Fact Sheet

DISTRIBUTION SYSTEM MANAGEMENT

Modeling And Monitoring

Optimizing Distribution System Water Quality through Modeling and Monitoring

Quick Facts

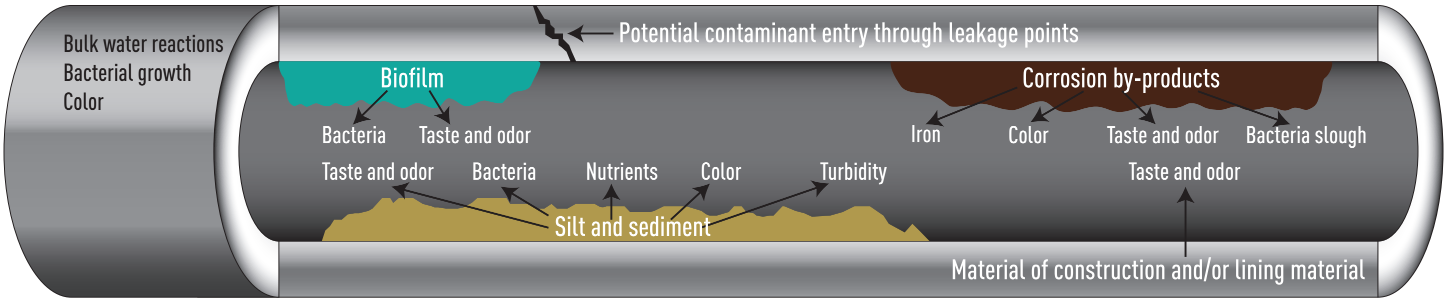
- Computer models have become valuable tools for water utilities; software is available to help plan and improve a system's performance.
- Online, real-time monitoring allows utilities to constantly monitor conditions and react quickly to adverse conditions.
- An optimal pressure management program to address pressure transients, or surges, will combine modeling and monitoring.

Overview

Water quality deteriorates in distribution systems due to a multitude of factors. Finished water from treatment facilities may contain bacterial growth, fine particles of silt, or iron, which can accumulate in the piping to create chlorine demand and aesthetic problems. Structural factors like piping material, leaks, and breaks, as well as issues like water demand patterns, can also affect water quality (Figure 1).

Computer simulations of distribution system hydraulics and water quality have become valuable tools for water utilities. Computer models play a significant role in monitoring and sampling. Online, real-time monitoring allows utilities to react quickly to adverse conditions that may impact public health. Continuously collected data can support real-time water quality and hydraulic modeling and provide the basis for a comprehensive utility decision support system. Modeling and monitoring are also important for pressure management, which ensures adequate water supply at higher elevations and prevents contamination during pressure surge events.

Because distribution system water quality is so complex, a comprehensive monitoring program from source to tap is required. More research is needed to develop advanced sensors for online monitoring, and to develop advanced and integrated water quality models to result in better water quality management.



Source: Kirmeyer et al. 2002

Figure 1. Piping effects on water quality

Modeling

Considerable research has resulted in advanced and integrated water quality models that can be used to accurately predict water quality in the system.

Hydraulic Modeling

Water distribution system models are used in many ways such as studying factors like disinfectant loss, evaluating alternate strategies, planning cost-effective pipe cleaning and replacement, designing sampling programs, and analyzing water age and constituents such as chlorine (AWWA 2012).

Software: The U.S. Environmental Protection Agency's (EPA's) flagship model, EPANET, is free, open source software that helps water utilities maintain and improve a system's hydraulic performance and the quality of water delivered to consumers. It can assist with such elements as pipe placement, energy minimization, fire flow analysis, vulnerability studies, and operator training (Rossman 2000).

Storage Facilities Modeling

Tanks and reservoirs that store finished water provide emergency storage, equalize pressure, and balance water use during the day. Their design and operation affect water quality, particularly water age, which can be used as a surrogate for other water quality parameters (EPA 2006).

Software: A WRF project, *Water Quality Modeling of Distribution System Storage Facilities*, produced a tool to help utilities design, operate, and retrofit current and future storage facilities for optimum distribution system water quality (Grayman et al. 2000).

Water Quality Constituent Modeling

Most software packages allow for input of a kinetic equation of any order, with the most commonly used option being first-order decay for disinfectant residual. Equations differentiate reactions occurring in the bulk water from those at the pipe well.

Software: EPA has released EPANET-MSX, which allows users to enter any water quality equation to model complex reaction schemes between multiple chemical and biological species in both the bulk flow and the pipe wall (Shang et al. 2008).

Online Monitoring

Sensors and online monitoring systems have clear and multiple benefits for water utilities. Currently, reliable and well-established online sensors are frequently used for monitoring physical parameters such as flow rate, turbidity, pH, and water temperature; some chemical reaction-derived monitors such as iron and chlorine; and some biomonitors such as those based on algae.

Sensors based on chemical or biochemical detection processes have proven more challenging to meet practical utility needs and thus have not been effectively implemented. Other possible applications for online monitoring include intake protection, control of operations, security, and provision of information to customers.

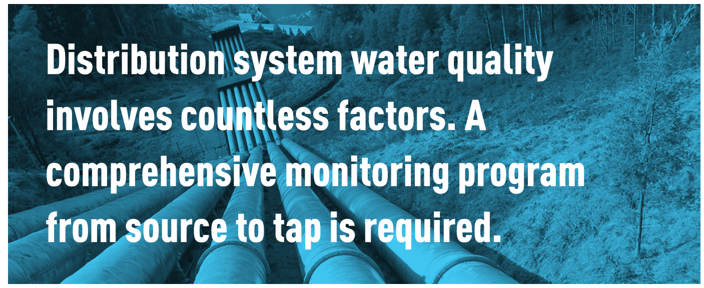
Pressure Modeling And Monitoring

Providing safe drinking water to customers is dependent upon the integrity of the water distribution system. Pressure transients (sometimes called "water hammer" or "surge") are pressure waves that change from one flow condition to another. Low or negative pressure transients create a temporary situation where external chemical and microbial contaminants from higher pressure areas can enter the distribution system.

Because pressure transients are usually brief, often lasting less than a minute, they are rarely monitored or alarmed. No study to date has established a quantitative relationship between negative pressure transients and public health, so regulatory standards have been lacking or loosely defined.

A WRF project, *Managing Distribution System Low Transient Pressures for Water Quality*, provides research to enable the development of best practices that reduce the microbial infection risks of intrusion due to negative pressure transients (LeChevallier et al. 2011).

Pressure management plays an important role in alleviating the magnitude of negative pressure transients in many situations, which significantly reduces the risk of infection. However, occasional short periods (seconds) of low or negative transient pressure below 20 psi often go undetected. To account for both normal and transitory pressures, an optimal pressure management program requires a combination of hydraulic and surge modeling, pressure monitoring, and transient pressure mitigations.



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