Determining Biofuels Potential For Cultivated Filamentous Algae For Water Quality Management

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Part I: PILOT TEST OF ALGAL TURF SCRUBBER TECHNOLOGY

Background

The Great Lakes watershed has long been impacted from high nutrient concentrations resulting from agricultural and urban runoff, which causes eutrophication of surface waters by stimulating a surge in the growth of algae populations, negatively impacting water quality and upsetting the balance of the ecosystem. The Algal Turf Scrubber (ATS) is a low-tech solution that involves growing algae on screens in engineered raceways on land, then harvesting those algae weekly, effectively removing excess nutrients with it. Algae has been grown in ATS systems located at the Great Lakes Center in Buffalo, NY, drawing water from the Black Rock Canal. Algae was harvested weekly throughout the growing season (approximately June to December) of 2010 and 2011. Harvested biomass was analyzed for ash-free dry mass (AFDM) and ash content.

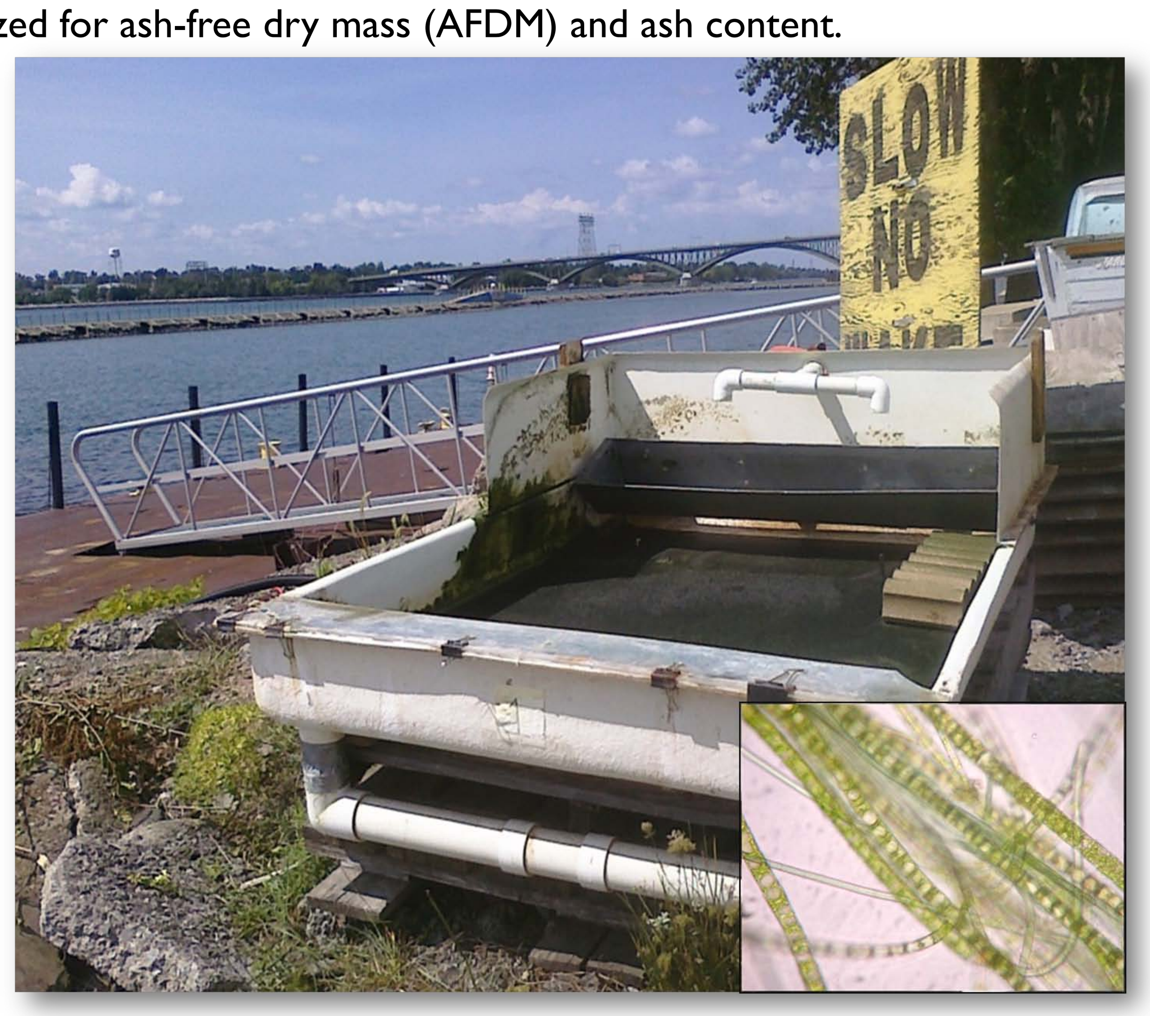

Figure 1: An ATS set up at the Great Lakes Center location on the Black Rock Canal; *lower right:* An image of *Chladophora* algae under a microscope .

Results and Discussion

Figure 2 below shows the daily productivity of a single ATS stationed at the Great Lakes Center in Buffalo, NY during the growing seasons of 2010 and 2011. Over the course of these two growing seasons, the average biomass production rate was 1.9 g AFDM m^{-2} d^{-1}. The average daily accumulation of ash (inorganic material) was 5.5 g m^{-2} d^{-1}. Although the production numbers were lower than expected, the ash content was higher than expected, suggesting recovery of suspended mineral sediment from the waterway.

