Understanding the Use of Flow Cytometry for Monitoring of Drinking Water

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Executive Summary

The aim of bacterial analysis of waters used for human consumption is to produce accurate and reproducible results. This in turn enables effective monitoring to promote reliable water treatment and distribution. Culture based methods for counting bacteria in drinking water give results which are inaccurate compared to ‘direct’ microscope counts or flow cytometry (FCM) methods. In addition, most final waters do not contain faecal indicators which can limit the scope for optimisation of these water treatment assets or improving the hygienic quality of product water due to limitations of culture based data.

Unlike culture based methods, FCM can provide rapid and accurate measurements of total and intact bacteria in water. FCM monitoring can provide early detection of changes in treatment works operation or in the drinking water storage and distribution systems. However, a current challenge with these alternative methods of bacterial monitoring, such as FCM, is data analysis and interpretation. This review and state of the art survey was carried out to determine how the FCM technique can help water companies determine microbial water quality for waters used for human consumption. This report presents information on the data obtained by FCM, the current limitations of the methodology and consideration of whether the method could be adopted for regulatory compliance monitoring.

A survey was undertaken to understand if (and how) each water company has approached FCM in England and Wales. Information about the nature of FCM use was presented with respect to the literature search and contextualised by a small international expert steering group. Determination of differences in investment level, opinion and local culture for ‘users’ and ‘non-users’ was compared. In total, 18 separate responses were received which represented all of the large water treatment and supply companies in England and Wales (a 95% response rate overall).

Most water companies are using FCM for monitoring of specific assets during investigations, notably samples from the water treatment works (WTW) inlet, post-coagulation / solids removal, post sand filter, or post chlorine contact tank. Final waters were the most commonly sampled location for routine sampling and using FCM for analysis. Where FCM has been used for monitoring distribution systems, most (~50 %) are using FCM on service reservoirs, highlighting the lack of information about these important assets. Fewer water companies (26 %) have been using FCM for monitoring distribution networks. Trend analysis and comparison with other datasets, alongside generation of prescribed values were the most common

ways by which FCM data was being used (each > 50 % of respondents). Both users and non-users were positive about the benefits of FCM over conventional heterotrophic plate count (HPC) methods. The perceived benefits included: ease of use, measurement of 'active' bacteria, and active management of water treatment and supply assets. 60 % of respondents considered that FCM was not useful for quantifying specific pathogens. Non-users were overall less positive about FCM but had similar views to users with respect to the benefits and limitations of the technology. Key challenges for implementing FCM for the industry included: method standardisation, data analysis and interpretation, difficulty of comparison with historic data, cultural change within water company institutions and instrument reliability. Speed, accuracy, data quantity and opportunity for online monitoring were thought to be the tangible benefits of using FCM.

Monitoring specific assets during water quality events and use of offline systems for routine analysis were identified as areas of opportunity. The use of online or discrete in-line automated FCM was seen as a practical approach for intensive root cause analysis of process deterioration and dynamic changes in microbial loading through a treatment works. Currently, regulatory monitoring requirements are clear that FCM is not required to for monitoring quality of drinking water. In addition, the lack of suitable prescribed concentration or value (PCVs), formal standard methods, or accreditation (e.g. through UK Accreditation Service) has so far limited the technology. As a result most water companies are using FCM as a sensitive measure of asset performance to reduce likelihood of compliance issues by detecting declines in asset performance. As FCM becomes increasingly used to make operational decisions, with potential financial and public health implications, it is important to have confidence in the results and therefore accreditation should be a desirable goal. It is considered that accreditation of FCM analysts competence is the most likely scenario with respect to standardisation.

However, water companies should ensure that data analysis is appropriate and standardised with consideration of the limits of FCM and the data generated. Data interpretation standardisation / guidelines are seen as the next big challenge for successful future use of FCM for the water industry. All water suppliers should continue to monitor assets for microbiological compliance using the approved indicator organism(s) of water quality to protect public health. As a broadly 'industry-led' initiative as opposed to 'regulation-led', FCM is an example of industry cooperation to attempt to solve the challenge of spot microbiological compliance events at generally well run and optimised water treatment and supply assets. Online FCM is identified as a key tool to reduce the risk to public health through optimised treatment and better asset understanding. The evidence suggests that FCM can produce information needed by operators to produce a more stable bacterial population which reduces the risk of pathogen penetration of water treatment barriers and subsequent regrowth within networks. While FCM has previously been proposed to be a panacea for microbial monitoring, the benefits of FCM come from the faster, cheaper and more reproducible bacterial analysis that enable it be used for diagnostic applications in water treatment.