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Exploring Algae Dewatering Techniques for Biofuel Production

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Introduction

Over the last two centuries, human activities have changed the atmosphere in a noticeable way. The amount of greenhouse gases has increased, mostly due to the release of large amounts of carbon dioxide (CO_2) as a result of the burning of fossil fuels. The level of CO_2 measured at the Mauna Los observatory in Hawaii has significantly increased in the past 10 years from 393.48 ppm to 420 ppm in April 2021. Additionally, in 2019, the amount of energy used resulted in the release of 5,130 million metric tons CO_2. These numbers keep increasing, and the damages are apparent. To minimize the effects of global warming, carbon neutral sources of energy are needed. Biofuels are energy options produced from renewable sources such as corn, sugar cane, sunflowers, root crop like cassava, palm, beets, and Jatropha. However, using plants that are commonly consumed as fuel has also impacted the prices of products produced from those plants.[1] The solution to these issues is utilizing sources of energy that produce more oil and are not major food sources. An alternative biofuel source is algae. Their ability to grow in locations unsuitable for crops, absorption of carbon dioxide for growth, as well as their coupling to wastewater treatment are some of the many benefits to algal biofuels. There are thousands of species of algae on earth, some of which are the fastest growing plants. Algae can produce 5000 gal/acre-per year, which is significantly higher than most other biofuel sources [2]. Utilizing fast growing species of algae will benefit the environment. Algae growth absorbs CO_2 and produces oxygen, which makes algae a carbon neutral source of energy. To make algal biofuels, first algae must be grown. Once the crop grows large enough, it is harvested and then dewatered. Then if making biodiesel, oils are extracted, or the algae is fermented to produce bioethanol. The complicated step is dewatering, as it requires a lot of energy and resources, and it is not cost efficient. We investigated the dewatering of algae utilizing manual filtration, vacuum filtration, flotation and tray drying.

Methodology

- The manual gravity filtration was performed by filtering the algae though a 20 μm-pore size mesh fabric.
- The agitated gravity filtration was performed by collecting algae on filter paper that was then dried in a tray dryer.
- The vacuum filtration was performed by filtering the algae through either a filter paper or mesh fabric. One run was followed by drying in the tray dryer.
- A fine bubble flotation was performed by diffusing bubbles that brought the algae to the surface. After collecting algae off the surface bubbles, it was dried in a tray dryer.

Figure 1. Vacuum filtration system for drying algae.

Results

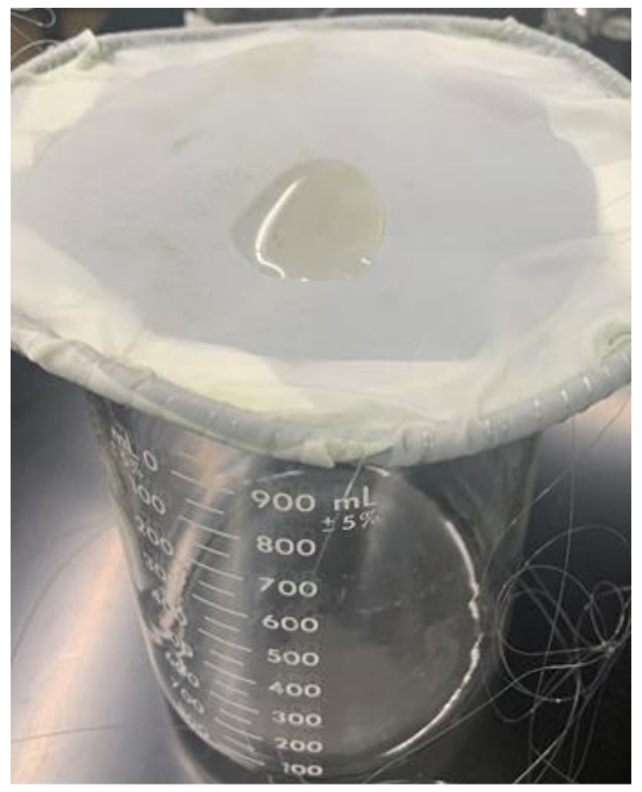

Figure 2. Run 1: Algae gravity filtered through a 20μm mesh fabric.

