The future of raw water colour

Assessing risk of increasing colour concentrations from climate and land use changes in Scottish drinking water sources

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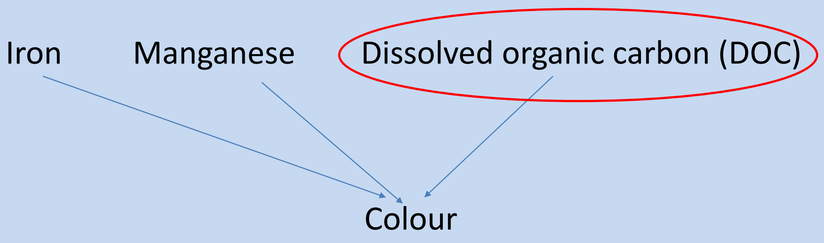
Colour in drinking water

Colour in Scotland mainly stems from dissolved organic carbon (DOC), produced in organic soils and transported into the water body at rainfall events.



Recent decades have seen an increase in water colouration in the Northern hemisphere [1], causing concern to drinking water providers.

It is undesirable in drinking water, because of
- brown appearance
- earthy smell
- carcinogens that may form during treatment

Methodology

For strategic investment into drinking water treatment plants and to effectively target mitigation measures, it is essential to understand how changes in climate and land use may influence colour concentrations, and estimate the risk for catchments providing our water.

Risk assessment for 127 Scottish drinking water catchments:

What drives seasonal patterns?
We tested the relationship of total organic carbon (TOC) concentrations to
- temperature (preceding 60 day average temperature)
- Short periods of rainfall (preceding 3 day total rainfall)
- Long periods of rainfall (preceding 60 day total rainfall)

using Spearman's rank correlation test.

What influences concentrations?
We modelled TOC median concentrations
- using catchment characteristics [2]
- including 2-way interactions

with stepwise backward linear regression.

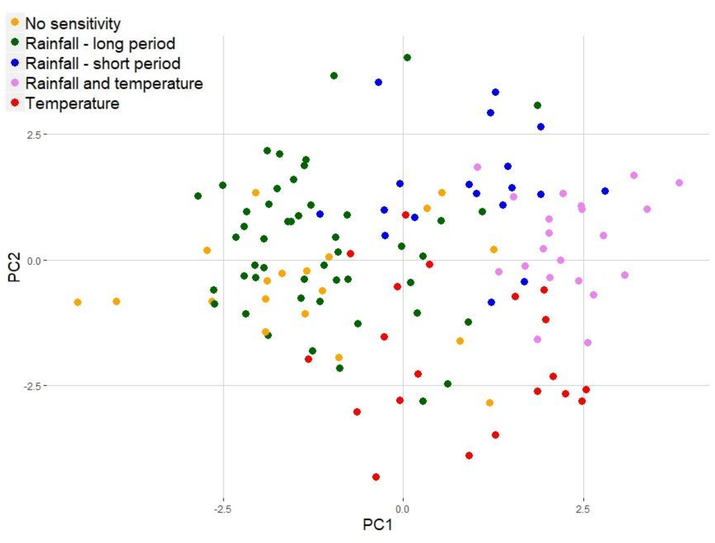


Figure 1: Catchment scores from a PCA on Spearman's rho values, visualising catchment sensitivity categories (PC1 broadly representing temperature, PC2 rainfall).

Sensitivity to rainfall and temperature

We could distinguish catchments that
- strongly reacted to **temperature**, but showed no correlation to rainfall
- showed strong responses to **short period rainfall totals** (3 days)
- correlated to the **longer period of rainfall** (60 days)
- showed correlations to **both short period rainfall and temperature**
- showed **no correlations** to any of the variables (Figure 1).

We found that catchments reacting to temperature were peat dominated, wet catchments. Correlations to short periods of rainfall occurred mainly in river catchments.

Implications from modelling

Climate: We identified a slight diluting effect of rainfall for overall concentrations, but could not establish higher temperatures as related to higher concentrations.

Land use: Land uses can have different effects depending on local conditions. Coniferous forest plantations increase concentrations on organic soils, but may mitigate impacts on steep slopes. Sheep grazing seems to increase concentrations in wet catchment.

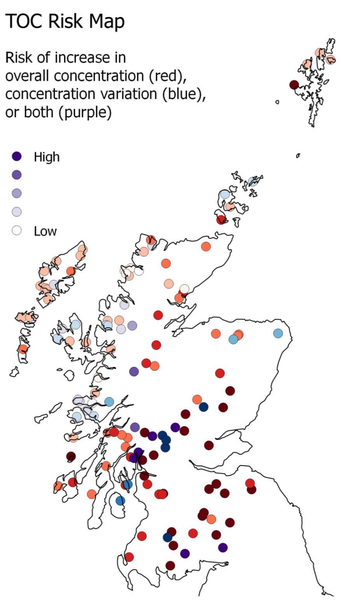


Figure 2: Catchment risk of increasing water colour (TOC as a proxy for DOC/colour), based on a decrease in summer precipitation (reference period 1981-2000, future period 2041-2060, UKCP18 RCM ensemble mean).

Risk map

The sensitivity analysis suggests that drier catchments need a longer rainfall period to flush out DOC, and mostly show higher overall concentrations. Rainfall seems to have an overall diluting effect. A decrease in summer rainfall has therefore been identified as the main risk factor, highlighting catchments in the South East as most at risk of increasing water colour (Figure 2).

References:
[1] Monteith, D.T. *et al.* (2007). Dissolved organic carbon trends resulting from changes in atmospheric deposition chemistry. *Nature*, **450**, 537-540
[2] Vorstius, C., Rowan, J.S., Brown, I., Frogbrook, Z., & Palarea-Albaldejo, J. (2019). Large-scale risk screening of raw water quality in the context of drinking water catchments and integrated response strategies, *Environ. Sci. & Policy,* **100**, 84-93

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