The Use of Algae (Ulva Lactuca) to Reduce CO_2 in the Atmosphere

Shirzad Sheybani

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Science Research

Abstract

There are many studies being done on how marine carbon dioxide (mCDR) removal methods could be exploited to remove the excess CO_2 in the atmosphere. These studies are being conducted to halt or slow down climate change. This project's goal is to speed up the rate CO_2 diffuses into the water or find a way to allow algae to gain direct access to the CO_2 in the air.

The algae used, Ulva, was able to reduce the CO_2 in the atmosphere effectively after using a method in which air was bubbled around the Ulva to help the Ulva access the CO_2 in the air. To do this a skeleton of PVC was created inside a large (3' radius and 3' height) cylinder. Then a plastic grate was zip-tied on top, where the algae was pinned using tubes. Then the tank was filled with water until there was about an inch of water above the level of algae. Finally, to seal the experiment from the outer environment, multiple methods were tried; plastic sheeting in a cone shape on top of the container was used which had to be changed to two panes of glass (due to seagulls attacking the plastic sheeting).

The CO_2 monitor was able to deduce that the CO_2 could be reduced, from 400 ppm (the CO_2 level outside) to 140 ppm in just 5 hours, meaning the experiment worked.

This method of using Ulva to reduce CO_2 worked effectively and proved that using mCDR methods to reduce CO_2 in the atmosphere is a very attainable possibility.

Introduction

Greenhouse gases such as CO_2 are major contributors to climate change. It is to battle this problem that in recent years different marine Carbon Dioxide Reduction (mCDR) strategies have been developed and used. These mCDR strategies are part of the ocean's carbon cycle, and with the correct use, could help with efforts of reduction of atmospheric CO_2 concentrations. Algae is a plant that grows in all the world's oceans. Most humans are familiar with the negative effects of algae. They are a nuisance that make the pool green or make the beach water toxic. However, due to its fast growth, adaptability, and sustainability, algae have enormous potential in many fields. There is research currently being done to use algae as biofuel, medicine, or a permanent food source. Algae also has many useful properties, such as its ability to survive in both salty and fresh waters. They are responsible for more than 70% (Yap n.d.) of CO2 removal in the world, which is the reason algae were chosen for this CO_2 removal experiment. Ulva is a type of algae, like lettuce, and when a branch of the plant is taken apart, the plant is not harmed and the two plant pieces can function independently and regrow into 2 plants. Most importantly, for this research's purpose, algae have shown itself to be able to survive elevated levels of CO2, up to 10,000 ppm, with minimal damage to the plant's lipids, making it an ideal candidate for this project. (Singh, 2014)

Due to the rising rate of CO2 emissions on earth, there is a greater demand for mCDR to maintain global temperatures and there are grants being given by the National Oceanic and Atmospheric Administration (NOAA) to find effective mCDR methods. Despite the many efforts being made on land to limit and reduce CO2 emission, create more conscientious consumers, and prevent rainforests from being destroyed, humanity is fighting a losing battle. 71% of the earth is the ocean. If an efficient way could be found to combat CO_2 and global warming using this vast natural resource, the human civilization might have a chance to survive global warming.

Materials

-PVC pipes

-PVC joints (T joints and right-angle joints)

-PVC cutter

-White Eggcrate Grid

-Clear Flexible PVC (cut to 2” pieces)

-Ulva (obtained from the pier, therefore possibly had contamination)

-Large plastic cylindrical tank (3’ radius, 3’ height)

-Zip-ties

-Drill

-Submersible Water Pump

-Plastic Sheeting ($3.5*10^{-3}$ in)

-Clear Duct Tape

-Glass Pane (½ inch)

