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Linking peatland redox conditions to pore water composition and greenhouse gas production

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As a result of limited decomposition under prevalent reducing conditions often over a timespan of thousands of years, organic soils store ± 600 Gt of carbon. Currently, almost 14% of the global peat carbon storage is threatened by degradation, which was responsible for 2% of the anthropogenic greenhouse gas emissions in 2019. Decomposition of peat is the result of metabolic processes of the microbial community in the soil (also referred to as microbial respiration or oxidation). This microbial respiration activity strongly depends on biogeochemical conditions and especially to the availability of (alternative) electron acceptors in the soil profile. The redox potential is a reflection of the dominant electron acceptors present and the prevailing biogeochemical processes in the soil. Knowledge on the correlation between electron acceptor availability and redox conditions in peat soils remains however confined to laboratory studies, in which the sample is likely to be disturbed and boundary conditions are artificial. In this study we compared 2 years of continuous field measurements of redox potential with the chemical composition of over 1500 pore water samples, collected at different depths (20, 40 and 70 cm) in five agricultural peat soils throughout the Netherlands. The aim of this research is to identify the important metabolic processes for distinctive ranges in redox and pH under field conditions and compare these with known theoretical thermodynamic equilibria. We show that redox conditions are strongly correlated with products of anaerobic metabolism. Additionally, we present breakpoints for zones with distinct metabolic processes and biogeochemical states, which we use to interpret time series of redox depth profiles. With these results we demonstrate the value of in-situ redox measurements to understand peat soil respiration rates and associated greenhouse gas emission from organic soils.