Influence of elevated nitrogen deposition on the dynamics of DON and DOC in peatlands

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Background

Soil is a major component in the global carbon (C) cycle, containing about 1500 Pg (1 Pg=1 Gt = 10^{15} g) of organic carbon, which is about three times the amount in vegetation and twice the amount in the atmosphere. About one third of the soil carbon reservoir is stored in peatlands. Yet despite the global significance of peatland C stores, there remains considerable uncertainty in the potential response of soil C dynamics to both climate change and the rapid global increase in the atmospheric deposition of reactive nitrogen (coming largely from agricultural fertilizers and fossil fuel combustion). In particular we know little about how changes in these environmental factors will alter the loss of dissolved organic matter (DOM) from these systems. DOM is a complex mixture of organic compounds which is commonly quantified in terms of dissolved organic carbon (DOC), although dissolved organic nitrogen (DON) and phosphorus (DOP) are also often measured, and may represent a major pathway, and eventual source, of these key nutrients to surface waters.

Over the last 20 years, concentrations of DOC have increase in freshwaters draining catchments containing organic soils across Europe ad North America (e.g. Evans et al, 2006). Many climate change driven mechanisms have been postulated to explain this trend, such as increase in decomposition rates due to increasing temperatures, increased DOC production under elevated atmospheric CO_2, increased frequency and severity of droughts and changes in runoff amount and timing. While others have suggested changes in the chemistry of atmospheric deposition (either (i) decline in sulphur deposition or (ii) increase in nitrogen (N) deposition) are responsible for the increases in DOC.

Bog peats are ‘ombrotrophic’ as they receive all of their water and nutrients from rainfall, and are therefore naturally acidic, nutrient-poor and N-limited. However, many peatlands receive inputs of atmospheric N deposition far above pre-industrial levels. Although this increase has caused shifts in N and C cycling within the ecosystem, most peatlands remain highly retentive of nitrogen, with much of the additional N being stored (sequestered) in soil organic matter. The N saturation concept describes how N supply exceeds biotic demand leading to an increase in dissolved inorganic fluxes of N from soils to streams (Aber et al., 1989). In contrast, to DIN, the alteration of DON and DOC dynamics with N loading is a topic of considerable uncertainty. Some researchers have found that DON losses remain constant across broad geographical regions despite variations in N loading (e.g. Perkis and Hedin, 2002), while others have observed increases in DON from long-term N manipulation experiments (e.g. Pregitzer et al., 2004). These manipulation experiments also reported marked increases in DOC leaching after 8 years of nitrate addition. However, a recent review of field nitrogen addition

experiments showed an inconsistent DOC response to N addition (Evans et al 2008), although responses do appear to be linked to form of N added, and resulting changes in acidity.

Overall, there is still considerable uncertainty regarding the mechanisms by which elevated N deposition affects DOC and DON availability in peatlands. In addition, few studies have examined the C and N content of DOM simultaneously and little is known about the relationships between DOM fluxes, stoichiometry (DOC:DON ratio) and N availability.

Project and aims

The overall aim of this research is to investigate the influence of elevated nitrogen deposition on DON and DOC dynamics in a peatland. The project will evaluate effects of 7 years' elevated N deposition on the biogeochemical cycling of nitrogen and carbon and the functioning of the associated microbial community of an ombrotrophic bog supporting dominated by *Calluna, Eriophorum* and *Sphagnum* species by addressing the following questions:

1. Determine how concentrations of DOC and DON respond to different forms (NH_3, NH_4 and NO_3) and loadings of N.
2. Determine how the chemical composition, DOC:DON ratio and reactivity of DOM changes with N loading.
3. Investigate the links between DON, DIN and DOC fluxes
4. Determine the processes controlling the behaviour of DOC, DON and DIN in peatlands
5. Identify processes affecting the release of DOC and DON from living plants using mesocosms taken from Whim and sprayed with labeled 15N.

The student will approach this project using a combination of methods, including (i) statistical analysis of existing data sets (ii) a new campaign of soil solution and soil sampling and analysis and (iii) laboratory experiments

Field Site

The proposed research will utilise a globally unique, long-term N manipulation experiment, established in 2002, providing different N forms (NH_4, NO_3, NH_3) to Whim bog (Figure 1), an ombrotrophic bog in the Scottish borders, 25 km from CEH Edinburgh. Gaseous ammonia, wet ammonium and wet nitrate are applied *in situ* to large (12.5 m^2) plots under real world conditions, at realistic concentrations and frequency and at N doses spanning the range of UK N deposition scenarios. Meteorological, chemical and biological data are available from 2002 providing significant added value.

Figure 1. Picture of Whim showing board walks used to access the site.

Training

The student will develop a range of research skills including, experimental design and maintenance, field sampling, chemical analysis, statistical analysis, data interpretation and presentation. Training will be provided in field/laboratory health and safety procedures and the use of field and analytical equipment. The School of Geography at Leeds and the Centre of Ecology and Hydrology (CEH) at Edinburgh are well equipped to carry out the required research. The student will benefit from spending time within both a University and environmental government research institute and benefit from this interaction. The student will have the opportunity to develop their research profile through publication and presentation of results at national and international conferences.

References

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