DISTRIBUTION SYSTEM MANAGEMENT

Water Quality

Understanding Deterioration of Water Quality in the Distribution System

Quick Facts

- Pipe deterioration and water quality failure in water mains can be caused by many different factors.
- Contaminants, corrosion, leaching, biofilm and bacteria are some of the main mechanisms driving water quality change.
- Many studies have been conducted and offer recommendations for the most effective treatments and solutions.

Overview

The deterioration of water quality in a distribution system is complex and can be caused by multiple mechanisms (Figure 1). Factors affecting water quality include internal corrosion and leaching of chemicals, accumulation and release of contaminants, biofilm formation and bacterial regrowth, and physical and chemical processes that occur in the pipe. (EPA 2006, Sadiq et al. 2009)

In order to provide guidance and oversight for this issue, the Water Research Foundation (WRF) has funded significant research for over 22 years. Additionally, in 2009, WRF and the U.S. Environmental Protection Agency (EPA) formed the Research and Information Collection

Partnership to further understanding of distribution system water quality. In addition, the EPA has developed regulations to protect water quality in distribution systems. Table 1 shows the relationship between the EPA rules and the application of those rules by water utilities.

Leaching

All materials used in distribution system infrastructure have the potential to leach chemicals or metals from the water mains into the water. As a cost-saving measure, rather than replace pipes, water utilities often choose cleaning and lining options. However, there is concern about leaching from the lining materials.

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A WRF project, *Impacts of Lining Materials on Water Quality*, examined three types of liners and recommended epoxy or polyurethane over cement mortar lining. An accompanying software project, available on CD, serves as a useful tool to guide utilities in the selection of a lining material (Deb et al. 2010).

Source: Sadiq et al. 2009

Figure 1. Conceptual map for water quality failures in water mains

Table 1. EPA regulations and examples of application	
Rule	**Application**
Surface Water Treatment Rules (EPA 2015c)	Disinfectant residual and sanitary survey requirements
Stage 1 and 2 Disinfectants and Disinfection Byproduct (DPB) Rules (EPA 2015b)	Monitoring for DBPs in the distribution system
Ground Water Rule (EPA 2015a)	Sanitary surveys
Revised Total Coliform Rule (EPA 2016)	Monitoring for bacterial contamination in distribution systems

Solids Accumulation and Release

Trace contaminants such as arsenic and radium have the potential to accumulate or release within water distribution systems. There are many potential sources of these contaminants, including cross-connection, main breaks, repairs, and the introduction of treatment chemicals such as iron- and aluminum-based coagulants. To protect against adverse health effects due to chronic consumption of trace contaminants, the EPA has developed drinking water standards for 16 inorganic and 5 naturally occurring radiological elements. Some contaminants can be removed by treatment processes such as filtration.

A WRF project, *Assessment of Inorganics Accumulation in Drinking Water System Scales and Sediments*, developed the following conceptual overview of the recommended approach for assessing and controlling these phenomena.

Step 1. Assess existing conditions and vulnerability
To determine the prevalence and properties of deposits, recommendations include actions such as inspecting pipes, assessing the adequacy of flushing programs, and collecting and analyzing deposit samples. To assess the conditions of treated water quality, recommendations include reviewing the treated water supply's inorganics history; assessing the presence of iron, manganese, and phosphate; and performing investigative monitoring.

Step 2. Address the existing deposits
Mobile deposits may be removed through high velocity flushing. For adhered deposits, recommendations include stabilizing water chemistry, removing adhered solids through pigging or rehabilitation, and replacing severely tuberculated pipe.

Step 3. Reduce contaminant and solids loading
Recommendations include treatment to remove trace contaminants to the lowest practicable levels or sequestration if removal is not possible. For contaminant sinks, water utilities are advised to provide treatment to remove iron, manganese, and naturally occurring suspended solids. Other guidelines include flushing, reservoir cleaning, and maintaining a disinfectant residual to control biofilm growth (Friedman et al. 2010).

Understanding the complex principles that drive distribution system water quality change is not easy. WRF has funded significant research on this topic for over 22 years.

Bacterial Regrowth

Biofilm formation and microorganism regrowth contribute to the deterioration of water quality in a distribution system. Bacterial regrowth may be influenced by pipe materials and linings, as well as organic carbon levels. The study, *Influence of Distribution System Infrastructure on Bacteria Regrowth*, tested different pipe materials such as ductile iron, cement lining, epoxy and PVC. While it was not true in every case, iron pipe showed the highest bacterial regrowth under certain conditions (Clement et al. 2003). Reducing organic carbon in the finished water may be helpful in reducing regrowth in the distribution system.

Finished Water Storage Facilities

Historically, finished water storage facilities were developed for hydraulic system operation, not water quality. However, maintaining water quality is crucial. Water age in many storage facilities can be excessive, which leads to water quality deterioration and the loss of disinfectant residual. Storage facilities are usually located at remote, unstaffed sites, making them difficult to monitor, inspect, and maintain.

The study, *Maintaining Water Quality in Finished Water Storage Facilities*, produced a manual with guidelines for water quality monitoring, inspection, maintenance, operations, and engineering design. The study recommended a target water turnover rate of three to five days. Recommended cleaning frequencies range from every six months for open reservoirs to five years for newer, covered, well-maintained facilities (Kirmeyer et al. 1999).

Nitrification

Nitrification is a microbial process that increases the concentration of hydrogen ions, resulting in reduced

pH, which increases the likelihood of lead and copper corrosion in the pipe. Elevated nitrate levels are a concern to water utilities because of public health impacts. Currently, the maximum contaminant level of nitrate is 10 ppm. Effective methods to remove nitrate in drinking water systems include ion exchange, reverse osmosis, and electrodialysis. Ⓠ

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