225-24-campbell

Cultivating, harvesting and processing microalgae for biodiesel production

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Project Objectives:

In this student project, algae species were reviewed, and one was chosen based on its growth speed and lipid-producing characteristics. A photobioreactor was designed and built. The algae grown were monitored and harvested. Due to the short duration of this project and difficulties in extracting the algae and a malfunctioning ultrasonic bath, the oil extracted was not sufficient for conversion into biodiesel. The heat of combustion of the produced fuel from used cooking oil was measured. The lessons learned are discussed.

The Steps:

- Microalgae species selection
- Bioreactor system design
- Cultivation
- Dewatering and harvesting
- Biodiesel production
- Suggested Improvements

Microalgae Species Selection

Chlorella

- Very common and cheap
- Reacted well to nutrients.
- Thrives in freshwater.

Nannochloropsis Oculata

- Higher oil yield per volume of biomass
- Reacted negatively to nutrients.
- May thrive better in salt water applications.

Photobioreactor (PBR) System Design (Fig. 1)

Closed System PBR

- Can use natural or artificial light.
- Higher initial cost
- Longer operating times
- Higher light contact area to algae

Open System PBR

Lower cost

- Harder to control what goes into system
- Requires more space.
- Lower density of biomass

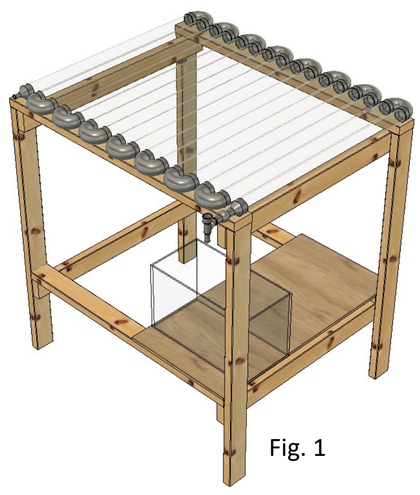
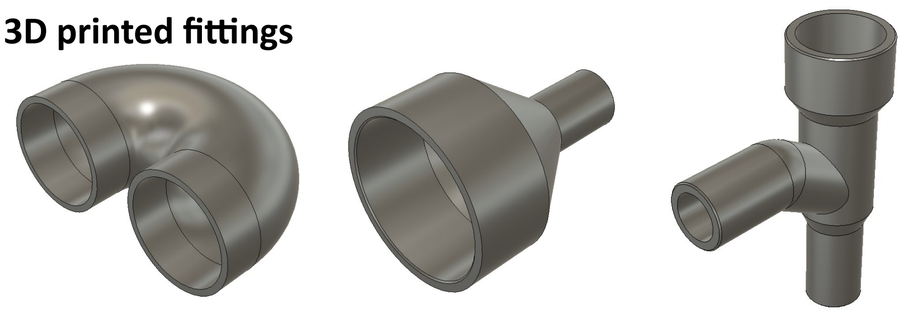


Fig. 1

Photobioreactor (PBR) System Design

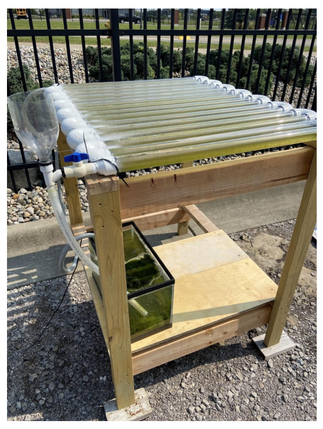
- Custom designed wooden frame to elevate acrylic tube apparatus.
- Custom 3D printed fittings and gravity aeration.

3D printed fittings



Microalgae Cultivation: Chlorella & Nannochloropsis

- Cultivated for about 2.5 weeks.
- Open system
- Added about 5 mL of nutrients.



Microalgae Cultivation: Chlorella

- Cultivated for 4 weeks.
- Added a lid to the tank to reduce evaporation.
- Added 1 mL of nutrients about twice a week.
- Added some pond algae.

Dewatering & Harvesting

Utilized a filter bag to extract large algae chunks while running the pump.

Removes most of the water leaving biomass and oil.

