Reference to Visual Data for Day 3-4 Research Findings

Introduction

This section presents key graphical data extracted from recent studies on microalgae photobioreactors, with a focus on *Chlorella vulgaris* cultivation. The selected visuals illustrate important factors affecting biomass productivity, such as reactor design parameters and species-specific growth performance. These graphs provide a comparative understanding of how variations in bioreactor scale and microalgae species influence cultivation efficiency, supporting the analysis and design considerations discussed in the research summaries.

Study 1

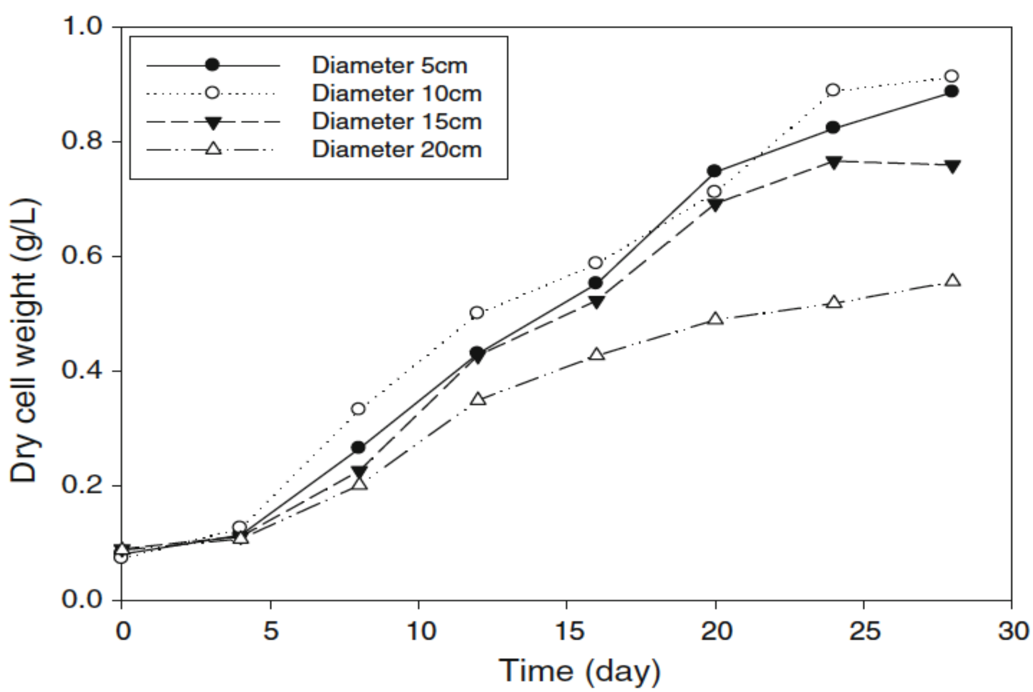


Fig. 4 Effect of column diameter on biomass productivity

What are the trends visible on the graph?

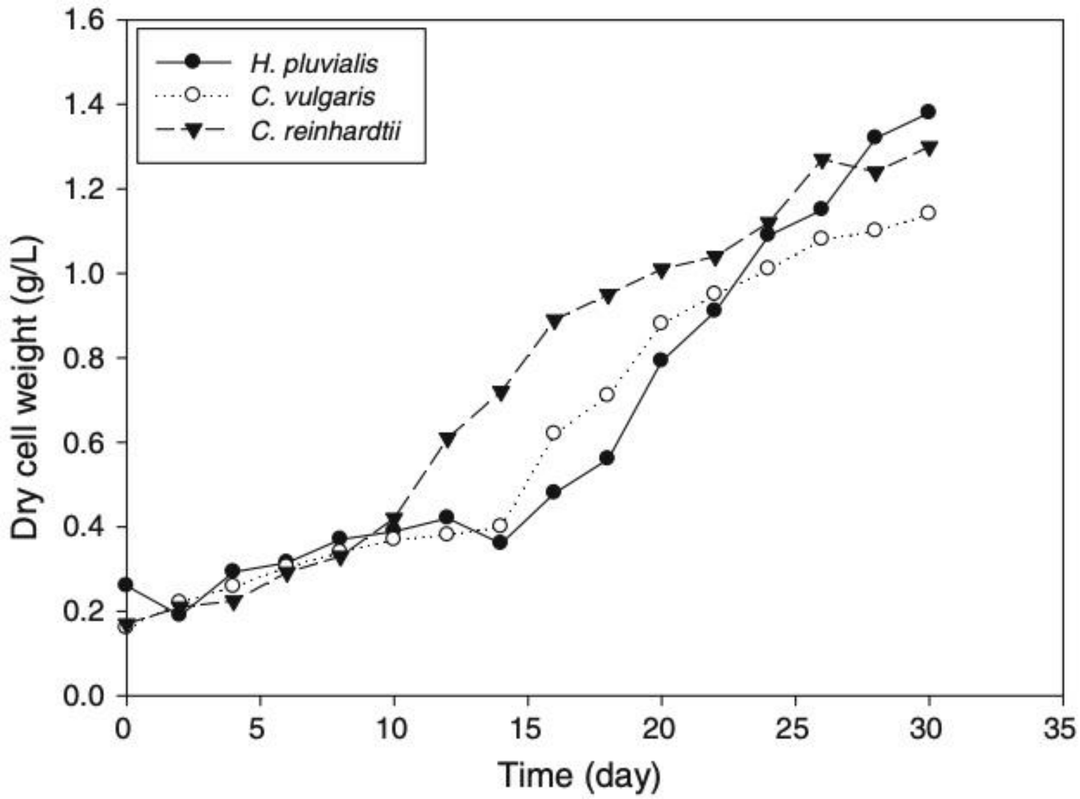
- The lower the column diameter, the higher the dry cell weight is produced.
- On day 0, all columns started with a dry cell weight of 0.1 g/L.
- From day 0 to day 4, all columns showed a similar increase to 0.14 g/L.
- After day 4, a steep increase in dry cell weight was observed.
- The 10 cm diameter column reached 0.9 g/L on day 24 and plateaued until day 27.
- The 5 cm diameter column reached 0.87 g/L by day 27.
- The 20 cm diameter column reached only 0.5 g/L by day 27, performing the worst among the four.

