Chromatographic Separation of Dissolved Organic Matter in Water-Saturated Tidal Beach Sands

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Background

- Recently, algal blooms have been a hot topic of coastal news, particularly those of "red tide" (planktonic, *Karenia brevis*) and sargassum (a macroalgae).
- Piles of sargassum on beaches prevent the success of nesting birds and turtles. Red tide blooms kill marine life and cause respiratory issues for air-breathers, including humans. Both sargassum and red tide blooms negatively impact the tourism economy.
- Once the algae is buried, it becomes a key element of the sedimentary decomposition process. The distribution of this dissolved organic matter (DOM) is critical for the microbial degradation process.
- The goal of this project is to investigate the transport and separation of this DOM, derived from algal blooms, through permeable silicate (SiO_2) and carbonate (CO_3) sands that are common along Florida shores.
- Anthropogenic nutrient pollution and global warming are major causes of the increase of these blooms. The results of this experiment will provide an understanding of what happens once the algae is buried, which will lead us to the next steps in how to mitigate the macro- and planktonic algae blooms.

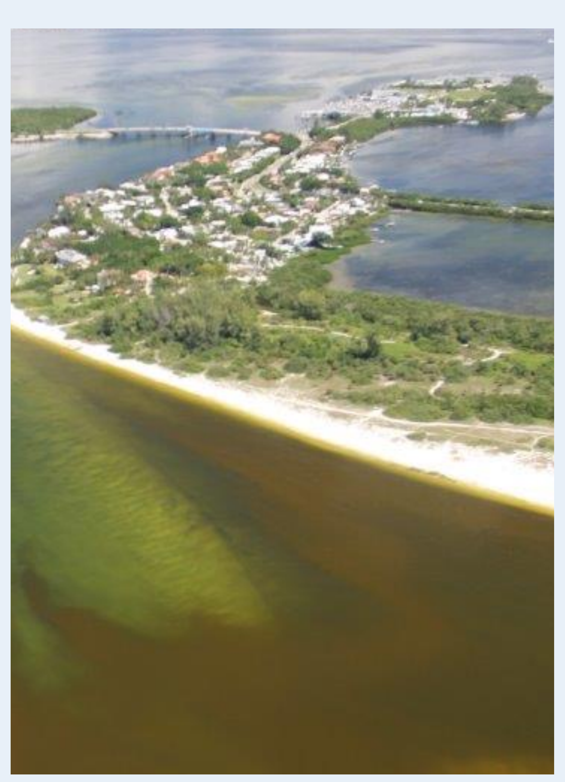

Fig. 1. Understanding algae pigment: an aerial view of red tide near Southwest Florida in the Gulf of Mexico (MOTE (via NCCOS) 2020).

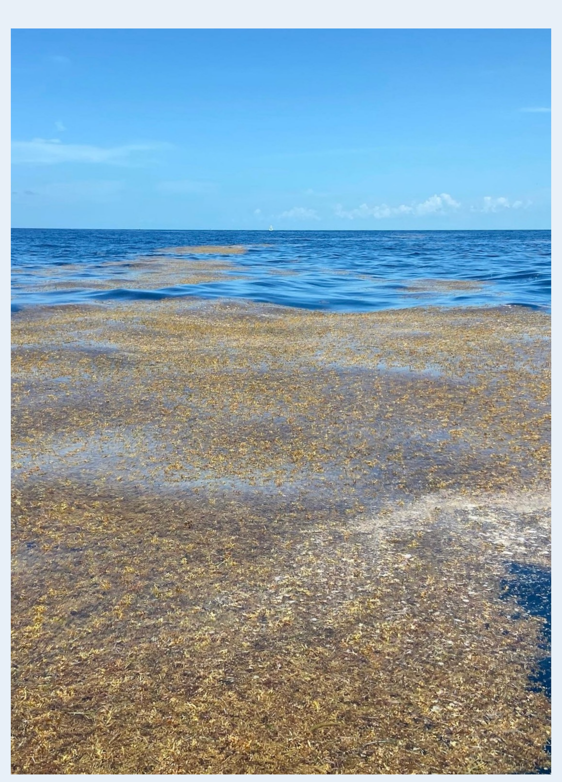

Fig. 2. Macroalgae: A sargassum patch floating near Sombrero reef in Marathon Key, FL after Tropical Storm Alex (Rosengarten 2022).

