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# Near real-time control of disinfection by-products in a full-scale distribution system through fluorescence sensors

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**Abstract:** This study investigates the potential of humic-like fluorescence sensors for real-time monitoring of DBPs in a full-scale drinking water distribution network. Several sampling campaigns were conducted covering various points in the distribution system, including drinking water treatment plant (DWTP) and a district-metered areas (DMA). The results show strong correlations between sensor and benchtop fluorescence data, demonstrating the reliability of the sensor technology. Additionally, significant correlations were observed between sensor fluorescence and total THMs concentrations, highlighting the potential of the sensor in tracking the fate of these compounds along the network. This approach may contribute to developing an innovative tool for real-time control of DBPs in water distribution systems.

**Keywords**: DBPs; fluorescence; sensors; monitoring.

Chlorination of drinking water may lead to the formation of undesirable compounds known as disinfection by-products (DBPs), as a result of reactions between chlorine and natural organic matter (NOM). Several hundreds of DBPs are frequently identified, such as trihalomethanes (THMs), haloacetic acids (HAAs), haloacetonitriles (HANs), haloacetamides (HAMs), haloacetaldehydes (HALs). Many organizations and states have established DBPs regulations, given the health risks posed by DBPs, including cancer development. For instance, the new European Directive on drinking water (2020/2184) introduced limits for HAAs (60µg/L) and both chlorites and chlorates 0.25 mg/L. To face new regulations, DWTPs may need to improve their treatment train or employ different strategies, including the removal of formed DBPs, the use of different disinfection methodologies, and the removal of DBPs precursors. However, the question of "best practice" remains open: the use of these strategies does not always guarantee a reduction of DBPs and the risk of exposure remains high since additional DBPs could be formed. Therefore, another relevant strategy aimed at limiting the risks of DBPs exposure that water managers may need to consider is the monitoring of DBPs in the distribution supply system up to the tap. Several methods have been developed for monitoring DBPs concentrations based on UV-Vis absorbance measurements, such as $\Delta UV_{254}$, $\Delta UV_{272}$ and $\Delta UV_{280}$. However, absorbance lacks specificity and is less sensitive compared to fluorescence. Fluorescence offers detailed insights into the NOM composition, making it effective for detecting and monitoring the precursors. The aromatic and carbon-rich fraction of NOM, including aromatic compounds, humic and fulvic acids, is considered the major precursor of DBPs (e.g., THMs and HAAs). Several studies showed strong relationships between DBPs and humic-like fluorescence, often referred as I5 peak of the excitation/emission matrix (EEM). Thus, the real-time monitoring of the humic-like fluorescence in distribution networks may indirectly provide a tool for real-time monitoring of DBPs. The objective of this study was to test humic-like fluorescence sensors to evaluate the potential for

real-time monitoring of DBPs in a full-scale drinking water distribution network. For this purpose, nine sampling campaigns were conducted (February-November 2024) in a full-scale water distribution network. The samples (some were quenched with sodium thiosulphate) were collected at the effluent of the DWTP, at the rechlorination tank, and various points within a district-metered area (DMA). Fluorescence measurements were carried out in the laboratory following calibration performed on a raw water sample collected at the inlet of the DWTP.
The results demonstrated strong correlations between sensor and benchtop fluorescence data, indicating high reliability of the sensor measurements (Figure 1). Additionally, robust correlations were observed between sensor fluorescence and total THMs (TTHMs) concentrations, both for quenched and unquenched samples (Figure 2). Ongoing experiments aim to extend these findings to online and real-time monitoring of DBPs. These results support the use of fluorescence sensors as a reliable tool for DBP monitoring in water distribution systems, helping to reduce human exposure risks.

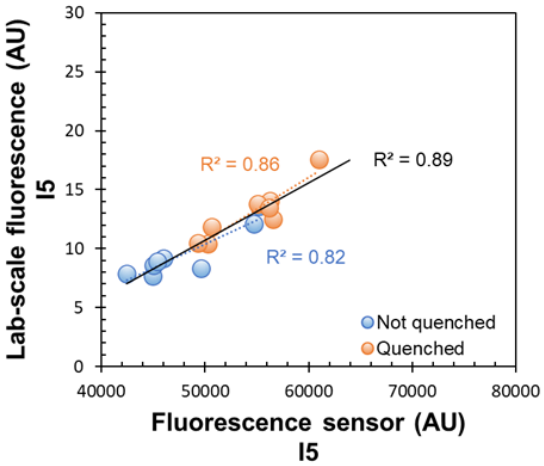


**Figure 1** Linear correlation between humic-like fluorescence data of sensor and benchtop fluorometer for both quenched and not quenched samples. AU stands for Arbitrary Units

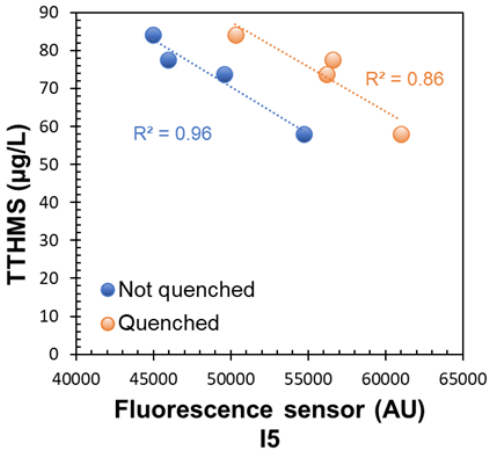


**Figure 2** Linear correlations between actual TTHMs concentrations and fluorescence data by sensor

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