Explaining why this is important.

- A photo-bioreactor with a 10 cm diameter achieved the highest biomass yield.
- The 5 cm diameter reactor produced 97% of the 10 cm yield, showing only a slight reduction.
- Larger diameters (15 cm and 20 cm) led to significantly lower yields:
- 15 cm: 83% of 10 cm yield
- 20 cm: 61% of 10 cm yield
- This demonstrates that light path length (diameter) critically affects light transfer efficiency and thus biomass productivity.
- The results also emphasize the importance of the height-to-diameter (H/D) ratio:
- An H/D ratio of 6:1 offers better mixing performance than 3:1 or 9:1, leading to better growth conditions.

Conclusion

- Column diameter significantly influences biomass productivity in photobioreactors.
- An optimal diameter of 10cm ensures sufficient light penetration and mixing, leading to the highest biomass yield
- Larger diameters of 15-20cm reduce light efficiency and mixing resulting in a lower biomass yield.
- Therefore, light path and reactor geometry, specifically the height-to-diameter ratio are critical design parameters that must be considered for designing photobioreactors.



What trends are visible?

- Chlorella vulgaris growth starts steadily at ~0.2 g/L and rises sharply after day 14.
- By day 30, C. vulgaris reaches about 1.1 g/L dry cell weight.
- Haematococcus pluvialis shows the highest biomass, reaching 1.4 g/L by day 30.
- Chlamydomonas reinhardtii grows consistently, achieving ~1.25 g/L by day 30.

Explaining why this is important

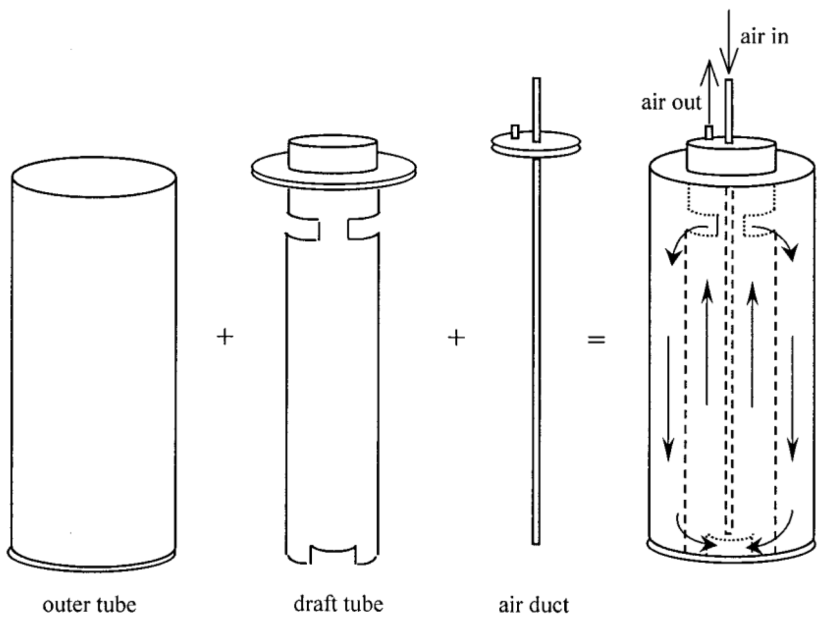
- Demonstrates that the vertical tubular photobioreactor supports robust growth of multiple microalgae species.
- Confirms C. vulgaris can be effectively cultivated despite slightly lower biomass compared to others.
- Supports the bioreactor's versatility for commercial and research applications involving different algae.
- Highlights potential for optimizing cultivation conditions tailored to each species.

Conclusion

- The vertical tubular photobioreactor successfully cultivates Chlorella vulgaris with comparable biomass productivity to other microalgae species.
- Despite a slightly lower yield, C. vulgaris remains a viable candidate for large-scale biomass production in this system.
- This demonstrates the bioreactor's flexibility for cultivating various microalgae, supporting its application in diverse algal biotechnology projects.

