Mitigating Carbon pollution using a Thermophilic Cyanobacteria, *Thermosynechococcus elongatus*

Rebecca Miller, Jed Eberly, and Roger Ely,
Department of Biological and Ecological Engineering Oregon State University, Corvallis, OR

Oregon State University
College of Engineering

Introduction

- Energy demands are increasing and with them comes a rise in CO_2 emissions.
- Sequestration of the CO_2 in flue gas by cyanobacteria is a novel approach to both reducing these emissions and creating renewable forms of energy from cell biomass.
- Through photosynthesis, unwanted carbon pollutants are stored biomass and can then be utilized as biofuels, fertilizers, animal feeds, pharmaceuticals, health food products, or compost.
- *Thermosynechococcus elongatus* is a thermophilic cyanobacteria found naturally in hot springs.
- Using a thermofile cyanobacteria helps prevents contamination and saves energy by not having to cool hot waste water streams to temperatures suitable for most cyanobacteria.
- *T. elongatus* is also able to remove some of the nitrogen, phosphorus, and other metal ions present in waste water streams.
- Growth rates and stored levels of glycogen, lipids, and polyhydroxybutyrates (PHB's) were found to better understand how T. *elongatus* responds to varying levels of CO_2 availability.

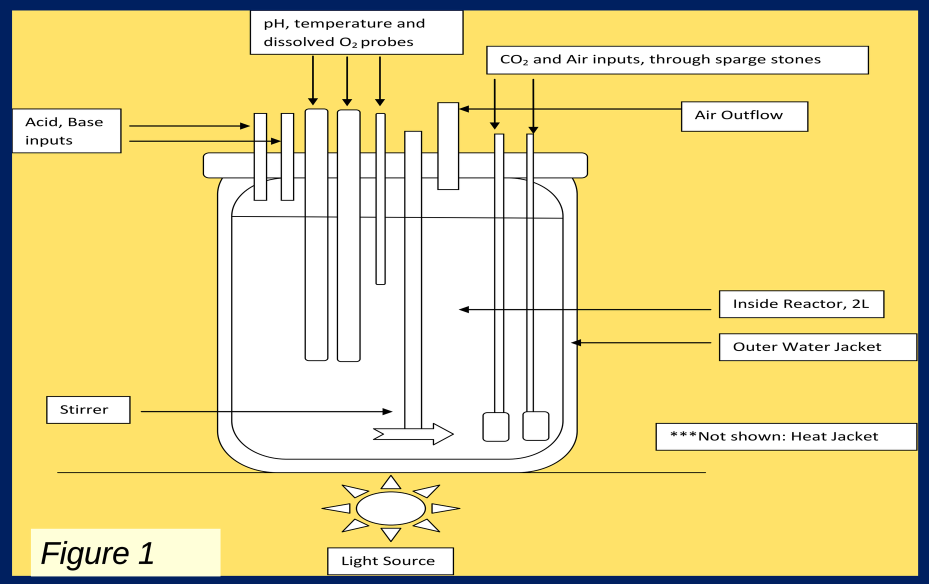

Figure 1

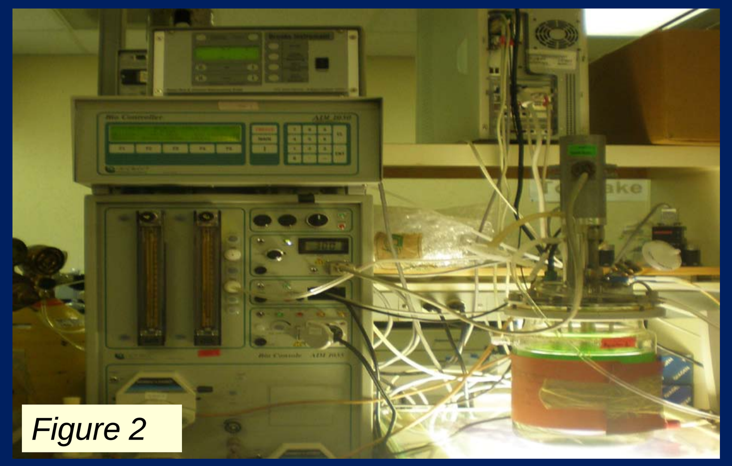

Figure 2

Figure 1 Bioreactor schematic. Figure 2 Bioreactor during experimental run.

