UK Centre for Ecology & Hydrology

Rising concentrations of dissolved organic matter in drinking water supplies: can peatland restoration help?

One of four FREEDOM-BCCR project briefing notes considering options to increase resilience in the water industry to climate change impacts on dissolved organic matter

Dissolved Organic Matter (DOM) in upland drinking water sources poses an increasing challenge to the water industry as concentrations have risen substantially in recent decades. Work undertaken during the FREEDOM-BCCR project has highlighted the potential of future climate change to exacerbate DOM concentrations further, with important implications for water treatment. There is an urgent need to consider the most efficient and effective adaptation and mitigation options open to the industry to manage any resulting deterioration of raw water quality.

The peatland catchments of many UK upland water sources used for water abstraction are subject to a range of land management pressures, including artificial drainage, commercial plantation forestry, over-grazing and prescribed rotational burning (Box 1, p2). It has been argued that these activities may have contributed to a rise in DOM concentrations in receiving waters, although the dominant driver is thought to have been an increase in the solubility of soil organic matter as soils recover from the effects of acid rain.

Peatland restoration has, therefore, often been proposed as a means of at least counteracting recent rising DOM trends, while simultaneously achieving a range of other benefits, including the re-establishment of more natural hydrological characteristics and peat forming vegetation - changes that can enhance carbon sequestration, improve biodiversity and increase the resilience of peatland catchments to future climate change.

If peatland restoration is able to improve raw water quality at source, it may reduce or remove the need for costly and complex engineering solutions at water treatment works (WTW). There is, however, considerable uncertainty around the impact such measures have had on the concentrations and treatability of DOM (see Table 1, p3 and refer to briefing note 4 of this series for more information on DOM treatability), and it is becoming increasingly difficult to justify the associated costs when considering water quality benefits alone.

For future water resource planning it is important to acknowledge that the likelihood of achieving a specific water quality outcome as a result of peatland restoration works in the catchment will be considerably lower than for direct treatment interventions made at the WTW. Water companies in the north of England have spent tens of millions of pounds on catchment restoration measures, including peatland revegetation and ditch blocking, and associated water quality monitoring over the last 10 to 15 years. Evidence is emerging that restoration can reduce DOM concentrations in soil water and streams in the immediate vicinity of interventions, and there is compelling evidence that such actions are bringing real benefits for habitat quality and peat integrity. It is not yet clear, however, whether they can be sufficiently wide reaching across catchments for water quality effects to be detectable at WTWs, either immediately or at some point in the future (Box 2, p4).

The latter issue is particularly pertinent given that the investment cycles used by water companies to plan and implement DOM mitigation options may not span the length of time necessary to detect catchment scale ecosystem change following peatland restoration. Peatland restoration is unlikely to provide 'quick wins' for DOM reduction, and needs to be viewed over the long term and in light of the wide range of other ecosystem services that it can deliver.

Work conducted under the FREEDOM-BCCR project has highlighted the importance of catchment characteristics in influencing sensitivity of DOM to variation and change in climate, but detailed spatial information on key attributes of upland drinking water catchments such as soil type, peat depth and vegetation characteristics are not often readily available.

BOX 1 PRESSURES ON PEATLAND

Clockwise from top left: Drainage; forestry; heather burning; sheep grazing

Determination of DOM risks posed by climate change and the potential for peatland restoration to make a significant impact, would clearly benefit from a more comprehensive compilation of data quantifying key catchment characteristics to provide the necessary context for associated long-term water quality records. This would enable both more robust site-specific assessments, as well as inter-catchment comparisons (both within and between water companies).

