Historical climate effects of permafrost peatland surprise researchers

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Credit: Tarmo Virtanen

Peatlands are an important ecosystem that contribute to the regulation of the atmospheric carbon cycle. A multidisciplinary group of researchers, led by the University of Helsinki, investigated the climate response of a

permafrost peatland located in Russia during the past 3,000 years. Unexpectedly, the group found that a cool climate period, which resulted in the formation of permafrost in northern peatlands, had a positive, or warming, effect on the climate.

The period studied, which began 3,000 years ago, is known as a climate period of cooling temperatures. The climate-related effect of permafrost formation brought about by the cooling was investigated particularly by analyzing the ancient plant communities of the peatland, using similarly analyzed peatland data from elsewhere in Russia, Finland and Sweden as a comparison.

"Our studies demonstrated that the effect of permafrost peatlands on the climate can be difficult to predict. Studies encompassing longer periods of time are valuable, as they help us to understand future change," says researcher Minna Väliranta from the Faculty of Biological and Environmental Sciences, University of Helsinki.

The study linked data on ancient plant communities with information about how rapidly contemporary northern peatlands bind and sequester carbon, or how rapidly peat accumulates. In addition, data on carbon emissions to the atmosphere were utilized. These factors constitute what is known as the peatland's radiative forcing, which has either a warming effect on the climate when the peatland emits more carbon into the atmosphere than it binds from it, or a cooling effect when the peatland serves as a carbon sink and binds more carbon from the atmosphere than it releases into it.

Rather unexpectedly, the researchers found that a cool climate period, which resulted in the formation of permafrost in northern peatlands, had a warming effect on the climate. This was caused by the habitats of the plant communities living in the permafrost peatlands drying up, after which they no longer bound carbon from the atmosphere very

effectively. In fact, a reverse process took place in which previously formed peat, which used to store carbon, was released back into the atmosphere as a result of accelerated decomposition and degradation.

Moreover, the permafrost processes even created bare peat surfaces entirely devoid of vegetation in the peatlands. Such surfaces emit, in addition to carbon dioxide, also nitrous oxide, a potent greenhouse gas, into the air. These emissions clearly increased the peatland's warming effect on the atmosphere.

Other typical peatland surfaces do not emit significant quantities of nitrous oxide into the atmosphere, which is why such emissions have been considered insignificant. The study demonstrated that such bare peat surfaces have previously been much more prevalent. However, it appears that this type of surfaces have regained their plant cover over time, consequently reducing the extent of bare surfaces.

Climate change can drive the development of permafrost peatlands in unforeseen directions

"This was the first study in which the long-term development of bare peat surfaces was investigated. Consequently, further research is needed in order to better forecast the fate of such surfaces typical of permafrost peatland and the future development of permafrost peatlands in general," says Väliranta.

The climate effects of the greenhouse gas emissions of the peatlands studied were associated with changes in plant life, which, in turn, are determined by the peatland's hydrological balance. The researchers predict that the thawing of the permafrost may lead to rising peatland water levels and, therefore, substantial methane emissions that will warm the climate further. At the same time, global warming is thought to

accelerate carbon intake from the atmosphere due to the intensification of the basic production processes of plants. In other words, photosynthesis is binding carbon dioxide from the air with increasing efficiency.

More information: Minna Väliranta et al, Warming climate forcing impact from a sub-arctic peatland as a result of late Holocene permafrost aggradation and initiation of bare peat surfaces, *Quaternary Science Reviews* (2021). DOI: 10.1016/j.quascirev.2021.107022

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