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Carbon Emissions Reduction From Our Daily Lives: Introduction of Bioreactors into Large Structures

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Carbon Emissions Reduction from Our Daily Lives.

Introduction of Bioreactors in Large Structures to Improve Air Quality

By

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Abstract

As carbon emissions are at high levels, we need to think of ways to reduce contributions from our daily lives. We need to try to actively lower levels through innovation, and new ways of thinking. In this study we propose to investigate the design of large structures. Instead of looking to keep them upright in the wind. It is felt that we could better benefit from using the wind to our advantage. With the implementation of bioreactors in design, we could potentially harness the wind that is usually pushing against the structure instead funnel it into the structure, and into bioreactors built into the structure. Allowing the introduction of fresh air in to the structure, and letting it pass through bioreactors to help remove CO_2 from the air.

This is with the added benefit of collecting biomass to help offset the use of fossil fuels by the structure itself. If we capture the wind using turbines on the prevailing side forcing into piping or channels to introduce fresh air into the structure, and to the south side of the structure to allow for adequate capture of light to stimulate the bioreaction. With proper monitoring of the bioreactor using various sensors, the reactors could actively monitor and harvest the growth of algae. This could remove excess buildup and deposit it for use in a fermenting tank to produce ethanol for the building energy needs, with the flue gasses being collected and introduced into the bioreactors.

Introduction

What is a bioreactor?

A bioreactor is a device or system that uses biological organisms to complete a specific chemical or biological process. For the purpose of this paper, the organism will be algae. As it can be grown in the reactors and harvested for food and in this case biofuel for the structure through the fermentation of the biomass collected in a storage tank and fermented into hydrogen or methane fuel.

Figure 1: Algae Bioreactor

An algae bioreactor uses photosynthetic microorganisms to CO_2 from the air and produces biomass that can be then used as a renewable fuel source. The bioreactors come in systems such as open ponds, closed systems, or photobioreactors, these are generally operated under different conditions depending on the desired outcome.

Microbial Fuel Cell

MFC as they are referred to use bacteria to convert organic matter into electricity. They work to break down the organic matter and generate electrons, which are transferred to an electrode to generate electricity. They have been shown to have potential applications such as wastewater treatment, biofuel production, and generating electricity for remote locations.

How could this reduce Building stresses?

There is a lot of engineering that goes into keeping large structures standing. One of the many causes of failure can be the effects of high winds. Allowing more air to pass through the structure. The resulting redirection would allow the opportunity to introduce fresh air into the structure. It could also be cycled through the reactor to help remove CO_2 from the environment and from the structure itself.

Design

The structure would incorporate the introduction of fresh air from the prevailing side of the structure, this will allow for excess wind loads to be dispersed through the structure. This would be assisted using turbines that would help to channel the air through, as well as disperse air as needed. This combined with CO_2 monitors could bring fresh air into a heat recovery ventilator (HRV) that would actively monitor the CO_2 levels of the conditioned spaces of the structure. As CO_2 levels begin to climb the HRV would be able to let fresh air into the building and expel the displaced air entering the conditioned space. This would allow the HRV to cycle air with higher concentrations of CO_2 into the bioreactor to help stimulate growth.

The size of the bioreactors should be carefully designed to ensure optimal performance. The bioreactors are located on the south side of the building to allow for maximum sunlight exposure. Monitoring the CO_2 levels is crucial for maximum yield. This with various other sensors could monitor the growth of the biomass and allow for automation of the collection and fermentation process of the biomass. The fermented biomass would then be supplied to the boiler-type system which would then, in turn, provide hot water, and can heat the structure. The flue gases produced during the production of and combustion of biodiesel could then be supplied to the bioreactors to even further lower CO_2 emissions.

A cost-benefit analysis should be conducted to determine the overall economic feasibility and sustainability of large-scale implementation. Furthermore, monitoring factors such as temperature, humidity, pH, and algae nutrients is vital for the maximum biomass yield.

How to calculate energy yield

- The number of algae that is produced: This can be calculated using the following equation:

  Algae biomass (g) = Light intensity (μmol/m2/s) x Photosynthetic efficiency (%) x Culture volume (L) x Culture period (days) as per Brennan et al.[1]

- The energy content of the algae: The energy content of algae varies depending on the species, but it is typically around 20-40% of the dry weight.