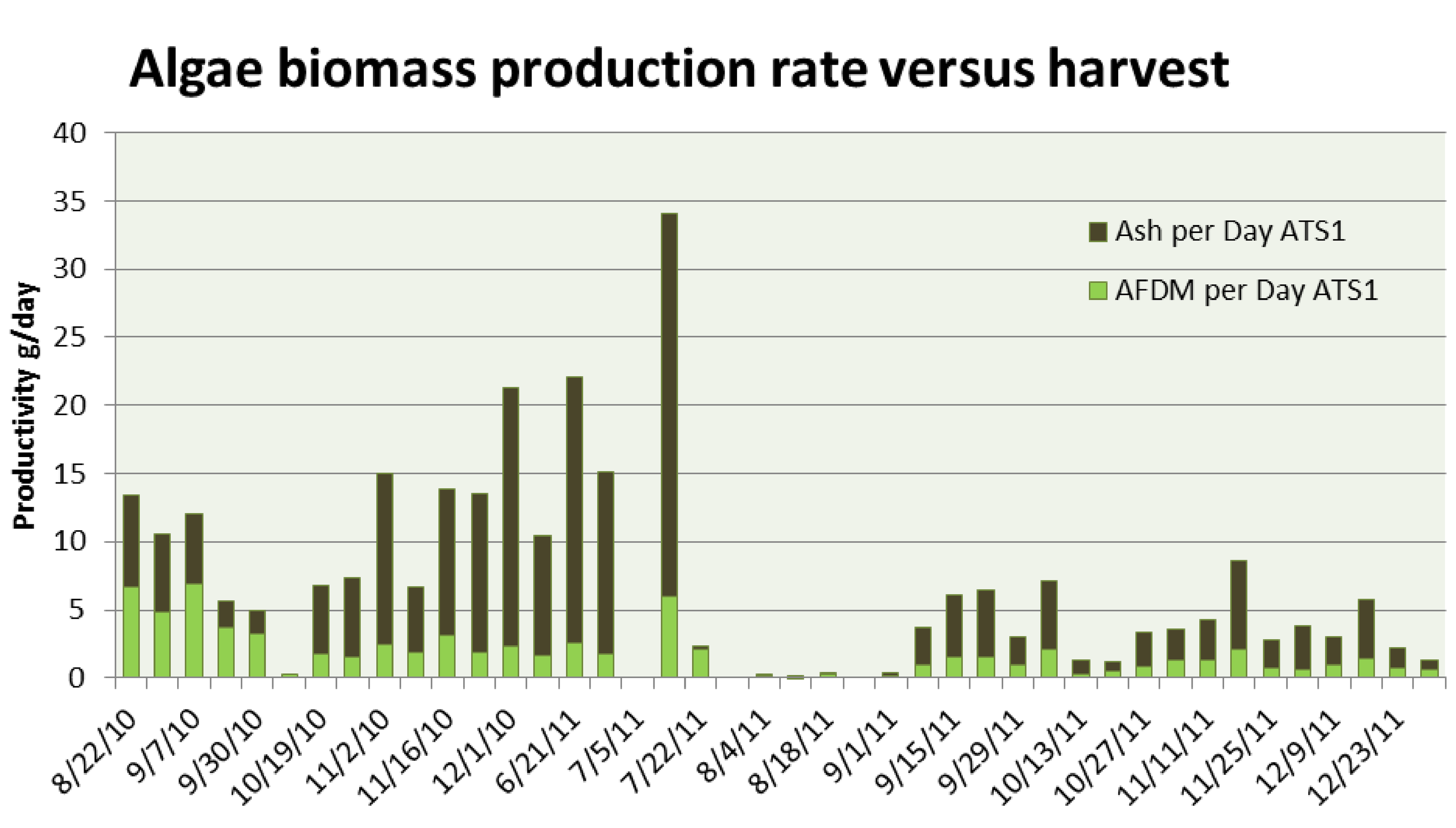

Figure 2: Algae production rates from ATS 1 during the growing seasons of 2010 through 2011

Part II: CONVERSION OF ALGAE TO BUTANOL

Introduction

This project will involve the lab testing of the conversion of cultivated algae into biofuel in the form of butanol. The conversion of the harvested algal biomass from the Great Lakes Center ATS units into a biofuel adds considerable economic benefit to the process and is an important component of an overall life cycle analysis for ATS technology in Western New York. The basic approach for this research will be to hydrolyze algae samples by mixing it with a dilute acid and running the sample through an autoclave. The sample will then be analyzed for sugars using spectrophotometric methods.

