# Well-Oiled Green Cleaning Machines: Harnessing the synergy of algal biofuel production and brewery wastewater remediation

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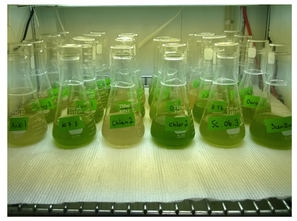
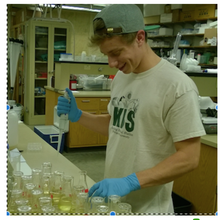
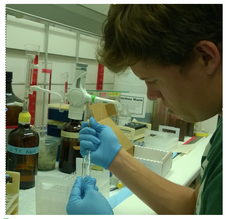


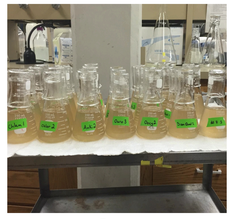
**Introduction**: As fossil fuels diminish at an alarming rate it is imperative that we find an alternative source of energy. Biofuel derived from algae is a promising renewable energy source with extremely high energy yields, fast generation times, small land requirements and potential carbon neutral footprint. But a main hindrance to its commercial realization is algal crops high nutrient demands. Coupling mass algal cultivation with a high nutrient waste stream could offer an ideal synergy supplying high, inexpensive nutrients to the crop while the algae remediate the wastewater through nutrient uptake (phycoremediation). Green algal species were cultured in wastewater from Bell's brewery (Galesburg, MI) and we characterized their growth, physiology, overall lipid productivity, and their ability remediate the effluent in terms of total nitrogen removal.

## Total N and P From Bell's MCR6 Tank

| | Average +/- Std. Error | Range |
|---|---|---|
| Total N | 247.79 +/-28.45 mg/L | 56.4-842 mg/L |
| Total P | 148.73 +/-7.89 mg/L | 45.7-306 mg/L |







## How much total nitrogen can be removed from brewery wastewater with green algae and which species display the best overall lipid productivity?

## Experimental Design

- 6 Species of Green Algae
- Cultured as monocultures and an collective polyculture in 80:20 BWW:$H_2O$ at 29°C
- Light Level: Constant 200 µE $m^{-2}$ $s^{-1}$
- Sampling for Total N, P, Lipids, and Growth Rates Every 4$^{th}$ Day
- Duration: 12 Days

## Most Successful Treatment?

By comparing the total nitrogen and phosphorus removal rates of each monoculture and the collective polyculture we can establish:

- The most effective candidate(s) for treatment
- The superior lipid yielding culture
- Whether diversity from the polyculture was beneficial for nutrient removal rates and overall productivity

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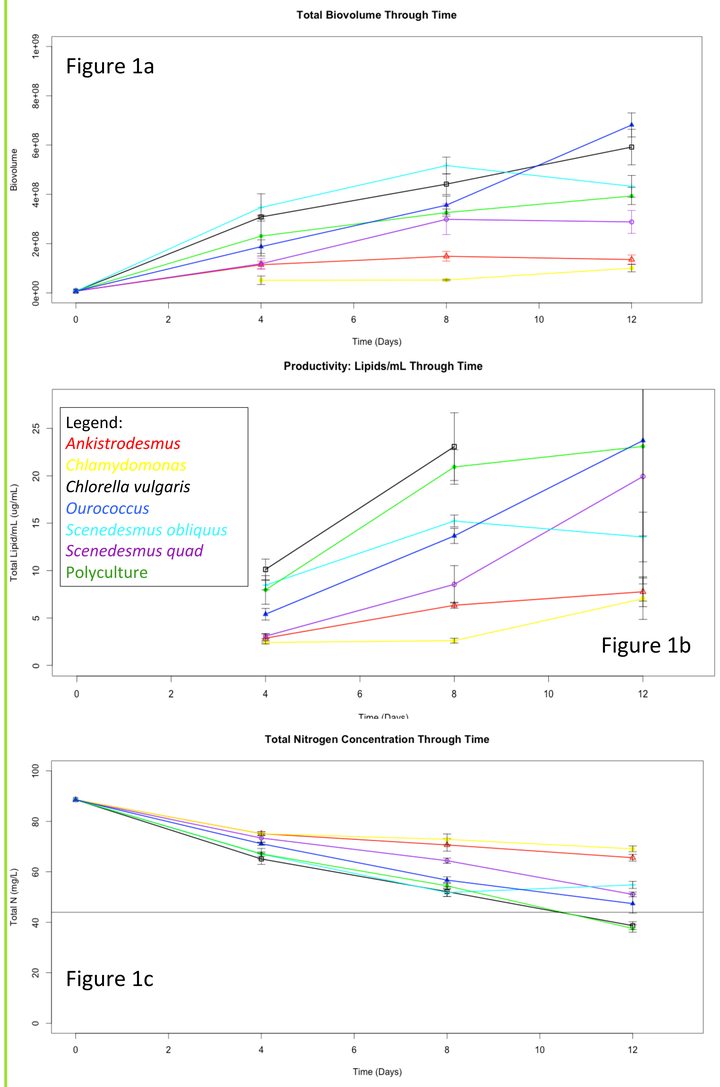
# Results

