The Frequency and Causes of Bacteriological Non-Compliance in Drinking Water

K. Ellis[1,2], B. Ryan[2], M. R. Templeton[3] and C. A. Biggs[1]

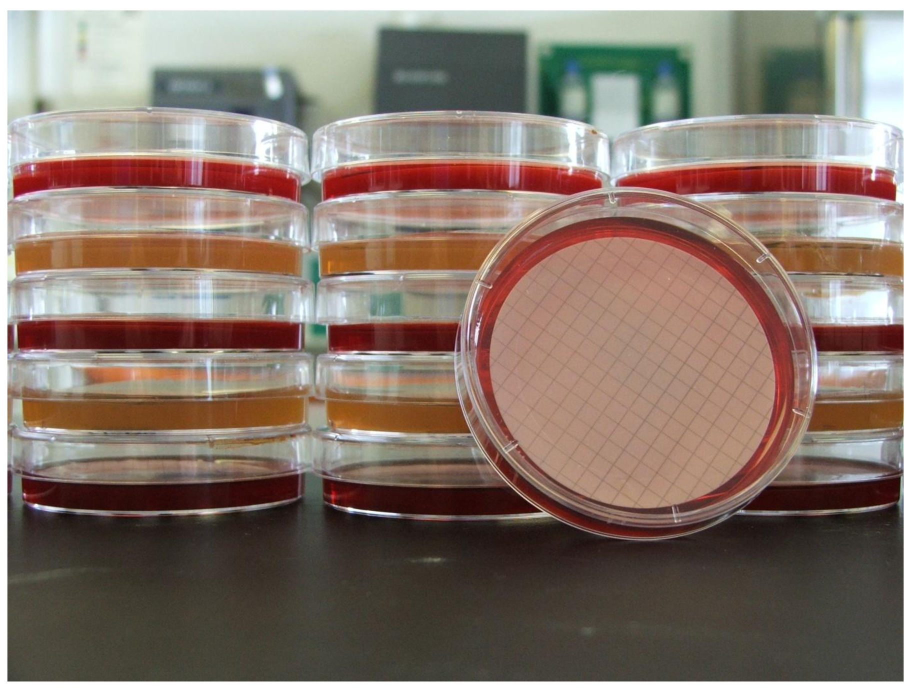
[1] Department of Chemical and Biological Engineering, The University of Sheffield, Sheffield, UK

[2] Research and Development, Severn Trent Water Ltd., Coventry, UK

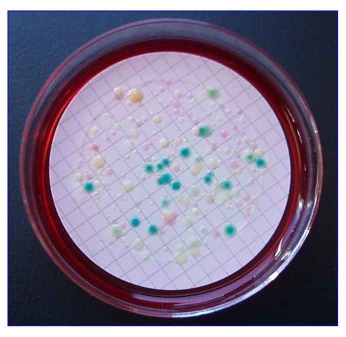
[3] Department of Civil and Environmental Engineering, Imperial College London, London, UK

Introduction

Drinking water in England and Wales exhibits high compliance with quality regulations. Severn Trent Water Ltd. (STW) rarely experiences quality failures, achieving 99.98 % compliance in 2010[1]. Approximately half of non-compliances are for bacteriological parameters, a finding that is common across most water companies in England and Wales[2]. The goals of bacteriological quality monitoring are to assure the safety of drinking water for consumers and to monitor the performance of treatment processes. It focuses on indicator organisms: coliforms, *Escherichia coli*, Enterococci and *Clostridium perfringens*. 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[3]. The aim of this study was to provide insight into the frequency and causes of bacteriological non-compliances in the STW region to inform future management strategies.

