Oxidation of POC in Floodplain Environments, Evidence from Eroding Blanket Peatlands

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Introduction

Particulate carbon losses from eroding peatlands are very large (up to an order of magnitude greater than dissolved losses (Evans *et al*. 2006, Pawson *et al*. 2008)). Losses of these magnitudes have the potential to shift peatland systems from carbon sinks to carbon sources. However, incorporation of these losses into Greenhouse gas budgets is problematic because of uncertainties about the fate of eroded peat (particulate organic carbon - POC). POC is potentially processed to dissolved and gaseous forms either in-stream or by oxidation from depositional sites, such as floodplains. Figure 1 shows an example of eroded peat which has subsequently been deposited on a floodplain. Pawson (2007) suggested that such losses might be up to 30% by mass annually (implying that the scale of 'climatically active' POC loss from eroding systems might equal or exceed that from DOC), but direct measurements are required.

Figure 1. POC deposits on a floodplain

Aim

In light of the potential significance of POC loss and subsequent processing for peatland carbon budgets, the aim of this research is to assess the importance of floodplain environments in 'processing' POC derived from eroded blanket peatlands. Specifically:

- What is the magnitude of carbon flux from floodplain sites?
- How does the carbon flux from unmodified sites compare to those with POM deposition?
- How does the carbon flux from mature peat deposits compare to that from fresh deposits?

Study Site

Experiments will be undertaken at the eroding Bleaklow plateau in the Peak District, at the Manchester Upper North Grain research catchment. The catchment is a small (0.43 km^2) headwater catchment of the River Ashop, which feeds the Ladybower Reservoir in the Upper Derwent Valley. The catchment lies within the National Trust High Peak estate in the Peak District, south Pennines, UK (Figure 2 (a)).

The catchment lies between altitudes of around 480 and 540 m. The principle landcover is blanket peat which varies in thickness with maximum depths of 4 m. The catchment is heavily eroded with deep Bower Type I peat gullies (Bower, 1961), often cut to the base of the peat, although some gullies have begun to revegetate (Evans *et al*., 2004). The dense gully network in the catchment is shown in Figure 2 (b). The catchment has a vegetative cover comprising predominantly *Eriophorum vaginatum*, *Calluna vulgaris*, *Erica tetralix*, *Vaccinium myrtillus*, *Empetrum nigrum* and patches of *Sphagnum* spp. The catchment also has existing environmental monitoring infrastructure including a weather station, and discharge monitoring.

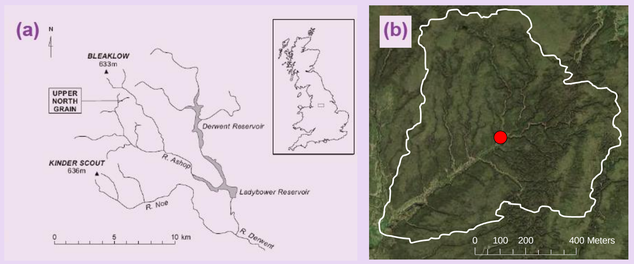

Figure 2. (a) The Upper North Grain catchment in its regional setting; (b) Aerial photograph of the catchment showing the dense erosion gully network.The location of the monitoring equipment used in this study is marked in red.

Methods

In order to monitor the carbon flux from deposited POC, 24 gas collars have been installed on a floodplain in the research catchment, marked in red on Figure 2 (b). Six replicate collars of four different treatments have been installed on the floodplain area, in two blocks of 12. The four treatments are:
A. Unmodified floodplain surface (shown in Figure 3 (a))
B. Floodplain surface covered by a 20 mm particulate organic matter (POM) layer (Figure 3 (b))
C. 20 mm POM layer isolated from the soil surface (Figure 3 (c)); and
D. 20 mm POM layer isolated from the soil surface, refreshed on a monthly basis to simulate fresh peat deposits (the design of this collar is also shown in Figure 3 (c)).

Figure 3. The various different treatments used in the study (a) gas collar enclosing unmodified floodplain surface; (b) floodplain surface with 20 mm POM; (c) POM isolated from the soil surface

The collars were made from 150 mm diameter ABS plastic pipe which cut into various lengths. For treatments A and B, the bottom 50 mm of the collars were driven into the peat. As treatments C and D are isolated from the underlying soil surface, collars were shorter, fixed to a plastic base plate and the join was sealed using silicone sealant to preclude gas exchange with the surrounding atmosphere during gas flux measurements. Each collar had two 11 mm drainage holes at a 90° angle so incident rainwater would not saturate the peat in the collar. The holes were covered with 2 mm mesh on the inside to prevent losses of POM (see Figure 3 (c)).

