Floating Microalgae Harvesting Boat to Prevent Algae Blooms and Produce Renewable Energy

Phillip Rich, Blake Allred, Austin Bettridge, Tyler Johnson, Jeff Keller, Jacob King, Anastasia Matkovska, *Dr. Kevin Shurtleff
*Correspondence author: kshurtleff@uvu.edu, 801-360-9799

Introduction

Harmful algal blooms (HABs) are a serious environmental issue worldwide. HABs occur when water conditions (temperature, solar insolation, nutrients) foster rapid growth of cyanobacteria (blue green algae) and other microalgae. As photosynthetic organisms, microalgae like to grow at the surface of the water, so that they can obtain as much sunlight as possible. When the microalgae reach high concentrations, incoming sunlight is blocked, preventing photosynthesis. This results in death of the microalgae, which release endotoxins that are harmful to other organisms, including humans.

The purpose of this research project is to design, build, and test technologies capable of harvesting microalgae. If we can control the microalgae concentration in Utah Lake, it will help prevent HABs, while still allowing the microalgae to participate in the ecosystem.

Methods

We have designed, built, and tested seven, lab-scale, microalgae harvesting technologies. We tested the effectiveness of each technology at removing low concentrations of microalgae from water over time. We used a Vernier Labquest 2, handheld, data acquisition unit with visible light spectrometer to measure the absorbance of the water at 415 nm before and after filtration. The algae concentration is proportional to the absorbance (i.e. the higher the algae concentration the higher the absorbance).

Results and Discussion

Of the seven technologies tested, only two of the technologies were deemed effective: 1) a continuously-swept diatomaceous earth (DE) filter we designed (Figure 1), and 2) a conventional plate and frame filter press with body addition of cellulose (Figure 2).

After demonstrating the continuously swept DE filter worked, we determined the cost and time required to scale-up our filter design made it less favorable compared to using a conventional plate and frame filter press (Figure 2). Since a plate and frame filter press is not continuously swept, algae would plug the filter quickly, preventing formation of a stable filter cake between the plates. Consequently, we determined that by adding powdered DE or cellulose filter aid to the algae containing water before the filter, we could prevent plugging of the filter press and encourage formation of a stable filter cake.

We decided to use pure cellulose filter aid with the filter press so the resulting algae/cellulose filter cake could be used as a biomass fuel. DE will turn into glass during gasification or combustion. In addition, the filter press produces an algae/cellulose filter cake that is 80% solids. This means less drying is required. For comparison, the continuously swept filter will produce an algae slurry with only 20% solids.

Full-scale Algae Harvester

Based on our filter results, we designed a full-scale, 10 foot wide x 30 foot long, algae harvesting barge (Figure 4). This algae harvester will filter 1.73 million gallons of water during each 16 hour day, removing 589 kilograms of dry algae (at an average algae concentration of 0.1 gram per liter). The barge can filter 1 square mile of water every 20 days. We envision a fleet of algae harvesters operating globally to prevent algal blooms. We hope to deploy the first, prototype microalgae harvester on Utah Lake in the spring of 2019.

Table 1: Test results of continuously swept DE filter.

<table>
<thead>
<tr>
<th>Absorbency/Water</th>
<th>Tank</th>
<th>Filtrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test 4</td>
<td>2.278</td>
<td>0.119</td>
</tr>
<tr>
<td>Test 5</td>
<td>0.968</td>
<td>0.817</td>
</tr>
<tr>
<td>Test 6</td>
<td>1.500</td>
<td>0.835</td>
</tr>
<tr>
<td>Test 7</td>
<td>1.115</td>
<td>0.630</td>
</tr>
</tbody>
</table>

Most tests show a significant decrease in absorbance (i.e. algae concentration) after one pass through the filter. However, Test 5 shows only a small decrease. We think during this test, the filter created a hole in the DE, allowing the algae containing water to bypass filtration. We added DE to the water and monitored the filtrate absorbance over time as it repeatedly recirculated back through the filter. This is shown in Figure 3. We think the additional DE plugged the hole, improving filtration again.

We will use the harvested algae/cellulose filter cake as a carbon-neutral biofuel to produce electricity. Figure 6 shows an All Power Labs GEK gasifier with a 20 kilowatt ICE generator. The system consumes 20 kilograms of biomass to produce 20 kilowatts of electricity each hour. It costs $20,000 complete. We will eventually run the algae harvester on carbon-neutral, algae/cellulose, biomass using a gasifier like the GEK. It is satisfying to think we can run the algae harvester using the algae it harvests.

Conclusions

We were able to design, build, and test a successful, small-scale, algae filtration system in the laboratory. Based on the results for this system, we were able to select a filtration technology that can be scaled-up for a full-scale, floating, algae harvesting barge. This algae harvester can collect algae from Utah Lake, preventing algae blooms and producing an algae/cellulose biofuel.