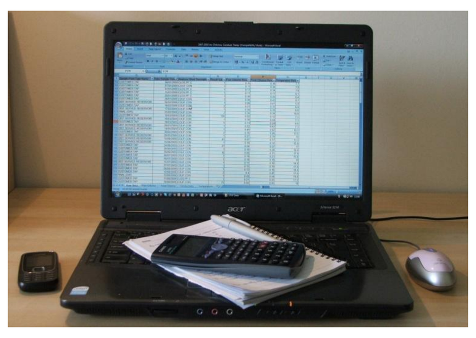


Methods



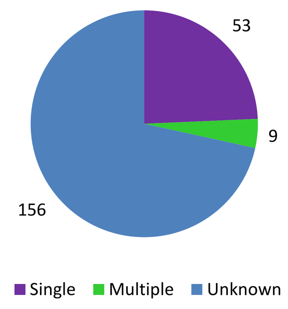
Failure data collection

+



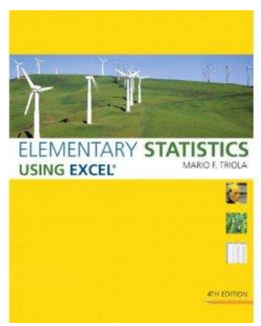
Background data collection

→



Graphical analysis

+



Statistical analysis

Results

Between 1st January 2008 and 31st December 2011, there were 218 bacteriological failures (Table 1). No cause was identified for two thirds of these failures (Fig. 1); where a cause was identified, the failure was most commonly attributed to the condition of the tap (Fig. 2). Low chlorine residuals and high water temperatures were risk factors in unknown cause failures (Figs. 3 and 4). Surface water influenced supplies had higher incidence of failure compared with groundwater sources (Table 2).

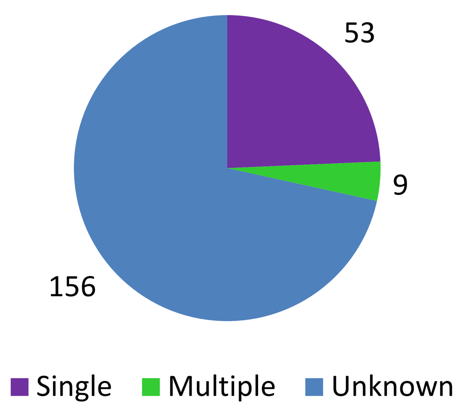


Fig. 1: Number of bacteriological failures by success of cause identification.

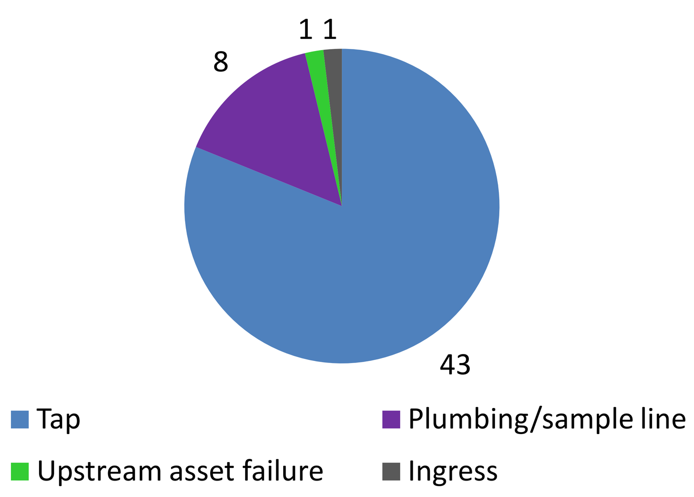


Fig. 2: Number of single causes identified by cause of failure.

Table 1: Number of failures by year, indicator organism and sample point (WTW = water treatment works; Reservoir = service reservoir) as absolute numbers and as percentage of all bacteriological analyses for that parameter.

Year	Number	% of bacteriological analyses	Organism	Number	% of bacteriological analyses	Sample point	Number	% of bacteriological analyses
2008	59	0.091	Coliforms	188	0.16	WTW	16	0.024
2009	43	0.066	*E. coli*	13	0.011	Reservoir	69	0.059
2010	42	0.065	*C. perfringens*	16	0.171	Customer tap	133	0.175
2011	74	0.114	Enterococci	1	0.006			

