Connecting Chemical Composition and Methane Production in a West Michigan Peatland

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Introduction:

Methane (CH_4) is a potent greenhouse gas, the production of CH_4 from natural wetlands will be an important feedback for future climate change. However, current biogeochemical models do a poor job predicting differences in CH_4 emissions among wetlands. Our goal was therefore to develop a predictive framework for the production of CH_4 from the decomposition of organic matter in peatlands.

Specifically, we investigated the influence of the biochemical composition of the organic matter. Biopolymers must be broken down via hydrolysis and then fermented to produce the necessary substrate for methanogenesis. Depolymerization and fermentation are currently considered the rate-limiting steps in the production of CH_4. Therefore, we measured the concentration and composition of hydrolysable neutral sugars, which represent the potentially fermentable carbohydrate content of the peat.

Hypothesis:

Lower rates of methane product will be observed from peat samples deeper within the bog due to the depletion of easily hydrolysable and fermentable carbohydrates in older peat samples.

CH_4 production will be correlated with total sugar content, indicating labile substrate availability.

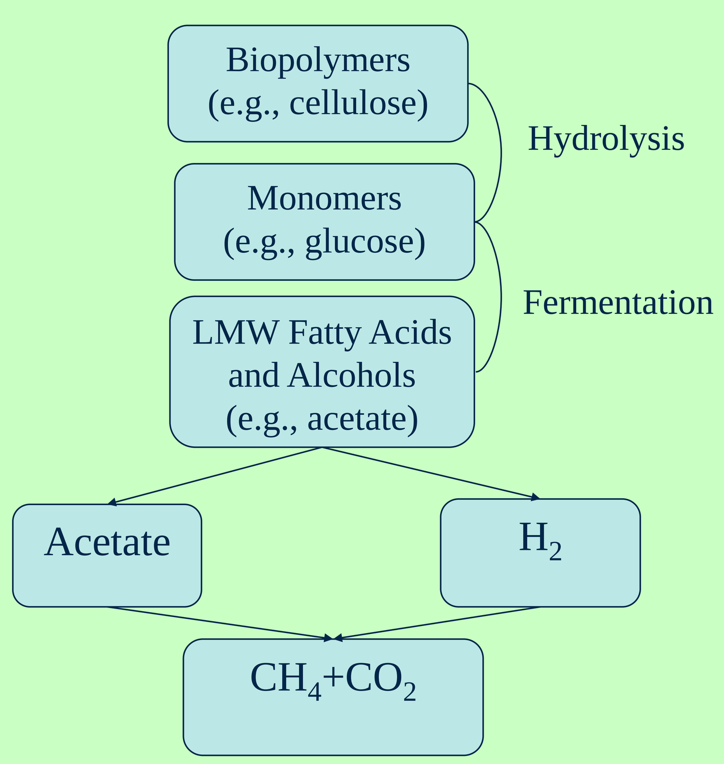
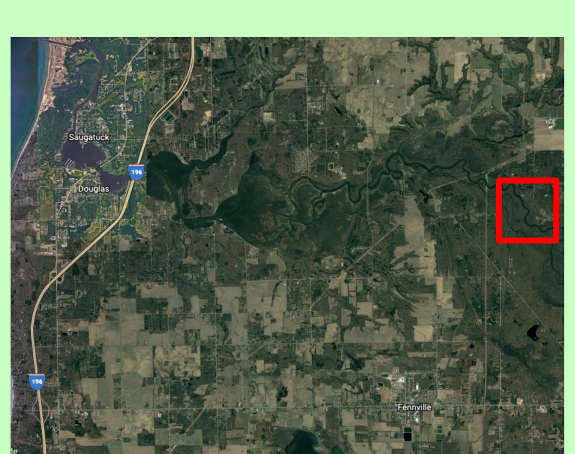


Fig. 1 Flowchart representing the process of anaerobic organic matter decomposition from the hydrolysis of biopolymers to methanogenesis.

Site Description:

Peat cores were collected from five different sites in Miner's Lake Bog in Allegan Township, Michigan which is a peat bog with local access. We sampled peat with a coring device measuring 3 meters in length. Each core sample was 500 cm long. Cores were collected from both hollow and hummock micro-topographies in the bog and the surrounding fen.

