4-14-2023

Organic Matter Quality Influences Aerobic and Anaerobic Respiration Rates in Peatland Soils

Rachel Shaw
Hope College

Lauren Bryan
Hope College

Madison Smith
Hope College

Christian Lundy
Hope College

Alexis Koehl
Hope College

See next page for additional authors

Student Author(s)
Rachel Shaw, Lauren Bryan, Madison Smith, Christian Lundy, Alexis Koehl, Grace Behrens, Mackenzie Dole, and Madeleine O'Donnell

Organic matter quality influences aerobic and anaerobic respiration rates in peatland soils

Rachel Shaw, Grace Behrens, Lauren Bryan, Mackenzie Dole, Alexis Koehl, Christian Lundy, Madeleine O'Donnell, Madison Smith, Michael Philben

INTRODUCTION

Northern-hemisphere peatlands are crucial ecosystems from a global warming perspective due to their ability to sequester roughly 2x the C in the atmosphere and thereby produce an overall "cooling" effect on the global climate. This is because C inputs from plant growth have outpaced C losses from decomposition in these ecosystems. However, the ability for C accumulation to outpace loss may be jeopardized as decomposition rates increase with temperature due to global warming.

There are many factors affecting the decomposition and respiration rates of peat. The availability of C for decomposition and conversion into GHGs, as well as the availability of other biochemical components such N and the chemical makeup of the environment can vary these rates.

Fig. 1 Picture of the moss genus *Sphagnum*, which is the dominant genus of plant contributing to the makeup of peat in northern hemisphere wetlands.

The overall "quality" of peatland organic matter is determined by the ease with which it is decomposed by the microbial community. Proxies such as depth, carbohydrate composition, hydrolysable amino acids, pH, nutrient availability, and C:N were predicted to be indicators of the quality of our samples.

QUESTIONS & HYPOTHESES

Will a PCA-based index of various biochemical analytes and proxies be able to predict the organic matter quality of peat?

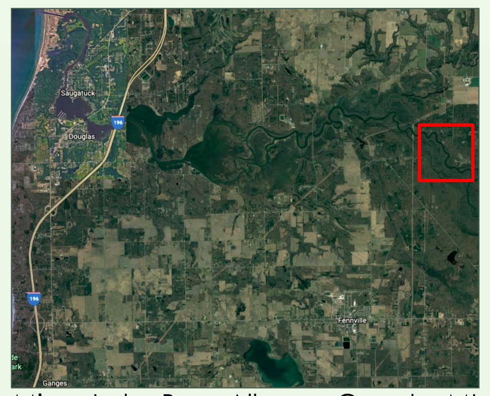
Will such an analysis produce a relationship that predicts anaerobic and aerobic respiration of the greenhouse gases (GHGs) CO_2 and CH_4?

SITE DESCRIPTION

Peat cores were collected from five sites in Miner Lake Bog in Allegan Township, Michigan, a peat bog with local access. Each core was 3 m in length and collected from a variety of microtopographies within the bog (**Table 1**).

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

Table 1 Table listing site descriptions within Miner Lake Bog (MI).



Miner Lake Bog, Allegan County, MI

Core locations within the bog.

METHODS

We measured various parameters that could be related to anaerobic and aerobic respiration and GHG production through a variety of methods.

Sample Processing

Fig. 2 Processing of peat samples from left to right: peat core in the field, samples drying in oven, ground peat sample, processed HPLC samples.

Ion Chromatography

IC was used to measure various ion and acid concentrations. This method was used to determine inorganic N and inorganic acid content.

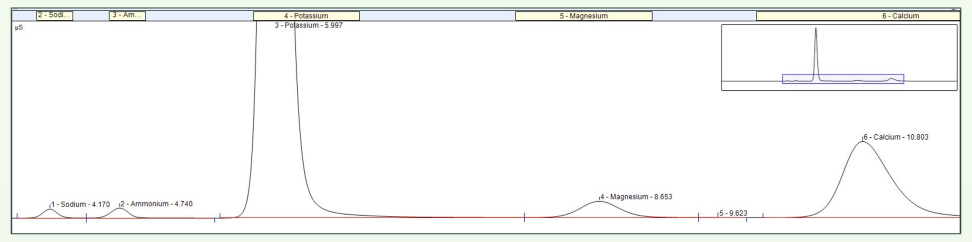


Fig. 3 IC chromatogram showing cation concentrations from a peat sample.

High Performance Liquid Chromatography

HPLC was used to measure 18 amino acid concentrations as organic N undergoing mineralization. The parameters Mol % Glycine, % N as AA, % C as AA, Mol % Hydroxyproline, and C Normalized Yield of Hydroxyproline were determined using this method.

