Carbon source impacts algal growth and shapes microbiomes in outdoor ponds

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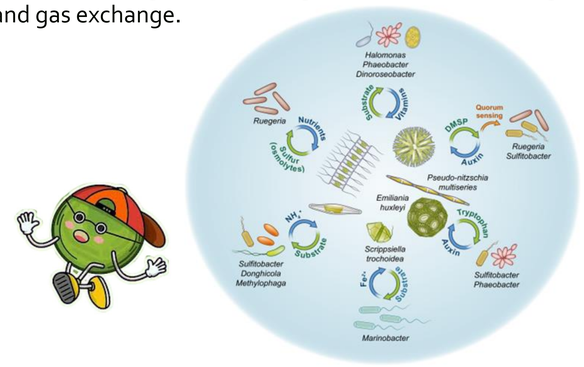
Introduction

Marine microalgae are essential to the functioning and health of aquatic ecosystems as keystone species and providers of an estimated 50% of atmospheric oxygen among other ecosystem services. Recent interest in large scale microalgae cultivation is driven by their strong potential for carbon capture as well as commercial applications such as biofuels, pharmaceuticals, foods, cosmetics, and even plastics. Large scale algae cultivation is often done in large, open raceway ponds, and efforts to optimize this process have led to developments in the growth media composition, bioreactor design, strain of algae and conditions of light and gas exchange.



However, these microalgae do not grow in isolation, instead hosting a constantly changing and understudied microbiome. It is known that this can have impacts ranging from nutrient uptake facilitation to competitive or pathogenic effects. The aim of our project is to investigate the effects of different carbon sources on algae cultivation and the resulting microbiome changes on microalgae growth rates, photosynthetic health, and more.

Results

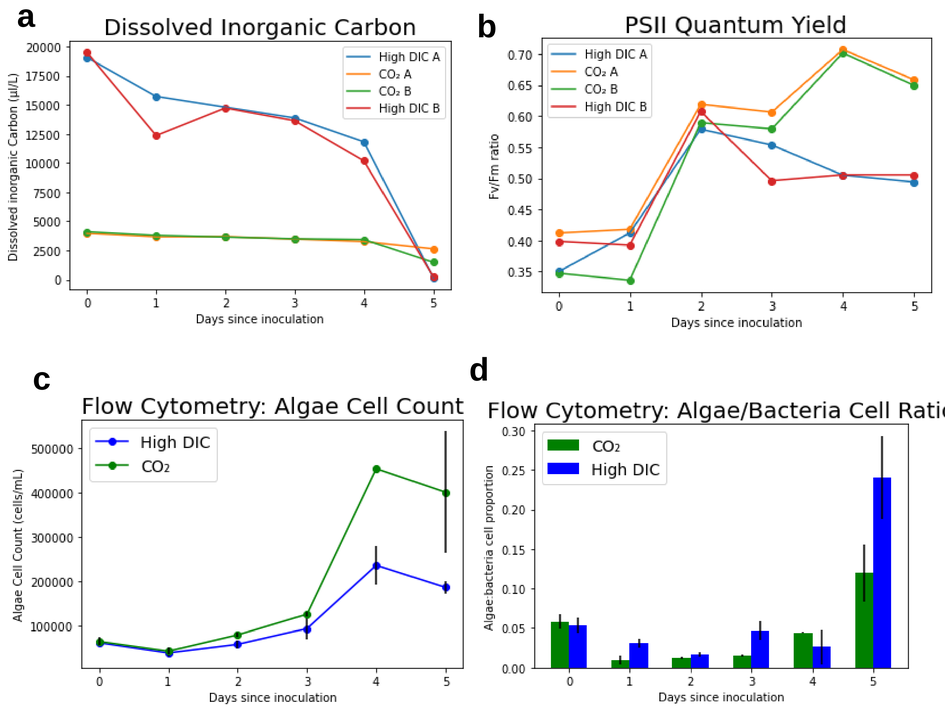
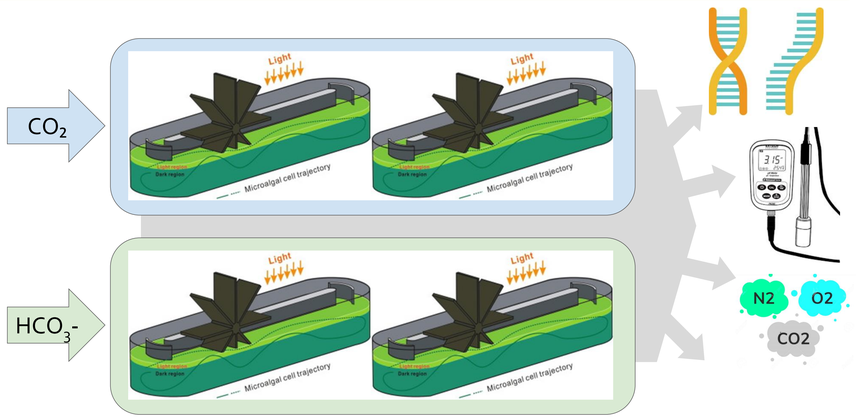


Figure 1.

