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Selective Preservation of Structural Carbohydrates During Peat Formation

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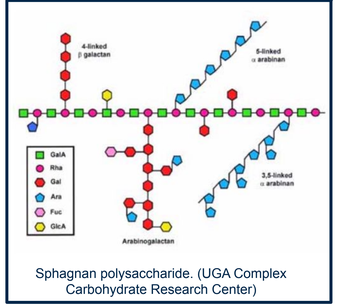
Hope College, Holland, MI

Background



Sphagnan polysaccharide. (UGA Complex Carbohydrate Research Center)

Northern peatlands are comprised mainly of *Sphagnum* species and are estimated to store up to 1,055 petagrams of carbon. However, the fate of this carbon is currently unknown, as rising temperatures threaten to increase the rate of *Sphagnum* decomposition, thereby increasing carbon output. Previous studies indicate the importance of the structural carbohydrate "sphagnan" in slowing *Sphagnum* decomposition, aiding in peat accumulation; however, it is currently unclear if sphagnan persists beyond early-litter degradation or plays a role in long term peat preservation. Sphagnan is comprised of an alternating galacturonic acid and rhamnose backbone, and this study sought to further understand the mechanisms of *Sphagnum* breakdown by investigating the role of sphagnan in preventing *Sphagnum* decomposition over both short and long timescales. Moss and peat samples were taken from a bog in Allegan County, MI, with rhamnose used as a proxy for sphagnan. Sugar concentrations were tracked before and after moss degradation to demonstrate short-term trends, while samples taken throughout peat cores to demonstrate long-term trends in structural carbohydrate concentrations. Rhamnose concentrations were found to increase over the course of moss degradation, implying a selective preservation of sphagnan, but stable concentrations of rhamnose throughout peat cores indicated that sphagnan was decomposed at roughly the same rate as other sugars. Glucose concentrations were also tracked as a proxy for cellulose, though the method was optimized for rhamnose.

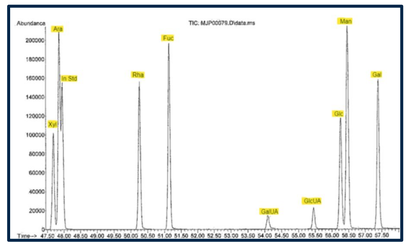
Hypothesis

We hypothesize that over both *short-term moss decomposition* and *long-term peat formation*:

(1) Higher sphanan content reduces the rate of decomposition

(2) Sphagnan accumulates due to selective preservation

Methods



Moss samples originated from three distinct areas for each microtopography, and one sample of *Polytrichum* moss as control. Six 3-meter peat cores were used. We used laboratory moss decomposition experiments to measure chemical changes during early decomposition (1 year), then examined changes with depth in the peat cores to evaluate decomposition over longer timescales (thousands of years). Quantification of sugars was achieved via a three step process of hydrolysis, silylation, and extraction designed to break sphagnan into its monomers, which could then be quantified via GC/MS. Sugar content was then calculated based off of mixed standards with the nine most common sugars.

Moss Decomposition Results

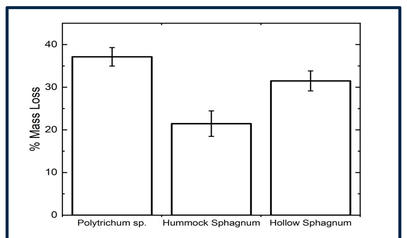


Figure 1: Percentage of mass loss in moss types over the course of incubation.

Over a one-year period of controlled lab decomposition, total sugars (%C as sugars) in *Sphagnum* can be seen to decline, indicating an overall selective decomposition of sugars. However, rhamnose concentrations (mol%) can be seen to increase relative to other sugars, indicating a selective preservation of sphagnan during early litter decomposition. Glucose neither decreases nor increases, indicating cellulose decomposes at the same rate as other sugars. Levels of rhamnose were found to be significantly different between initial and final groups (P>0.05).

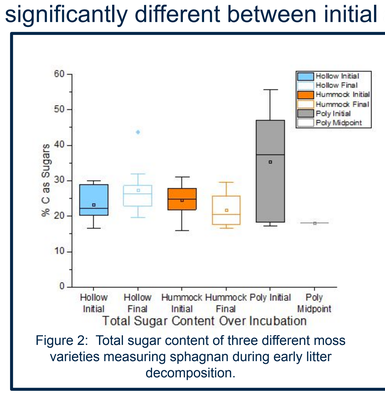


Figure 2: Total sugar content of three different moss varieties measuring sphagnan during early litter decomposition.

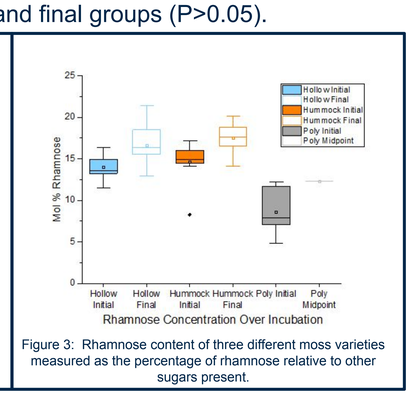


Figure 3: Rhamnose content of three different moss varieties measured as the percentage of rhamnose relative to other sugars present.

Peat Results

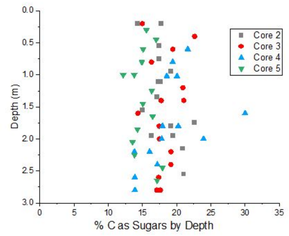


Fig. 4: Total sugar content of six peat cores measured as a percentage of carbon stored in sugars.

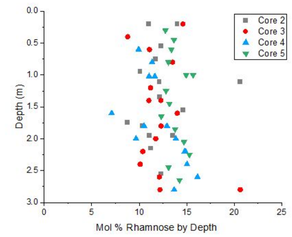


Fig. 5: Rhamnose content of six peat cores measured as a percentage of rhamnose relative to other sugars present.

After the early stages of decomposition, total sugar levels stabilize, indicating that more easily removable sugars are no longer present once peat has been formed. Rhamnose concentrations also remain fairly stable, indicating that over extended periods of time, sphagnan decomposes at roughly the same rate as other sugars. Higher concentrations of rhamnose reduce the decomposition rate (measured as CO_2 production) in aerobic incubations, but not in anaerobic incubations.

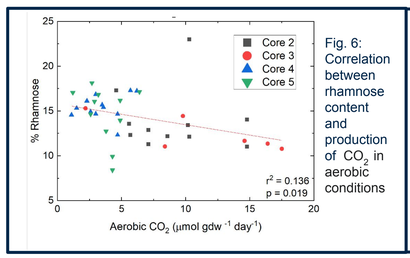


Fig. 6: Correlation between rhamnose content and production of CO_2 in aerobic conditions

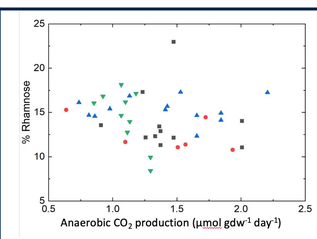


Fig. 7: Correlation between rhamnose content and production of CO_2 in anaerobic conditions

Conclusions

Sphagnan is selectively preserved in the early litter decomposition process of *Sphagnum,* and is associated with lower decomposition rates. However, the relationship is much weaker in older peat, and sphagnan does not appear to accumulate with increasing depth. Future research will look to expand the sample base, optimize our method for uronic acids, and investigate the trends in other sugars, like the microbial sugar fucose.

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