Public Meeting Series to Inform Potential Revisions to Microbial and Disinfection Byproduct Rules

Opportunistic Pathogens and Disinfectant Residuals

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May 20, 2021
Presentation Overview and Objectives

- Background
- Estimated Remaining Public Health Burden from Opportunistic Drinking Water Pathogens
- Current Regulatory Information
- Relevant Data and Information
- Participant Discussion Questions for Information Gathering
Background

- **Known Opportunistic Pathogens of Concern in Drinking Water Distribution Systems**
  
  - **Legionella**
    - Can cause Legionnaires’ Disease (LD) – a severe form of pneumonia, and Pontiac Fever, a milder flu-like illness. Risk factors for developing an infection include age (>50 years), smoking, and lung conditions (e.g., asthma).
  
  - **Mycobacterium avium** Complex (MAC)
    - Primary diseases include lymphadenitis in children; respiratory infection in the elderly; and respiratory, intestinal, and disseminated disease in HIV-positive patients and those with immunocompromising conditions.
  
  - **Pseudomonas**
    - Can cause a variety of health effects, including pneumonia, septicemia, and meningitis, particularly in those immunosuppressed or immunocompromised, and having human tissue compromised by illness or injury.
Magnitude of Health Concern from Opportunistic Pathogens

• Health departments reported almost 10,000 cases of LD to CDC in 2018 (CDC, 2020), a nearly 10-fold increase since 2000.

• Collier et al. (2021) estimated in 2014 there were 11,000 cases and 995 deaths from LD, 68,900 non-tuberculous *Mycobacteria* (NTM) infections with 3,800 deaths, and 15,900 cases of *Pseudomonas* pneumonia with 730 deaths.

• Adam, et al. (2017) estimated 3,359 Emergency Department visits annually for LD, with 91% resulting in hospitalizations.

• Less than 5% of people develop LD following exposure to *Legionella*; more than 90% develop Pontiac Fever (CDC, 2018).

• The National Academies of Science estimates 52,000-70,000 cases of LD annually (NAS, 2020), some portion of which are due to drinking water exposure.
Legionnaires’ Disease Outbreaks

• There were 184 reported LD outbreaks for drinking water with 1030 outbreak-associated cases reported to the Waterborne Disease Outbreak Surveillance System from 2001-2017.

• According to Cohn et al., 2015, a health department found evidence linking legionellosis outbreaks to distribution system water age and sediment buildup, clustered around a storage tank.
Studies on Opportunistic Pathogen Occurrence

• LeChevallier published two studies in 2019 which examined *Legionella* occurrence in distribution systems.
  • One of 576 cold weather samples was positive among 12 volunteer utilities.
  • Fourteen of 573 warm weather samples were positive among 10 volunteer utilities.

• A source-to-tap study of the two New Orleans systems suggested *Mycobacteria* amplification in the distribution system or premise plumbing and ubiquitous *Legionella* occurrence (Hull et al., 2017).

• Lu et al. (2016) sampled a major city distribution system using qPCR and found 57% of samples to be positive for *Legionella*, 88% positive for *Mycobacteria*, and 24% positive for *Pseudomonas*. 
Studies on Opportunistic Pathogen Occurrence (cont’d)

• Pryor et al. (2004) observed a decrease in *Legionella* occurrence following a switch from chlorine to chloramines, but an increase in *Mycobacteria*.

• qPCR analysis of samples from two chloraminated distribution systems found *Legionella* in at least 69% of the samples, *Mycobacteria* in 100%, and *Pseudomonas* in no more than 13% (Wang et al., 2012).

• Lu et al. (2015) found 12/18 *Legionella* positive samples from storage tanks sediments.

• Using qPCR Qin et al. (2017) found *Legionella* evidence in 50% and *Mycobacteria* in 88% of sediment and water samples, and *Pseudomonas* in 50% of water samples from eight storage tanks.
Conditions Favorable to Opportunistic Pathogen Occurrence

- Inadequate disinfectant residuals in the distribution system can enable *Legionella* growth in buildings and in some parts of distribution system.
  - Can be caused by factors such as high residence time (e.g., in storage tanks), reactions with distribution system materials (e.g., iron), and excess biofilms.
  - LeChevallier (2019) found no *Legionella pneumophila* after flushing and maintenance of 0.1 mg/L free chlorine residuals in areas of the distribution system that previously had positive samples.

- Nutrients that can support growth can enter through a variety of sources, including from the source water, and the distribution system (e.g., pipe and storage breaches).
  - Nutrient control may help to impact the ability of *Legionella* to grow in free-living amoeba (NAS, 2020).
Conditions Favorable to Opportunistic Pathogen Occurrence

• High Water Age can provide conditions for opportunistic pathogens to grow (e.g., *Legionella* can grow in storage tanks with inadequate water turnover and in dead ends).
  • Stagnant water has been found to have higher organics concentrations (Wang et. al., 2012), and can allow protozoa, in which opportunistic pathogens reside, to grow.
  • Managing distribution system hydraulics can reduce areas of stagnant water, and help maintain disinfectant residual levels (NAS, 2020).

