The Influence Pore Water Transport Has on Sargassum Macro-Algae Degradation When Embedded in Submerged Coastal Sands

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Background

Sargassum macroalgae produce enormous blooms that pollute Florida coastal waters, sediments, and beaches. In this project, we seek to uncover processes that control the degradation of Sargassum (our study organism) and the complex relationships with permeable coastal sediments after the burial of the algae. One of the permeable sandy sediments' main characteristics is that liquids can flow through them. Wave-, wind-, and tide-driven currents in coastal environments flush the surface layers of permeable sediments creating a great environment for aerobic microbes. However, it is not known how this pore water flow affects the decomposition of buried algae that had settled on the seafloor. My experiment investigated Sargassum degradation embedded in submerged silicate and carbonate sand. We tested the null-hypothesis that pore water flow through the permeable sediment does not influence the decomposition of the algae in these typical Florida sands. The results of this study provide local officials, and coastal managers with Sargassum degradation rates. This is critical information required to estimate the approximate time it takes for Sargassum algae to degrade and thus for planning cleanup efforts.

Methods

My project involves two different experiments.

The first experiment: Degradation of Sargassum algae in seawater [Water Jars]

This experiment quantified sargassum degradation rates in aerobic seawater. The results produced reference data for the second experiment that quantified sargassum degradation rates in submerged silicate and carbonate sands.

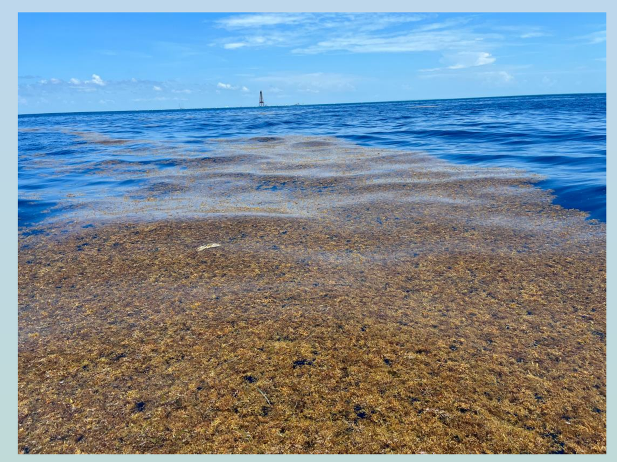
The second experiment: Determination of embedded Sargassum algae degradation in permeable silicate and carbonate sands flushed with air-saturated seawater via the oxygen and carbon dioxide measurements [Sediment Columns]

- 16 3.6 cm diameter, 10 cm long columns were used. Divided 50/50: 8 columns were filled with 30 cm3 of Silicate sands and the remaining 8 columns were filled with 30 cm3 of Carbonate sands.
- Within the 8 Silicate sand columns, 4 of which were filled with 1g of fresh but dead sargassum algae. The remaining 4 were deemed our control columns, and no algae were buried within them. The same process was repeated for the Carbonate sand columns.
- Once finished we were left with 8 Silicate sand columns (4 of which had buried Sargassum algae) and 8 Carbonate sand columns (4 of which had buried Sargassum algae).

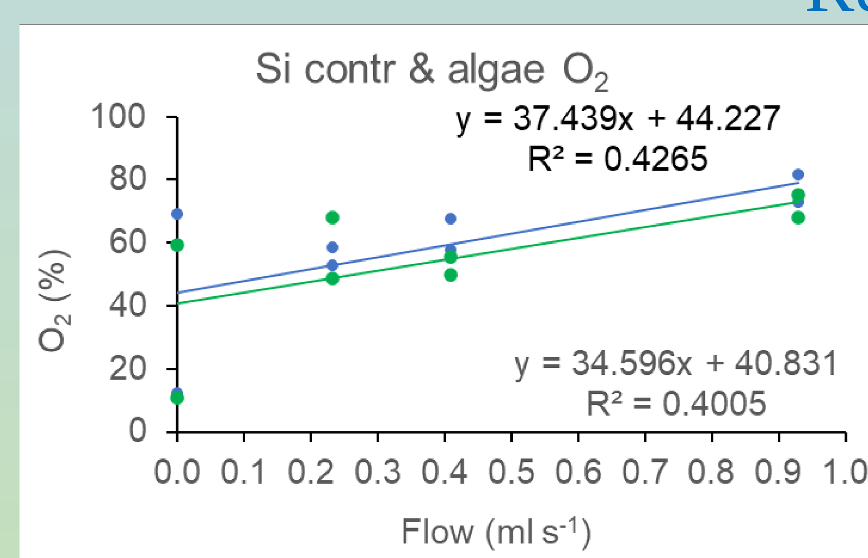
Likewise, the O2 (oxygen) consumption and CO2 (Carbon Dioxide) production in the columns are determined by sensors installed in the water circulation loop (shown in the schematic to the left). From these production and consumption rates, the decomposition rates of Sargassum in flushed Silicate and Carbonate sands can be calculated

