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Simulated climate change impact on summer dissolved organic carbon release from peat and surface vegetation: Implications for drinking water treatment

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ABSTRACT

Uncertainty regarding changes in dissolved organic carbon (DOC) quantity and quality has created interest in managing peatlands for their ecosystem services such as drinking water provision. The evidence base for such interventions is, however, sometimes contradictory. We performed a laboratory climate manipulation using a factorial design on two dominant peatland vegetation types (*Calluna vulgaris* and *Sphagnum Spp.*) and a peat soil collected from a drinking water catchment in Exmoor National Park, UK. Temperature and rainfall were set to represent baseline and future conditions under the UKCP09 2080s high emissions scenario for July and August. DOC leachate then underwent standard water treatment of coagulation/flocculation before chlorination. *C. vulgaris* leached more DOC than *Sphagnum Spp.* (7.17 versus 3.00 mg g^{-1}) with higher specific ultraviolet (SUVA) values and a greater sensitivity to climate, leaching more DOC under simulated future conditions. The peat soil leached less DOC (0.37 mg g^{-1}) than the vegetation and was less sensitive to climate. Differences in coagulation removal efficiency between the DOC sources appears to be driven by relative solubilisation of protein-like DOC, observed through the fluorescence peak C/T. Post-coagulation only differences between vegetation types were detected for the regulated disinfection by-products (DBPs), suggesting climate change influence at this scale

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can be removed via coagulation. Our results suggest current biodiversity restoration programmes to encourage *Sphagnum Spp*. will result in lower DOC concentrations and SUVA values, particularly with warmer and drier summers.

1. Introduction

Dissolved organic carbon (DOC) is of interest as it is a major flux of carbon from catchments, particularly in parts of the UK where organic-rich peat soils create a large reserve (Billett et al., 2010; Grand-Clement et al., 2014). DOC is also of interest to water utilities as it imparts taste, colour and odour. When present during chlorination, DOC can form disinfection by-products (DBPs) (Rook, 1974) which are a potential concern to human health (Nieuwenhuijsen et al., 2009). In the UK, trihalomethanes (THMs), a class of DBPs, are regulated at a maximum of 100 $\mu g\ l^{-1}$ in drinking water (DWI, 2010), however numerous other classes have been identified which may pose a threat to human health (Richardson et al., 2007).

Increasing DOC concentrations in surface waters have been observed across parts of North America and northern Europe since the 1980s (Eikebrokk et al., 2004; Eimers et al., 2007; Evans et al., 2005; Freeman et al., 2001a; Monteith et al., 2007). This trend has been attributed to a number of possible causes including catchment recovery from acidification following the introduction of air pollution controls (Evans et al., 2011, 2006; Monteith et al., 2007), changes in precipitation (Hongve et al., 2004; Lepistö et al., 2008) and increases in temperature and CO_2 due to climate change (Freeman et al., 2004, 2001a). Recent evidence suggests that the decline in sulphate and non-marine chloride deposition may be the most important cause in catchments which have been acidified (Evans et al., 2012; SanClements et al., 2012). As acidic deposition approaches background levels, climate change may become a more dominant factor (Clark et al., 2010) although soil and surface water chemistry may be slow to recover from acidification (Akselsson et al., 2013).

The effect of climate change on DOC will be varied as a number of biogeochemical mechanisms alter the production, transport and cycling of DOC within the catchment (Ritson et al., 2014). The vegetative source of DOC is of significance as radiocarbon studies have suggested that the majority of DOC in surface waters has recently entered the system and therefore most likely originates from decaying litter and the upper soil horizons (Palmer et al., 2010; Tipping et al., 2010).

The role of vegetation in DOC production is of further interest as a number of schemes in the UK have aimed to reverse damage to peatlands caused by artificial drainage, burning, acidification and erosion. The restoration of ecosystem services in peatlands has been undertaken for biodiversity, water quality, carbon storage and cultural service reasons and in many cases includes the (re)establishment of *Sphagnum Spp*. as one of the goals (Grand-Clement et al., 2013; Lunt et al., 2010). Further evidence in support of the management of vegetation is needed, particularly in terms of specific water treatment outcomes as opposed to simple DOC concentration measurements.

As well as the quantity of DOC produced, its treatability, in terms of amenability to removal and propensity to form DBPs, is also of interest as some studies have found this to have changed over time (Worrall and Burt, 2009). Treatment of surface waters for DOC removal in the UK commonly consists of coagulation using a metal salt in conjunction with a clarification/filtration step before chlorine/chloramine is used as a disinfectant. It may be possible to optimise these processes in response to dynamic changes in raw water quality through the use of online measurements of SUVA (specific ultraviolet absorbance at 254 nm) or fluorescence, as these techniques can give information on the treatability of DOC (Bridgeman et al., 2011; Weishaar et al., 2003).

How climate change will affect DOC production from vegetation is currently unclear. Our previous work (Tang et al., 2013) provided preliminary information in this area but was limited as it did not monitor DBP formation (only coagulation performance) and it only considered a mixed litter and peat soil rather than individual vegetation types. The investigation described in this paper extends the previous scope by conducting a longer climate simulation with three different sources of DOC (*Calluna Vulgaris*, *Sphagnum Spp*. and a peat soil). *C. Vulgaris* will be referred to by its common name, heather, for the remainder of the manuscript. Also investigated are the effects of climate/source on a wide range of water quality parameters including fluorescence signature, chlorine demand and carbonaceous and nitrogenous DBP (N-DBP) formation.

The objectives of this research were therefore to a) assess the influence of DOC source versus temperature and rainfall and thus the importance of different climate change drivers on DOC treatability; and b) examine the utility of fluorescence spectroscopy and UV techniques for water treatment optimisation. This will inform and develop the evidence base for vegetation management for water quality in peatland dominated systems. This builds on work in the USA (Reckhow et al., 2007) and suggestions of forest management for water quality in northern Europe (Eikebrokk et al., 2004). Climate simulations were performed comparing baseline production and leaching of DOC from different DOC sources to that under future UK temperature and rainfall projections taken from the UKCP09 2080s high emissions scenario (Jenkins et al., 2009).

2. Methods

2.1. Field site and sample collection

Samples were collected from two sites in Exmoor National Park, UK; Aclands (51° 07′54.2″ N 3° 48′43.3″ W) at