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Temperature Sensitivity of Nitrogen Mineralization in Peat from Bogs Across a Michigan Transect

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Temperature sensitivity of nitrogen mineralization in peat from bogs across a Michigan transect

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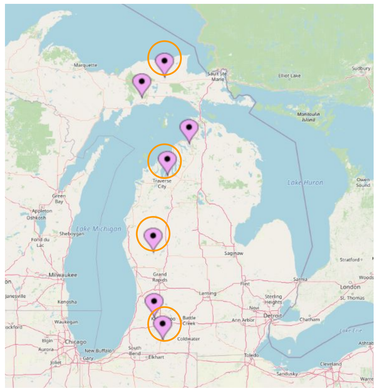
Abstract

In this study, seven peat bogs across a latitudinal transect of Michigan were used to analyze inorganic nitrogen (nitrate and ammonium) release from peat to predict the impact that climate warming has on peatland nitrogen cycle. More nitrogen release is expected in samples kept at warmer temperatures (simulated climate warming) and also from samples from lower latitudes. 1-m peat core samples were taken at each site. 20 g of acid washed sand was added to upper chambers of microlysimeters (two-chambered filter towers). 50 g of peat was added onto the sand and was left to equilibrate for a week. Microlysimeters were leached with 80 mL of 0.01M $CaCl_2$ solution and nitrogen was 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.

Introduction



Map of bogs sampled along the Michigan transect. All bogs were tested with plant root simulators. Circled bogs tested in lab with microlysimeters.

We are investigating nitrogen mineralization rates in bog soils when subjected to different temperatures to simulate climate warming. To test this, we are studying peat cores gathered from four different bogs at two different temperatures. Experimental temperatures, 23 and 13°C, were chosen based on average growing season temperatures (13° C) and projected increase in temperature (23°C) due to climate change. We hypothesize that nitrogen release will increase with warming temperature, and also that there will be higher release in peat from southernmost bogs.

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.

Peat core from Brinkman bog in the Russian Peat corer

Sampling in Richmond Lake bog

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 (purple stake pictured). They contain a resin that absorbs available soil anions and cations. Plant root simulators were installed in seven bogs across a transect of Michigan using latitude as a proxy for temperature shifts expected with climate change. PVC pipe collars were installed into the peat, and plant root simulators were stuck into the peat in the collar. A total of 129 simulators were installed, 9 at each bog, in clusters of 3 at a site.

Results: Lab N Mineralization

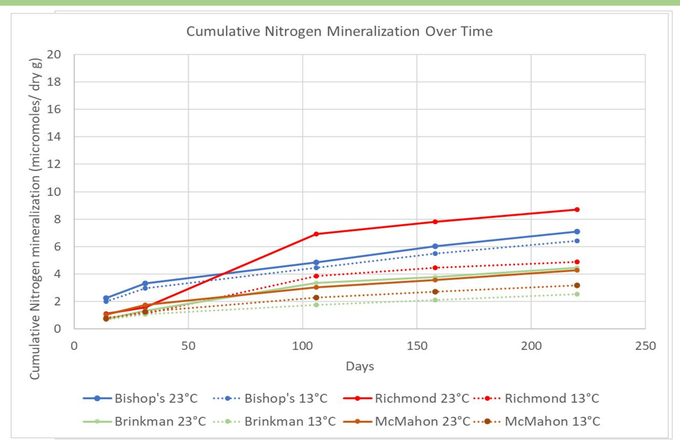


Figure 1. Total cumulative nitrogen mineralization over 220 days. Seven extractions were conducted to evaluate the change in mineralization rate over time. Mineralization rates were consistently highest in soils from Richmond lake kept at a warmer temperature, which matches field data. Solid lines indicate 23°C, dotted indicate 13°C. Warming consistently increased mineralization in all four soils.

Results: Lab N Mineralization

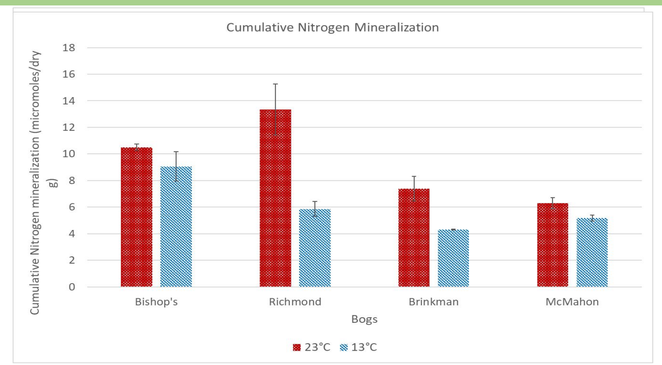


Figure 2. Total nitrogen mineralization from four bogs comparing results from incubations at two temperatures (23°C and 13°C). Warming significantly increased mineralization in Bishop's Bog and Richmond Lake samples.

Results: Field N Mineralization

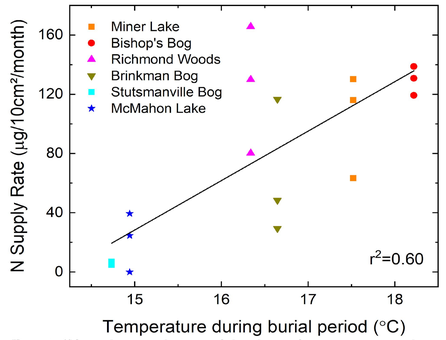


Figure 5. Plant Root Simulator data with the nitrogen supply rate of each sample site. The rate of N mineralization was correlated with the average air temperature during the period when the probes were buried.

Discussion

Both field and laboratory approaches indicated that warming increases N mineralization in Michigan peat soils. In the field experiment, mineralization rates were correlated with natural variations in air temperature across the transect. In the lab experiment, warming of each soil directly resulted in greater mineralization. This suggests that N availability is higher in the southern sites, resulting in higher mineralization rates regardless of temperature. This is supported by the observation that peat from Bishop's Bog and Richmond lake (the southernmost sites) exhibited the highest mineralization rate at both temperatures in the lab incubation experiment. Additionally, Richmond lake, although it is not the southernmost site, has the highest amount of mineralization. This may be explained by field results, which indicate highest mineralization in Richmond lake. Overall, our results suggest that plant N availability will increase will warming, helping plant growth to offset warming-induced C losses due to increased organic matter decomposition.

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