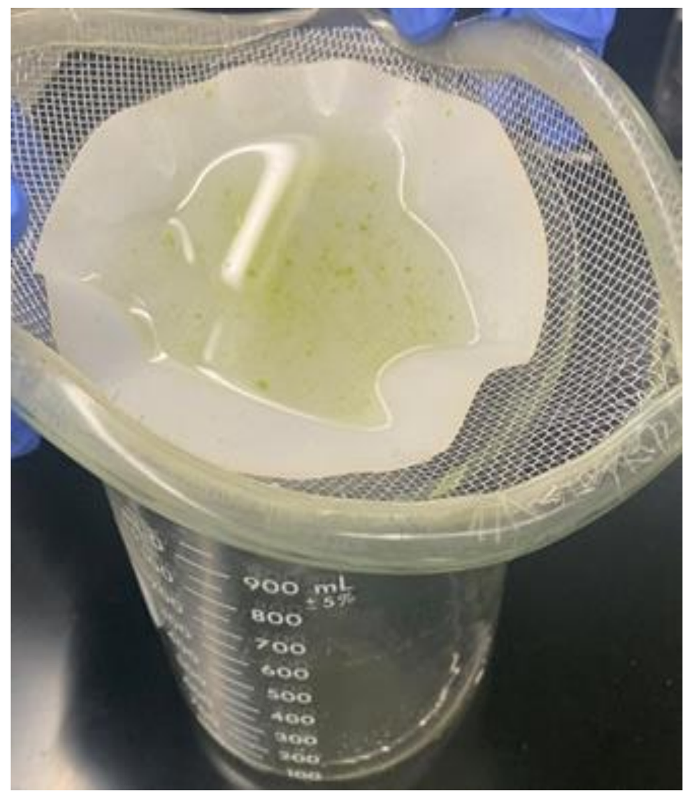

Figure 3. Run 2: Algae being agitated by hand and filtered through filter paper.

Figure 4. Run 2: Algae after gravity filtration dried using a tray dryer on filter paper.

Figure 5. Run 3: Algae dried on filter paper using vacuum filtration.

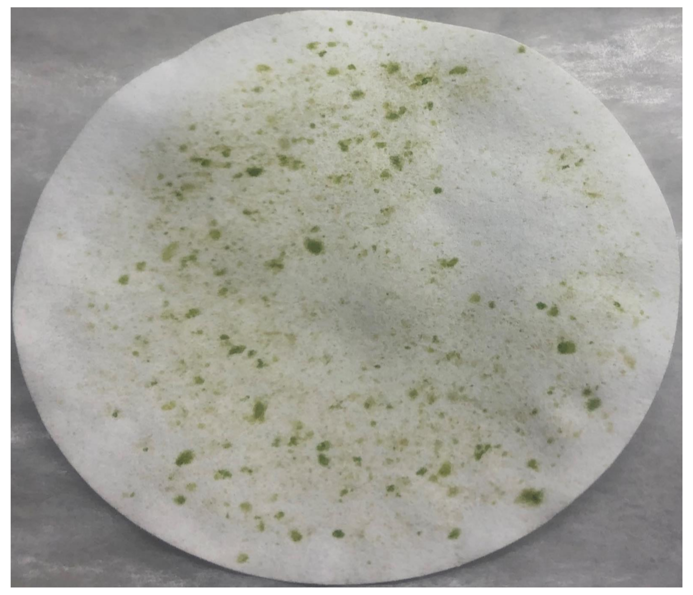

Figure 6. Run 4: Vacuum filtrated algae dried in a tray dryer.

Figure 7. Run 5: Algae dried on a mesh fabric using vacuum filtration.

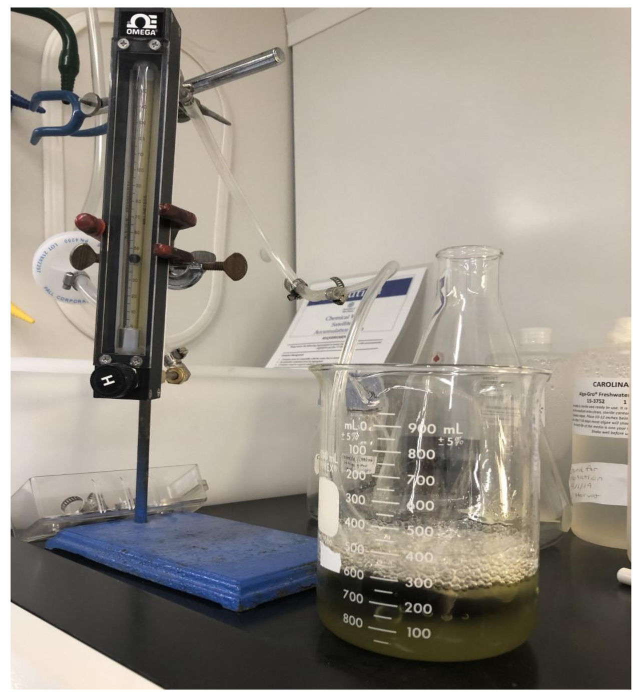

Figure 8. Run 6: Air being bubbled into an algae solution using fine bubble diffuser.