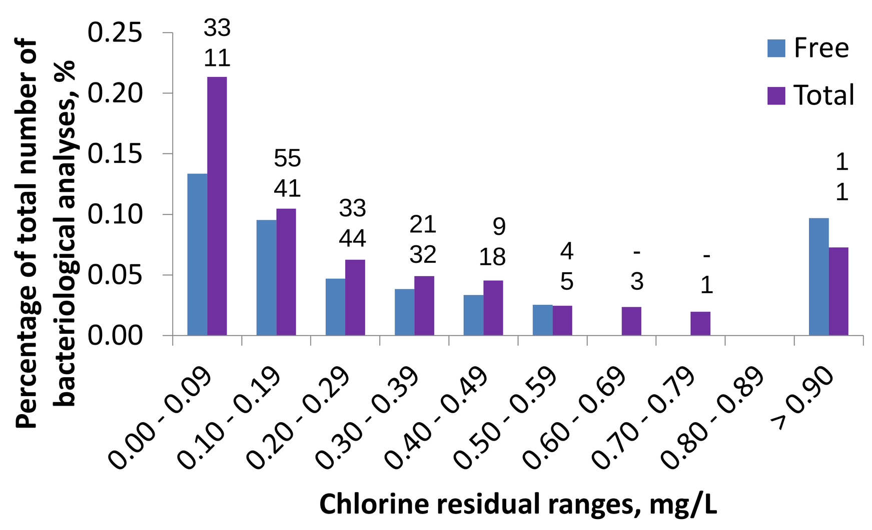


Fig. 3: Percentage of bacteriological failures with no known cause per total number of bacteriological analyses grouped by free and total chlorine residual between 2008 and 2011. The number of failures per chlorine residual range is presented above the bars, from top: Free, Total; - = no failures in this range.

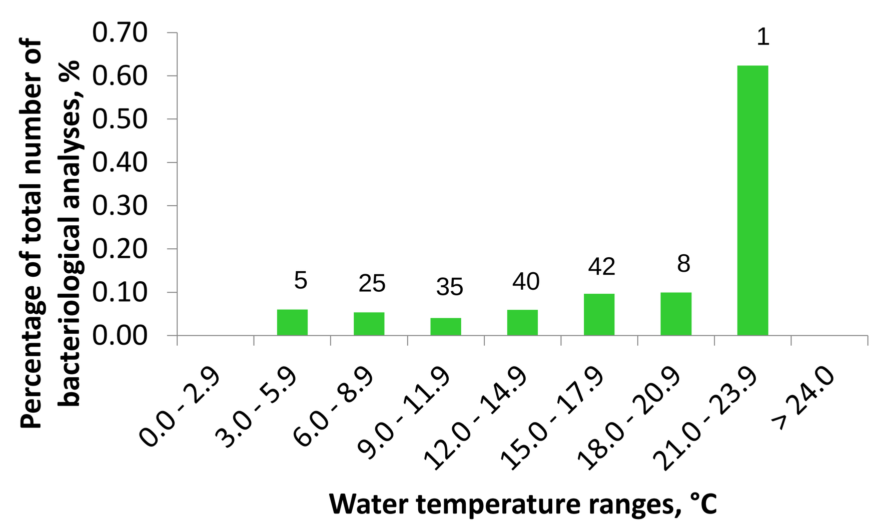


Fig. 4: Percentage of bacteriological failures with no known cause per total number of bacteriological analyses grouped by water temperature between 2008 and 2011. The number of failures per temperature range is presented above each bar.

These data show that failures occur even at high chlorine residuals and low water temperatures and regardless of the source water type. They also show that a quarter of failures are due to sample points, ingress, etc and not water quality, representing a high proportion of false positives in the monitoring of bacteriological quality.

Table 2: Number of failures with no known cause by source water type as absolute numbers and as percentage of all bacteriological analyses for that parameter.

Source water	Number	% of bacteriological analyses
100 % surface water (S)	62	0.067
100 % groundwater (G)	51	0.045
Blend S > G	28	0.056
Blend G > S	14	0.063
Blend S = G	1	0.063

Conclusions and Recommendations

STW exhibits high compliance with drinking water quality regulations and has engaged in research to reduce the number of failures at WTWs and Reservoirs. It is recommended that a) greater focus is given to compliance under cooler water temperatures, especially regarding residual free chlorine; and b) further efforts be made to reduce the number of false positives through enhanced maintenance and protection of sampling points.

Acknowledgements

Thanks are expressed to the Water Quality Compliance and Information Team at Severn Trent Water for their assistance in compiling data. This research is funded under the STREAM Industrial Doctorate Centre and is a collaboration between EPSRC, Severn Trent Water, The University of Sheffield and Imperial College London. Catherine A. Biggs also wishes to acknowledge the EPSRC for an Advanced Research Fellowship (EP/E053556/01) and further project funding (EP/E036252/1).

References: [1]Drinking Water Inspectorate. (2011). *Drinking Water 2010: A report by the Chief Inspector Drinking Water Inspectorate.* London: Drinking Water Inspectorate. [2]UK Water Industry Research. (2006). *Bacteriological Indicators of Water Quality.* London: UK Water Industry Research Limited. [3]Council of the European Communities. (1998). *Council Directive of 3 November 1998 on the quality of water intended for human consumption. 98/83/EC.* European Commission.

The University Of Sheffield. | SEVERN TRENT WATER | stream The Industrial Doctorate Centre for the Water Sector | EPSRC Engineering and Physical Sciences Research Council