

Abstract

Algae have been identified as a promising biofuel feedstock because of their prolific growth rate and species-specific specialization in producing carbohydrates, lipids, or proteins. Lipids extracted from algae can be converted to biodiesel through a transesterification process. However, technology to economically mass produce algae specifically as an energy source is not yet available. If secondary objectives are added to the algae cultivation, such as nutrient mitigation and carbon sequestration, the production process may become more economically feasible. Species of algae are able to thrive in a range of nutrient environments, making them capable of utilizing municipal and agricultural waste streams as nutrient resources. Algae production is considered as one of the most viable means to sequester carbon and together with the ability to remove soluble nutrients from wastewater this suggests an environmentally sound means for sustainable and renewable energy production.

This project attempts to develop a process for growing high-lipid algae periphyton communities in open photo-bioreactors.

The first step is to determine the optimum growth conditions for the algae using small-scale experimental units. Ultimately, this process will extract lipids from the harvested algae to be transesterified into biodiesel. The press cake after this step could then be anaerobically digested to produce biogas or dried into an animal feed. Such a system would be especially important to facilities such as water treatment plants and livestock production farms, providing on-site nutrient management and biofuel production (Figure 1).

Background

A new approach to an old problem.

Algae have generally been grown in one of two ways: open, recirculating ponds and closed photobioreactors consisting of transparent tubes and artificially created conditions. This project aims to merge the best aspects of both techniques to create a new method of growing algae for biofuels that is both economical and sustainable, a goal previously unreached.

This project will produce an open-air environment photo-bioreactor, which eliminates expensive enclosures and is similar to pond culture. Unlike pond culture these photo-bioreactors will have high output rates that are carefully controlled through flow conditions. This high level of flow and control are similar to closed photo-bioreactors, but use less expensive equipment in an open environment and natural lighting.

Materials and Methods

Current experimentation is focused on small-scale reproductions of a prototype photo-bioreactor surface (Figures 2,3,4, and 6). These 12 by 6 inch concrete slopes sit on stands where slope, flow rate/velocity, light, and nutrient loading can be carefully controlled. Artificial lighting is used to initially eliminate light intensity differences as a variable. Through manipulation of these parameters, relationships to biomass production and oil accumulation can be derived. The experiments were inoculated with a slurry of a wild periphyton community and Poultry Manure Extract (PME).

Phase one of the project will manipulate slope and flow rate to find the optimum water velocity and depth for growth of the periphyton. Light and nutrient levels will be held constant to pinpoint the exact cause for increased growth. Phase two will manipulate light and nutrient levels individually to examine their implications. After this testing, a model for optimum growth will be developed to assist in the design of a prototype reactor.

Algal Biofuel and Nutrient Management

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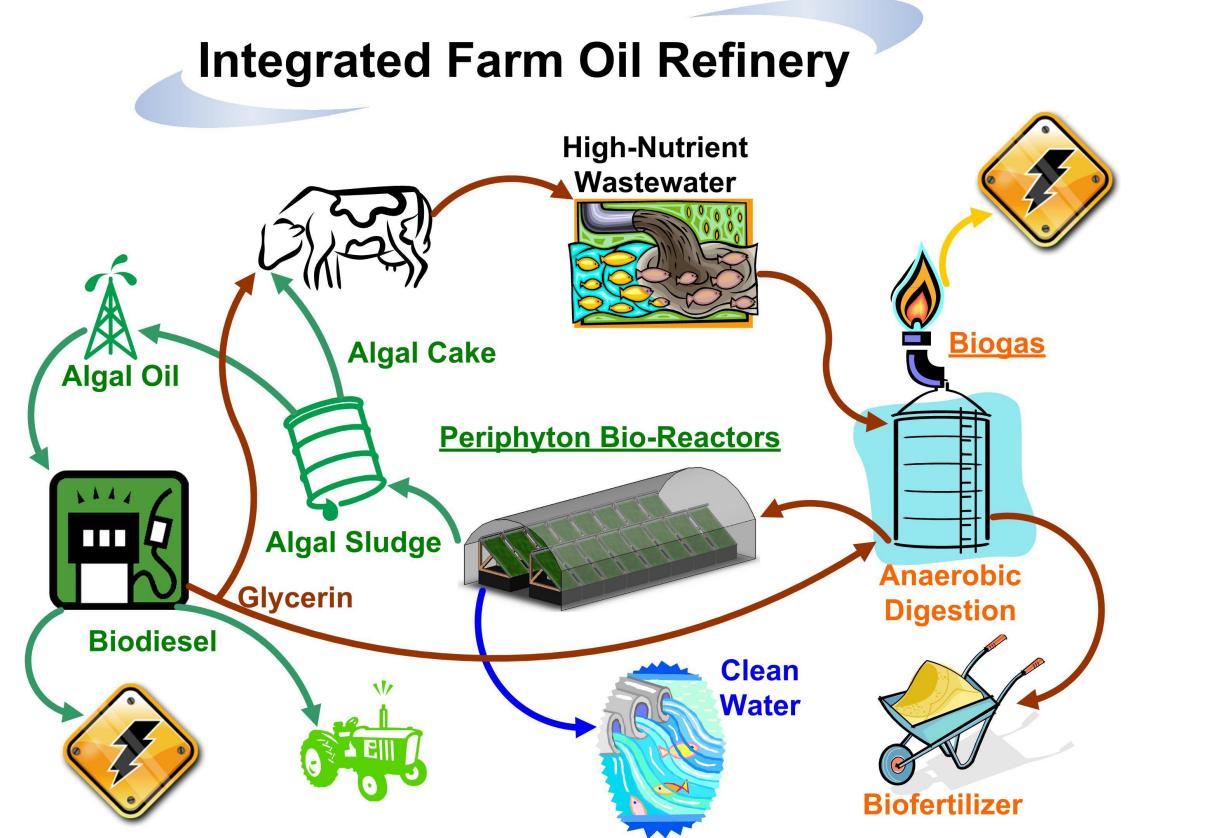