Methods

- Reactor levels at 0%, 10%, and 20% CO_2 were run in triplicate.
- Cells were grown in two identical 3 Liter reactors using standard BG-11 media for 9 days
- CO_2 and compressed air were fed into the reactor using separate rotameters and were bubbled into the reactor media through sparge stones. The amount of air that entered the reactor was varied to reach a desired percent CO_2 in the reactor.
- Cell density, percent of CO_2 in the headspace, cell dry weight, and pH were monitored and recorded daily.
- pH was maintained at 7.8 throughout the experiment.
- At the end of a run, the dry weight of 50ml of cells and chlorophyll content (measured at OD_{665}) were determined.
- After collecting the cells PHB levels were analyzed using a method by Law and Slepecky, 1960. Lipid levels were analyzed using a method by KGR, 2008. Glycogen levels were analyzed using a Sigma Glucose Assay Kit (GAGO-20, Sigma Aldrich, St. Louis, MO).

Growth On Elevated Levels of CO_2

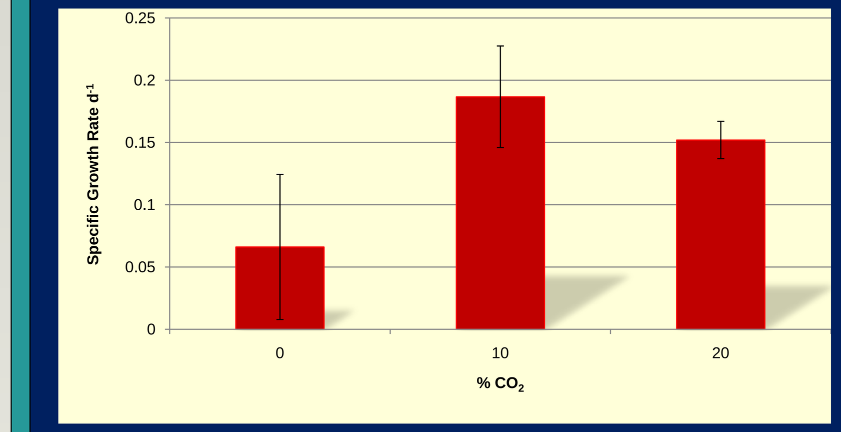

Figure 3: Specific growth rate, during exponential growth

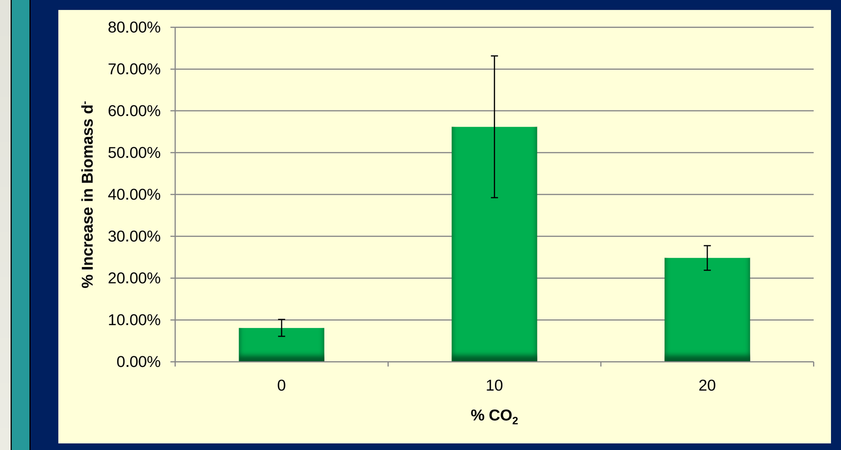

Figure 4: Average rate of increase in biomass per day as a percent increase

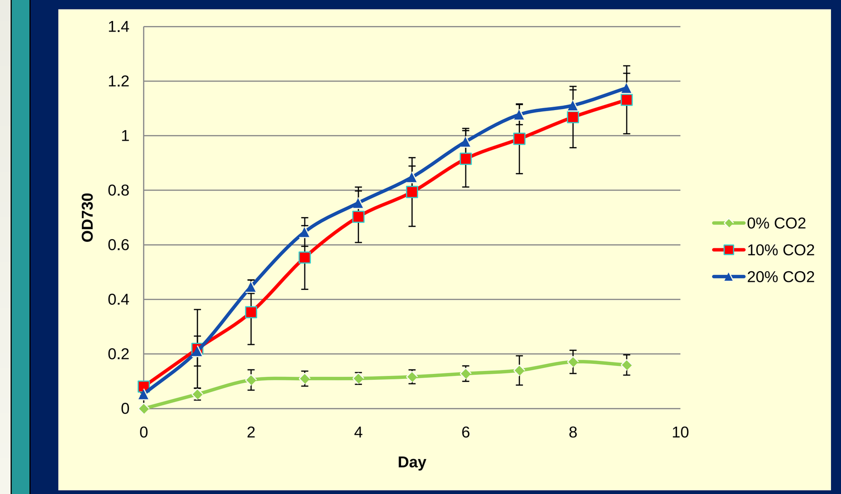

Figure 5: Growth of cells as measured by cell density (OD730)

Results and Discussion

Growth was positively affected by the additional carbon made available at 10% and 20% CO_2. Cells gained more biomass and reached higher cellular densities in these treatments (figure 3). The highest cell and biomass growth rates occurred at 10% (figures 4,5).

