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Temperature Sensitivity of Nitrogen Mineralization in Peat From a Southwestern Michigan Bog

Madison Smith
Hope College

Lauren Bryan
Hope College

Rachel Shaw
Hope College

Mackenzie Dole
Hope College

Madeleine O'Donnell
Hope College

Temperature Sensitivity of Nitrogen Mineralization in Peat Cores From Miner Lake Bog

Madison Smith, Lauren Bryan, Mackenzie Dole, Madeleine O'Donnell, Rachel Shaw
Michael Philben
Departments of Chemistry and Geology, Hope College, Holland MI

Abstract

In this study, we measured inorganic nitrogen (nitrate and ammonium) released from peat cores from Miner Lake bog at two temperatures to analyze the impact of climate warming on the peatland nitrogen cycle. We hypothesized a higher nitrogen release in samples incubated at warmer temperatures. Furthermore, previous research indicates shallow peat decomposes faster than deeper peat. Therefore, we hypothesized faster nitrogen mineralization in shallow samples. We collected peat cores from two locations from Miner Lake Bog in Allegan County, Michigan: a plot in the center of the bog and a fen site near the edge. Two samples for each depth (0-0.5 meter, 1.5-2 meters) were taken at both sites and homogenized. Microlysimeters, consisting of two-chambered filter towers, were acid washed and 20 g of acid washed sand was added to each upper chamber. 50 g of peat was added onto the sand and was left to equilibrate for four days. Microlysimeters were leached with 80 mL of 0.01M $CaCl_2$ solution and the concentration of nitrate and ammonium in the leachate were quantified using ion chromatography. Microlysimeters were incubated for two weeks before leaching procedures were repeated. A separate field-based cation-anion exchange analysis was performed through the installation of plant root simulators. Bog cumulative mineralization produced significantly more nitrogen than the fen data. In both the bog and field data, we found that mineralization was higher in surface peat than in more degraded deep peat layers. Additionally, we pretty consistently found that mineralization was higher at the warmer temperature, indicating that warming will increase the rate of nitrogen cycling in bogs. Current rates of nitrogen mineralization may indicate an eventual plateau.

Introduction

As global temperatures increase, carbon losses from peatlands will increase due to microbial decomposition. Carbon inputs may also increase due to faster plant growth, but plants in peatlands are strongly limited by nitrogen availability. Nitrogen mineralization, in which microbes convert organic nitrogen into plant-available forms nitrogen (nitrate and ammonium), is a bottleneck for further plant growth. If warming increases mineralization, it could allow carbon inputs from plants to "keep up" with carbon losses from microbial decomposition. We investigated nitrogen mineralization rates in bog soils when subjected to different temperatures to simulate climate warming. To test this, we are studying peat cores gathered at two different bog depths (0-0.5 meters and 1.5-2 meters) kept at different temperatures. We hypothesized that shallow peat sites will release more nitrogen than deep sites due to higher plant decomposition in shallow sites. Additionally, we hypothesized that nitrogen release would increase with warming.

Above, example peat core with less degraded, shallow plant matter and soils on the left and more degraded, deeper plant matter and soilson the right.

Right, samples from the inner bog area and the outer fen area were taken: two shallow (0-0.5 meter) and two deep (1.5-2 meters). The peat corer, the long pole with the handle, was used to take both shallow and deep cores.

Lab Methods: Microlysimeters

Nitrogen mineralization was measured in the lab using microlysimeters. These consisted of a filter tower filled with 20g of sand and 50 g of peat. Microlysimeters were incubated in the dark, allowing mineralized nitrogen to accumulate. Every 2-4 weeks, the accumulated nutrients were extracted with 80 mL 0.01M CaCl2 solution. The solution was filtered and analyzed for nutrient concentrations using ion chromatography.

Microlysimeter (green) with peat core attached to vacuum set to 70 kPa.

8 microlysimeters with 20 g of sand added before peat was added to reduce clogging

Field Methods: Plant Root Simulators

A field nitrogen mineralization study was conducted with the use of plant root simulators (orange stake pictured). These contain a resin that absorbs available soil nutrients. Deep set simulators attached to strings were put in place with PVC pipes. Shallow simulators were also installed. A total of 36 simulators were installed, 12 at each of the three sites, in clusters of 3 at a site.

