquatic wastewater, synthetic water, and hospital wastewater containing antibiotics and pesticides.

Moreover, Chlorella Pyrenoidosa helps in removing dyes, organic compounds, and certain bacterial pathogens. The chlorella sorokiniana removes heavy metals like copper and lead in industrial wastewater by performing biosorption (>90%).

These species' versatility across wastewater types – from municipal to industrial – suggests their suitability in bioreactors to help in wastewater treatments.

Approach to Algae Selection

Based on a review of literature, I examined 3 Chlorella species – C.vulgaris, C.sorokiniana, and C.pyrenoidosa - focusing on key parameters relevant to my bioreactor conditions. C.vulgaris showed optimal growth at temperatures around 20-30 degrees Celsius, matching well with the experimental temperature of 25 degrees celcius. The biomass productivity reached up to 1.0g/L/day under low C02 levels, with carbon capture efficiency being up to 90%. In contrast, C.sorokiniana, prefers slightly higher temperatures of 30 to 35 degrees Celsius with a similar biomass productivity but thrives better under higher C02 levels. *C. pyrenoidosa* has a broader temperature tolerance but generally shows lower biomass productivity at 25°C. Given these data, it is reasonable to conclude that *Chlorella vulgaris* was most likely used in the study, as its growth parameters align closely with the reported experimental setup.