Study 2:

This picture shows the photobioreactor setup



Dimensions and Volume

- The reactor features an illuminated surface area of 1.337 m^2.
- The draft tube was positioned inside the outer tube of the reactor.
- Both the top and bottom of the riser (draft tube) had four openings each, with a total area of 0.017 m^2 per set, allowing liquid to circulate between the riser and downcomer sections.
- The working volume of the reactor setup was 100 liters.
- The outer tube had an internal diameter of 0.30 meters and a height of 1.50 meters.
- The draft tube (riser) had an internal diameter of 0.19 meters and a height of 1.55 meters.

- The airduct supplying gas had an internal diameter of 0.016 meters.

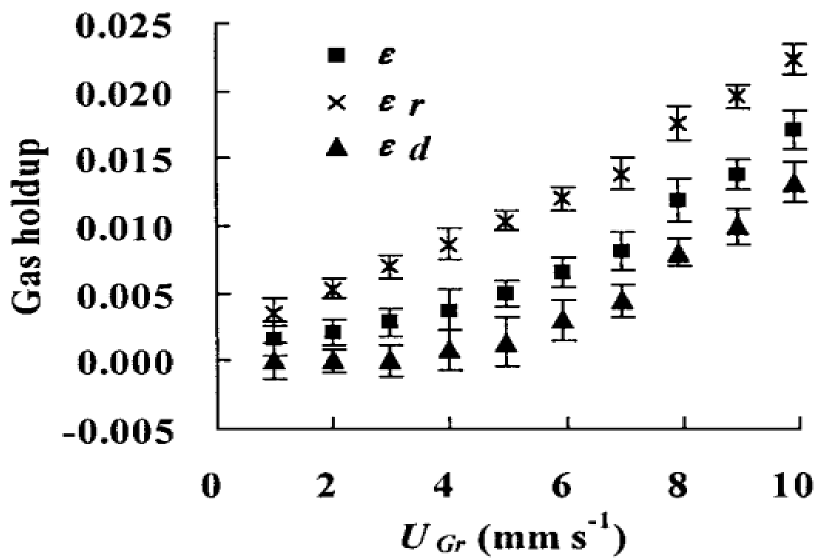


Fig. 2. Overall gas holdup (ε), the separate gas holdup in the riser (ε_r) and downcomer (ε_d) of the airlift reactor as functions of superficial gas velocity in the riser (U_{Gr}). Vertical bars represent standard deviation.

What trends are visible?

- As the superficial gas velocity in the riser increases, the gas holdup also increases.
- This is especially seen in the riser (the lifting part of the system)
- The riser holds more gas than the downcomer

Explaining why this is important

- When there is more gas, there is more carbon dioxide available for algae
- Better gas distribution that increases carbon capture
- Understanding this helps create smarter bioreactors that optimize gas delivery for algal growth and carbon capture

How this could help my project

- Guides airflow settings in the digital model
- Helps in designing riser and downcomer with proper dimensions

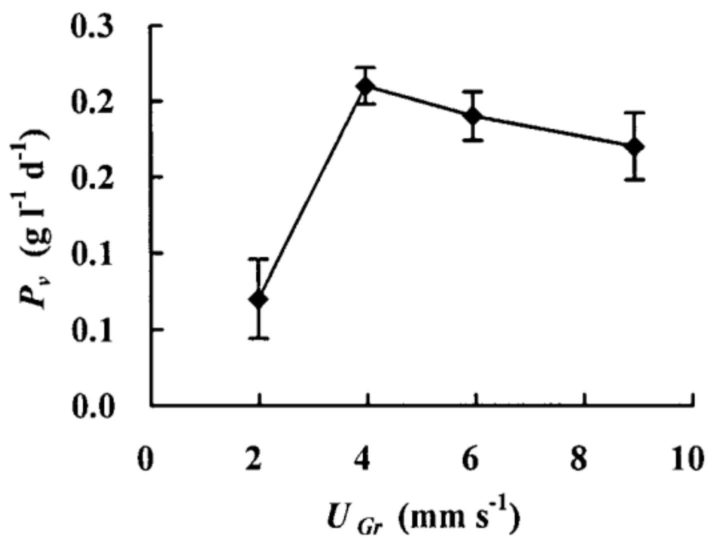


Fig. 5. Biomass volumetric output rate (P_v) of *Chlorella* sp. as functions of superficial gas velocity in the riser (U_{Gr}). Vertical bars represent standard deviation.

What trends are visible?

- Biomass output increases up to a point of 4mm/s
- After that point it ends up dropping even after gas flow keeps increasing

Explaining why this is important

- When too little gas is present, there is not enough carbon dioxide resulting in slow growth of the algae
- Too much gas causes too much stress or poor light distribution to the algae that can also be bad
- This means an optimal zone is required for the algae to efficiently grow

How this could help my project

- Helps set a target gas velocity in the bioreactor design
- Supports a design that balances growth, efficiency and sustainability