Biorenewable Systems
TSM/ABE 325

Elmin Rahic, James Killpack and Chris Weldon

Microalgae vs Macroalgae as a Feedstock

Introduction

- As global demands for alternative energy sources rise along with GHG emissions, humans are looking at all options to improve upon our fuel dependence.
- Recently, researchers have been developing methods of utilizing algae to assist in meeting energy needs. The idea of using algae as a feedstock is growing in popularity as they have a very fast growth rate and hold a higher percent of oil (30-70%) than most other forms of biomass[1].

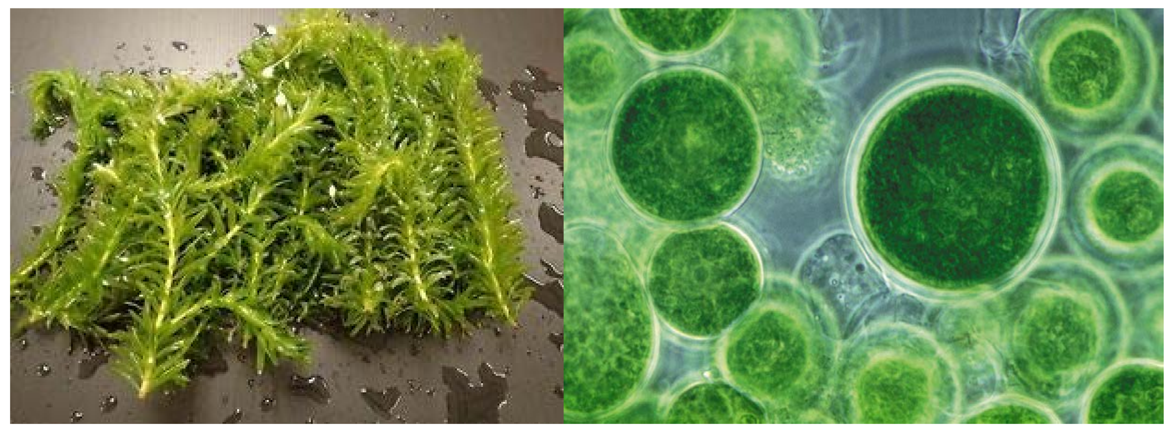

Figure 1. Macroalgae on the left and Microalgae on the right.

- Not all algae are created equally. There are two classifications of algae: macroalgae and microalgae.
- Macroalgae are much bigger than microalgae; having the potential to grow tens of meters. Microalgae, however, are measured in micrometers[2].
- Both have ability to grow in marine & freshwater habitats. This provides more opportunities and space for growth without disrupting current water supply [1]

Background Information

- Unlike most biomass, macroalgae can be harvested over 5 times in a single year. It also has the ability to grow without the help of any outside chemicals/fertilizers when grown in saltwater, reducing overall costs [3].
- Algae are capable of growing anaerobically as well. They are even used in wastewater treatment as they will feed off of organic nutrients in the wastewater. Similarly, they can be broken down/digested anaerobically. This process isn't as straight forward due to numerous technical restraints[6].

Figure 1 - Comparison of different sources of biofuel

Crop	Oil Yield (L/ha)	Land Area Needed (M ha)
Corn	172	1,540
Soybean	446	594
Canola	1,190	223
Jatropha	1,892	140
Coconut	2,689	99
Oil palm	5,950	45
Microalgae (a)	136,900	2
Microalgae (b)	58,700	4.5

Table 1. Column three represents land area needed to meet transportation needs in the US.
a: 70% oil by weight in Biomass
b: 30% oil by weight in biomass [3]

- Microalgae grow at an incredible rate. Doubles in size within 3.5-24 hours. [2]
- According to Table 1, microalgae's potential is way higher than other, more commonly used, biomass. This is what spiked the interest of so many researchers.

Constraints and Opportunities

- Mass cultivation systems of heterotrophic algae (algae that obtains energy without the sun) require too much capital and operational costs. This leads to the use of photoautotrophic algae, which has a lower productivity rate from variations in solar irradiance[1].
- Photobioreactors (PBR) are a popular technology for microalgae cultivation as all environmental factors are controlled. This allows for high productivity, but it is currently very costly and non-profitable[3].

Figure 2. Example of a photobioreactor[3].

- According to one study, a simplified economic analysis was generated using a Scenedesmus spp. [type of green algae], which produced 0.21 g/l/day of biomass, with a lipid content of 21%. In this model, petroleum-based oil would have to cost approximately $710 per barrel for this organism to be economically viable at these growth and lipid.[5]
- For reference, current crude oil price per barrel is $57.37. [7]

Potential Solutions

- The way it is seen now, macroalgae's large biomass yield and harvestability makes it a great choice as a feedstock, while microalgae would be better suited for renewable diesel production due to its high lipid content.
- Genetic engineering is being viewed as the best (and only) solution to bring at least a few strains of algae to economic viability[5].

Figure 3. Promoting algase as a future fuel source. [8]

- The idea of using algae as a feedstock is still in its young stages and is quickly gaining popularity. As time goes on, more research will be done and new solutions may arise to have competition against petroleum.

References

1. https://vtechworks.lib.vt.edu/bitstream/handle/10919/48544/442-886_pdf.pdf?sequence=1
2. http://ojs.cnr.ncsu.edu/index.php/BioRes/article/view/BioRes_09_1_Renganathan_Review_Algae_Biofuel/2600
3. http://www.academicjournals.org/journal/AJB/article-full-text/759466B62779
4. https://doi.org/10.1016/j.rser.2015.03.086
5. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3152439/
6. https://www.sciencedirect.com/science/article/pii/S2211926414000216
7. http://www.macrotrends.net/1369/crude-oil-price-history-chart
8. http://sites.psu.edu/fuelingthefuture/2015/04/03/algae-biofuels-literally-green-energy/