Site	Description	pH
Site 1	Hollow; middle of bog	5.0
Site 2	Hollow; edge of bog	5.4
Site 3	Hummock; middle of bog	4.3
Site 4	Sedge meadow; outside bog	4.9
Site 5	Thick hummock	4.6



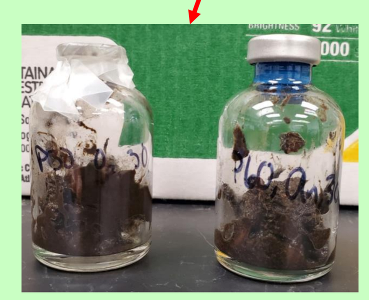
Miner's Lake Bog, Allegan Township, MI

Locations of cores within the bog

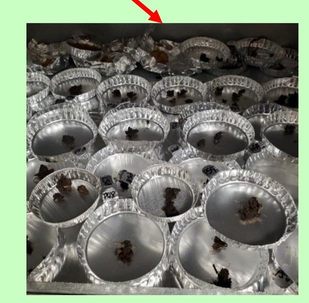
Methods:

The core was partitioned into 20 cm slices for the following analyses:

Taking a peat core in the field



Anaerobic incubations: 10 grams were partitioned into incubation bottles to simulate aerobic and anaerobic conditions. The samples were analyzed by gas chromatography to measure the carbon dioxide and methane production during decomposition.



C:N Analysis: 5 grams were separated out to dry in the oven for elemental analysis to find the carbon and nitrogen content of the peat.

pH, Ion Chromatography and Iron Analysis: 3 grams of peat were extracted by KCl, from the core, to determine the soil pH, terminal electron acceptor concentrations (NO_3^- and SO_4^{2-}) as well as the ferrous iron content.

Results and Analysis:

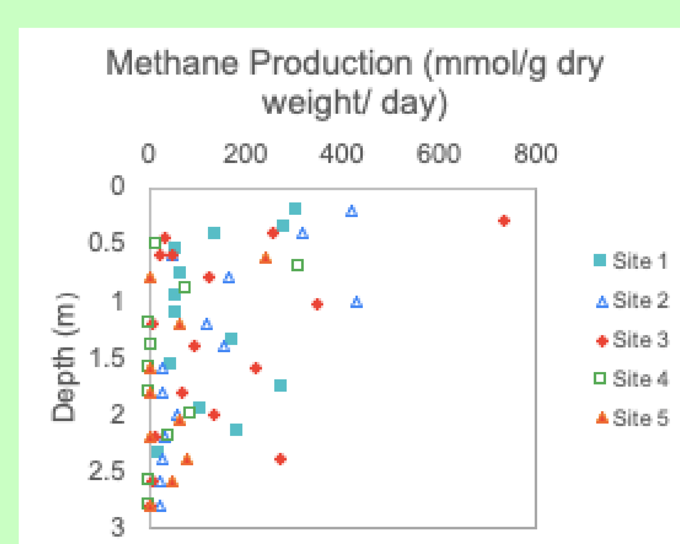


Fig. 2: Profile of CH_4 production vs. depth in the peat core.

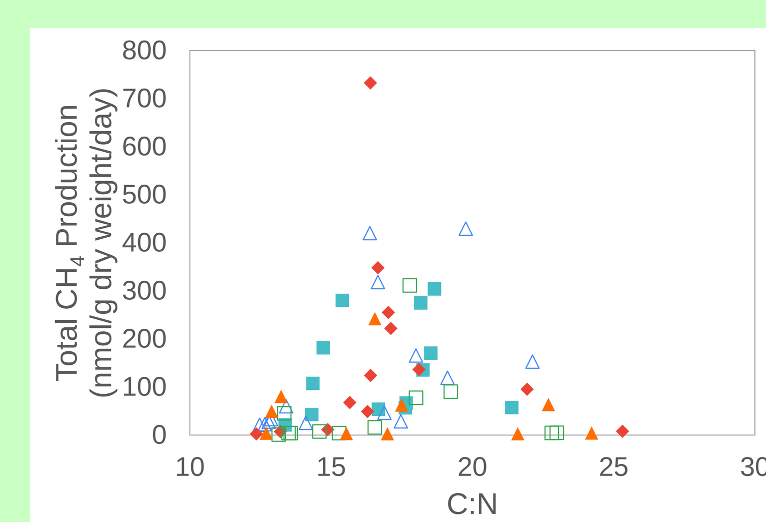


Fig. 3 Relationship between C:N and CH_4 production. Linear regression analysis indicated the correlation was not significant.

Methane production was found to decrease with increasing depth, supporting the hypothesis that methane production is highest at the surface of the bog.

It was hypothesized that C:N could provide a proxy for decomposition, as carbon is lost while nitrogen is recycled during decomposition, resulting in a C:N declining with decomposition. However, a poor relationship was found between C:N and methane production (Fig. 3).