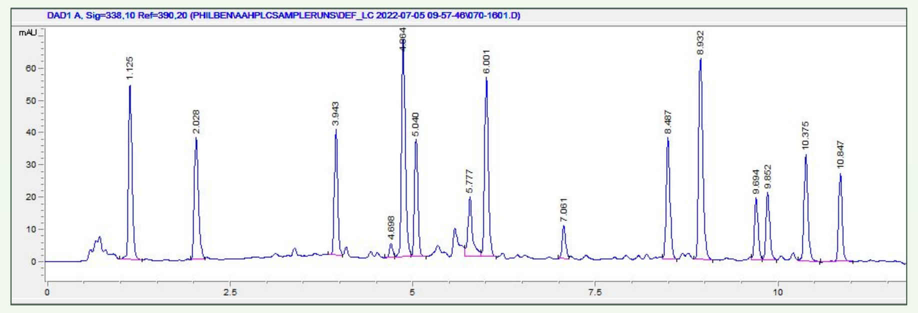


Fig. 4 HPLC chromatogram showing concentrations of 15 amino acids from a peat sample.

C:N Elemental Analysis

Elemental analysis was used to measure the total amounts of all C and N for each sample. This method was used to determine mol % glycine, % N as amino acids, % C as amino acids, % C as sugars, and C:N.

Gas Chromatography – Mass Spectroscopy

GC-MS was used to determine the concentrations of different sugars. This method was used to determine % C as sugars, % Glucose, and % Rhamnose.

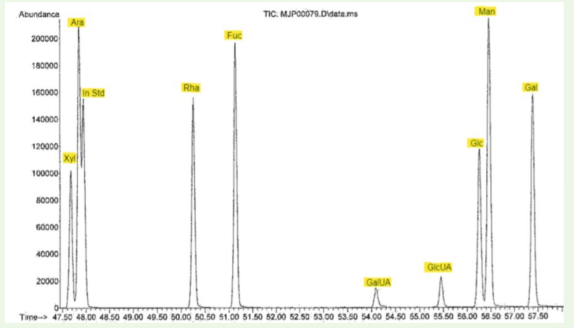


Fig. 5 GC-MS chromatogram showing concentrations of varying sugar compounds from a peat sample.

RESULTS

We performed a principal components analysis comparing various chemical parameters for each peat sample. Parameters that were grouped closer together were found to be correlated.

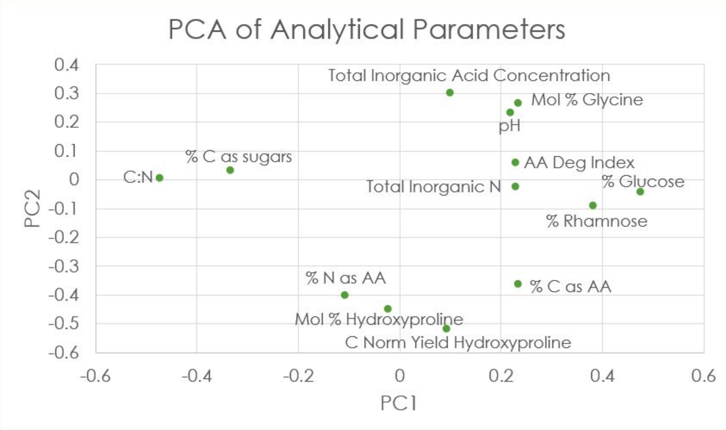


Fig. 6 PCA of C:N, % C as sugars, total inorganic N, AA degradation index, [total inorganic acid], pH, mol % glycine, % glucose, % rhamnose, % C as AA, % N as AA mol % hydroxyproline, and C normalized yield of hydroxyproline. PC1 was found to be a better indicator of peat decomposition state.

A correlation was found between the first PCA and the depth of each peat sample, implying that these parameters do predict decomposition state. This correlation was more prominent with the hollow microtopography, but a relationship between PC1 and depth was also found for the hummocks.

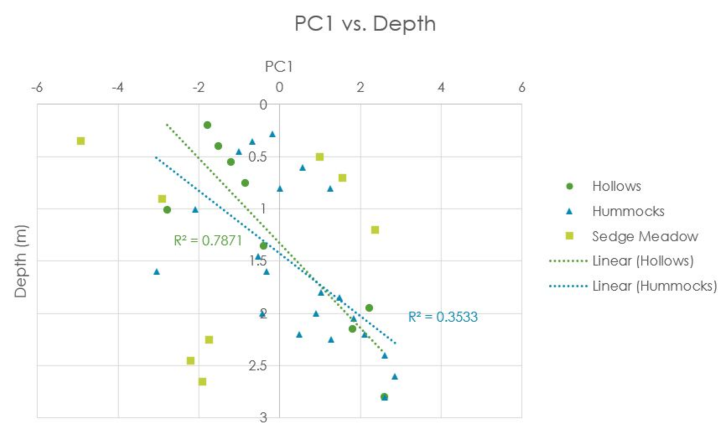


Fig. 7 Graph correlating the relationship between PC1 and the depth of each sample. PC1 was found to predict the decomposition state of the hummock and hollow microtopographies by using depth of each sample as a proxy for decomposition state.

