2014

Case-Based Reasoning Approach For Managing Water Quality Incidents In Distribution Systems

Stephen Robert Mounce

Richard Mounce

Joby Boxall

11th International Conference on Hydroinformatics
HIC 2014, New York City, USA

CASE-BASED REASONING APPROACH FOR MANAGING WATER QUALITY INCIDENTS IN DISTRIBUTION SYSTEMS

S. R. MOUNCE (1), R. B. MOUNCE (1) & J. B. BOXALL (1).
(1): Pennine Water Group, Department of Civil and Structural Engineering, University of Sheffield, Sheffield S1 3JD, UK.

Access to safe drinking water is universally considered as a fundamental human right and customers regard a reliable supply of safe, clean water as the most important aspect of the water supply service. However, water quality failures do occur, with some of the hardest to understand and manage occurring within distribution systems. In the UK, a regulatory process is applied in which water companies must report on significant water quality incidents, their causes, actions, responses, and outcomes. The Drinking Water Inspectorate (DWI) assesses these reports on an annual basis and their findings are made publically available. It is hypothesized here that these reports form a valuable resource that can be 'data mined' for improved understanding and to help with future incident management. A software tool, called WaterQualityCBR, has been developed for this purpose. This methodology can support decision-making for water utilities in managing drinking water incidents.

INTRODUCTION AND BACKGROUND

In drinking water distribution systems, when a hazard occurs from catchment to consumers' taps, it is considered as an incident. The term 'incident' is broadly defined by Hunter et al. [1] as any circumstance in which there is a reasonable suspicion about the safety of water being supplied for drinking. The quality of drinking water in England and Wales has been regulated and these standards enforced by the DWI since 1990. The DWI assesses the water companies' response to the most significant incidents on an annual basis at a national level (provided in report form). Water companies' responses and/or resolutions sometimes do not meet the expectation of the inspectorate and they can be fined if their performance is below a specified standard.

Case-based reasoning (CBR) is a knowledge-based problem-solving (memory based) technique from the field of Artificial Intelligence that relies on the reuse of past experience [2]. Examples are used directly to solve new problems, based on the assumption that similar problems from the past have similar solutions and hence that deriving solutions to new problems can be effectively addressed by reusing (and adapting) past solutions. CBR systems are particularly useful for diagnosis classification (identifying faults) and for prediction. Fenner et al. [3] proposed a CBR methodology for modelling sewer infrastructure performance and condition.

METHODOLOGY

The WaterQualityCBR software system, was developed as a decision support tool for water companies to deal more effectively with water quality incidents (e.g. water discoloration or contamination) by using information from previous incidents. The tool manipulates a database (compiled in XML) of past significant events from several years DWI reporting. Expert subjective scoring of each DWI finding for each incident was conducted. A software tool called waterQualityCBR was developed as an MS Windows application in Visual Studio to perform the required aspects of CBR functionality. The software has an intuitive GUI interface allowing for use by non-expert water company users. Figure 1 provides a schematic overview of the system operations. Figure 2 shows a sample screenshot of potential actions taken, along with occurrence and score, in response to iron related issues. The full system design and methodology with example searches and results of application to also provide information at a strategic level, for example to help inform water company policy / guidance documents, is described in Mounce et al. [4].