Results: Lab N Mineralization

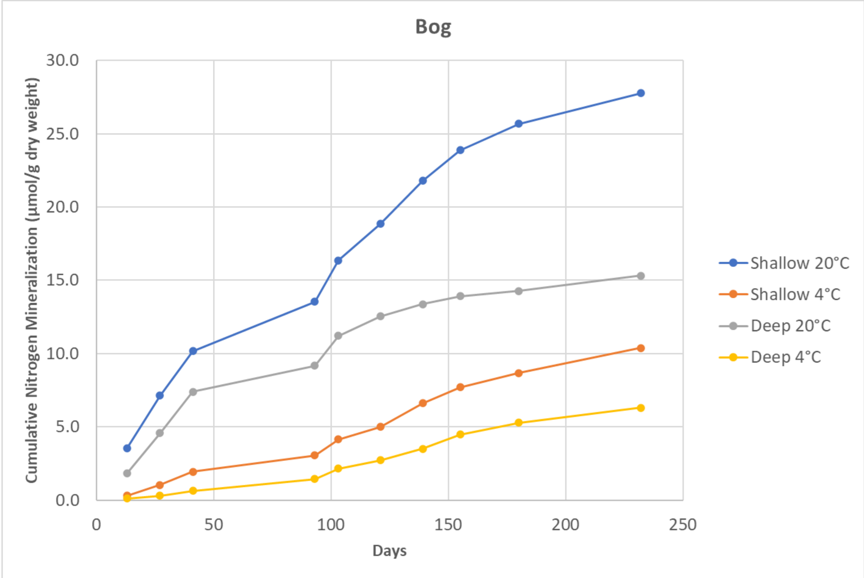

Figure 1. Cumulative nitrogen mineralization in the bog site. Mineralization increased over time in all samples, but appears to be slowing down over time (indicated by a flattening of the curve).

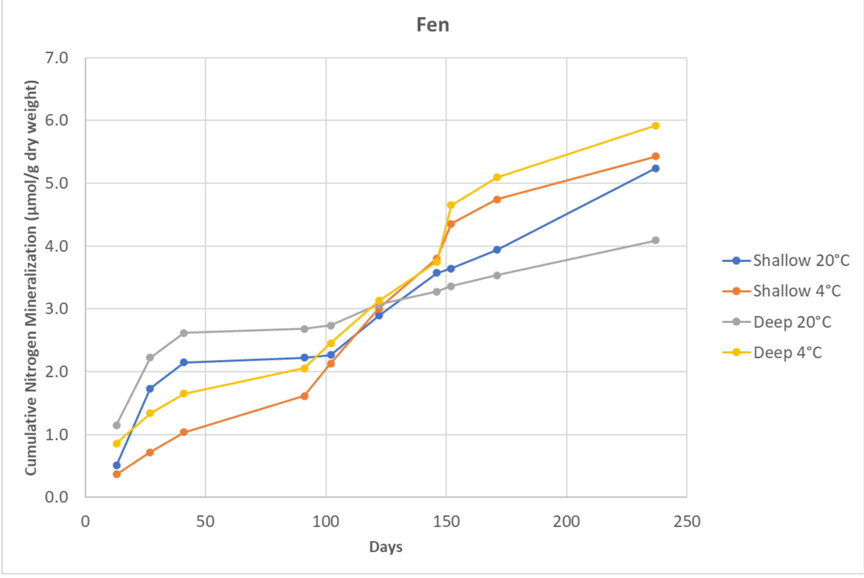

Figure 2. Cumulative nitrogen mineralization in the fen site. General trends of slow increase across all groups. Similar rates and levels of nitrogen clustered around 100-150 days.

Results: Lab N Mineralization

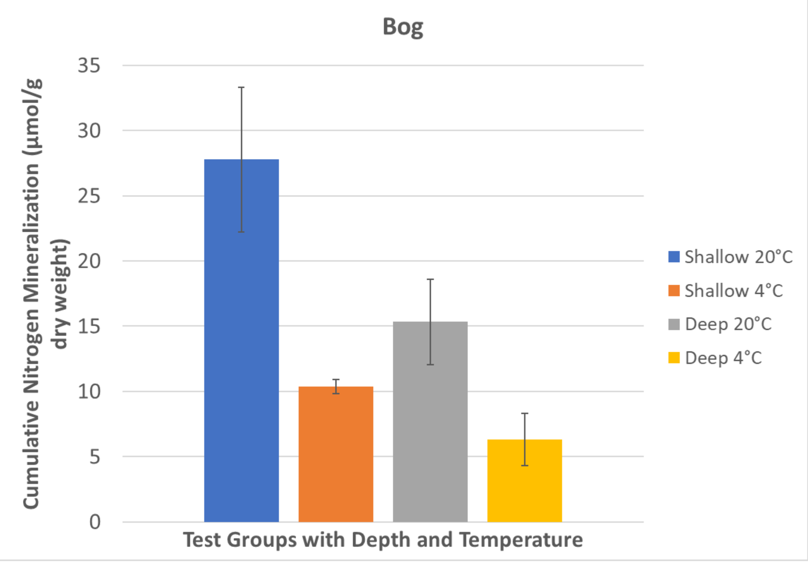

Figure 3. Cumulative nitrogen mineralization from the bog site. Cumulative data from both 20°C groups was higher than the 4°C groups. Cumulative data from both shallow groups had higher mineralization than deep groups.

