Measures and tools for disinfection byproducts (DBPs) minimisation strategies

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Executive Summary

In the UK, legislation requires that DBP concentrations must be kept as low as possible without compromising the effectiveness of the disinfection. In addition, a prescribed concentration of 100 µg L^{-1} has been set for the sum of the concentrations of the four trihalomethanes (THMs) measured at the consumers tap. Although haloacetic acids (HAAs) are not regulated in the UK, they can be monitored as part of the Risk Assessment process required to be carried out by water companies (DWI, 2010). On 1 February 2018, the European Commission published a proposal for a revision of the Directive on the quality of water intended for human consumption (the Drinking Water Directive). The proposal is a response to a fitness assessment which concluded that the 20-year old directive is fit for purpose, but needs updating. One element of the proposal was an updating of the water quality standards with a proposed value for nine haloacetic acids of 80 µg L^{-1} http://www.europarl.europa.eu/RegData/etudes/BRIE/2018/625179/EPRS_BRI(2018)625179_EN.pdf).

THMs and HAAs are the two most abundant groups of DBPs and it is thought that they serve as good indicators for monitoring DBP performance overall (WHO, 2011). This is likely to be the case on a mass basis but does not take into account the formation of nitrogenous or iodinated byproducts which can be present at lower concentrations but are thought to be more cytotoxic and genotoxic (Plewa et al., 2002). There have been more than 600 DBPs identified (Richardson, 2003) but it is not practical to measure them all. An alternative to measuring DBPs is to monitor gross water quality measures. These include, but are not limited to: UV absorbance, total and dissolved organic carbon (TOC/DOC), specific UV absorbance (SUVA), differential ultraviolet light (UV) absorbance and fluorescence measurement. All of these measurements have been shown to correlate to DBP formation or adsorbable organic halogen (AOX) to some degree, but these correlations vary widely and are often source specific. These measures are discussed at length in the literature review (Section 2) in terms of their suitability for on-line measurement and the information obtained from the measurement.

It has been established that relationships between individual byproduct groups and gross measurements tend to be specific to a single water source and also vary seasonally (Goslan et al., 2002, Sharp et al.,

2006). Therefore it may be possible to establish works specific relationships for some of the surrogate parameters.

Common practice is to minimise DBP formation through removal of the precursor material by appropriate use of a range of processes including coagulation, adsorption, membrane filtration as well as source control approaches such as catchment management (Bond et al, 2011). Consequently, it is not possible to directly link removal of precursor compounds with reduction in DBP formation nor can current treatment processes target removal of specific precursor compounds over bulk removal. As such current practice is to minimise bulk precursor concentrations by monitoring DOC and UV absorbance of the water at 254 nm.

The aim of this project is to investigate a range of measures that may be of value in disinfection byproduct (DBP) minimisation strategies. This was done by subjecting waters to different treatment types, measuring the resulting DBP formation potentials (FPs) and a range of surrogate measures (AOX, DOC, UV absorbance pre and post chlorination, UV differential, total nitrogen, zeta potential, fluorescence and SUVA). The surrogate parameters were assessed together with the measured DBP FPs to determine any correlations. The use of DBP formation potentials (effectively the maximum concentration that can be formed) means that DBP concentrations are significantly above those normally found in distribution.

Experiments carried out to determine optimal treatment in terms of DBP FP minimisation showed that there was no single treatment that was best for all of the source waters investigated. The optimal treatment process depended on the type of organic compounds present.

The only surrogate measure that demonstrated promise in predicting measured DBP FPs was AOX. However, at present, this is a time consuming and expensive measurement that is not widely available in water company laboratory facilities. The current practice of considering THMs as a surrogate for all DBPs is not appropriate. HAAs by mass were the most prominent DBP.

The role of THMs as a surrogate for all DBPs has not been shown to be effective. HAAs were more suitable but when the two groups are combined they showed better potential as a surrogate for all measured DBPs as well as AOX. This is due to the fact that they make up most of the mass of the measured DBPs.

The relationships found in this study between DBP formation and surrogate measures have fairly wide confidence limits but these improve for individual water sources. The findings of this study are consistent previous literature that relationships need to be developed for specific water sources rather than using a single approach for all sources.