Photodegradation in peat decomposition

Photpeat
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Project duration: 30 man days, 5 days in May-June, 25 days in August/September
Call 31 October 2012

Background

Several recent studies have indicated that photodegradation, enhancement of decomposition rate caused by exposure to light, may play an important role in plant residue and soil organic matter decomposition (Austin and Vivanco 2006; Parton et al. 2007; Day et al. 2007; Foereid et al. 2011; Meyer et al. 2012). Photo-exposure leads to increased emission of a number of carbon containing gases, including the potent greenhouse gas CH_4 (Lee et al. 2012). The mechanism for how photo-exposure affects litter mass loss is insufficiently known, but recent work suggests that it particularly affects the degradation of lignin, the plant compound most resistant to microbial degradation (Austin and Ballare 2010), and that photo-exposure can enhance subsequent microbial degradation (Foereid et al. 2010). A large proportion of the planet's carbon stores are in the soil, and a disproportionally large percentage of this is found in northern latitude peats (Batjes 1996; IPCC 2007). However, surprisingly little is known about the controls of peat decomposition in natural and semi-natural ecosystems. Decomposition appears to be patchy with a large portion of the peat seemingly inactive at any one time, but with hot-spots of microbial activity (Fenner et al. 2011). The difference between active and inactive patches has been difficult to understand.

Previous studies on terrestrial photodegradation have mostly focused on tropical semi-arid areas, but there is potentially enough radiation in the summer also at higher latitudes on surfaces free of vegetation or with low vegetation cover to have an effect. Ruthledge et al. (2010) showed that photodegradation plays a role for carbon fluxes in a de-vegetated peatland in New Zealand. I have previously done a simulation of potential photodegradation world-wide that showed a relatively large potential in some high latitude areas, due to low vegetation cover (Foereid et al. 2011). It could be a factor in explaining the patchy nature of peat decomposition, as my previous work has also shown that exposure to sunlight can prime plant residues for subsequent microbial degradation (Foereid et al. 2010). It is possible that exposure to sunlight in some exposed areas of the peat primes it for microbial activity, and therefore explains the patchy nature of peat decomposition. This hypothesis will be tested in this project.

Objective: to determine the role sunlight plays as a driver for peat decomposition and green house gas emission at high latitudes, and to what extent it interacts with microbial degradation.

Hypothesis 1: Sunlight is an important driver of peat decomposition in high latitude areas.

Hypothesis 2: Sunlight acts in tandem with microbial degradation, by making the peat more degradable.

Hypothesis 3: Both CO_2 and CH_4 emissions can be increased by photo-exposure.

Justification: The drivers of trace gas fluxes and fluxes in the carbon cycle in high latitude areas are important questions for the call, and the Mukhrino site is specially focussed on elucidating the carbon cycle of high latitude areas. Furthermore, Siberian mires store a large proportion of the world's carbon, and elucidating the mechanisms at play there is therefore more important than in other areas where the total area covered by peat is much smaller (i.e. Scotland). The Mukhrino site has started some monitoring of greenhouse gas fluxes that would be useful in the project, and laboratory facilities are nearby. Abisko is also a good site as it has a lot of experience in carbon cycle monitoring and experimentation, and should also have ample data sets useful for the project.

Research methods and material, ethical issues

Surface peat samples will be collected in spring/early summer, both top 2 cm and the 2 cm below it, to compare peat already exposed to the sun to some extent, to previously un-exposed peat. Peat will be sampled from the main peat types in the area. The peat samples will be dried, weighed and put in bags. Half of the bags will have UV-transparent plastic on top, the other half will have non-transparent plastic on top (controls). All bags will have fine netting on the bottom, stapled to the plastic. The netting will facilitate gas exchange, prevent over-heating and allow moisture that gets in to evaporate. The bags will be placed on a table in full sun and where any water can drain away freely. The bags will be left outside for the summer, and collected in early autumn. The bags will be weighed dried and dry weight and water content determined. The samples will then be incubated, one set at close to field capacity and one saturated/submerged. CO_2 and CH_4 production will be determined three times a week for 2-3 weeks. It will then be possible to determine the direct effect of sunlight, and to what extend it changes degradability of peat and the potential emissions of CO_2 and CH_4, and if exposure to sunlight may explain the patchy nature of peat decomposition. A sample of the peat before and after the incubation as well as before exposure will also be dried and kept for potential further analysis (microbial parameters, total carbon and nitrogen).

