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Impact of long-term wetting on belowground respiration and methanogenesis in Luther Bog, Ontario

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Peatlands play a major role in the global carbon cycle. They store one-third of total world soil carbon, sequester carbon dioxide (CO_2) and release CO_2 and methane (CH_4). Climate and land-use change are predicted to cause either wetter winters and wetter summers or wetter winters and drier summers in the area where northern peatlands are located. Feedback on processes in the peat is poorly understood on the time scale of decades. In this study, we investigated impacts of long-term wetting and long-term fluctuating water table on potential CO_2 and CH_4 production rates and organic matter quality of the fractions bulk peat, pore water and leachate.

Bulk peat potential CO_2 production rates of 2.38 to 25.55 μmol g^{-1} d^{-1} (aerobic) and 1.53 to 7.33 μmol g^{-1} d^{-1} (anaerobic) decreased with depth along with a decrease in organic matter quality. Potential CH_4 production rates (0.002 to 2.60 μmol g^{-1} d^{-1}) increased with anaerobic conditions and a lack of electron acceptors rather than being dependent on the availability of labile organic matter. This pattern was less evident in solute fraction samples where labile compounds in top layers were probably either too labile to be detected or water movement obscured differences between depths.

Bulk peat potential anaerobic CO_2 and CH_4 production increased through long-term wetting. As wetting did not change organic matter quality or aerobic production rates, increased anaerobic production rates likely originate from microorganisms adapted to anaerobic conditions. All indicators of organic matter quality, FTIR ratios, $SUVA_{254}$, E2:E3, HIX, FI and PARAFAC, provided similar results. Other than expected, wetting did not result in higher organic matter quality in bulk peat and leachate. Drier conditions in summer led to reduced organic matter quality. In pore water, long-term wetter conditions resulted in a higher organic matter quality. Slow-down of decomposition due to anaerobic conditions is unlikely, as this was not the case with respect to the other fractions. Mixing with groundwater could have transported organic matter of high quality to the wetted site. Potential CO_2 production rates were not affected by long-term water table change. Organic matter quality of the wetted site may have been also overestimated in our study as vegetation change may have changed litter and peat quality as well.

This study revealed that long-term wetting probably does not change organic matter quality as decisively as expected. Potential anaerobic CO_2 and CH_4 production rates rather increased as long as conditions were more constantly anoxic. Long-term lowered or fluctuating water table could potentially result in smaller future emissions due to a reduced organic matter quality, but also to less carbon sequestration.