Geochemical and hydrological limitation of carbon sequestration and methane release in anoxic peat soil from Luther Marsh, Canada

Westfälische Wilhelms-Universität Münster

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Introduction

In deep peat layers, anaerobic respiration showed a slow-down due to the lack of solute transport which causes an accumulation of metabolic end products (i.e. DIC and CH_4). This accumulation can lower the Gibbs free energy levels available to the terminal respiration processes, potentially leading to an inhibition in the methanogenesis which occur near thermodynamic minimum energy levels.

We conducted a column experiments with an ombrothrophic peat over a period of 300 days at 20°C, to test the hypothesis that alteration in solute and gas transport rates can remove this biogeochemical inactivation of DIC and methane turnover rates.

Experimental design

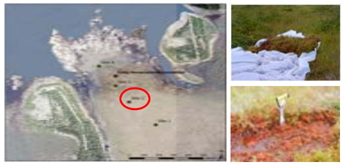

Figure 1 (left) Map of the study area "Luther Marsh", Ontario, Canada, and sampling site.
Figure 1 (right) Overview of the sampling technique.

Figure 2. Overview of the set up of the treatments

The study was conducted at the Luther Marsh bog, Ontario, Canada (Fig 1). Peat samples were collected from the depth of 20 cm up to 30 cm after the removal of the vegetation parts (ca. 15 cm depth) .

We tested

1. **Control (C)** treatment with no gas and solute transport,
2. **Advective flow (A)** treatment with a flow water of 10 mm d^{-1} and a water reservoir to degas water before to return into the columns,
3. **Ebullition (E)** treatment with methane removal by conduit transport as surrogate for bubbling,
4. **O_2-free atmosphere (O_2-free)** close system, oxygen free to test the effect of remote transport of electron on anaerobic decomposition.

We set up 85 cm length columns with 3 replicates per each treatments.

Water table is kept constant at 10 cm depth.

Net turnover rates and thermodynamic calculation

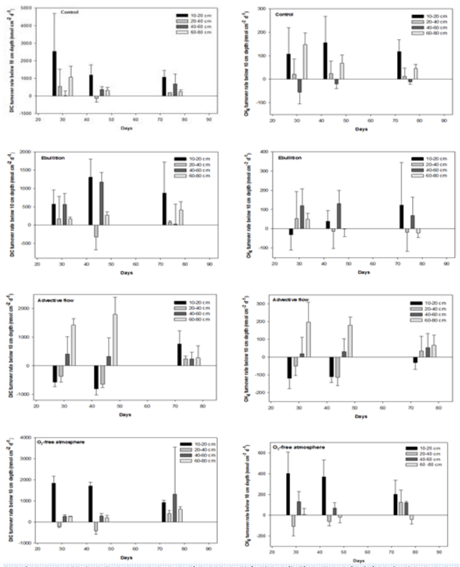

Figure 1. Calculated net turnover rates (nmol cm^{-2} d^{-1}) of DIC (left) and CH_4 (right) in the four treatment below the water table (10 cm) over a period of 75 days. Values expressed as mean over replicates.

Net turnover rates of DIC and CH_4 were calculated below the water table level (10 cm depth) over a period of 75 days (Fig. 1). Single depths were clustered into four main depths: 10-20; 20-40; 40-60 and 60-80 cm. During the first 75 days, DIC and CH_4 were mainly produced close to the water table (10-20 cm) in the **C** and **O2-free** treatments, showing a decrease over depths. Consumption of DIC and CH_4 were calculated for shallow depths (10-40cm) in the **A** treatment. In this treatment, DIC and CH_4 production increase with depth and over time. In contrast, DIC and CH4 production generally showed high variability with depth and over time, in the **E** treatment.

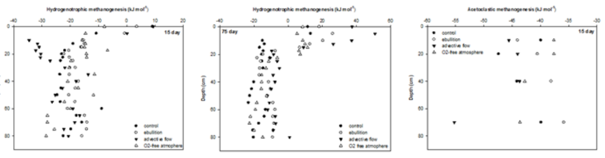

Figure 2. Values of ΔG (kJ mol^{-1}) for hydrogenotrophic (left and center) and acetoclastic (right) methanogenesis over depth and selected time points (15 and 75 days).

Acetoclastic methanogenesis was more advantageous process in all treatments with a range of -36 to -55 kJ mol^{-1} acetate after 15 days, especially at larger depths in the **A** treatment and just below the water table in the **C** treatment (Fig.2, right). Similar values for hydrogenothrophic methanogenesis was calculated after 15 day only in the **A** treatment at 10-25 cm depth, averaged -30 to -40 kJ mol^{-1} CO_2 (Fig. 2, left). In all treatments, the hydrogenothrophic methanogenesis became less exergonic over time in the deeper layers with positive values in the oxic layers.

Conclusion and Outlook

In this initial phase of the experiement, acetoclastic methanogenesis was a thermodynamically feasible process in all treatments..