- The efficiency of the biofuel production process: This can be calculated using the following equation:

  Biofuel yield (L/kg) = (Algae dry weight (kg) x Energy content (kJ/kg)) / Energy content of biofuel (kJ/L) (as per Kumar et al., 2019[2]

To calculate the amount of CO_2 that could be removed using algae bioreactors, it is necessary to consider the following factors:

1. The amount of CO_2 that is present in the air: This can be measured using a CO_2 sensor or calculated using the following equation:

   - CO_2 concentration (ppm) = (CO_2 mass (g) / Air volume (L)) x 1,000,000 (as per Mensah et al.[3]

2. The CO_2 absorption rate of the algae: This can vary depending on the species and conditions, but it is typically around 1-5% of the dry weight per day.

3. The total surface area of the bioreactors: This can be calculated using the following equation:

   - Total surface area (m^2) = Total volume (L) / Depth of the culture (m) (as per Frosh [4]

The schematic is shown below FBeal et al [5]

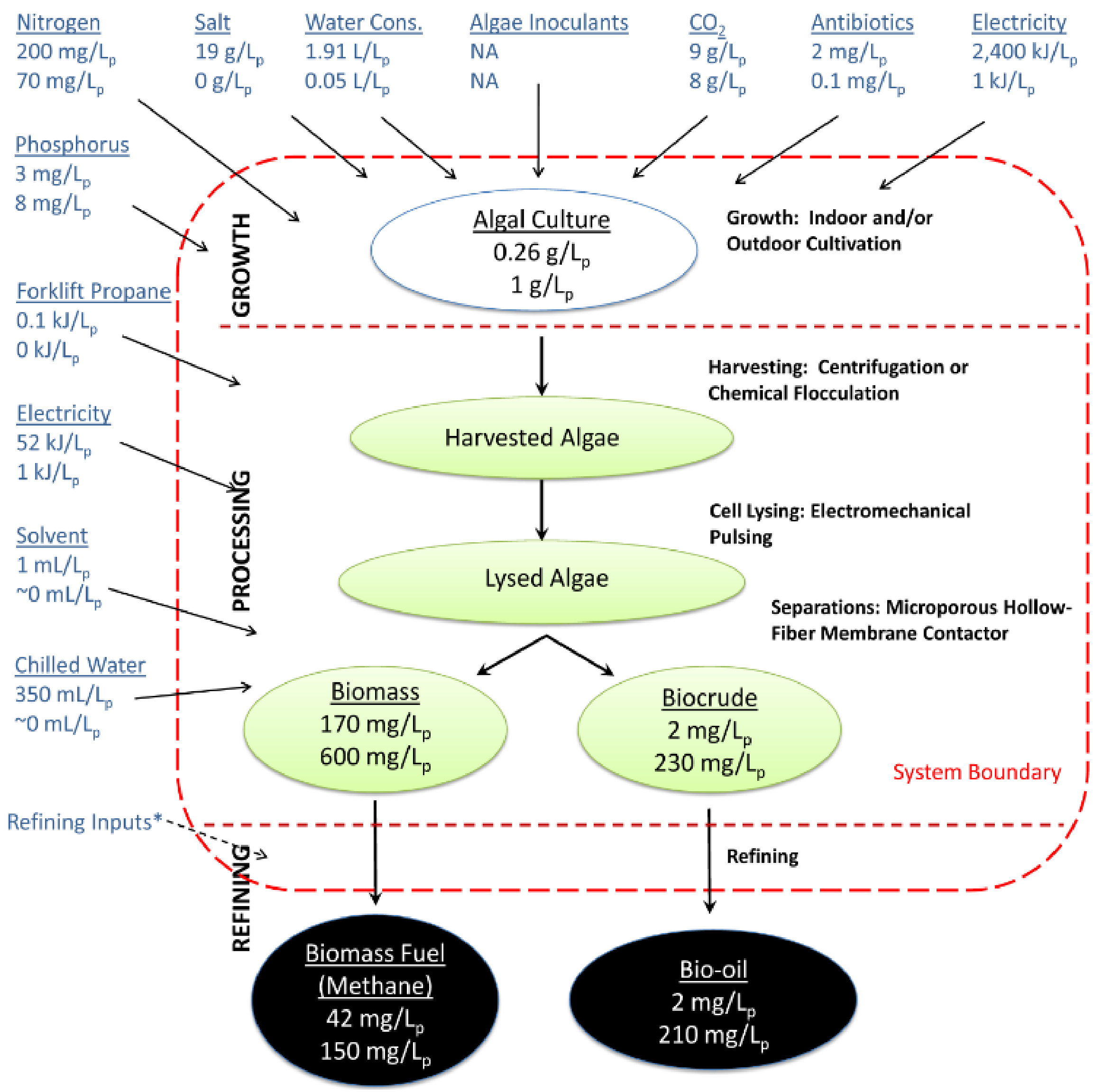
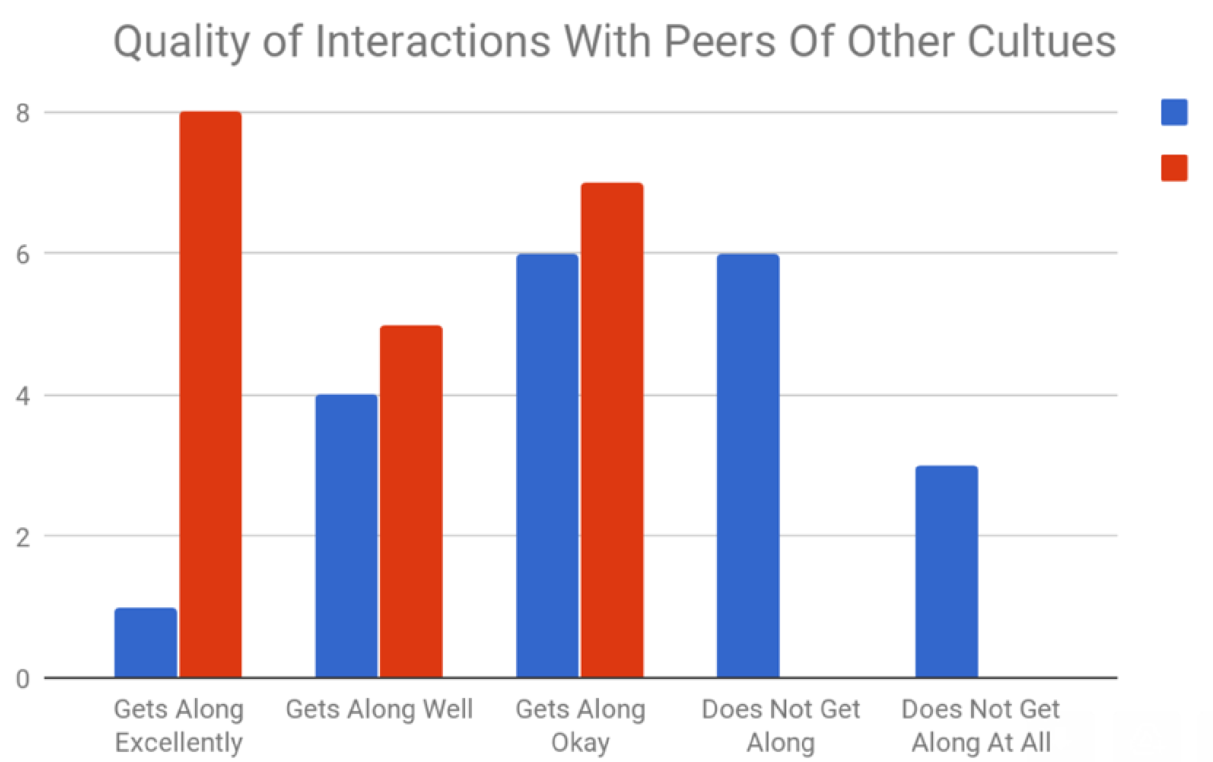