The POM used to simulate floodplain deposition consists of peat that collected from a nearby exposed peat face. The friable surface peat (that peat which is likely to be mobilised during rainfall events and be deposited on the floodplain) was removed and passed through a 11.2 mm sieve. The peat was well mixed to ensure homogeneity and added to collars B, C and D. The collars were arranged in two plots of 12, each plot with three replicates of each of the four treatments. The arrangement of the treatments can be seen in Figure 4.

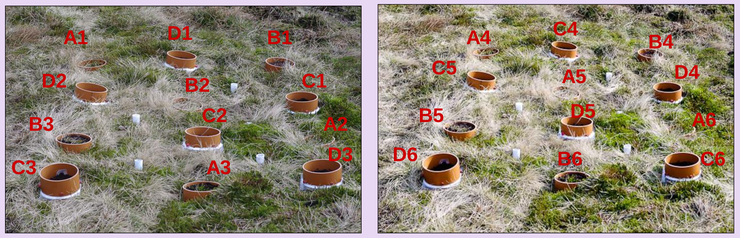

Figure 4. Arrangement of the four treatments A1 – 6, B1 – 6, C1 – 6 and D1 – 6 on two adjacent plots on the floodplain

CO_2 flux is measured using a field portable PP Systems' IRGA and a 25x25 cm chamber which is placed on the collars. During measurements from treatments C and D rubber bungs are inserted into the 11 mm drainage holes to ensure an air-tight seal and to eliminate gas exchange with the surrounding atmosphere. (see Figures 3 (c) and 5 (b)). Dark and light measurements are taken at each site, as shown in Figure 5. Fluxes can be interpolated using temperature and radiation measurements to separately quantify CO_2 fluxes associated with floodplain soil respiration, primary productivity of floodplain vegetation and oxidation of deposited POM.

Readings will be taken at two week intervals over 12 months to produce an annual carbon budget

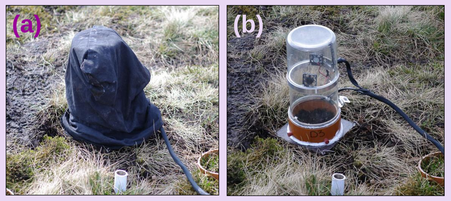

Figure 5. (a) Gas flux measurements using the IRGA and chamber (a) dark and; (b) light readings

Results

Figure 6 shows the results from one set of readings, taken on 23rd March 2011. As the collars were installed on 23rd February 2011, the POM deposits in all collars represents peat that is four weeks old. As such, treatments C and D are grouped together (i.e. the POM in collars D has not yet been refreshed so treatments C and D are effectively equivalent).

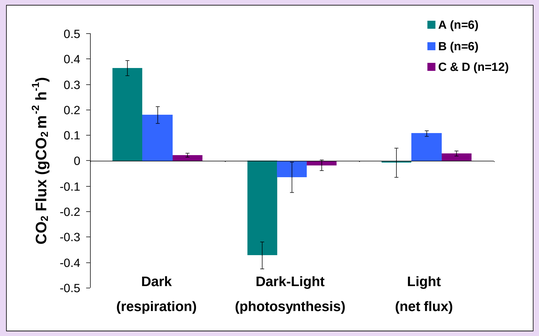

Figure 6. CO_2 flux from the unmodified floodplain surface (series A), the floodplain surface with POM layer (series B), and a 20 mm POM layer isolated from the soil surface (series C&D). Bars represent two standard errors. Data collected on 23rd March 2011

The 'dark' readings represent CO_2 flux from respiration, the 'light' readings represent CO_2 flux from photosynthesis and respiration (net flux), with the difference between the two being CO_2 flux from photosynthesis alone. It would appear from this data that unmodified floodplain (treatment A) is the only treatment which is a net CO_2 sink. Both the floodplain surface with POM layer (treatment B), and the 20 mm POM layer isolated from the soil surface (treatments C and D) are net CO_2 sources. Although the net CO_2 flux from treatments B, C and D seems relatively small, when these figures are extrapolated over a 12 month period, this does represent a significant proportion of the total peatland carbon budget. It should be noted that these figures represent one set of monitoring data and that it may not be entirely representative of longer-term monitoring data.

Summary

- The carbon flux from eroded POC which has been deposited on peatland floodplains is potentially significant in terms of the peatland carbon budget and we need direct measurements to quantify the significance of this flux.
- Carbon flux from floodplain POC is being monitored in the Upper North Grain catchment, an eroded peatland catchment in the South Pennines.
- Carbon flux measurements are being from 24 gas collars with four different treatments, incorporating unmodified floodplain, floodplain with POM, and mature and fresh POM deposits isolated from the floodplain.
- Readings are being taken at fortnightly intervals over a 12 month period to establish an annual carbon flux.
- Preliminary results indicate that oxidation of POC on floodplains may represent a significant component of the overall carbon budget.

References

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