Hypothesis:

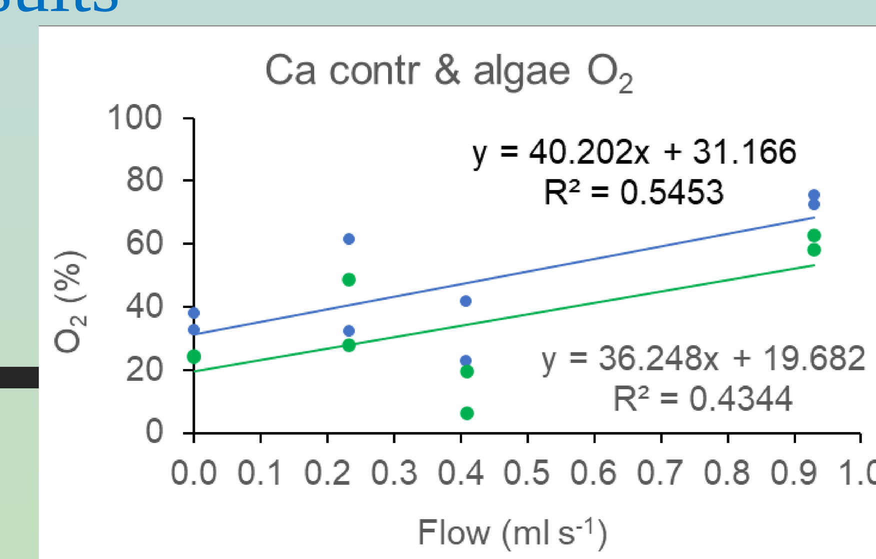
If pore water circulated through Silicate and Carbonate sand columns divided 50/50 with buried algae and controls with no algae, then the amount of pore water flow and Sargassum algae introduced will have no connection to Sargassum algae degradation rates.



