ANALYSIS OF SOIL IN A CHESAPEAKE BAY SALT MARSH USING FOURIER TRANSFORM INFRARED SPECTROMETRY: EFFECTS OF GLOBAL CLIMATE CHANGE AND SEA LEVEL RISE IN COASTAL MARSHES

University Honors Capstone Presentation

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WHY STUDY SALT MARSHES?

• Average global atmospheric carbon dioxide concentration has increased by more than 38% since the beginning of the industrial evolution

• Salt marshes are crucial carbon sinks, known as the Blue Carbon sink

• They store more than 20 times more carbon than deep-sea carbon burial sites, which cover a much larger portion of the globe

• Changes in climate and land-use can turn these natural carbon sinks into sources of anthropogenic carbon dioxide emissions
StudY Site

- Chesapeake Bay salt marsh in the Blackwater National Wildlife Refuge
- Located on Eastern shore of Maryland
- Sea level has risen 1-3 mm/yr since 1930s; increased to 4-10 mm/yr in 2011
- Ideal location to analyze changes in soil organic matter in relation to accelerated water rise
ANALYSIS OF SOIL ORGANIC MATTER (SOM)

- SOM is vital to the health of an ecosystem, contributing to soil nutrients, water storage and other ecosystem services
- Previous info on level of carbon sequestration, but no studies on the chemical properties of organic matter and how it changes with sea level rise
- Analysis will show changes in vegetation and degradation rates in the marsh
SAMPLES

- 5 cores (1/2 meter long), divided into 1cm intervals
- Samples were dehydrated, homogenized, acid fumigated
- 20 samples ran using FTIR
- 7 vegetative samples
- 3 samples from Sedge, High Marsh, Ghost Forest, and Transition cores; deep, middle, and upper soil
- 1 sample from Upland core
FOURIER TRANSFORM INFRARED (FTIR) SPECTROMETRY

• Measures how well a sample absorbs light at each wavelength; each functional group has a characteristic wavelength.

• Different functional groups in SOM can indicate distribution of carbohydrates, proteins, lipids, and other major chemical compounds.

• Changes in chemical makeup of SOM will show effects of sea level rise and climate change.

• I used the KBr Pellet Method.
FTIR RESULTS

Ghost Forest - Upper Soil

Intensity

Wavenumber (cm⁻¹)
<table>
<thead>
<tr>
<th>Compound Class</th>
<th>Type</th>
<th>Mode</th>
<th>Band Position (cm(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carboxylic Acid</td>
<td>-COOH</td>
<td>C=O stretching</td>
<td>1705</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C-O stretching</td>
<td>1267</td>
</tr>
<tr>
<td></td>
<td></td>
<td>O-H</td>
<td>1424</td>
</tr>
<tr>
<td>Ester</td>
<td>Aliphatic</td>
<td>C=O stretching</td>
<td>1739</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C-C-O stretching</td>
<td>1158</td>
</tr>
<tr>
<td>Amide</td>
<td>Amide I</td>
<td>C=O</td>
<td>1658</td>
</tr>
<tr>
<td></td>
<td>Amide II</td>
<td>C=O</td>
<td>1544, 1565</td>
</tr>
<tr>
<td>Lignin</td>
<td>Aromatic Rings</td>
<td>Ring vibrations</td>
<td>1512</td>
</tr>
<tr>
<td>Paraffin</td>
<td>Aliphatic</td>
<td>CH(_3)</td>
<td>1379</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CH(_2) scissoring</td>
<td>1452</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td></td>
<td>CH(_3) asymmetric</td>
<td>1467</td>
</tr>
<tr>
<td></td>
<td></td>
<td>O-H stretching</td>
<td>3395</td>
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<tr>
<td></td>
<td></td>
<td>C-O asymmetric</td>
<td>1035</td>
</tr>
<tr>
<td></td>
<td></td>
<td>O-H out-of-plane</td>
<td>663</td>
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<tr>
<td>Aliphatic Chains</td>
<td>Methyl</td>
<td>CH(_3)</td>
<td>2918, 2849</td>
</tr>
</tbody>
</table>
FTIR CONCLUSIONS

- All cores consisted of the same set of main functional groups: carboxylic acids, esters, amides, lignin, paraffin, carbohydrates, and aliphatic chains.

- With depth, all cores showed a decrease in carboxylic acids and an increase in carbohydrates. This corresponds with previous studies of sediment organic matter which found that carboxyl groups exhibit losses first, followed by carbohydrates, and then aromatic compounds and clay minerals (Li, Minor, and Zigah. 2013).

- I predict that deeper samples of the same cores would show a gradual loss of carbohydrates and an increase in clay and aromatic compounds.
FTIR RESULTS CONCLUSIONS
• A 2D correlation program was used to create synchronous plots to detect changes in soil composition across the four cores along the same depths.

• The program compares changes in spectra against a certain perturbation (such as depth).

• By spreading overlapping peaks over two dimensions, the spectral resolution is increased and interpretation of one-dimensional spectra is greatly simplified.
2D CORRELATION CONCLUSIONS

• All cores have major auto-peaks at ~1040 cm\(^{-1}\) and ~3415 cm\(^{-1}\), which indicates changing carbohydrates and carboxylic acids respectively.

• The decrease in carbohydrates as elevation increases may be explained by an increase in oxidative degradation of polysaccharides and other carbohydrates as the soil becomes less water-logged.

• Carboxylic acid moieties decreased slightly as distance from the marsh increased, which may also be explained by faster degradation rates at higher elevations. The results of another study of the same cores also showed increasing oxidative degradation with increasing elevation using high acid:aldehyde ratios in lignin-derived phenols.


QUESTIONS?