Greenhouse gas fluxes, particularly CH_4, are presently being measured in chambers throughout Siberia and at Abisko. These data will also be analysed using multivariate statistics to find out if including irradiance in the prediction of CH4 fluxes improves predictions compared to only using temperature and moisture as predictors. It may be a problem to find data on solar radiation for the area. For the older data, NASA global data set (http://eosweb.larc.nasa.gov/cgi-bin/sse/sse.cgi?+s01#s01) will be available. Availability of other radiation data fro the area will be investigated in order to also make use of newer data. At Abisko meteorological records will be available.

The risks are connected with general risks concerning field work and specific risks in connection with doing work in Russia. There are risks associated with leaving the samples outside, i.e. they may be blown away in bad weather. To avoid this, samples will be attached firmly, and collected early, before autumn storms are expected. There are also risks associated with working Russia. These risks are minimized, however, as good connections with Russian scientists have been established and the work can be carried out within Russia. This means that problems with taking samples out of Russia can be avoided. Furthermore, a risk in this project is that radiation data cannot be obtained. This means potentially that only older methane emission data can be used in correlation, where radiation data from NASA will be available.

I am not aware of any ethical issues with this proposal. Ethical approval internally in the institution will be obtained before the work begins following normal procedures.

Implementation: timetable, budget, distribution of work

The best site to do the work will be Mukhrino station in Western Siberia, meaning that visa is needed. The samples will be collected and put out in spring/early summer. They will be left exposed to the sun for the summer. In late summer/early autumn the samples will be collected and the incubation carried out. Two visits to the station will therefore be necessary. The incubation and gas analysis can be carried out at Yugra State University or at the wetland field station of Institute of Forestry Science in collaboration with Dr. Mikhail Glagolev. This avoids the problem of taking samples out of Russia. During this time, climate records and methane measurements will also be collated, and the theoretical work carried out between measurements, also in collaboration with Dr. Mikhail Glagolev and other Russian scientists. Dried samples will be kept both at the station and transported back for potential further analysis. However, if it is not possible to carry out the work in Russia, Abisko in Sweden is a possible alternative. This station may be easier to work at in terms of access and facilities.

	B. Foereid May/June	B. Foereid August/September
Mukhrino	5	3
Yugra State University		22

Budget travel and logistics (Euros):

Dundee-Edinburgh	40	X2	80
Edinburgh-Moscow	500	X2	1000
Moscow- Khanty-Mansiysk	700	X2	1400
Local transport	200		200
Visa			35
Total			**2715**

Expected results and possible risks

The research is expected to quantify the potential role photodegradation in peat decomposition and methane emission from peatlands in high latitude environments, as well as answering to what extent photo-exposure can prime peat for subsequent microbial degradation. It is therefore expected to contribute to the mechanistic understanding of peat decomposition and methane emission, which could also guide further measurement efforts to better identify potential hotspots. There are some risks connected with fieldwork and working in Russia, these risks are addressed above.

The results will be published in scientific journals, also comparing the results obtained here to a similar study carried out in Scotland. This will make it possible to conclude if the mechanisms identified can be assumed to be universal, or if they are very dependent on the environment concerned. The results will also be presented in conferences, and will be discussed with Russian scientists with the objective of also making a short version available in a Russian publication. The results will also be disseminated through our channels of interaction with the public, such as open days, science week etc. The data will also be available at the research infrastructure, to be used by other researchers.

Key Literature

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