Geophysical Research Abstracts
Vol. 20, EGU2018-2871, 2018
EGU General Assembly 2018

Towards explaining CH_4 production in wetlands –the role of particulate and dissolved organic matter as electron acceptors and of substrate quality

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Peatlands are major sources of atmospheric CH_4 and an important carbon pool in terrestrial ecosystems. Controls on CH_4 production in water logged, anaerobic peatlands have been studied for several decades. Most importantly, temperature, substrate quality, water table position and availability of electron acceptors for organic carbon oxidation have been identified. However, many studies found that inorganic electron acceptors did not suffice to explain the observed production of CO_2 and suppression of methanogenesis. Only recently suitable electrochemical techniques became available to access stocks and changes in electron accepting capacities (EAC) of dissolved and particulate natural organic matter (NOM), which can potentially serve as an additional electron acceptor. Here, we studied turnover of electron acceptors including NOM, and if CO_2 production in anoxic incubation of peat can be balanced by methanogenesis or consumption of inorganic and organic electron acceptors. Moreover, we tested the influence of temperature on EAC turnover and the potential of oxidation by ambient oxygen to replenish capacities of EAC of NOM. To this end, we set up anoxic incubations of different peat materials and monitored the production of CO_2 and CH_4 as well as changes in EAC of organic matter over time.

In an incubation over 8 weeks, 54 - 80% of CO_2 stemmed from methanogenesis. Of all remaining, 0.4 – 0.6% of non-methanogenic CO_2 was explained by inorganic EA. The consumption of EAC of particulate organic matter (EAC_{POM}) was closely related to the observed production of non-methanogenic CO_2. Moreover, the contribution of EAC_{POM} by far exceeded EAC_{DOM}. EAC of organic matter (EAC_{POM} + EAC_{DOM}) could explain around 25 % of CO_2 production of a weakly decomposed peat, around 30 % in a well decomposed peat. Except methanogenic and electron acceptors, only 15 – 31% of CO_2 production remained unexplained. In addition, we incubated a highly oxidized peat material rich in sulfate. In this peat, non-methanogenic CO_2 production could be explained by 70%, of which EAC of organic matter contributed 55% and inorganic EA contributed 15%. As expected, EAC_{POM} consumption rates increased with temperature, and Q10 values were around 2.0. Moreover, exposing the peat material to oxic conditions under ambient air, EAC_{POM} could be regenerated completely within 12 hours after 8 weeks of anoxic incubation.

The results show that the EAC_{POM} is the major electron acceptor in peat controlling CO_2 production and suppression of methanogenesis. DOM likely only acted as a mediator for electron transfer. Short time exposure to air showed that EAC_{POM} can readily be renewed by atmospheric oxygen and thus suppress CH_4 production under again anaerobic conditions.