Oil Extraction

Ultrasonic bath

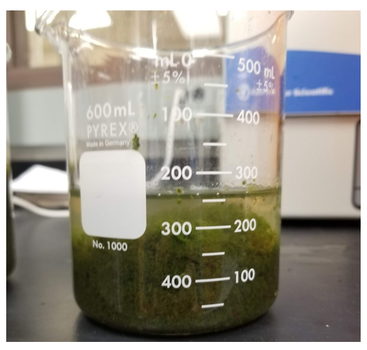
Not able to use

Blending + settling

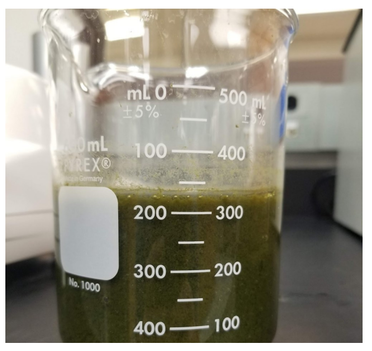
Did not let much algae to separate.

Crushing + Settling

Some oil separated, needed to settle for oil extraction.



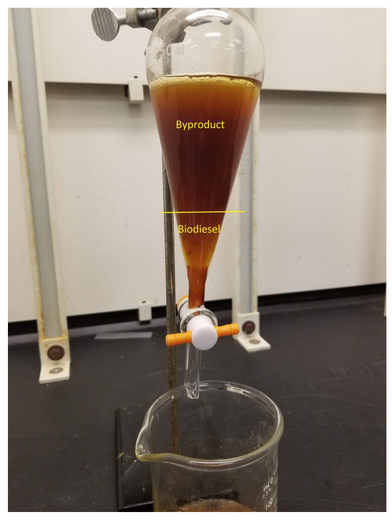
Crushing + Settling



Blending + Settling

Biodiesel Production - Chemistry:

Performed transesterification reaction to produce Glycerol and Biodiesel.

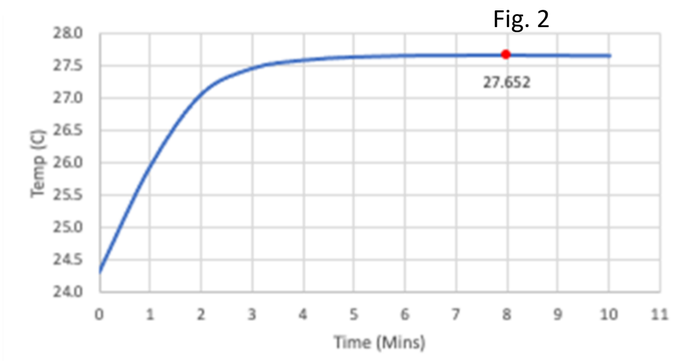


Calorimetry (Fig. 2)

Detonated fuel and measured temperature rise.

LHV of Biodiesel = 38 MJ/Kg

Fig. 2



Bill of Materials

Item #	Description	Quantity	Price Per Unit	Total Price
1	2PC 2" Clear Acrylic Tube 36" Long	8	$21.95	$186.14
2	Nannochloropsis algae	2	$9.35	$19.82
3	Chlorella algae	2	$13.10	$27.77
4	Fertilizer 500mL	1	$19.99	$21.19
5	3/4" Ball Valve	1	$6.04	$6.40
6	3/4" Braided Tubing 10ft	1	$18.99	$20.13
7	PETG filament (1kg)	2	$18.99	$40.26
			Total	$321.71

Suggested Improvements

- Plumbing Joint Manufacturing (Fig. 3)
- Keep Joints same size for algae extraction/cleaning (Fig. 4)
- Slower Flow and more consistent nutrient dosing (Fig. 5)
- Secure a sonicator/ultrasonic bath for oil extraction

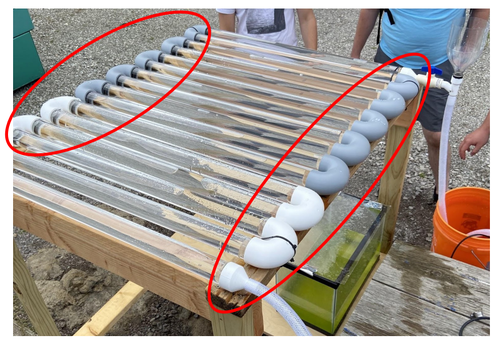


Fig. 3

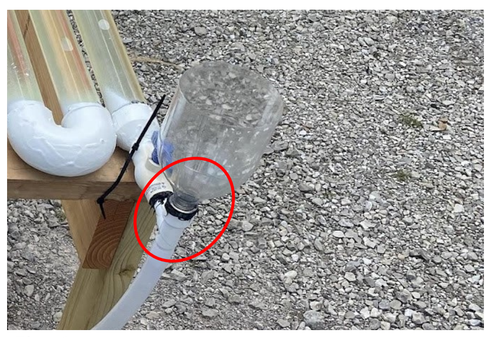


Fig. 4

Fig. 5

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