Evaluation of a Floating Algae Cultivator for Water Pollution Control and Biomass Production
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ABSTRACT SUMMARY
Eutrophication of waterways in the Great Lakes region has become a significant water quality issue in the past few decades. At the same time, process design for attached algae cultivation has matured and proven to be effective for water quality management in other regions of the country. Thus proposed in March of 2012 was the design and testing of a novel floating algae cultivator. The design has small capital costs, requires no energy input for operation, and recovered biomass from the apparatus has the potential to be used as a feedstock for biofuel production all contributing to a potentially cost-effective technology for pollutant nutrient recovery. Preliminary results show that the recovered biomass has a high ash content versus ash free dry mass. Results of this study on the performance of the apparatus will provide operational parameters that can inform the design for viable large-scale in situ algal production for water quality mitigation in the lower Great Lakes watersheds.

Cultural eutrophication is the enrichment of surface waters from human-generated nutrient sources resulting in deleterious water quality impacts. As the human population has grown around the Great Lakes and invasive Dreissena mussels have appeared, increased levels of nitrogen and phosphorus have been found in the Great Lakes1. As a result, excessive algal growth has occurred which has negatively impacted local waterways in terms of fishing, recreational boating, biodiversity and beach quality2.

ALGAL CULTIVATION TECHNOLOGY

A potentially viable and sustainable option for removing excess nutrients from surface waters is through controlled cultivation of algal turfs3. Because of their high level of primary production, algal turfs can be utilized in engineered cultivation systems to absorb pollutant nutrients and thus improve water quality4. New research from the Chesapeake Algae Project (ChAP) at the College of William and Mary has resulted in a design for an offshore floating algal cultivator that achieves high productivities with lower energy inputs compared to land-based systems in the Chesapeake region5. Inspired by this work, the UB Algae Research Team has developed a simpler floating cultivator prototype for testing productivities in the nearby watersheds in the Great Lakes (Figure 1).

Wild algae from the natural environment was expected to colonize on the floating cultivator screen directly, using it as a coarse substratum for basal stalk attachment. After colonization, the growing turf would absorb excess nutrients from the surrounding water and periodic harvest of the biomass would remove the nutrients from the system. Collected biomass can then be used after various refinement processes to produce bio-fuels, fertilizers or other products6.

MATERIALS AND METHODS

Four cultivators were built to specification (Figure 2) using commercially-available materials (Table 1). A HOBO temperature/PAR data-logger was deployed on each cultivator at each location to continuously monitor temperature and light levels. One was south facing while the other is north facing to determine greatest sunlight intensity and smallest sunlight intensity, respectively. Material that collected on the screen was harvested on a periodic (usually 7-9 days) basis using a common ice scraper and ten gallon bucket.

RESULTS

Results from harvests showed that recoverable biomass had high mean ash content (87.3% ± 11.8%, n = 90). In addition, overall production numbers did not seem to correspond to temperature or light trends.

Table 2: Productivity Results for Regular Harvests of Cultivator Screens

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mean (±S.D.)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Productivity (g AFDM m⁻² d⁻¹)</td>
<td>0.185 (±0.239)</td>
<td>0.0003 - 1.444</td>
</tr>
<tr>
<td>Productivity River (A) (g AFDM m⁻² d⁻¹)</td>
<td>0.298 (±0.196)</td>
<td>0.0003 - 1.444</td>
</tr>
<tr>
<td>Productivity Lake (B) (g AFDM m⁻² d⁻¹)</td>
<td>0.0566 (±0.0739)</td>
<td>0.001 - 0.474</td>
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Overall, low AFDM productivity was found for all systems (Table 2). Also, AFDM productivity at the river site (A) was 5-10 times greater, suggesting that water bodies with unidirectional flow are better suited for this technology. Microscopic analysis of recovered samples revealed several species of cyanobacteria and diatoms such as Oscillatoria and Frustulia, respectively. Possible reasons for low AFDM include lateral disturbance of growing medium, loss from heterotrophic grazing, loose attachment of algal species, and possible loss from harvest methods.

Final analysis reveals that this technology has productivities on the low end of algal production technology (typically around 5 g m⁻² d⁻¹)7. More tests with altered designs will need to be performed to determine the suitability of the substratum materials. Future results of algal production, energy usage calculations, nutrient uptake, carbon content and content of carbohydrate and fatty acids will allow modeling of the economic viability of largescale algal production processes in the region. In particular, carbohydrate and fatty acid content will reveal the quality of the biomass as a bio-fuel feedstock. Scaling up this process could result in the development of large scale, low-cost, low-energy usage technology for the removal of excess nutrient pollution in local waterways for mitigation of cultural eutrophication.

REFERENCES

Figure 1: Schematic of the Water Remediation Process Using a Floating Algae Cultivator

Figure 2: Schematic Diagram of the Floating Algae Cultivator

Table 1: Materials and Deployment Parameters of the Algal Cultivators

| Materials: | PVC piping, Plastic Bat House Netting, Worm Drive Hose Clamps (SS16), Plastic Zip Ties |
| Unit Cost: | $83.92 |
| Overall Dimensions (m): | 1.0 length X 1.0 width X .54 depth |
| Screens Per Unit: | 2 |
| Total Growth Area (m²): | 3.95 |
| Orientation of Growth Area: | Vertical |
| Sites of Deployment: | A: River, B: Lake |
| Water Flow Conditions: | A: Unidirectional, 3 m³/s discharge B: Multidirectional, wind-driven, variable |

Figure 3: Deployment Locations in Amherst, NY

(A) Ellicott Creek Site (B) Lake LaSalle Site

Figure 4: Harvest Results

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