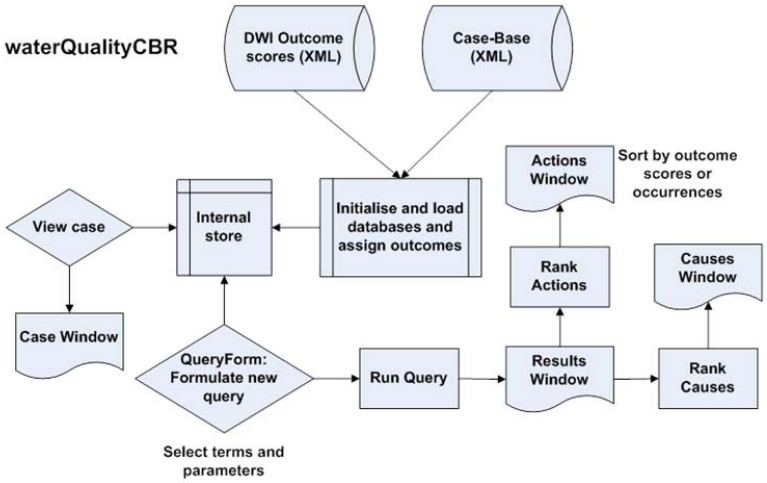
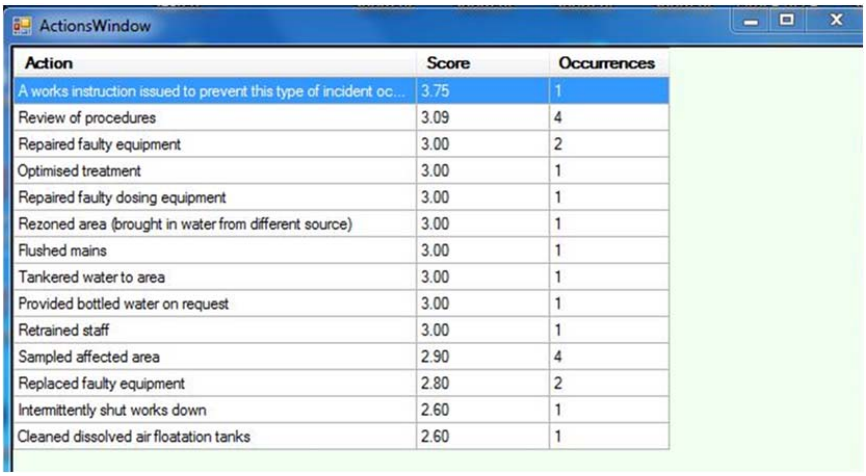


Figure 1. WaterQualityCBR software system main operations (from [4])



Action	Score	Occurrences
A works instruction issued to prevent this type of incident oc...	3.75	1
Review of procedures	3.09	4
Repaired faulty equipment	3.00	2
Optimised treatment	3.00	1
Repaired faulty dosing equipment	3.00	1
Rezoned area (brought in water from different source)	3.00	1
Flushed mains	3.00	1
Tankered water to area	3.00	1
Provided bottled water on request	3.00	1
Retrained staff	3.00	1
Sampled affected area	2.90	4
Replaced faulty equipment	2.80	2
Intermittently shut works down	2.60	1
Cleaned dissolved air floatation tanks	2.60	1

Figure 2. Action scoring and occurrence screen

SUMMARY

This paper presents a Case Based Reasoning tool and examples of its application as a decision support tool with the potential to enable water companies to deal more effectively with water quality incidents by using information from previous incidents.

Acknowledgements
This work was supported by the Pipe Dreams project funded by the UK Science and Engineering Research Council, grant EP/G029946/1. The authors would particularly like to thank Mr. Hieue T. Nguyan for data preparation. They also acknowledge the DWI in making publically available the annual reports.

REFERENCES

[1] Hunter, P., Andersson, Y., Von Bonsdorff, C., Chalmers, R., Cifuentes, E., Deere, D., Endo, T., Kadar, M., Krogh, T. and Newport, L., "Surveillance and investigation of contamination incidents and waterborne outbreaks". *Assessing microbial safety of drinking water*. Edited by A. Dufour, M. Snozzi, W. Koster, J. Bartram, E. Ronchi and L. Fewtrell. ISBN 92 4 154630 1 (WHO) and 1 84339 036 1 (IWA Publishing), (2003).

[2] Kolodner, J., *Case-based reasoning*. Morgan Kaufmann, (2003).

[3] Fenner, R. A., McFarland, G. and Thorne, O., "Case-based reasoning approach for managing sewerage assets". *Proceedings of the Institution of Civil Engineers Water Management*, 160, 15-24, (2007).

[4] Mounce, S. R., Mounce, R. B., and Boxall, J. B., "Case-based reasoning to support decision making for managing drinking water quality events in distribution systems". *Urban Water Journal*. Under review, (2014).