A correlation was found between the first PCA and the aerobic CO_2 for all three microtopographies. A weaker correlation was found between PC1 and anaerobic CO_2 production. This implies that the PCA parameters may indicate CO_2 production in both anaerobic and aerobic environments.

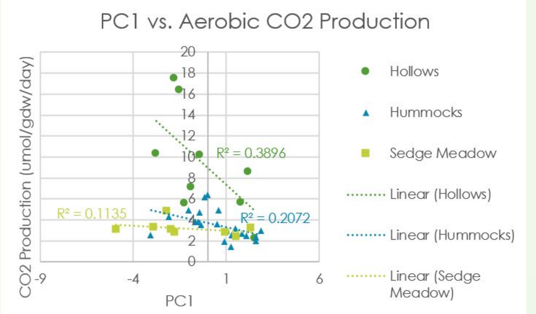


Fig. 8 Graph comparing PC1 to aerobic production of CO_2. A relationship between all three microtopographies was found.

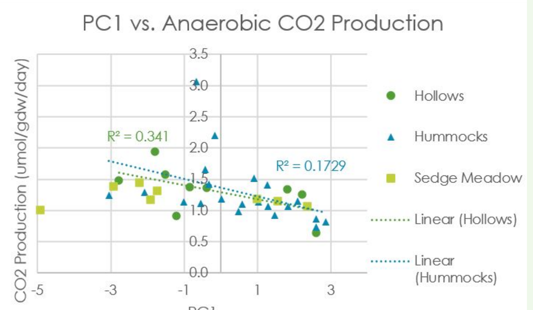


Fig. 9 Graph comparing PC1 to anaerobic production of CO_2. A relationship between the hummock and hollow microtopographies were found.

No correlation was found between PC1 and CH_4 production in any of the microtopographies. Thus, the PCA parameters were not found to be good indicators of CH_4 respiration.

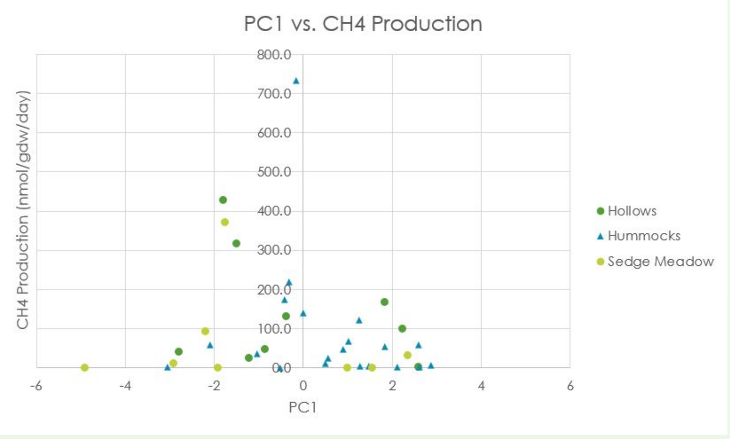


Fig. 10 Graph comparing PC1 to CH_4 production, which occurs only anaerobically. No relationship was found between any of the microtopographies.

CONCLUSION & DISCUSSION

We created an index using a principal components analysis in order to predict organic matter quality of peat. Since our PCA correlated well with the depth of our samples, which we have used as a proxy for decomposition state, our index can thus be reliably used to predict organic matter quality.

We found a strong relationship with aerobic production of CO_2, an intermediate relationship for anaerobic production of CO_2, and a poor relationship with CH_4 when plotted against our PCA. Thus, our index of biochemical parameters can be used to predict the rate of CO_2 respiration in aerobic environments, whereas it is not a sufficient indicator of CH_4 respiration rates.

Fig. 11 Sampling in Miner Lake Bog in Allegan County, MI in June 2021.

Microtopographical type for each sample was relevant to the reliability of our index. The hollow microtopography consistently had the strongest correlation with our PCA, and the sedge meadow seldom displayed a significant relationship with the PCA. This may be due to the lack of the dominant contributor to peat formation in sedge meadows, *Sphagnum*. This genus of moss is decomposed at a far slower rate than other plant species, allowing for a larger gradient of decomposition state and more GHG release over time.

In the future we would like to both expand our index and determine proxies/parameters that may predict CH_4 respiration rates. Future work may include:

- Analyzing Fe^{3+}
- Creating a survey of data from various Michigan peatlands in order to expand our current index
- Using plant survey data as a reference point for fresh peat material

Fig. 12 Sampling in Miner Lake Bog in Allegan County, MI in July 2022.

ACKNOWLEDGEMENTS

- Hope College Chemistry & Biochemistry, Geology & Environmental Sciences, and Biology Departments
- Dr. Michael Philben, Dr. Li, and Dr. Brown
- Michigan Space Grant Consortium
- Past and present members of the Philben lab