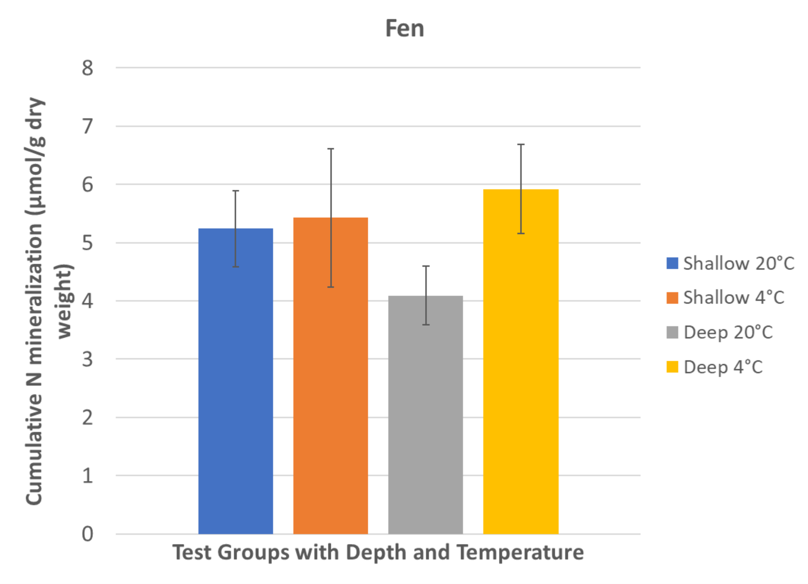

Figure 4. Cumulative nitrogen mineralization from the fen site. Note the difference in scale with the figure for the bog site. Significant difference between deep 20°C and deep 4°C. No other significant differences.

Results: Field N Mineralization

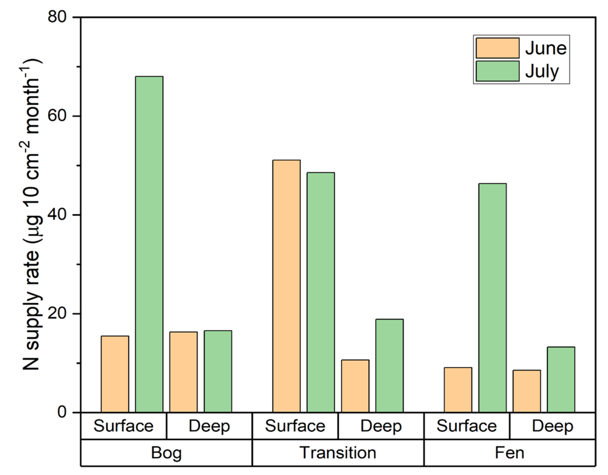

Figure 5. Plant Root Simulator data with the nitrogen supply rate of each sample site. Bog rates were higher than fen rates, consistent with lab results.
Mineralization in July (when it was warmer) was generally higher than in June

Discussion

We found that there is a large difference in nitrogen release between sites, with the bog zone (27.77 µmol/g) releasing significantly more nitrogen than the fen (5.91 µmol/g). The cause for this difference is not clear, but is hypothesized to be due to iron content in the fen protecting organic nitrogen through co-precipitation. Trends in the cumulative bog data show that there is higher cumulative nitrogen mineralization in warmer samples rather than cooler samples. This supports the hypothesis that warming will increase mineralization. This suggests that peatlands may release more nitrogen as global temperatures rise, before an eventual plateau. Data from the fen site doesn't fully support this; there is only a significant temperature difference between deep 4 and deep 20 (1.82 micromoles per gram difference). In the bog site, there was significantly higher nitrogen mineralization in shallower peat samples than there is deep samples (12.44 shallow, 4.02 deep more µmol/g). This supports the hypothesis of fresh peat releasing more nitrogen than degraded deep peat. However, the hypothesis was not supported by the fen data. Starting this summer, we will analyze temperature sensitivity of nitrogen mineralization in bogs across a transect of Michigan from down near the Indiana border up to the Upper Peninsula.

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References

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