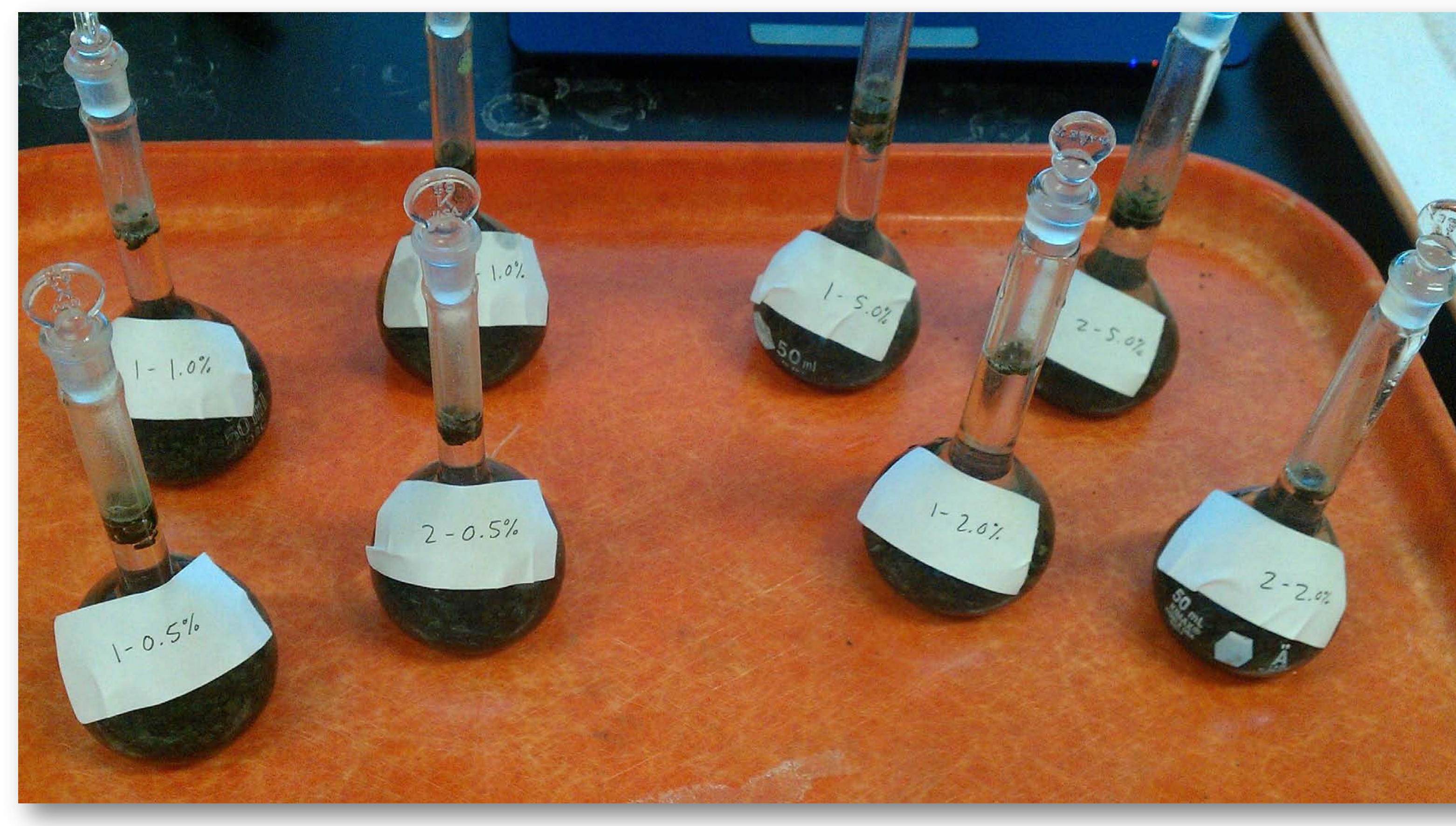

Figure 3: Samples of lab-grown algae ready for concentration trials to determine the optimum acid concentration for hydrolysis.

Experimental Design

- Samples prepared in 50mL volumetric flasks
- Reagent for hydrolysis: sulfuric acid
    - Trials will be performed to determine the optimum sulfuric acid concentration
- 5g ground algal biomass mixed with 50mL solution of sulfuric acid
- Samples heated at 125°C at optimum time
    - Trials will be performed to determine the optimum time spent in the oven
- Reagents for colorimetric determination of sugar content:
    - DNS Solution (3,5-dinitrosalycilic acid, phenol, sodium sulfite, sodium hydroxide, potassium sodium tartrate solution (40%) (Rochelle Salt)
- 3mL DNS solution added to 3mL hydrolyzed sample
- Sample is heated to 90°C for 5-15 minutes to develop color
- 1mL Rochelle Salt added to stabilize color
- Absorbance recorded with a spectrophotometer at 575nm

Expected Results

The expected results of these experiments are to yield optimum values for the acid concentration and reaction time for the hydrolysis step in refinement of algae for butanol production. These experiments will also result in yield values of fermentable sugars found in algae harvested from ATS operating in the field. Overall, these values will provide information to help define design parameters for process development for the refinement of biofuels from ATS algal biomass.

Part III: LIFE CYCLE THROUGH AN ATS

With data generated from these research efforts, a life-cycle analysis will be performed to assess the viability of algae cultivation for water quality management and biofuels production in the western New York. Figure 4 below shows a schematic of the life cycle of an ATS system. The ATS is run off of solar power, as well as some electricity to run pumps. Water, loaded with excess nutrients from sewage and farm run-off, as well as carbon dioxide from the atmosphere, allow algae to grow in the ATS. The two raw products of the ATS are cleaner water and the harvested algal biomass.

Algae biomass can be used for a wide variety of things, including biofuels, fertilizer, farm feed, and green materials such as paper and building materials. This research will focus on the conversion of algae to butanol. The analyses will help inform a total life cycle analysis assessing the economic value and environmental footprint of ATS technology in Western New York.