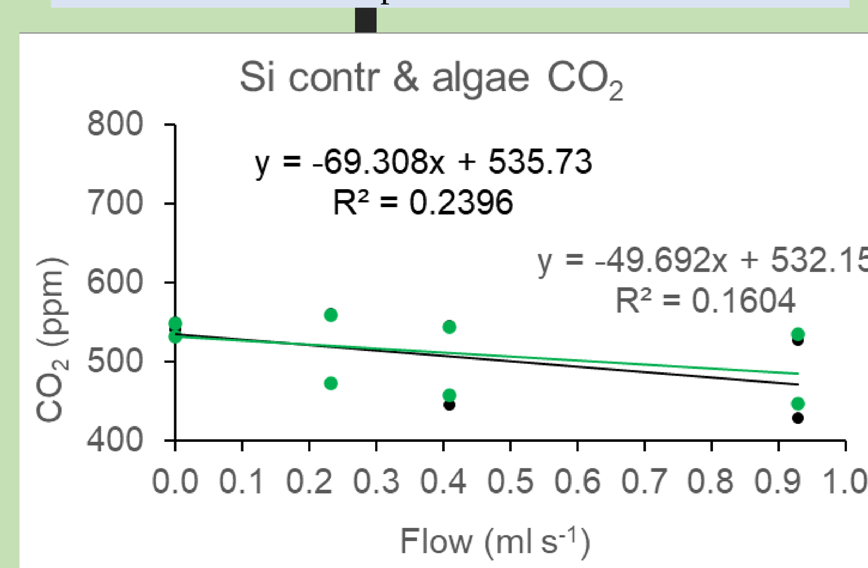
Results



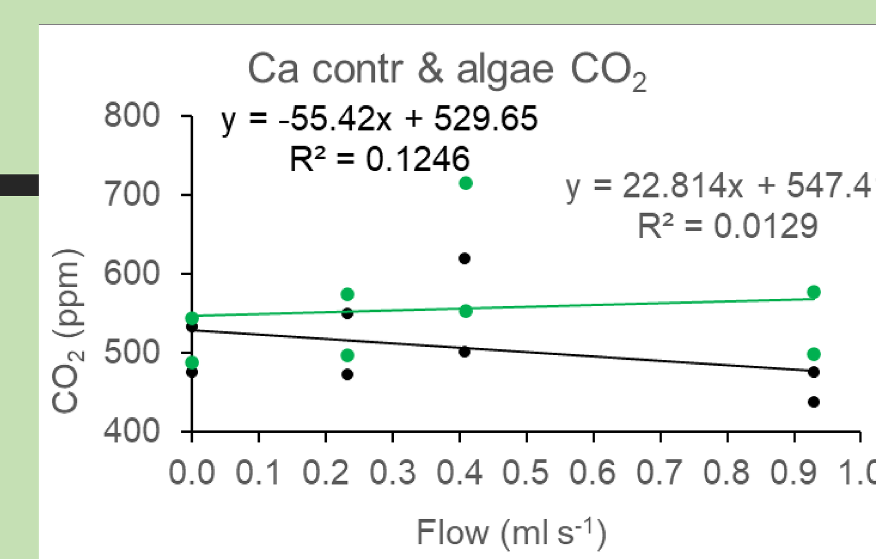
The positive slopes on the graph indicate an increase in O_2 consumption in both the control and algae columns. Silicate sands produce higher O_2% because they allow more pore water flow.



The positive slopes on the graph indicate an increase in O_2 consumption in both the control and algae columns. Carbonate sands produce lower O_2% the Silicate sands because they allow less pore water flow.



The negative slopes on the graph indicate a gradual decrease in CO_2 production in both the control and algae columns. As more pore water flows through at faster rates, less CO_2 can be released.



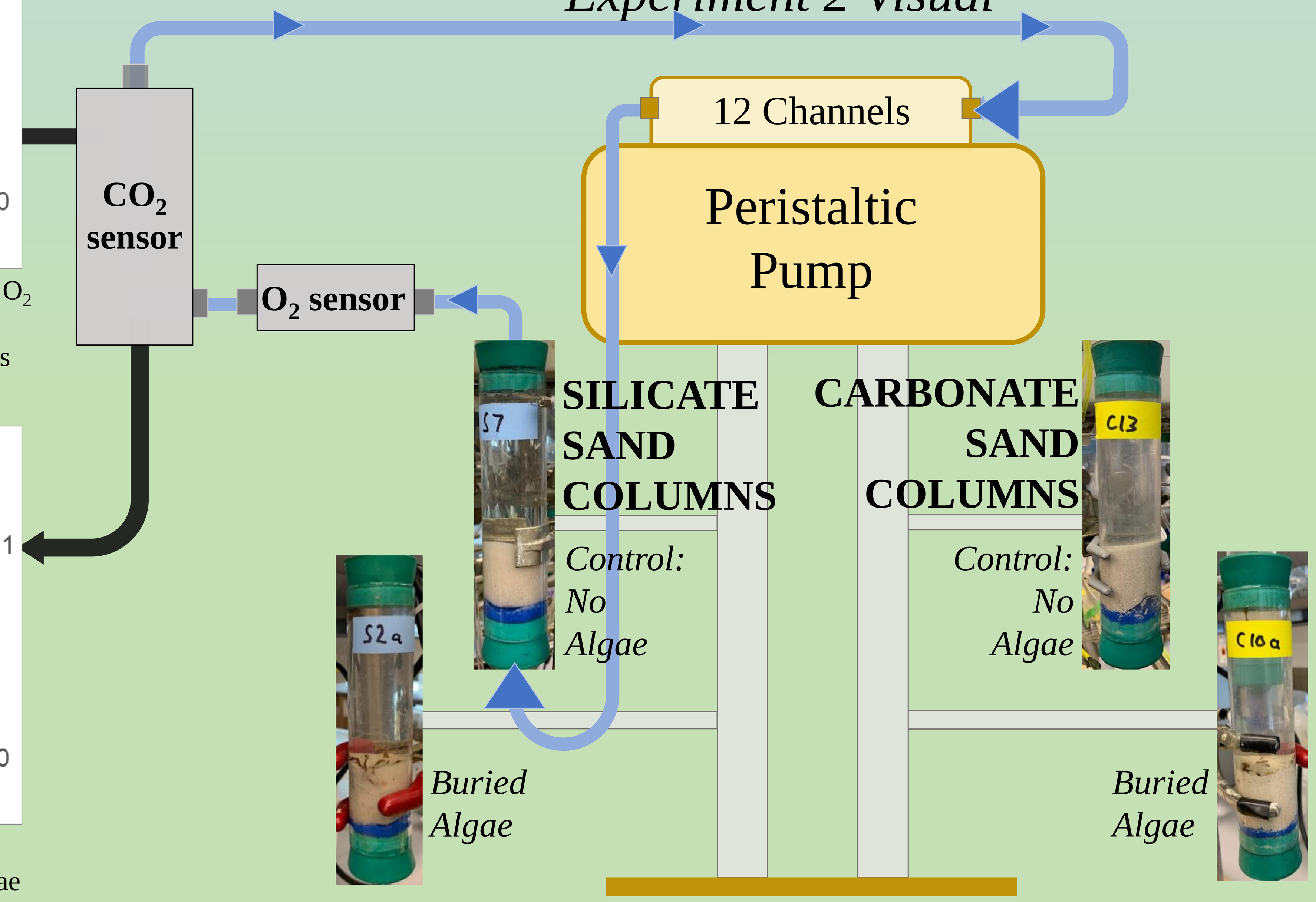
The negative slopes on the graph indicate a gradual decrease in CO_2 production in both the control and algae columns. The slight plateau of the algae trendline relates to the algae switching to anaerobic processes.