Catchment intervention	Observed impacts on DOM concentration	Observed impacts on DOM treatability
Restoration via ditch blocking	Increase [3] No change [7] Decrease [7]	Increase [3] No change [5] Decrease [2]
Restoration via revegetation to grass species	Increase [1] No change [3]	Decrease [1]
Restoration via revegetation to heather	Increase [1] No change [1]	Decrease [1]
Restoration via revegetation to *Sphagnum*	No evidence assessed	Increase [1]
Restoration via forest to bog conversion, and clearfelling	Increase [5] No change [2] Decrease [2]	No evidence assessed
Forest planting	Increase [5]	Species dependent increase [1] Decrease [2]
Prescribed heather burning	Increase [3] No change [1] Decrease [3]	No evidence assessed

TABLE 1

Summary of the impacts of catchment management activities, including peatland restoration, on DOM concentrations and treatability in pore water, ditch water and head water streams from peer reviewed papers published in scientific journals. The effects of the intervention on DOM were reported as either an increase, a decrease or no change and the numbers in brackets refer to the number of studies showing that effect in each case. For DOM treatability, an increase indicates that the DOM has become more treatable due to a shift in DOM composition to a more humic type, and a decrease shows a shift to a less treatable type. Adapted from Table 2 of Williamson et al. (2020; submitted and in review Hydrology & Earth Systems Science).

Take-home message: restoration measures deliver multiple benefits for peatland ecosystems and have the potential to reduce DOM in surface waters. To mitigate the uncertainty surrounding restoration effects on DOM, measures should be undertaken on a site-specific basis, where the scale, effect size and duration of the intervention are considered in relation to subsequent biogeochemical processing that occurs in the reservoir, the treatment capacity of the WTW and future projected DOM trends

Evidence for the success of peatland restoration in reducing DOM concentrations and improving DOM treatability is mixed for a number of reasons, including:

i. **Research design of study** - making long-term comparisons of water quality data at multiple sites is expensive, and studies do not always employ a B-A-C-I design (Before After Control Impact). Without this design, it is difficult to measure the specific effect of the intervention.

ii. **Location of monitoring** – very few (if any) published studies look at the impact of catchment management on water quality at the point of abstraction or at the WTW. Rather, they tend to focus at either the plot or hillslope scale. One possible solution would be to analyse water industry records of water quality at the point of abstraction before and after interventions have occurred in the catchment.

iii. **Effectiveness of intervention** – e.g. ditch blocks can fail because of blow out, bypass flow, erosion and underflow, and therefore not all restoration measures are of comparable quality.

iv. **Location and scale of intervention** – larger scale and nearer to reservoir interventions are more likely to have an observable impact on DOM at the WTW.

v. **'State' of peatland before intervention** – recent work by UKCEH shows that ditch blocking on blanket bog in north Wales had no impact on DOC concentrations as the water table was high before blocking occurred.

vi. **Response time of intervention** – e.g. forest to bog restoration can take a long time (in the order of decades) for DOC concentrations to return to same as pre-intervention forestry due to high levels of disturbance associated with the restoration technique.

All the above factors should be considered when new evidence is presented, as they have the potential to impede meaningful comparisons between studies.

BOX 2 WHY IS THERE MIXED EVIDENCE SURROUNDING THE EFFECTIVENESS OF RESTORATION MEASURES TO MANAGE DOM?

How to cite

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About the FREEDOM-BCCR project

FREEDOM-BBCR (Forecasting Risks of Environmental Exacerbation of Dissolved Organic Matter in the upland drinking water supply – Building Climate Change Resilience) is led by the UK Centre for Ecology & Hydrology and funded by the Climate Resilience Programme (www.ukclimateresilience.org) - jointly led by UK Research & Innovation (UKRI) and the Met Office under the Strategic Priorities Fund (SPF).

Through the development of a community of scientists and water industry representatives, FREEDOM-BCCR aims to improve understanding of the risks posed by climate change to the quality of water in upland drinking water sources and develop a conceptual framework of mitigation and adaptation options to maximise the future resilience of the supply. The vision of the Climate Resilience Programme is "To enhance the UK's resilience to climate variability and change through frontier interdisciplinary research and innovation on climate risk, adaptation and services, working with stakeholders and end-users to ensure the research is useful and usable."

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Partners

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