Microbial greenhouse gas production in permafrost peatlands of the Hudson Bay Lowlands, Canada

Adam H. Kirkwood[1]
Pascale Roy-Léveillée[1]
Nathan Basiliko[1]
Jim McLaughin[2]
Maara Packalen[2]

[1]*Laurentian University, Vale Living with Lakes Center, Co-operative Freshwater Ecology Unit*
[2]*Ontario Forest Research Institute, Ministry of Natural Resources and Forestry*

Abstract

The Hudson Bay Lowlands (HBL) is an important yet understudied peatland that spans across continuous and discontinuous permafrost zones and contains 30 Pg of carbon. The objective of this research is to determine the amount and decomposability of organic matter in thawing permafrost features of the HBL. The field work component of this research took place in August 2017 near Peawanuck, Ontario, which is in the continuous permafrost zone. Samples collected in the field were incubated to determine the production potential of carbon dioxide (CO_2) and methane (CH_4); two powerful greenhouse gases. Preliminary results suggest that the initial off-gassing during the thaw period constitutes a significant contribution to greenhouse gas emissions linked to permafrost degradation. Samples from greater depths produce more CH_4 and less CO_2, whereas samples closer to the surface producer much higher amounts of CO_2, and thermokarst samples have also proved to be very prolific producers of CH_4.

Keywords: continuous permafrost; organic matter; decomposition; incubations; methanogens; climate change

Introduction

Peatlands are important in the global carbon cycle and climate system. They act as both long-term sinks and sources of atmospheric carbon dioxide (CO_2) and as a significant source of methane (CH_4). The role of north temperate and boreal peatlands in carbon cycling and responses to environmental changes has been investigated, but important knowledge gaps exist in the biogeochemical functioning of permafrost peatlands and their responses and feedbacks to current and future climate change (Schuur *et al.*, 2008).

The Hudson Bay Lowlands is also the world's second largest peatland complex, with ~30Pg of stored C in soil organic matter and spans across continuous and discontinuous permafrost zones (Packalen *et al.*, 2014). Despite its relatively low latitude, the Northernmost areas of Ontario have sub-arctic climates that are also warming rapidly due to changing sea-ice dynamics in Hudson Bay. As such, permafrost features in the Hudson Bay Lowlands (the lowest latitude continuous permafrost in North America) are at particular risk of rapid degradation (Pironkova, 2017).

Palsas are prominent features in the study area. Palsas are composed of peat deposits that have been raised by the formation of segregated ground ice. Upon completion of a palsa lifecycle, thawing of the segregated ground ice causes subsidence and increased surface water (Sepällä, 1986). Such an increase in surface water results in anoxic environments where methanogenesis may occur

In Far North Ontario, Canada, these features are very common but little is currently known about how they will respond to climate change in terms of microbial greenhouse gas feedbacks. This research investigates the quantity and decomposability of organic matter, and aims to characterize microbial CH_4 and CO_2 production potential responses to simulated climate warming across intact and degraded palsas in Northern Ontario.

Methods

Samples were taken from five sites in Polar Bear Provincial Park in August 2017, where cores of the active layer, permafrost, and adjacent thermokarst terrain were acquired. In the laboratory, cores were split into depth segments of 10 cm, and subsamples representative of each depth were assessed for thaw subsidence potential, organic content, and incubated at two different temperatures. Selected temperatures were 4°C and 14°C, and were incubated in identical bio-chambers to determine differences in production potential of GHGs. After off-gas measurements were taken, samples were mixed with water to ensure an anaerobic environment conducive to production of gases by methanogens. Gases were re-evacuated, and placed back

into the bio-chambers, where they were allowed to decompose for a prolonged period of time.

Preliminary Results

There were substantial emissions of CO_2 and CH_4 associated with the thawing of organic rich peat materials. The amount of CO_2 released upon thaw was similar to what was produced after seven days of decomposition. However, there was considerably more methane released during thaw, compared to what was released during the first week of decomposition. Generally, CO_2 production from palsa and thermokarst active layer samples was greater than samples from near the top of permafrost. The opposite was observed for CH_4 production: as samples from the bottom of the active layer and top of permafrost produced much higher levels of the gas.

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