Methodology

I set up an experiment in order to simulate how DOM is moved through sediment as a result of pore water flow. The set-up consisted of two columns filled with sediment: one fine SiO_2 and one fine CO_3 - connected to a Harvard Apparatus Mechanical infusion Pump. Water, first dyed with food dye and then, on a second run, with phytoplankton pigment (the pigment that is released when algae decomposes), was pumped through the columns at a rate of ~5mL/hr to determine (a) relative transport velocities of the different types of DOM, and (b) if the dyes or pigments were separated within each sediment type.

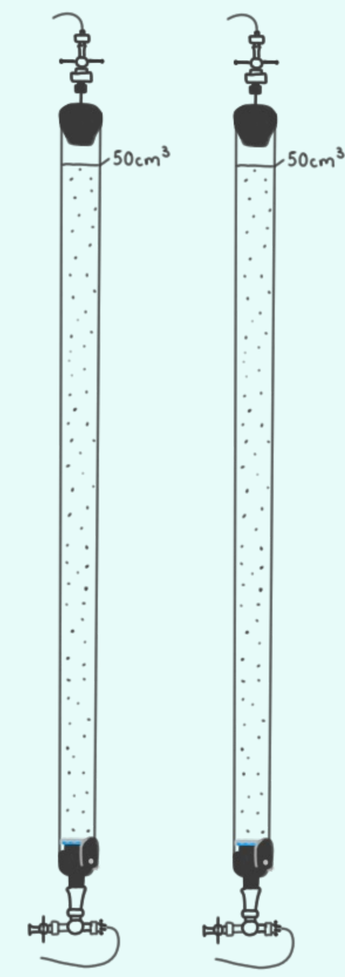

Fig. 3a. (above) The set-up of two sediment-filled columns.

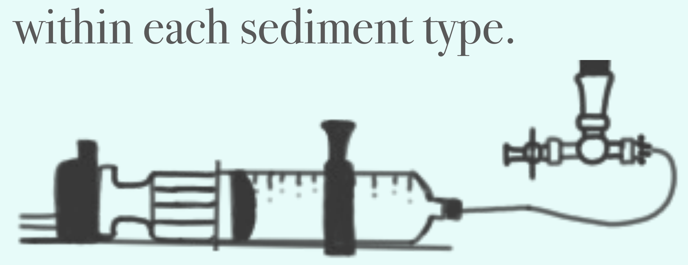

Fig. 3b. The connection of the water-filled syringe (which is emptied by the infusion pump) to the bottom of the column.

After all dye or pigment had exited the column (12 5mL samples for each column with run time totaling 11 hours), samples were run through a spectrophotometer to determine the attenuation spectra of dyes and pigments and at what time the peaks came out of each column.

Results

Fig 4. Samples collected when running organic dye through (a) SiO_2 and (b) CO_3 sands; and phytoplankton pigments through (c) SiO_2 and (d) CO_3 sands; shows the color separation over time in the two sediments.