-Extension Cord

-5 Gallon Bucket

-Eco weather CO2 monitor

-Eco weather Light monitor

Method

In order to build the framework for the experiment, a variety of different tools and materials were needed. To start, it was decided that the best place to build the experiment would be near the ocean, where the light levels and other factors would be the similar to the natural habitat of Ulva and keeping the cost in mind, many parts were recycled throughout the building process. The experiment's main container was a large plastic cylindrical tank, which served as the water holder and allowed us to keep the experiment under control without the external elements affecting the results. For the internal infrastructure, PVC pipes were used, which also required the tools to cut, drill, and connect them. For cutting the PVC, a manual handheld cutter was used, along with a tape measure to ensure the PVC pipes would connect properly. Once the pieces were cut into the correct length, 90 degree and T-joint pipe connectors were used to join the pipes in a lattice form, to create the base framework for the later additions. (Figure 1-11) Once the PVC pipe lattice structure was completed, it was moved to the tank. (Figure 12) The tank was filled at AltaSea sight with ocean water. (Figure 13) After the PVC lattice structure was securely installed into the tank, a plastic grate was rested on the first level. (Figure 13) A flexible clear PVC was cut to lengths of about 3 inches and a lengthwise slit was made on it to allow for the pipe to curl up and have a snug fit in the holes in the grate. (Figure 14)

The next task was to harvest the Ulva, an easy yet time-consuming task. After enough Ulva had been gathered from the pier, the cut clear pipes were placed strategically to pin the Ulva to the plastic grate. (Figure 15) The last step was adding the circulation for the water. This was decided to be done by a jet spray system that would both supply the needed circulation of water, imitating the ocean, as well to create bubbles and provide greater surface area between the system’s air and the water in order to transfer the CO_2 into the water. (Figure 17) Finally, to make a closed system, isolated from the outside's CO_2 levels, a cone structure made of plastic was placed on top of the project. (Figure 21) After implementing a CO_2 sensor (Figure 23) and allowing the experiment to run successfully for a few days, the data started to fluctuate randomly. Upon further investigation, it became clear seagulls ripped holes into the cone, so the cover was replaced with 2 sheets of glass. (Figure 23-25)

Continuing running and monitoring the experiment to allow for the Ulva to establish in its new environment led to few more problems and failures; The flex tape that was used to patch a whole in the main container leaked, resulting on reduced water levels and death of the Ulva. A bulkhead was ordered and used to block and seal the whole. New Ulva had to be collected from the pier and the experiment had to be reset. Another setback was caused by a power outage that shut down the pump as well as the internet connection of AltaSea and again the experiment had to be restarted. Finally, a light sensor was added to see the reason for the variety of data, which turned out to be due to the weather fluctuation and the warehouse's shadow. (Figure 30-31)

Results

Through experimentation it was found that the CO_2 levels in the air where the experiment was running was around 400 ppm (parts per million), and after about 3 hours, the CO_2 level in the air of the experiment dropped to the low level of 250 ppm and continued to fall to levels of 117ppm over time. This result is lower than the lowest naturally achieved CO_2 recorded on earth, measured at 172 ppm, which was found in an ice cap. (CO2 Past n.d.) When control data was collected using the same testing setup without the bubbling mechanism to increase CO2 in the water, the CO2 level started at 400 ppm. However, this time the CO2 level first rose by 70 ppm and then gradually it got reduced to 300 ppm over 5 hours. As the other factors such as time of day, temperature, and light were kept the same, the rapid drop and low levels of CO2 achieved could only be due to the bubbling mechanism.

Discussion

The growing business of aquaculture could be exploited to reduce CO_2 levels and slow or even stop climate change using cost-effective methods. Based on this research, the Ulva in the system, a miniscule amount compared to sea farms, lowers the CO2 to 140 ppm level. Taking this concept to the mass-producing sea farms should make the results much more efficient than the small-scale experiment that was conducted. The hypothesis of the CO_2 levels decreasing more rapidly and efficiently by increasing the surface area and access of Ulva to CO2 using the bubbling mechanism yielded correct. The control experiment (without the bubbler) was much less effective in reducing overall CO2 levels. It was noted that the CO_2 levels during the night went up to 250 ppm for the experimental data. This was due to the plants' breathing cycle, and the levels were brought back down at sunrise.

