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Decreasing snow cover causes increasing methane production in frozen lakes

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New, unexpected consequences of climate change keep presenting themselves. A new study from Uppsala University and SLU shows that a decreased snow cover on frozen lakes in boreal forests may inhibit the activity of methane degrading bacteria beneath the ice, thereby causing an increased net production of methane, a powerful greenhouse greenhouse gas.

The climate debate often emphasizes the potential for boreal forests to act as carbon sinks. An important and sometimes overlooked factor in this regard, is the role played by the many small lakes present in such forests. A large part of the forests' carbon cycle passes through the lakes, and considerable amounts of carbon are released as carbon dioxide to the atmosphere. Such lakes may also produce other greenhouse gases, such as methane. Much of this, however, never reaches the atmosphere as it is degraded by so called methanotrophic ("methane eating") bacteria in the water. The microbial life of the lakes thus have a large impact on their emission of greenhouse gases.

In the boreal zone in particular, winter plays a crucial role to this process. Ice coverage effectively inhibits the emission into the atmosphere, and snow affects both water temperature and light levels. This, in turn, is important to the photosynthetic processes of the water, exclusively driven by algae, and by extension to oxygen-depending microorganisms.

Ongoing climate changes will affect this situation in boreal forest lakes. Snow cover is expected to melt earlier, exposing frozen lakes to prolonged periods of direct sunlight. A new study shows that frozen lakes without snow contain less methanotrophic bacteria and hence also degrade less methane, which may be released into the atmosphere once the ice melts. The study has been conducted by researchers from the Uppsala University and the Deparment of Forest Mycology and Plant Pathology at the SLU.

Sari Peura from the SLU is the project leader.

"We examined the water of a frozen, snow covered lake in northern Sweden during one week. Then we removed the snow, and did the same samples and measurements for one more week," Sari says. "Our hypothesis was that the increased light would result in more active algae and therefore more oxygenized water, which in turn should benefit the microbial community and cause an increased methane reduction, compared to snow covered lakes."

However, the hypothesis turned out to be incorrect. Although the amount of chlorophyll increased in proportion to the increase in light, this did not lead to an increase in methanotrophic activity in the water. Instead, the methane concentration increased, and the amount of methantrophic bacteria dropped.

"We don't know yet exactly what causes this, Sari says. We assumed that the entire microbial community would benefit from the increase in available oxygen, but this was not the case. Our new hypothesis is that the algae activated by the light also produce and exude certain substrates that benefit other bacteria than the methanotrophs. Indeed, we could see an increase in such bacteria, but not in methanotrophs."

The idea is that these bacteria subsequently outgrow the slow-growing methanotrophs, which would diminish the degradation of methane. Another possible explanation could be that the increased algae activity caused a phosphate shortage, which has previously been reported as a limiting factor to methanotrophs.

It is important to understand the limitations in this particular study, Sari concludes. The experiment only went on for two weeks. It clearly shows that a decrease in snow coverage on frozen lakes may lead to increased methane concentration in the lake, which in turn may lead to increased methane emissions into the atmosphere once the ice melts, thus potentially increasing global warming. However, to study this process over a longer time frame, a new study is required. We now mean to apply for a grant to conduct such a study.

More information: Sarahi L. Garcia et al. Decreased Snow Cover Stimulates Under-Ice Primary Producers but Impairs Methanotrophic Capacity, *mSphere* (2019). [DOI: 10.1128/mSphere.00626-18](https://dx.doi.org/10.1128/mSphere.00626-18)

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