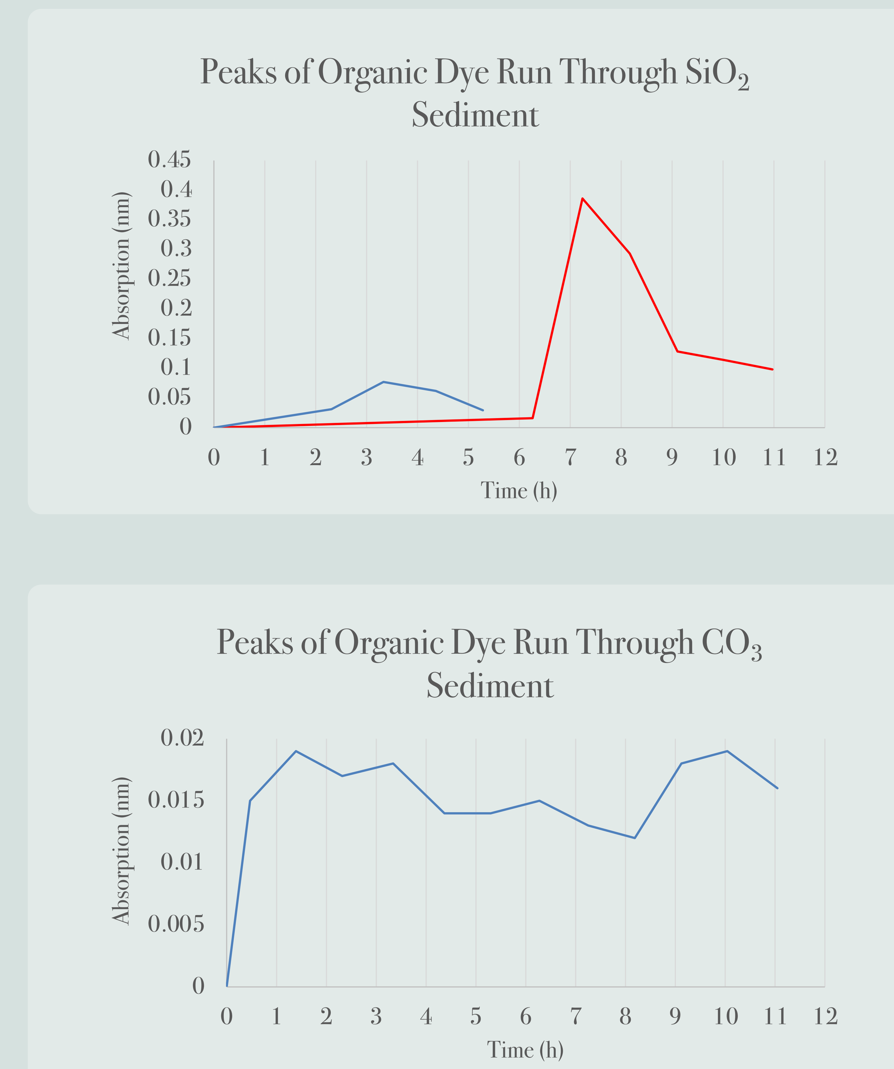

Fig 5. Examples of the sequence of peaks appearing when running organic dyes through SiO_2 and CO_3 sands.

