Automated Microalgae Photobioreactor

Design and Development of an Automated Continuous Harvesting System for Microalgae Photobioreactors

K. Badura, B. Bazyler, C. Garko, B. Lemos, Y. Lopes, T. Solano, J. Ordonez, J. Vargas, N. Gupta

FAMU-FSU College of Engineering , Federal University of Paraná

Project Definition

Background

There is no existing way to continuously harvest and separate microalgae for biomass production.

Biofuels are promising alternatives to take the place of diminishing fossil fuels , and microalgae in particular, are of interest for biodiesel production due to their ability to produce very high amounts of oil compared to other plants as well as their minimal space consumption. Current microalgae photobioreactors are very dependent on consistent maintenance to keep the algae growing. Additionally, there are no viable methods for the automated harvesting of the microalgae, which limits the production of microalgae for use as a large-scale biofuel source.

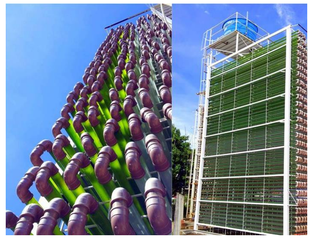


Fig 1. (Left) Photobioreactors at NPDEAS (UFPR), PR, Brazil as compared to open raceway ponds (right).

Objective

Design of a scalable energy efficient system which autonomously cultivates and continuously harvests various species of microalgae for increased biomass production.

Constraints

- Must work with current photobioreactor infrastructure,
- Must function in various environments (16-27 °C).
- The biomass must remain usable for biodiesel.
- The system's flow rate will be adaptable to growth rate.

Design

Automated Continuous Harvesting System

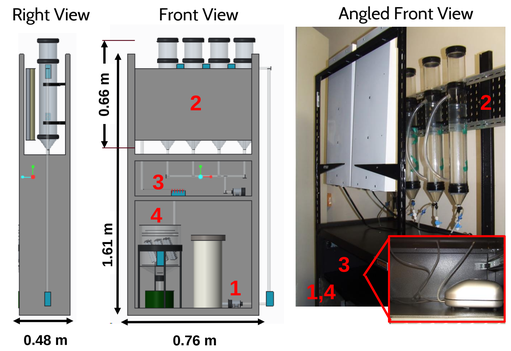
Fig 2. (Right) Full system CAD from cultivation to harvest, (Left) full system construction.

Stage 1: Nutrient input preparation

Stage 2: Cultivation of microalgae

Stage 3: PEF Lysis treatment

Stage 4: Modified lamella separation



Cultivation

The 8 L airlift is a closed cultivation system allowing:

- More reliable culture condition control
- A more compact and portable design
- Growth stages developing simultaneously

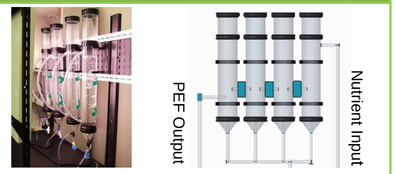


Figure 3. (Right) Constructed airlift, (Left) airlift CAD.

Harvesting

- Pulsed electric field (PEF) lysis
  - Electric field of >40 kV at different algae dependent frequencies.
- Lamella separator
  - Will increase the settling rate of the biomass and facilitate the oil extraction.

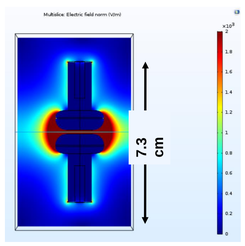


Figure 4. Finite element analysis for modified Bruce electrode PEF chamber.

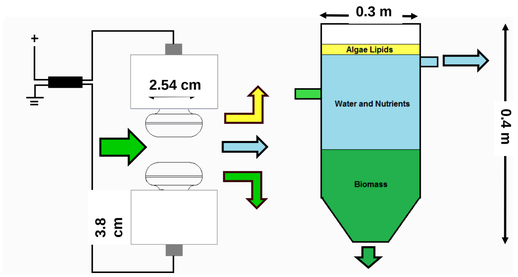


Figure 5. Harvesting process diagram, algae receives PEF treatment and separates in lamella separator.

Automation

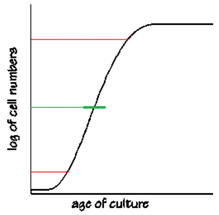


Fig 6. Algae growth curve used to develop system automation. The green line denotes the maximum growth rate of the algae which is when it is transferred to final (fourth) tube for maturing.

- LED light sensor
  - Determines if algae has reached appropriate cellular density for extraction.
- Pump and solenoid valve
  - Synchronized through microcontroller to maintain system's constant volume.

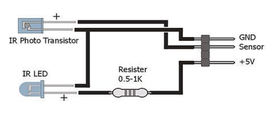


Fig 7. (Left) sensor schematic, (Right) actual sensor.

Future Work

- Optimize PEF treatment for various algae.
- Refinement of mathematical model for different species of algae.
- Add sugar reservoir to augment algae growth.

Acknowledgements

We would like to thank::

- FIPSE Program, and the UFPR- FSU partnership

We would also like to extend our gratitude to:

- André Mariano, NPDEAS principal investigator
- Diego Araujo, a UFPR M. Sc. in Mechatronics
- Peter Cheetham, a FSU EE Ph.D candidate
- Hai Hoang Van, a FSU IME Ph.D candidate
- Lorena Moura, a UFPR Chemical Engineer

For more information please visit: http://eng.fsu.edu/me/senior_design/2016/team09/index.html