Figure 2: Experimental Photo-Bioreactor Setup



Figure 4: Bio-Prospecting for Native Algae Species

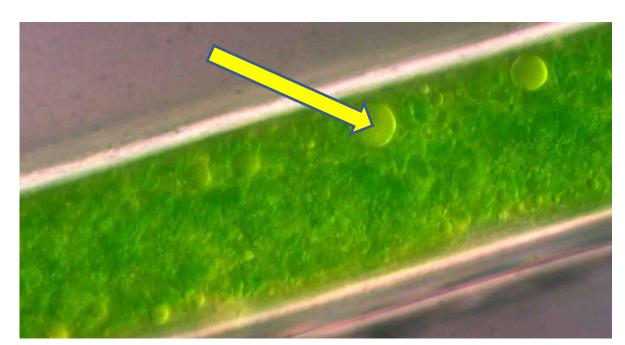


Figure 5: Intracellular Lipid Bodies

Figure 1: Integrated Farm Oil Refinery- Integrated "Closed Loop" Nutrient and Energy System for Agriculture



Figure 3: Side View of Experimental Photo-Bioreactor Setup

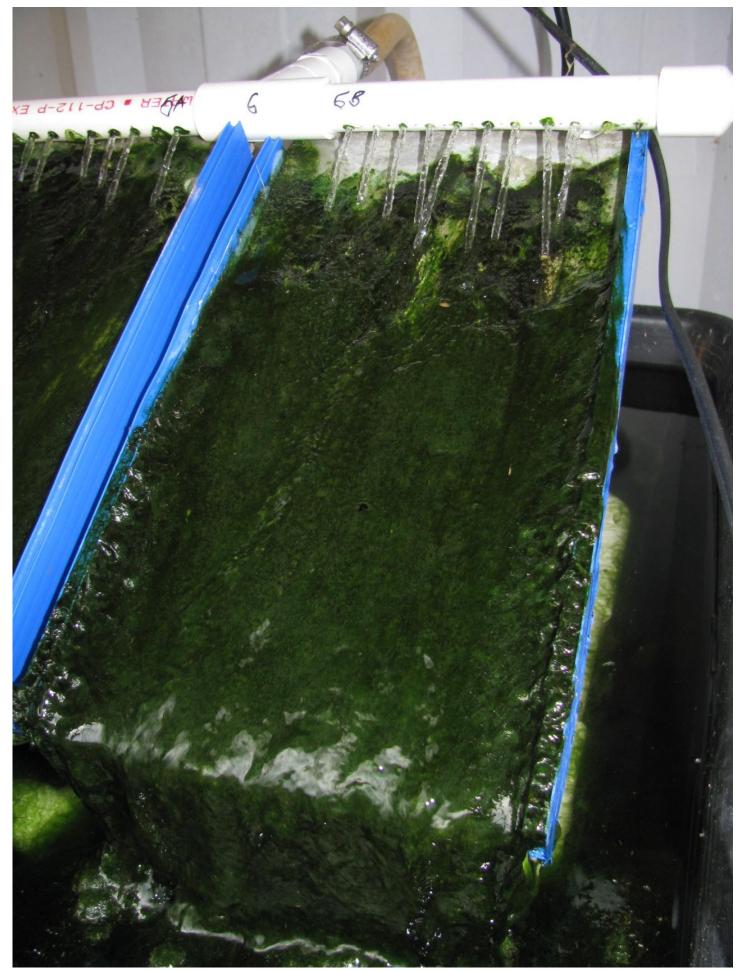


Figure 6: Diverse and Prolific Periphyton Growth

Results

After testing and analysis of the experimental data is complete, a prototype photo-bioreactor will be constructed to use wastewater as a nutrient source. After prototype testing is complete, a process for large-scale production of highlipid algae from wastewater will be developed.

Currently the project is working with concurrent research in bio-prospecting for algae with the right combination of high lipid content and high growth rate. Once several similar species have been selected the growth parameters could be modified to accommodate the needs of the individual species. Parallel research is also investigating lipid production triggers that could be implemented in the design of growth systems.

Depending on individual use needs, the species present in a photo-bioreactor could be manipulated to produce the specific portfolio of fuels and waste treatment needed by the user.

Discussion

So far, substantial growth rates of a high-lipid algae have been sustained on the experimental photo-bioreactors. Microscopy analysis will be conducted for the species present in the periphyton by visual identification, and the oil content of the community will be assessed using a Nile Red Stain.

The open photo-bioreactors produced by this project will have a substantial impact on the way that agricultural and municipal wastewater is handled, developing a synergy between biofuels and nutrient waste management.

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University Scholars Program: http://www.scholars.ufl.edu

UF Bio-Energy and Sustainability School: http://biogas.ifas.ufl.edu/internship

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