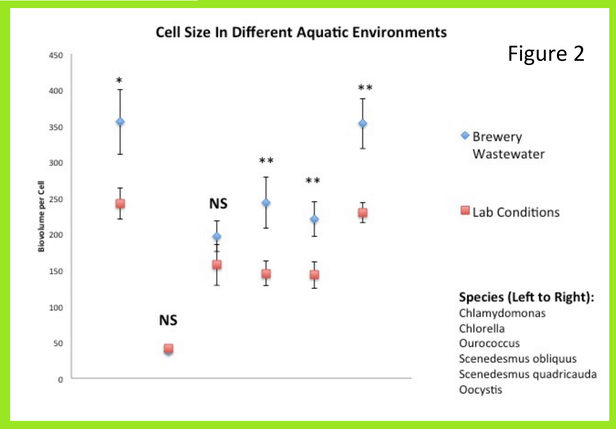



- Observed total biovolume at day 12 was highest for the polyculture, *Ourococcus*, and *Chlorella.*
- *Ankistrodesmus* and *Chlamydomonas* achieved the least amount of biomass (Figure 1a).
- Poor performing cultures were dominated by microbial activity, while successful cultures overcame bacteria.

- The polyculture and *Chlorella* were significantly superior in lipid productivity through day 8 of the experiment (Day 12 to be analyzed).
- *Chlamydomonas* and *Ankistrodesmus* displayed the lowest values for overall lipid productivity (Figure 1b).

- The polyculture, *Chlorella*, and *Ourococcus* removed the most amount of total N by day 12.
- *Chlamydomonas* and *Ankistrodesmus* removed the least amount of total N by day 12 of the experiment.
- Cultures exhibited nitrate levels lower than the EPA regulated value (44.3 mg/L) when treated by the polyculture and *Chlorella* (Figure 1c).

- Brewery wastewater is a harsh environment for phytoplankton to inhabit. Figure 2 shows the change in cell size in response to being cultivated in BWW compared to nutrient rich W/C medium used for lab cultivation.
- 7 of the 9 species significantly increased in cell biovolume when cultured in BWW.
- *Ankistrodesmus* sp. (not pictured due scaling) exhibited the strongest response ($p<.00001$), at times forming swollen nodules ("baby bumps").




# Conclusions

- ✓ Some green microalgae significantly reduce Total N levels in 12 days, within EPA dischargeable levels
- ✓ High growth, total lipid production and total nitrogen removal rates were correlated
- ✓ In response to a harsh aquatic environment, most algal species significantly increased biovolumes
- ✓ 21 algal species (10 Greens, 5 Diatoms, 5 Cyanobacteria, 1 Chrysophyte) were screened to measure growth, lipid production and nutrient removal rates, only 7 species showed positive growth
- ✓ High nutrient wastewater can be used as fertilizer to cultivate microalgae for bioproducts (biofuel, fertilizer, food, pharmaceuticals) and this work needs to continue.