- **a**: Dissolved inorganic carbon (HCO_3 + CO_3 + CO_2) levels over time. The water with bicarbonate had higher initial DIC, but dropped to control levels by the end of the experiment
- **b**: Photosynthetic health indicated by active fluorescence
- **c**: Flow cytometry data from each pond and averaged to the plots above shows algae count grew till D_4, then decreased on D_5.
- **d**: Algae/Bacteria ratio follows the same trend; however, bicarbonate ponds mostly had higher ratios

Methods

- Four 1000 L outdoor raceway ponds were set up to grow *Nannochloropsis* sp. Co18
- Two ponds were only bubbled with CO_2 (control) and two ponds (treatments) were supplied with water and a higher concentration of dissolved inorganic carbon in the form of a bicarbonate (HCO_3-)
- Measures of algae growth (turbidity, optical density etc.), photosynthesis (chlorophyll), biomass composition (FTIR), pond conditions (temperature, pH) and more were collected over the six days growth cycle
- Daily DNA and RNA samples were taken from each pond for downstream taxonomic and functional analysis of the host-microbiome interactions



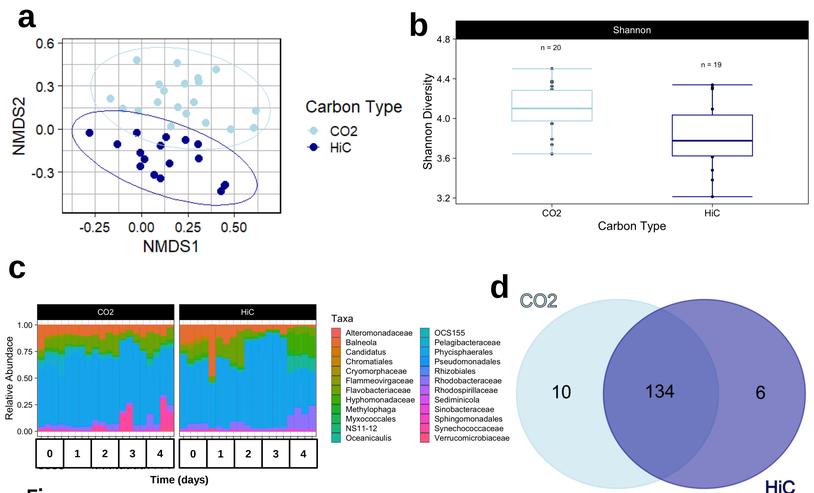


Figure 2.

- **a**: NMDS ordination based on Bray Curtis dissimilarity revealed effects of carbon source on microbial community structure
- **b**: Shannon Diversity was similar for CO_2 and HiC ponds.
- **c**: Synechococcaceae experiences a period of increase in CO_2 ponds from D_3 onwards, which could be associated with findings in Figure 1c and 1d.
- **d**:Majority of taxa were found in both conditions

Conclusions

Based on algae pond measurements so far:

I. Microalgae grown with only bubbled CO_2 had higher growth rates and photosynthetic rates from day 3 onwards.
II. Concentrations of algae and bacteria varied by time and carbon source condition, with bacteria dropping steeply on the last day.
III. DIC type affects species distribution, including changes across time, and can even influence microbiome structure.

Ongoing work/Future Diections: continue metatranscriptomic analyses of the algae-microbiome interaction to predict functional features of each taxa of bacteria. We will also consider how this changes under pond conditions by analyzing differentially expressed genes. The work will help to inform the long term goal of optimzing algae growth by engineering microbiomes to enhance the commercialization of sustainable algae products.

Acknowledgements

This work was supported in part by U.S. Department of Energy grant numbers DE-EE0007091, DE-EE0008518 and DE-EE0009278 and U.S. Department of Agriculture (through Cornell University) grant number 2019-69012-29905 to ZIJ. This project was also funded by theDuke Bass Connections program. AEG was supported by a U.S./Mexico Fulbright award.

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