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Use of on-line water quality monitoring data to predict bacteriological failures

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Abstract

Variations in continuously monitored on-line water quality data were investigated to establish whether they could be linked to coliform detections at regulatory monitoring points. We focussed on chlorine residual, turbidity and flow rate at water treatment works (WTW)-A. Archived on-line monitoring data from WTW-A were analysed using cross-correlation and self-organising maps in MATLAB® to identify trends in the data running up to coliform detections. The results show that these tools could be developed to help manage WTWs to reduce the number of bacteriological failures. A fingerprint of WTW conditions relating to coliform failures was identified for this case study.

Keywords: Bacteriological water quality; data analysis; monitoring data; pro-active failure prevention

1. Introduction

The goals of bacteriological quality monitoring are to assure the safety of drinking water for consumers and to monitor the performance of treatment processes. Water samples are routinely collected from water treatment works (WTWs), service reservoirs and customers' taps. Monitoring focuses on indicator organisms because bacteriological pathogens are rarely isolated from drinking water due to their low numbers under normal circumstances. The principal bacteriological indicators are coliforms, *Escherichia coli*, Enterococci and

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Clostridium perfringens (Standing Committee of Analysts, 2002). Positive results in analyses for these microorganisms are indicative of environmental or faecal contamination of treated water and all four parameters have prescribed values of 0 cells per 100 ml (Council of the European Communities, 1998). Heterotrophic plate counts (HPCs) per ml are also monitored; they represent a common indicator of the general microbiological quality of water (Standing Committee of Analysts, 2012).

This work focuses on WTW-A, which produces 120 Ml d^{-1}. WTW-A is owned and operated by Severn Trent Water Ltd. (STW), UK. It treats surface-water using the process outlined in Fig. 1:

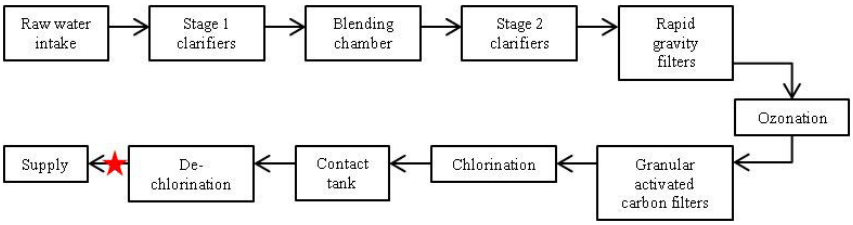

Fig. 1. Process flow diagram for WTW-A; ★ marks the location of the on-line monitors and final spot-sampling point.

Monitoring at WTW-A final sampling point detected a single coliform in March 2011 and March 2012. Despite extensive investigations, neither of these failures had causes identified. This is the outcome for approximately two thirds of all failure investigations (Ellis et al., 2013). Since no cause was identified, these failures were selected for the data analysis in this work. The supply network for WTW-A is extensive and it is important to STW to determine the causes of these non-compliances so that they can protect their consumers.

In our previous work (Ellis et al., 2013) we observed that there were weak correlations between the presence of indicator organisms in drinking water samples and other data relating to spot samples: free and total chlorine and water temperature amongst others. The reliance on spot-sampling data was a weakness of this study. Work by Codony et al. (2005) observed that discontinuous chlorination affected the efficacy of disinfection as demonstrated by HPCs. Their work involved neutralising the chlorine in a test reactor for periods of several days. This project seeks to identify whether short-term variations in archived on-line residual free chlorine, turbidity and flow could have impacted bacteriological water quality at WTW-A.

Nomenclature

CFU	colony forming units
DPD	diethyl-p-phenylene diamine
HPC	heterotrophic plate count
HPC22	heterotrophic plate count at 22 °C
HPC37	heterotrophic plate count at 37 °C
NTU	nephelometric turbidity units
SOM	self-organising map
STW	Severn Trent Water Ltd.
WTW	water treatment works

2. Methods

2.1. Data collection

Spot-sampling occurs daily at WTW-A final sampling point. There were two coliform detections: one in March