Experimental Investigation of the Degradation of the Nuisance Algae Sargassum Buried in Beach Sands Ventilated by Tidal Pumping

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***Sargassum* Algae found in Florida Keys**

***Sargassum* Algae buried in Sediment**

Abstract

Vast amounts of the macroalgae *Sargassum* washing onto Florida beaches have become a major problem as they emit toxic waste that negatively affects not only the ecosystem but the local and tourist civilians. The goal of this study was to quantify degradation rates of Sargassum that was embedded in silicate and carbonate beach sands. We tested the hypothesis that the degradation of the buried algae is accelerated through tidal gas exchange. The natural tidal pumping mechanism was recreated in a lab setting with the tidal water table oscillations in the sand pumping air into and out of the sediment. CO_2 production and O_2 consumption caused by *Sargassum* degradation in the sands was contrasted with the respective gas dynamics in beach sand with embedded algae but without tidal pumping. The results emphasize that the beach sands are natural biocatalytic filters that promote aerobic microbial decomposition processes. The decomposition rates determined here can be used by coastal managers for the planning of cleanup activities.

Background and Hypothesis

- Large blooms of macroalgae of the genus *Sargassum* recently have washed onto Florida beaches. When degrading, these algae can cause low oxygen levels and toxic sulfides that are harmful to beach organisms. The stranded algae have also brought up a number of other problems for local and tourist civilians, e.g. putrid smells or blocking water access.
- The *Sargassum* blooms are due to factors associated with increased anthropogenic nutrient input into the oceans and global warming, which boost Sargassum growth.
- Because *Sargassum* algae grow floating in the sea, they can also easily reach beaches, where they wash up before getting buried in the sediment. Beach sediments in north Florida consists mainly of crystalline quartz, while south Florida beaches are dominated by biogenic carbonate sand. All beach sands are characterized by relatively high permeability which allows tidal groundwater level changes to pump air into and out of the beach. Presently it is unknown how long *Sargassum* persists after burial in beach sands, and how the sand mineral composition and tidal beach ventilation affect the degradation rates.
- The main objective of the study therefore was to determine degradation rates of *Sargassum* embedded in silicate and carbonate sands ventilated by tidal pumping.

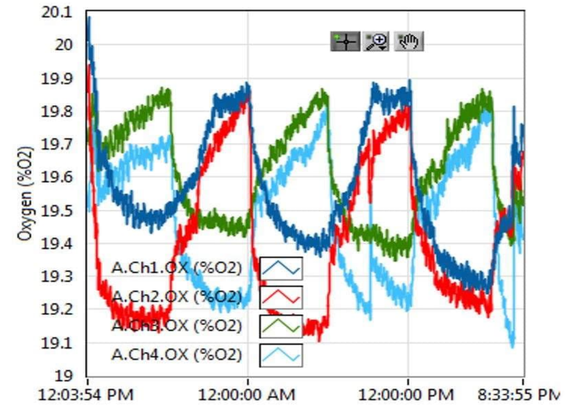
Hypothesis

- We tested the hypothesis that the degradation of Sargassum algae buried in silicate and carbonate beach sands is accelerated through tidal gas exchange.