At the end of the experiment, we expect that a negative feedback on decomposition will mostly occur in deeper layers in the control treatments due to the slowness of transport and where the accumulation of CO2 and CH4 will be eased, in line with the results presented in previous studies[3].

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References: 2. Schink, B. Energetics of syntrophic cooperation in methanogenic degradation. Microbiol. Mol. Biol. Rev. 1997, 61, 262-280. **3**. Blodau, C.; Siems, M.; Beer, J. Experimental Burial Inhibits Methanogenesis and Anaerobic Decomposition in Water-Saturated Peats. Environ. Sci. Technol. 2011, 45, 9984-9989.

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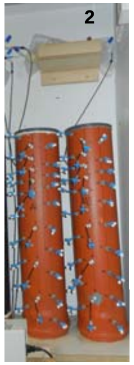

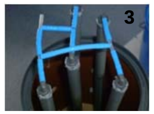

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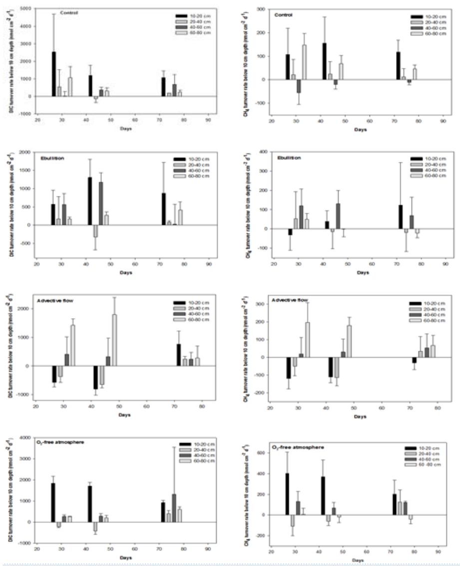

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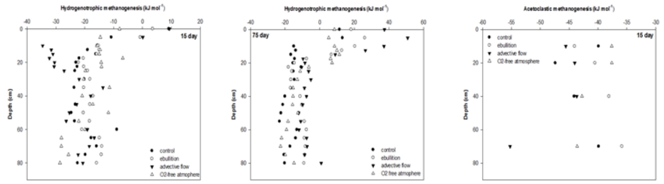

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Summary and outlook

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WESTFÄLISCHE
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Only low methane production and emissions in peat extraction sites after rewetting

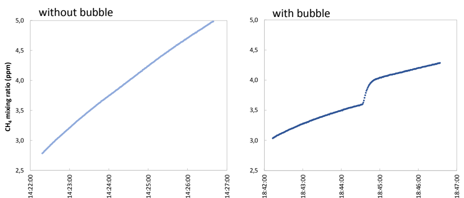
Svenja Agethen, Carolin Waldemer, Klaus-Holger Knorr

Introduction

Die Ems entspringt im Osten der Westfälischen Bucht in der Senne und mündet nach 370 km als der kleinste Strom Deutschlands in die Nordsee. Sie ist als Besonderheit über ihren kompletten Verlauf Sand-geprägt. rste Befestigungs- und Ausbaumaßnahmen fanden bereits in 18. Jh.

Methods

We measured CO_2 and CH_4 fluxes of a small and shallow water body (700 m^2; 0.3 to 0.6 m depth) and the surrounding floating mat in the Luther Marsh peatland in Ontario, Canada from July to September 2014. We used closed chambers combined with an Ultraportable Greenhouse Gas Analyzer at different distances from the shore of the pond and with different dominating plant types on the floating mat (shrubs, mosses, grasses). We were able to distinguish between methane fluxes with and without bubble due to the high temporal resolution of our measurement.



Results and discussion

Die Ems entspringt im Osten der Westfälischen Bucht in der Senne und mündet nach 370 km als der kleinste Strom Deutschlands in die Nordsee. Sie ist als Besonderheit über ihren kompletten Verlauf Sand-geprägt.

Erste Befestigungs- und Ausbaumaßnahmen fanden bereits in 18. Jh. statt und erreichten ihren Höhepunkt zwischen den 1930er und 1970er Jahren, mit dem Ziel die Sommerhochwässer komplett abzuleiten. Durch diesen Ausbau verkürzte sich die Laufstrecke der Ems um fast 20%, im Münsterland sogar um bis zu 50%.

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Die Kernprobleme der Ems liegen demnach in erheblichen hydromorphologischen Defiziten sowie mangelnder Durchgängigkeit.

Durch eine deutliche Aufweitung des Flussbettes auf 40 bis 50 m wird eine sekundäre Aue geschaffen, die trotz der Maßgabe stabiler Abflussvehältnisse für eine Vielzahl regelmäßig über-fluteter, amphibischer

Implications

Um die ökologisch-morphologische Situation der Ems zu verbessern, sind in den letzten Jahren einige Renaturierungsmaßnahmen der Bezirksregierung Münster umgesetzt worden. Häufig wurde dabei vor allem auf den Anschluss von Altarmen fokussiert.

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