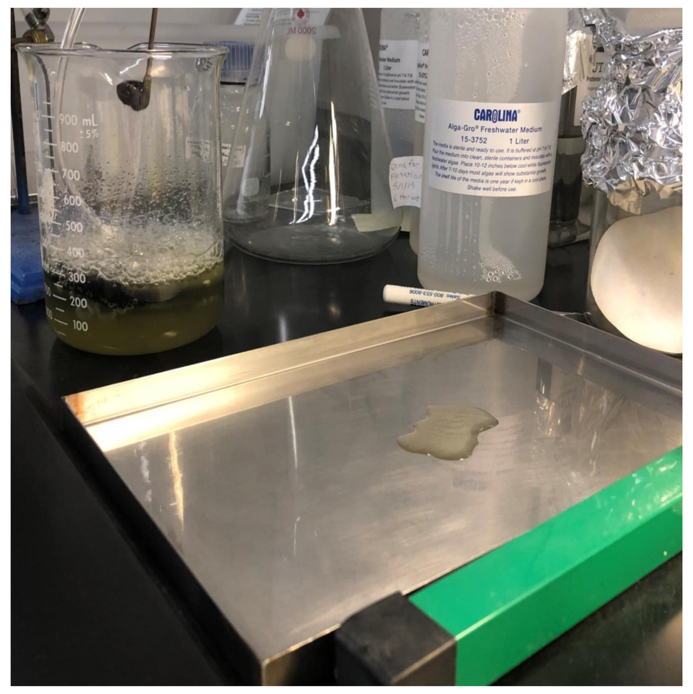

Figure 9. Run 6: Algae from bubble flotation being placed on a drying tray.

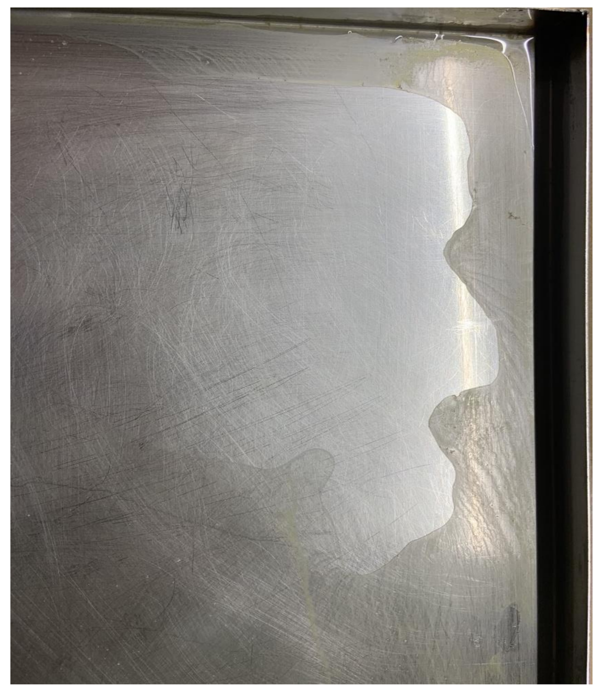

Figure 10. Run 6: Partially dried algae after three hours in a tray dryer

Summary of Results

Run	Method	% Solution Mass Dewatered
1	Manual gravity filtration	0%
2	Agitated manual filtration followed by tray drying	99.6%
3	Vacuum filtration using filter paper	98.8%
4	Vacuum filtration using filter paper followed by tray drying	99.1%
5	Vacuum filtration using mesh fabric	98.2%
6	Fine bubble flotation followed by tray drying	97.5%

Conclusions

- Gravity filtration does not work as a stand-alone drying method.
- Vacuum filtration worked well and quickly but no algae could be removed from the filter paper or mesh fabric.
- A more concentrated algae solution needs to be used for flotation and tray drying to be more successful.
- Tray drying resulting in effective algae dewatering, however this is expected to be the most energy intensive option.

Future Work

- Measure and potentially reduce the suction of the vacuum utilizing a pressure gauge in the system.
- Find an additive that would increase bubble production during flotation and bring more algae to the surface.
- Determine the amount of energy consumed during each step to determine the cost and energy efficiency of each method.

References

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