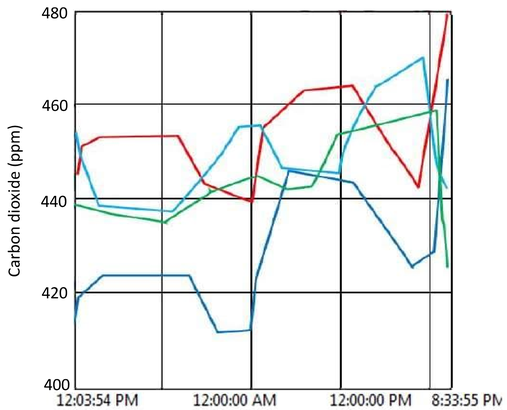
Experimental Methods

We developed an experimental setup that simulated the tidal gas exchange in silicate and carbonate beach sands. The composition of the gases exchanged across the surface of sands with or without embedded *Sargassum* was used to quantify the degradation rates of the buried algae. Three 140-liter containers were set side by side each with 12 large sediment columns placed vertically. Core liners filled with silicate or carbonate sands (median grain size 125-500 µm) were exposed in the containers to tidally changing water level (Containers A and B, 6-hour rise and 6-hour fall produced by a timer-controlled pump). 4 columns of each sand type had a layer of 8 g fresh but dead Sargassum buried at 10 cm depth. Degradation with tidal pumping was tested against algal degradation I non-tidal pumped sands (Container C) . The top of the cores was closed by rubber stoppers that had a port for gas exchange. Gas-tight tubing guided the exchanging. gases through CO_2 , O_2, and flow volume sensors.

Tidal pumping containers with algae packed sediment columns (Left). Pump timing mechanism used to switch tides (Right)



O2 levels in column outflow showing the effect of tidal pumping and embedded Sargassum. Cores with algae (red and light blue lines) released less O2 than cores without algae (dark blue, green lines).



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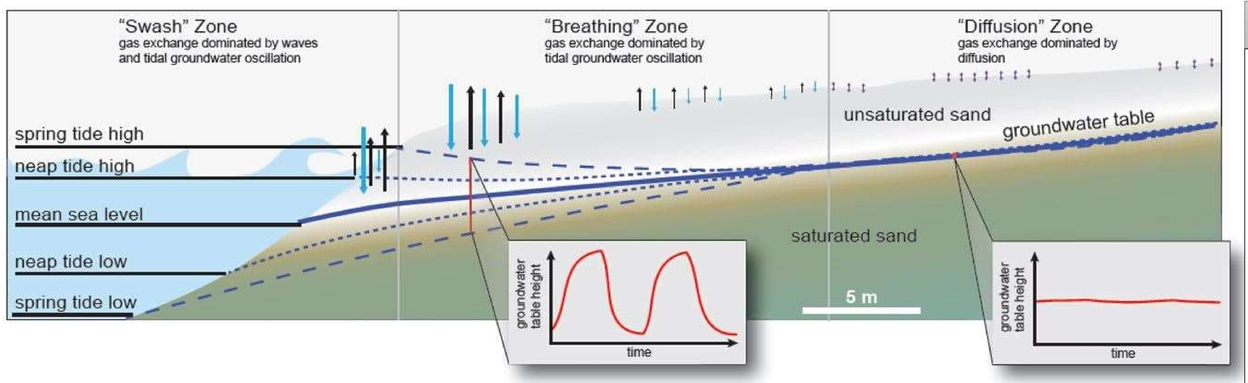

Tidal pumping increases gas exchange, drawing oxygen into the sediment, and expelling waste CO_2. During ebb tide, the dropping water within the beach draws air into the sand, transporting oxygen to the microbial communities that degrade buried algae. The flood reverses the transport, carrying waste products of the degradation process (e.g. CO_2) out of the sand thereby accelerating the sedimentary degrdatation process (Huettel 2000).

Results

- The gas exchange of the control (no algae) and treatment cores (embedded algae) showed a clear tidal pumping in the air released from the sand cores during the flood cycle had increased CO_2 and decreased O_2 concentrations.
- During ebb, air with room CO_2 (390 ppm) and O_2 (21%) concentrations were drawn into the sands. Embedded *Sargassum* enhanced CO_2 production and O_2 consumption in the sands.
- The carbonate sand had higher CO_2 release and higher O_2 uptake rates compared to the silicate sands.
- The sands that were not exposed to tidal pumping had much lower CO_2 release and lower O_2 uptake rates compared to the sands with tidal pumping.

Conclusion

Overall, our hypothesis was correct in that the tidal pumping mechanism is a significant process that enhances buried Sargassum degradation in permeable sandy beaches. Carbonate sands had higher degradation activity compared to silicate sands. This ongoing experiment is producing realistic degradation rate estimates for Sargassum buried in Florida beaches that can be used by coastal managers for beach cleanup planning.

References

Huettel, & Rusch, A. (2000). Transport And Degradation Of Phytoplankton In Permeable Sediment. Limnology And Oceanography, 45(3), 534–549. Https://Doi.Org/10.4319/Lo.2000.45.3.0534

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