It is worth noting that during this research the CO_2 levels only decreased from 1pm to 9pm. After installing the light sensor, it became clear that this was due to the warehouse's shadow falling on the experiment sight and not allowing the sunlight to shine on the project. The lack of sunlight caused the Ulva to take in oxygen to produce food for itself. In the future, this study should be tried on a larger scale with pure CO_2 that would be injected into the system, to see how the Ulva would cope with the higher concentrations and its rate of decrease. Theoretically the rate of CO_2 decreasing should be an exponential function to a negative power. It should also be tested if this system could be attached to a carbon emitter such as a power plant to see if the emissions would be reduced or not. If when attached to a main carbon emitter the algae can significantly reduce emissions, there may not be a need for any changes in everyday life for the restoration of low CO_2 levels, allowing humans to continue living as they please without the risk of severe climate change.

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Ulva Lactuca, A Source of Troubles and Potential Riches (n.d.). Retrieved October 5, 2022, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6627311/#:%7E:text=Ulva%20lactuca%20is%20a%20green,alga%20can%20produce%20dangerous%20vapors.

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Appendix

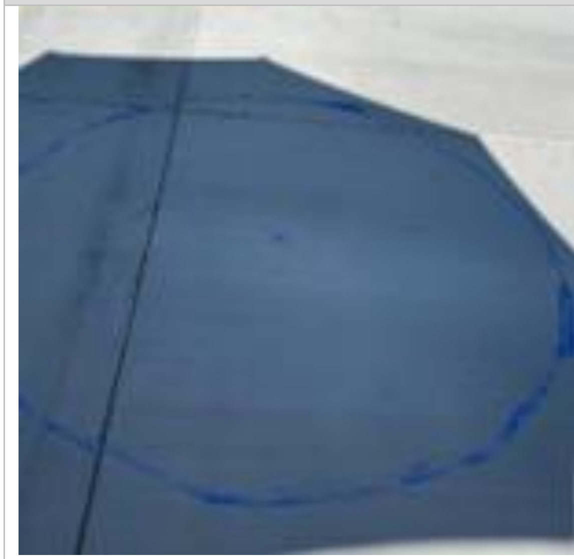
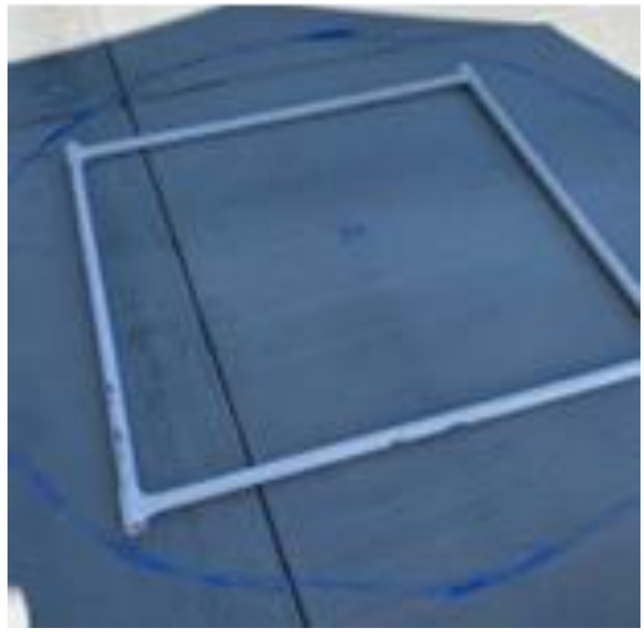
Building Lattice Support Structure	
 Figure 1: Chalk Outline of plastic cylinder's base	 Figure 2: Base of Lattice Structure
 Figure 3: Upward Right Elbow Joint	 Figure 4: First Spike Upward