Conclusion

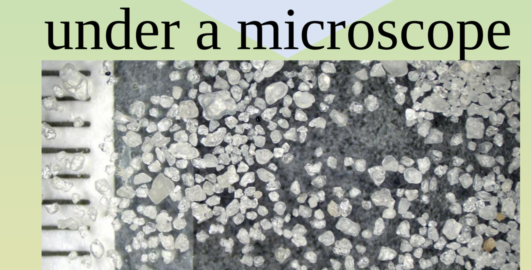
We can reject the null-hypothesis that pore water flow through the permeable sediment does not influence the decomposition of the algae in silicate and carbonate coastal sands. Silicate sands are mostly made up of smooth quarts crystals, which grants a smoother path for pore water and gives less surface area for microbial colonization. In carbonate sands pore water moves also through the porous biogenic particles allowing higher microbial colonization and activities. When algae are buried within those sediments, then degradation effects become amplified. This means that in carbonate sands degradation rates of Sargassum algae are faster when pore water can circulate as compared to degradation of the same amount of algae embedded in silicate sands circulated with pore water at the same rate. The results emphasize the importance of pore water flows for the degradation of organic matter embedded in coastal sand sediments. Increased coastal eutrophication, an excessive enrichment of nutrients into a body of water, and ensuing algal growth (including the growth of Sargassum macroalgae addressed in this study) can lead to a decrease of sediment permeability through deposition of large amounts of organic matter. Our experiments suggest that such a decrease of permeability would decrease the degradation of the embedded organic matter and thereby cause a negative feedback loop that could lead to a faster deterioration of the coastal sediment.

Experiment 1 Visual

Experiment 2 Visual



Silicate sand under a microscope



Carbonate sand under a microscope

References

Huettel, Markus, et al. "Hydrodynamical Impact on Biogeochemical Processes in Aquatic Sediments." The Interactions between Sediments and Water, 2003, pp. 231–236. https://doi.org/10.1007/978-94-017-3366-3_31.

Rasheed, Mohammed, et al. "Influence of Sediment Permeability and Mineral Composition on Organic Matter Degradation in Three Sediments from the Gulf of Aqaba, Red Sea." Estuarine, Coastal, and Shelf Science, vol. 57, no. 1-2, 17 Sept. 2002, pp. 369–384. https://doi.org/10.1016/s0272-7714(02)00362-1.

Santos, Isaac R., et al. "The Driving Forces of Porewater and Groundwater Flow in Permeable Coastal Sediments: A Review." Estuarine, Coastal and Shelf Science, vol. 98, 25 Oct. 2011, pp. 1–15. https://doi.org/10.1016/j.ecss.2011.10.024.