

Buried but not dead: Microbiome of permafrost soils in changing climate

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Arctic permafrost soils hold approximately half of the global soil organic carbon (SOC), estimated at around 1300 petagrams (Pg). Remarkably, one-third of this carbon is sequestered in cryoturbated organic matter (cryoOM), a process driven by cryoturbation—the mixing of soil layers due to freeze-thaw cycles. In this study, we present findings from an Arctic research project focused on understanding the role of microbial activity in the decomposition of cryoOM across Siberia, Greenland, and Canada, and assessing its vulnerability in a warming climate. Here are the key insights:

1. Microbial Communities Drive Carbon Dynamics:

The abundance of bacteria and fungi in cryoOM is closely linked to carbon loss. A low fungal-to-bacterial ratio appears to slow down cryoOM decomposition, making it a potential predictor of cryoOM vulnerability. Interestingly, the microbial communities in cryoOM differ significantly from those in the topsoil, resembling instead the communities found in surrounding subsoils. This mismatch between microbial composition and organic matter quality contributes to the delayed decomposition of cryoOM.

2. Nutrient Limitations and Organic Matter Accessibility:

Our experiments, including those with labeled substrates, revealed that microbial communities in cryoOM face distinct nutrient limitations. Nitrogen (N)-containing substrates triggered a significant priming effect, highlighting strong N limitation in these communities. Additionally, a substantial portion of cryoOM is bound to clay minerals, reducing its availability for microbial decomposition and potentially lowering its vulnerability to breakdown.

3. Slowed Decomposition: A Multifactorial Process:

The retarded decomposition of cryoOM is not solely due to harsh environmental conditions. It is also influenced by a combination of factors, including shifts in microbial community structure, reduced accessibility of organic matter, and slowed nitrogen cycling. These interactions create a complex barrier to decomposition, preserving cryoOM over long timescales.

Conclusion:

Our findings underscore the intricate interplay between microbial activity, nutrient cycling, and organic matter accessibility in shaping the fate of carbon stored in Arctic permafrost. As the climate warms, understanding these dynamics will be critical for predicting the vulnerability of cryoOM and its potential release into the atmosphere, with implications for global carbon cycling and climate feedbacks.