Figure 5: T joint on Spike

Figure 6: Second Upward Spike for second layer

Figure 7: T joint on Second Spike

Figure 8: Replicate on all 4 corners

<table>
<tr><td>
Figure 9: Adding sideways protrusions to support middle pipe</td><td>
Figure 10: Added middle pipe to support the crossing pipes</td></tr>
<tr><td>
Figure 11: Crossing pipes added</td><td>
Figure 12: Rebuilt structure inside container</td></tr>
<tr><td>Adding Ulva</td><td></td></tr>
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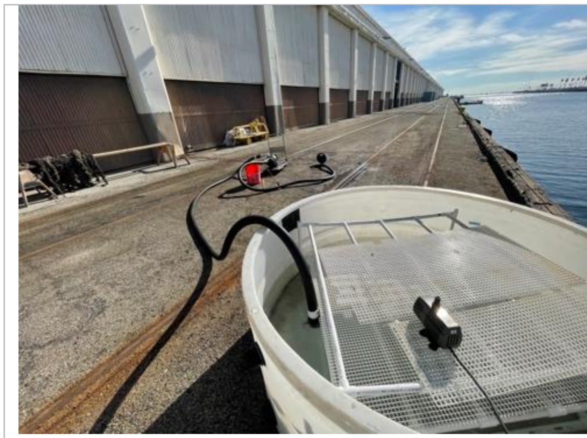
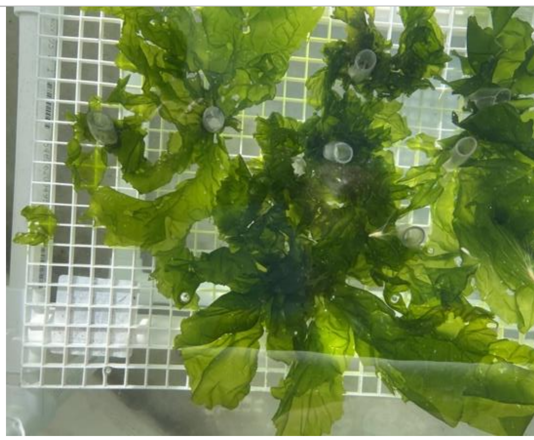
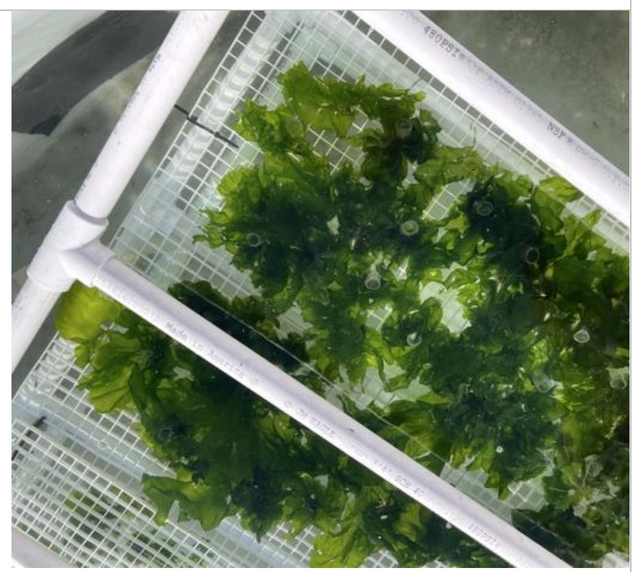
 Figure 13: Added Grate, Found Pump, and Filling Tank	 Figure 14: First Ulva
 Figure 15: Showing Pinning method	 Figure 16: Ulva Planting Finished
 Figure 17: Added Bubble Maker	
Container Seal Failure Leads to Drainage	

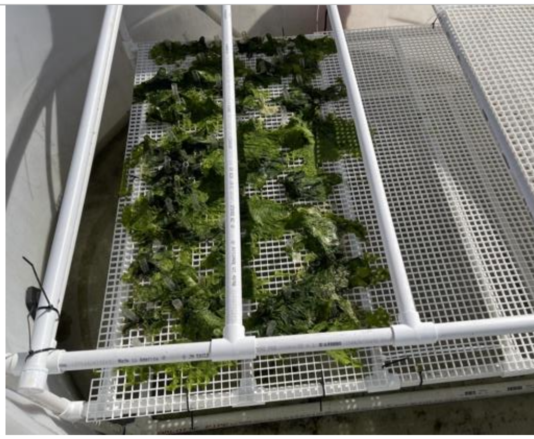


Figure 18: Punctured Seal, Drying Ulva

Figure 19: Dead Ulva

Adding Ulva (2nd time)

Figure 20: Ulva Replant after the repatch

Figure 21: Plastic Cone added

Figure 22: 3 Days Later

Figure 23: Changing the cover to glass (the CO2 sensor is in the tube)

