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Biogeosciences Discussions

Interactive comment on "Effect of peat quality on microbial greenhouse gas formation in an acidic fen" *by* M. Reiche et al.

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Dear A. Freibauer:

We are very appreciative of your comments on our manuscript in the interactive Discussion Forum of Biogeosciences, as we feel this is the best way for open, international scientific discussion. We wanted to thank you in particular for the thorough review and all the effort you spent on our data.

Your primary concern about our manuscript was that the new peat quality index may not be helpful to estimate peatland responses to changing conditions. You hypothesized that the variation in anaerobic CO2 and CH4 formation can be explained directly by (1) rooting intensity and the availability of fresh, decomposing plant material without

information on peat quality and (2) delayed anaerobic CH4 formation in topsoil samples due to aerobic conditions prior to sampling.

I will first address your second hypothesis. We fully agree that the delayed onset of CH4 formation is correlated with the presence of alternative electron acceptors with a higher redox potential in the soil solution prior to anaerobic incubation. Consequently, we have analyzed soil solutions from 2001 through 2009 with this in mind and have published several manuscripts showing this correlation (Küsel and Alewell, 2004; Küsel et al., 2008; Reiche et al., 2008; Reiche et al., 2009). However, this study did not attempt to explain differences in the onset of CH4 formation, but rather tried to explain the rate and amount of CH4 formed once peat reaches methanogenic conditions. We are sorry for this misunderstanding and will make changes to the text to clarify.

In regards to your first hypothesis we know that CO2 and CH4, as typical end products of anaerobic metabolism, are fuelled by the input of organic carbon (e.g. root exudates, or decomposing plant material) and the microbial community in the peat will respond to these changes in carbon supply. Therefore, it is not surprising that the upper peat layer was the most active layer and showed highest gas formation rates compared to deeper peat layers. However, some deeper peat samples showed negligible potentials. This fen has been extensively studied with respect to processes involved in the degradation of organic matter over the last 10 years; however, differences in gas formation potential from peat samples derived from different sites did not correlate with vegetation, rooting depth, water regime, or peat decomposition stage after von Post. When we started this project we hypothesized that there would be changes in methane formation pathways with increasing soil depth or different seasons, we were unable to find any correlations with these factors. This is the reason that we started to evaluate the peat quality.

To the best of our knowledge no analytical technique or parameter exists which describes the quality and quantity of peat and, in general, there is currently no common definition or widely accepted quantitative index of "quality". This is why we applied thermogravimetry to derive a quality index for peat organic matter which focuses not only on the amount of specific carbon substrates (e.g. root exudates, fresh plant litter or specific molecules), but also describes the whole organic carbon pool present in the peat. As we mentioned in the manuscript, the index has to be validated before it can be used to estimate gas emission rates. However, our results clearly show that this new peat quality index might be an easy tool to estimate (1) the quality of peat, and (2) the anaerobic gas formation potential for both CO2 and CH4 without additional knowledge about environmental conditions at the filed site.

Below, we will comment on your more detailed statements:

1. The average daily CH4 formation rates given in Table 3 were calculated as the average of the period after onset of methanogenesis as mentioned in chapter 2.4. To be more precise we will add a more detailed explanation to the materials and methods.

2. The cluster analysis (Fig. 1) is sensitive to CH4 as cluster analyses for both parameters CH4 or CO2 alone show a similar pattern. This analysis was used to define a threshold with which to differentiate between active and inactive peat with respect to the gas formation potential (see Fig. 3).

3. We agree that the subset of samples selected for Py-GC/MS analyses (Fig. 4) does not represent the full range of CH4 formation. Peat samples were selected for this analysis with respect to their differences in the peat quality index and used to identify major pyrolysis products. The samples used for Py-GC/MS cover the full span of the peat quality index (0.8-1.8) and even samples with the highest rates of CH4 formation were in this range. Therefore, this analysis was sufficient to identify important precursors which affect the formation of CH4 as well as CO2.

4. It is very common to relate gas formation rates obtained from soils to the amount of dry matter. We agree that it could be useful to use the amount of total carbon instead due to the variability in carbon content of the peat samples. However, it would not impact the pattern of gas formation and the values for individual conversions are given in Table 2.

5. We used laboratory conditions for the determination of gas formation as it's the only way to measure real formation rates. Compared to field measurements, which can be influenced by a variety of environmental factors (e.g. groundwater flow, effect of distinct redox zones, release of gas bubbles), the origin of CH4 and CO2 can be verified and determined under controlled conditions. The incubation period of 31 days we used should be sufficient enough to determine realistic initial and delayed methanogenic activities. Of course, laboratory incubations are not suitable for assessing the actual relevance of peatlands as source or sink of CO2 and CH4 in general but they help to understand and estimate underlying microbial processes.

6. The influence of changing environmental conditions on the formation of both gases was not the focus of this study but has been investigated previously (Reiche et al., 2009).

7. We decided to calculate the PQI as the ratio between the sum of thermal labile and recalcitrant C-based compounds and inert carbon compounds because pyOMlabile and pyOMrecalcitrant correlated positively and pyOMinert negatively with the corresponding gas formation rates. The fraction of pyOMlabile alone was not sufficient to define a precise and robust peat quality index compared to the ratio given above.

References

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