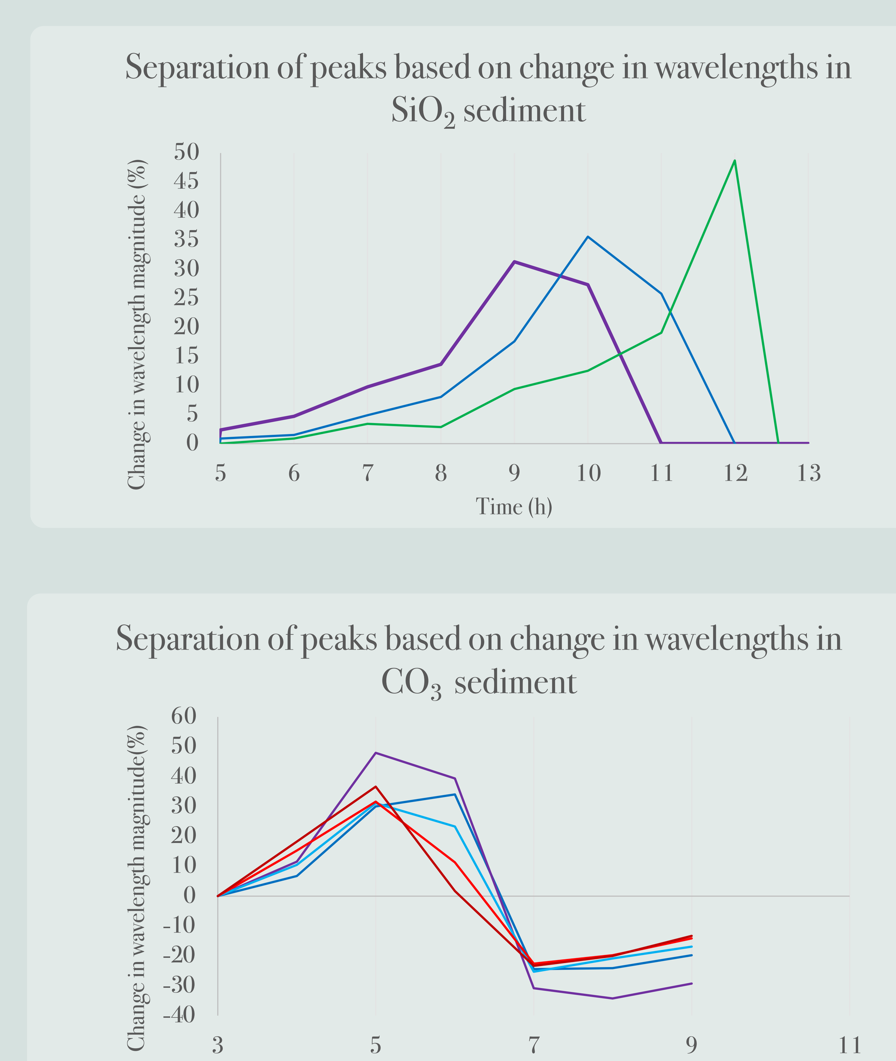

Fig 6. The sequence of peaks appearing when phytoplankton pigments move through SiO_2 and CO_3 sands.

Results (cont.)

- The organic food dyes separated within the two sands. For example, red dye separated into both blue and red, which then migrated at different velocities through the sediments.
- The migration velocities were similar between the SiO_2 and CO_3 sands, with slower migration of dyes compared to the pore water.
- Phytoplankton pigments separated within the two sediments similarly to that observed with the food dyes, and, again, with more pronounced pigment separation in the SiO_2 sand.

Fig 7. The "golden tide" culprit: sargassum floating over Sombrero Reef near Marathon Key, FL (Rosengarten 2022).

Conclusion

The experiments demonstrate that DOM is separated in permeable sediments when pore water flows transport this material through the intertidal space. This separation is caused by the interaction of the DOM molecules with the mineral matrix of the sediments and causes concentration of DOM in specific sediment layers. This concentration can enhance the microbial degradation of these substances.

Recommendations

- Future assessments of the degradation rates of DOM (originating from algal blooms) should consider the separation processes in permeable coastal sediments.
- Degradation may be reduced if too much organic material clogs the seafloor sediment.
- Algal blooms- ranging from less harmful sargassum blooms to HABs like red tide- can be mitigated by limiting runoff (particularly of nitrogen and phosphorous-based fertilizers). Legislation and efforts to lessen runoff are the next step in slowing both (1) these blooms and (2) organic matter input to coastal sediments.

References

Huettel, M., and A. Rusch (2000). Transport and degradation of phytoplankton in permeable sediment. Limnology & Oceanography, 45(3), 534-549.
MOTE Marine Laboratory. (2020, December 15). *NCCOS supports expansion of Red Tide Respiratory Forecast in Florida and Texas*. NCCOS. Retrieved March 21, 2023, from https://coastalscience.noaa.gov/news/nccos-supports-expansion-of-red-tide-respiratory-forecast-in-florida-and-texas/

Thank you to WIMSE for your continued support of my research!