Figure 24: Glass Added

Figure 25: Added Caution tape for Safety Purposes

Figure 25: 1 week later, Added Plant Food

Figure 26: 1 week Later, Immense Growth

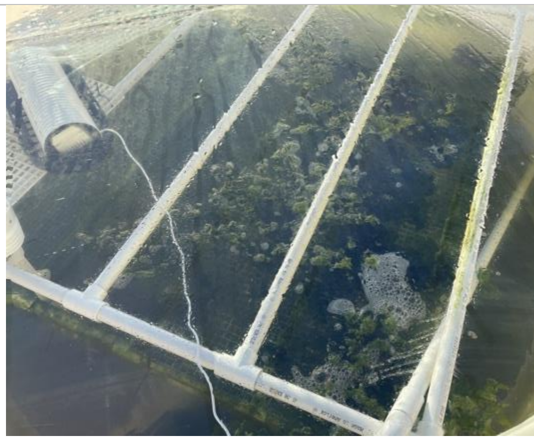


Figure 27: Moved bubble maker into water for no more bubbles but for there to still be circulation (a control experiment)

Data Collected

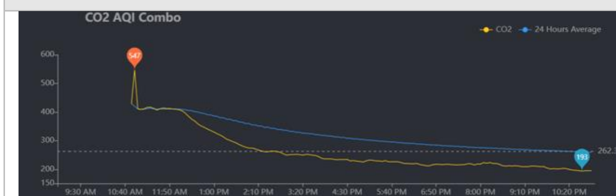


Figure 28: Data collected on a sunny day (experimental)

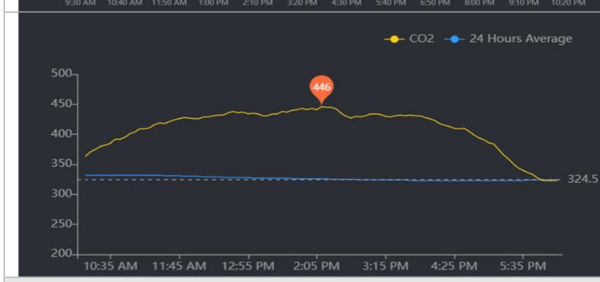
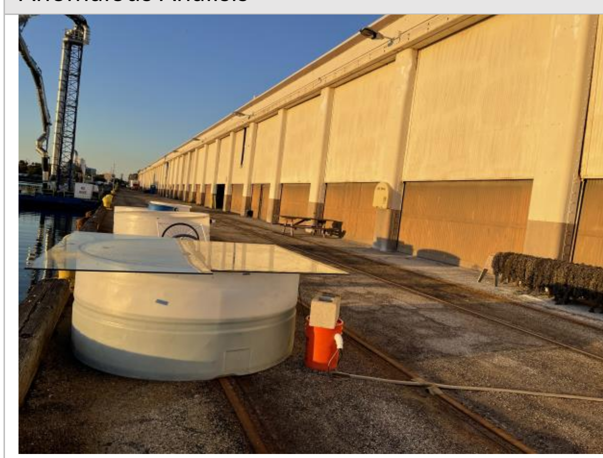


Figure 29: Data collected on a sunny day (control)

Anomalous Analisis



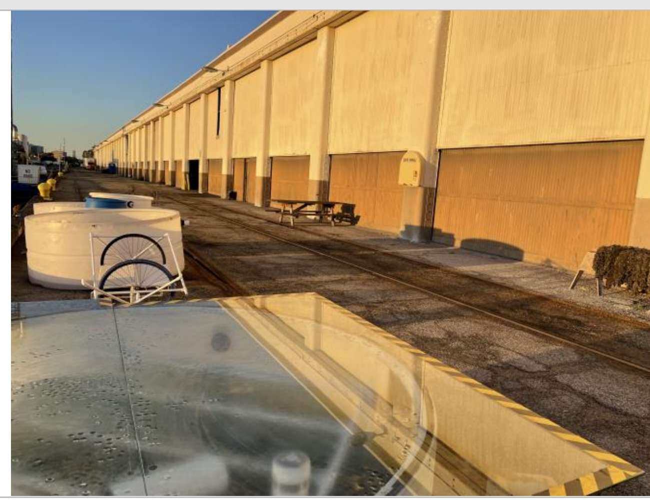


Figure 30+31: Warehouse that was blocking sun