Figure 2: The Process from harvesting/growth to refining

A problem which can emerge during the research / study—is the communication difficulty, ethnicity and cultural divide between the researchers who came from different backgrounds and spoke different vocabularies. Having a background in various engineering disciplines often yields different thinking process and approaches. Though all could even be from the United States, but possibly different ethnicities, their initial communications resembled interactions of people from different cultures. Learnings from prior research on interactions from students in different cultures were useful as shown in this study[6] previously. Please see Figure 3 which exhibits how this prior research showed a trend of improving quality of interactions increasing over a period of 5 months. This study and the project's research-team members remained patient and open to each other with confidence that comfort working with each other would improve with time.



Legend: **Blue** is in September and **Red** is in January

Figure 3: Quality of Interactions with Peers of Other Cultures [6]

Conclusion

In conclusion, the integration of bioreactors into the design of large structures can provide numerous benefits, such as reducing excess CO_2 from the air and environment. It can also be used for the generation of renewable energy. Proper design and monitoring of the bioreactors will have the biggest effect on performance and yield. With the use of sensors, and new emerging technologies the process could be automated for collecting and fermenting the algae into biofuel for the structure's energy needs. The implementation of bioreactors in large structures could bring us one step to net zero, a future where structures actively contribute to reducing CO_2 emissions. Further research is needed to determine the overall economic impact and contribution to the sustainability of large-scale implementation.

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