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Redox properties of peat organic matter controls on anaerobic carbon mineralization and its relation to bulk peat chemical properties around the globe

Klaus-Holger Knorr and Chuanyu Gao
University of Münster, ILÖK, Ecohydrology and Biogeochemistry Group, Münster, Germany (kh.knorr@uni-muenster.de)

The availability of terminal electron acceptors is one important control on CO_2 and CH_4 formation in anoxic peat. In particular, CH_4 production is suppressed by presence of alternative electron acceptors after drought phases, but these electron acceptors would support anaerobic respiration to CO_2. In organic soils, electron accepting capacities (EAC) for anaerobic respiration are dominated by EAC of organic matter. Yet little is known about typical ranges of EAC in natural peat soils, if measured changes of total EAC can explain the different between CO_2 and CH_4 production, and if OM redox properties are related to known peat chemical properties. Such information would be desirable to understand CH_4 and CO_2 production in peatlands upon water table fluctuations, drought phases or flooding - scenarios which are predicted to increase as a consequence of climate change.

We collected 60 peat samples from 15 peatlands located in Canada, western Europe, western Siberia, Patagonia, and northeast China to cover a range of peat properties in natural peatlands. Peat was obtained from four depths (10-20 cm, 30-40 cm, 60-70 cm, and a deep peat sample from ∼150-200 cm depth). EAC, electron donating capacities (EDC), and electron exchange capacities (EEC = EAC + EDC) were determined for solid and dissolved organic matter using mediated electrochemical reduction and oxidation. In addition, we quantified potential CO_2 and CH_4 production in 56 days at 20 ˚C of anaerobic incubation and compared excess CO_2 production over CH_4 with changes in EAC. In ongoing work, we aim at identifying relationships between OM redox properties and CO_2 and CH_4 production with peat chemical properties. Thus, we analyzed C, N, S elemental concentrations, stable isotopic signatures, further major elements, and bulk peat FTIR spectra.

EEC in the peats ranged from 809-1044, 668-919, 765-950, and 872-1119 μmol e^- g C^{-1} (95 % confidence interval) in the four depths, respectively. After 56 days of anaerobic incubation (20˚C) peats became methanogenic, and EAC had decreased by about 222-396, 178-321, 189-285, and 226-354 μmol e^- gC^{-1} for the 4 investigated depths, respectively. These decreases in EAC in incubations under anaerobic conditions would potentially be available to suppress CH_4 production and support anaerobic respiration to CO_2. About 32-55, 32-54, 24-41, and 28-43 % of the observed CO_2 production in the 4 respective depths could be assigned to CH_4 production, and 20-40, 23-46, 34-54, and 34-52 % of the observed CO_2 production could be explained by consumption of EAC of organic matter. In total, we could explain 62-86, 69-88, 67-88, and 67-91 % of all CO_2 production in our incubations of the 4 depths by either CH_4 production or consumption of electron acceptor equivalents. Comparing redox properties of peat materials under study with peat chemical properties, however, suggests a large impact of site-specific factors and only few relations were obtained for individual sites or specific depths.

In summary, our study demonstrates that peatland biogeochemists made considerable progress in understanding anaerobic carbon mineralization, improving the possibilities to predict consequences of climate change for carbon turnover in peatlands.