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Optimization of Operational Water Quality Parameters in a Drinking Water Distribution System Using Response Surface Methodology

Authors : Sina Moradi, Christopher W. K. Chow, John Van Leeuwen, David Cook, Mary Drikas, Patrick Hayde, Rose Amal

Abstract : Chloramine is commonly used as a disinfectant in drinking water distribution systems (DWDSs), particularly in Australia and the USA. Maintaining a chloramine residual throughout the DWDS is important in ensuring microbiologically safe water is supplied at the customer's tap. In order to simulate how chloramine behaves when it moves through the distribution system, a water quality network model (WQNM) can be applied. In this work, the WQNM was based on mono-chloramine decomposition reactions, which enabled prediction of mono-chloramine residual at different locations through a DWDS in Australia, using the Bentley commercial hydraulic package (Water GEMS). The accuracy of WQNM predictions is influenced by a number of water quality parameters. Optimization of these parameters in order to obtain the closest results in comparison with actual measured data in a real DWDS would result in both cost reduction as well as reduction in consumption of valuable resources such as energy and materials. In this work, the optimum operating conditions of water quality parameters (i.e. temperature, pH, and initial mono-chloramine concentration) to maximize the accuracy of mono-chloramine residual predictions for two water supply scenarios in an entire network were determined using response surface methodology (RSM). To obtain feasible and economical water quality parameters for highest model predictability, Design Expert 8.0 software (Stat-Ease, Inc.) was applied to conduct the optimization of three independent water quality parameters. High and low levels of the water quality parameters were considered, inevitably, as explicit constraints, in order to avoid extrapolation. The independent variables were pH, temperature and initial mono-chloramine concentration. The lower and upper limits of each variable for two water supply scenarios were defined and the experimental levels for each variable were selected based on the actual conditions in studied DWDS. It was found that at pH of 7.75, temperature of 34.16 ºC, and initial mono-chloramine concentration of 3.89 (mg/L) during peak water supply patterns, root mean square error (RMSE) of WQNM for the whole network would be minimized to 0.189, and the optimum conditions for averaged water supply occurred at pH of 7.71, temperature of 18.12 ºC, and initial mono-chloramine concentration of 4.60 (mg/L). The proposed methodology to predict mono-chloramine residual can have a great potential for water treatment plant operators in accurately estimating the mono-chloramine residual through a water distribution network. Additional studies from other water distribution systems are warranted to confirm the applicability of the proposed methodology for other water samples.

Keywords : chloramine decay, modelling, response surface methodology, water quality parameters
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