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Proactive Optical Monitoring of Catchment Dissolved Organic Matter for Drinking Water Source Protection (PRODOM)

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Identifying pressures

In Ireland, approximately 82% of public water supplies originate from surface water sources which require disinfection with chlorine to inactivate pathogens and prevent the spread of waterborne disease. The presence of dissolved organic matter (DOM) in source waters can lead to the unintentional formation of potentially harmful disinfection by-products (DBPs) such as trihalomethanes (THMs), of which Ireland has the highest number of reported exceedances for drinking water supplies in the European Union in recent years. The Proactive Optical Monitoring of Catchment Dissolved Organic Matter for Drinking Water Source Protection (PRODOM) project aimed to better understand the role of optically active DOM in the formation and forecasting of a range of DBPs, including the common regulated classes like THMs and haloacetic acids (HAAs) as well as emerging DBPs such as haloketones, haloacetonitriles and halonitromethanes (represented by chloropicrin). DBP formation was determined from chlorination of surface water and groundwater samples under uniform laboratory conditions with DOM spectroscopic and hydrochemical characterisation of raw water after primary filtration.

Informing policy

The research demonstrated a proof of concept for the application of machine learning tools in the prediction of DBP concentrations in treated water (after primary filtration and chlorination) using DOM spectroscopic variables and common hydrochemical parameters. Both regulated and emerging DBPs could be quantitatively predicted with high confidence. Models which included hydrochemical parameters only marginally improved prediction accuracy, demonstrating a way forward for automated low-cost high sample throughput applications for source water DOM management at water treatment plants. The application of portable in situ fluorimetry (measuring two DBP precursor wavelength pairs simultaneously) was also demonstrated, which could reveal high-frequency DOM export dynamics which govern raw water quality temporal variability in river water sources. The project also ranked landcover sources of DBPs for drinking water catchments in Ireland with tree cover (conifer) on upland peat soils found to have the highest risk for THM and HAA formation. Groundwater (as an alternative water source) was found to be a potential source of emerging nitrogenous DBPs.

Developing solutions

This research highlighted the importance of UV-visible fluorescence and absorbance spectroscopy as low-cost, non-destructive high sample throughput technologies suitable for proactive management of source water DOM quality. This is likely to be useful for drinking water source protection and early warning tool applications at water treatment plants for real-time process control and optimisation. Through the application of machine learning tools, greater automation and optimisation of DBP concentration prediction and forecasting (using DOM spectroscopic variables only) are demonstrated, with a workflow that is suitable for up-scaling to online monitoring for major water treatment plant operations in Ireland such as the proposed Water Supply Project Eastern and Midlands Region. Currently, only UV transmittance is routinely measured from raw water sources in Irish water treatment plants. It is recommended that the acquisition of raw water fluorescence excitation–emission matrices is adopted for public water supplies subject to THM exceedances for improved DBP formation risk management and precursor characterisation across different drinking water catchments in Ireland.

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