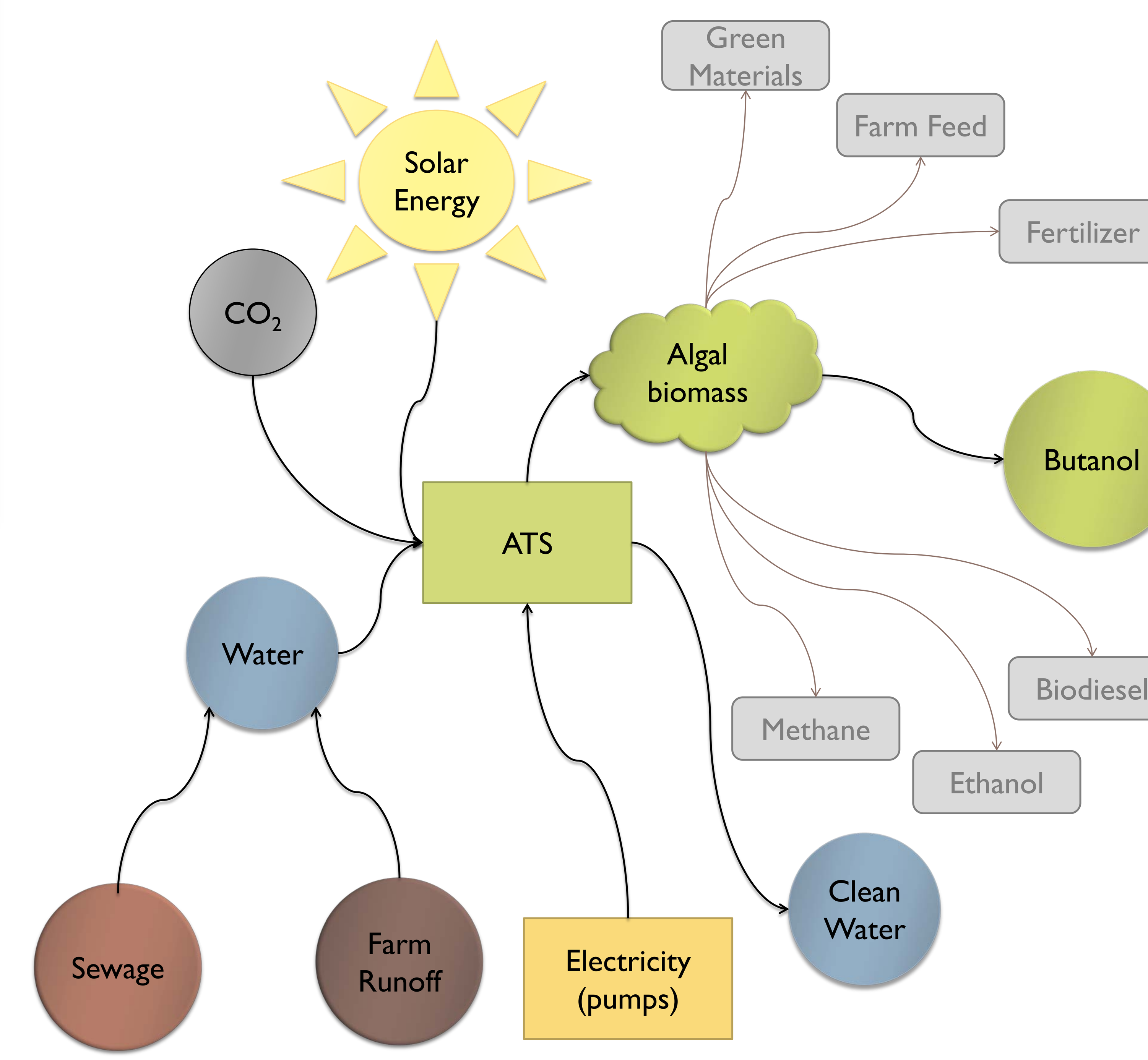

Figure 4: Schematic of the life cycle of an ATS; grey boxes are possible uses for algae on which this research is not currently focusing.

Expected Results

The data collected from ATS harvests and sugar analyses will to help produce an assessment of the economic viability of the ATS as a pollution control strategy for water quality management in the nearshore lower Great Lakes.

Acknowledgements

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