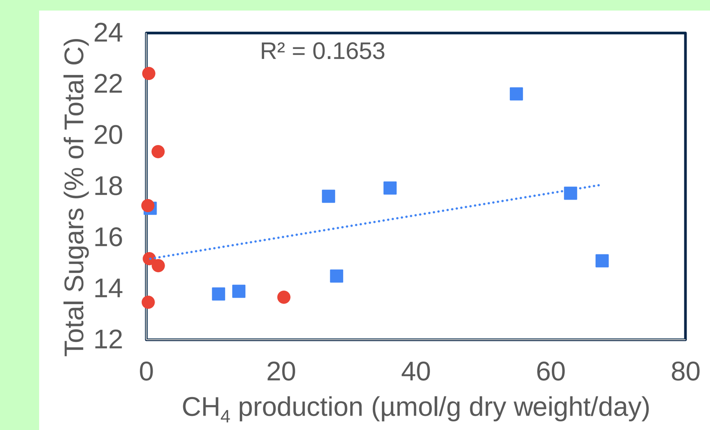


Fig. 4 Relationship between total sugar content (as a percentage of total C) and CH_4 production.

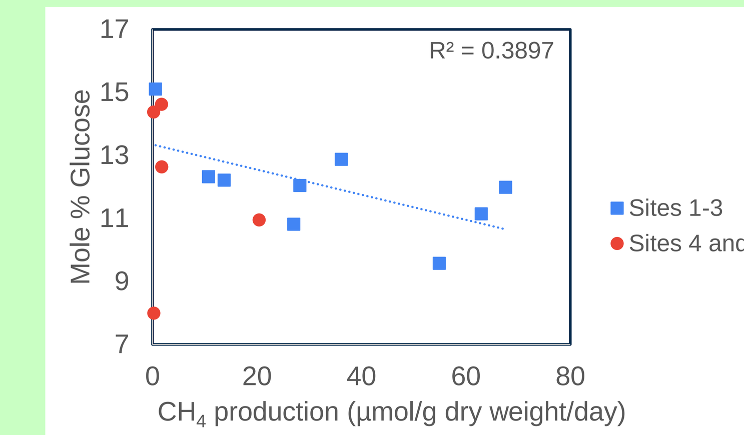


Fig. 5 Correlation of % glucose content with CH_4 production after the first 15 days of incubation

We found a poor relationship between the total sugar content within a peat sample and CH_4 production (Fig. 4). However, there was a stronger inverse relationship between mole % glucose and CH_4 production in three of the cores (Fig. 5). Samples from sites 4 and 5 had low CH_4 production regardless of sugar content and were excluded from this analysis. Glucose is found in cellulose, the primary structural polysaccharide in most plants. We observed that glucose increased in abundance relative to other sugars with increasing depth and decomposition, suggesting that more labile non-structural carbohydrates and hemicelluloses may be have selectively decomposed, leaving the remaining peat enriched in cellulose. This suggests that the sugar composition could be a useful indicator of the availability of easily fermentable sugars.

Discussion and Future Work:

Overall our results somewhat support our hypothesis that the decline in CH_4 production with depth is due to a decline in organic matter quality. However, the strength of this relationship appears weak because there was a relatively narrow range of decomposition states at our field site. Even the surface peat was found to have sugar yields much lower than fresh *Sphagnum*, indicating that it may have already lost its most labile carbohydrates prior to sampling. While carbohydrate composition appears to be a promising proxy for predicting CH_4 production, we will need to expand our sampling pool to account for a range of composition and CH_4 production potential.

Lab Group Field Work

Future work includes:

- Expanding our sampling sites to peatlands in colder climates (to capture a wider range of poorly decomposed peat samples).
- Analysis of organic acid and terminal electron acceptor concentrations to help explain variability in CH_4 between samples with similar biochemical composition.
- Analysis of hydrolysable amino acids as an additional proxy for peat quality.

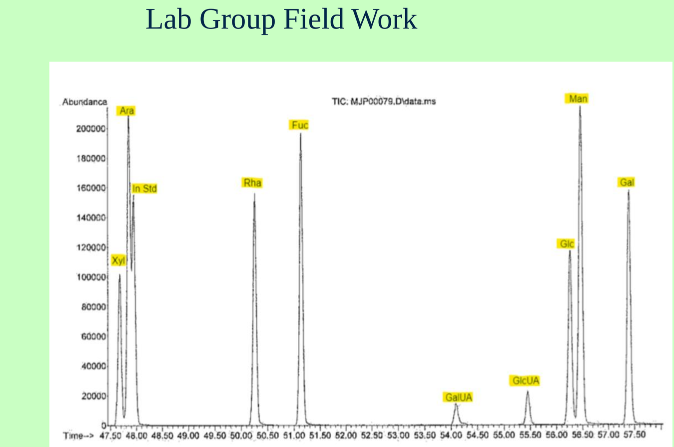


Fig. 6 Chromatogram of neutral sugars by GC/MS

Acknowledgments:

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