Lipid levels remained consistent across all three treatments, and were at the lower average end of what is seen in other cyanobacteria [1]. PHB levels were much higher at 0% than with the addition of CO_2 , likely a stress response due to lack of available carbon need for growth causing cells to enter a stationary phase increasing PHB's [2]. Glycogen levels were consistent across all treatments. (Figure 7)

In an industrial setting the amount of CO_2 available to cells during cultivation could determine what byproducts are most suitable for being manufactured from cell biomass. (Table 1)

Potential Cyanobacteria Products Table 1 [3]

Compounds	Products
PHB's	Plastics
Lipids	Biofuels
Glycogen and Biomass	Fertilizers, Animal Feed, Compost, Health Foods
Hydrogen	Hydrogen Fuel Cells
Other products: β-carotene, vitamin B, carotenoids, polyunsaturated fatty acids	Vitamins, Pharmaceuticals, Dyes, Health Foods

Cyanobacteria provide a useful biological tool, that if successfully utilized could significantly reduce green house gas emission, while producing carbon neutral fuels and other marketable products.

Carbon Storage

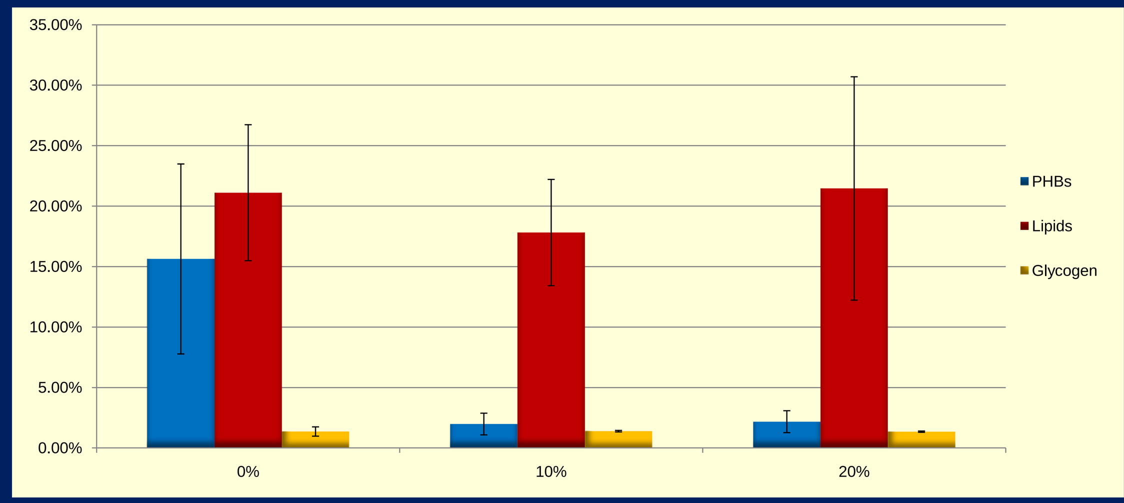

Figure 7: Lipids, PHB, and Glycogen contents in cells, measured as a percent of dry weight.

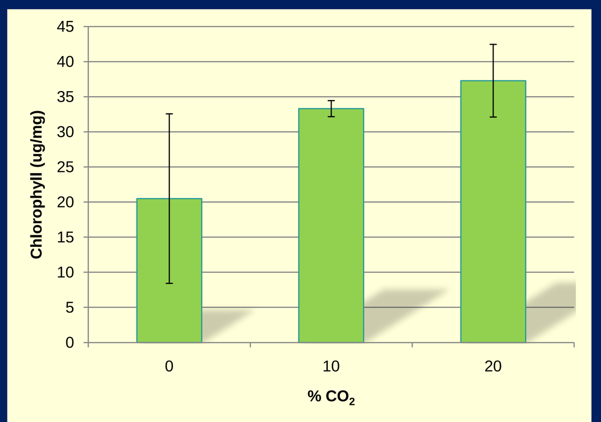

Figure 8: Chlorophyll content in cells measured in ug/ml.

Future Work

- How quantities of other marketable compounds vary with CO_2 levels
- Building full scale bioreactor set-ups, using flue gas as a CO_2 source
- Cleaning waste water using cyanobacteria

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References

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