• Corrosion and Infrastructure Condition
  • Iron corrosion may deplete disinfectant residuals, enhance biofilm growth, and create a habitat where *Legionella* is protected from disinfection (NAS, 2020).
  • Distribution system (e.g., main breaks) may seed premise plumbing with *Legionella* and lead to LD (NAS, 2020).
Conditions Favorable to Opportunistic Pathogen Occurrence

• Sediments can originate from treatment breakthrough, intrusions, corrosion, and other sources, and can accumulate in low flow areas (e.g., tanks).
  • Sediments can protect *Legionella* against disinfection and be a source of nutrients that may support *Legionella* and *Pseudomonas* growth.
  • The NAS recommends that public water systems (PWSs) routinely flush and clean the distribution system, and inspect and clean storage tanks (NAS, 2020).
Previous Input on Disinfectant Residuals and Opportunistic Pathogens

• Residuals and opportunistic pathogen related public comments received on the Six-Year Review 3 (SYR3):
  • Evaluate new information and consider numeric levels of minimum disinfectant residuals in the distribution system.
  • Promote enhancing the quality of water entering distribution systems (e.g., more biologically stable water).
  • Promote good management practices in distribution systems for risk reduction.
EPA received input on these issues during the October 2020 public meeting and in subsequent written comments submitted to the docket. Written comments include:

- **ASDWA**
  - “Merely detectable disinfectant residuals in the distribution system may not be adequate protection”
  - “States have recognized the importance of maintaining adequate disinfectant residuals as a starting point for managing Legionella in facilities served by public water systems”

- **AWWA**
  - “There are opportunities to revise risk management expectations for managing microbial risk associated with both source waters and distribution system infrastructure”
  - “AWWA views investments in program activities that address outstanding Legionella microbial risk and infrastructure integrity as most critical”
Role of Disinfectant Residuals

• Disinfectant residuals serve three main purposes:
  • Protect against microbial contaminants.
  • Act as an indicator of distribution system upset.
  • Control excess biofilm growth.
Current Regulations

• Related rule requirements under SWTRs:
  • Under the SWTRs, all systems using surface water or ground water under the direct influence of surface water must maintain a detectable disinfectant residual within the distribution system in at least 95% of the samples collected.
  • Systems must maintain a 0.2 mg/L disinfectant residual concentration entering the DS
  • Heterotrophic bacteria counts (using the HPC method) can be used as an alternative indicator and must be maintained at less than or equal to 500 cfu/mL.
Current Regulations

• Related rule requirements under SWTRs:
  • Monitoring must be conducted throughout the distribution system at the same time and locations as those used for total coliform monitoring and continuously at the entry point.
    • Systems serving fewer than 3,300 people can take one to four grab samples per day.
  • Systems that fail to meet the 95% residual requirement for two consecutive months is in violation of the SWTR treatment technique (TT) requirement.
  • Systems in violation of the SWTR TT requirements must provide the public notice as soon as practical, but no later than 30 days after the system learns of the violation.
Relevant Data and Information

• Consideration of disinfectant residuals:
  • Increasing the disinfectant dose to raise disinfectant residual levels may lead to potentially increased disinfection byproduct risks.
  • Disinfectant residuals may not remain at far reaches of the system.
  • Chloramine as a disinfectant residual may increase nitrification risks.
• States with numeric requirements as of 2015 (Wahman and Pressman):
  • Twenty-two states had minimum numeric free chlorine levels ranging from 0.02 mg/L – 0.5 mg/L and minimum numeric total chlorine levels ranging from 0.02 mg/L – 1.50 mg/L (Wahman and Pressman, 2015).
Relevant Data and Information

• Consideration of Heterotrophic bacteria as alternative indicators:
  • There appear to be limited data on the use of HPC measurements as an alternative to disinfectant residuals.
  • Data from one state (NC) with nearly 50,000 records show that when the free or total chlorine levels were less than 0.2 mg/L, 3.4% of samples exceeded the HPC threshold, whereas when the residuals were higher than 0.2 mg/L, 0.5% exceeded the HPC threshold.

• New information on analytical methods:
  • Method 127 published on the determination of concentrations of monochloramine in drinking water.
Relevant Data and Information

• Preliminary analytical results presented in next several slides are based on the SYR3 Information Collection Request (ICR) data (2006-2011).

• The data are preliminary and once the data have been compiled and the quality assured, data from Six-Year Review 4 (SYR4) ICR (2012-2019) could inform future analyses.

• Once finalized, Unregulated Contaminant Monitoring Rule 4 (UCMR4) data (2018-2020) could also be analyzed for further characterization of disinfectant residual types in distribution systems, among others.
Comparison of Disinfectant Residuals and Total Coliforms

Note: Routine samples only


% Total Coliform Positives

- 0 mg/L
- > 0 to 0.2 mg/L
- > 0.2 to 0.5 mg/L
- > 0.5 to 1.0 mg/L
- > 1.0 mg/L

Free Chlorine Only Residual (n = 1,216,373)
Free Chlorine Residual (n = 1,571,254)
Total Chlorine Residual (n = 1,102,664)

Note: Routine samples only
Free Chlorine Residual Levels in CWSs

Free Chlorine Only in Large Surface Water CWSs Below a Given Value

Systems Serving >17,200

Systems Serving ≤17,200

- The y-axes represent the percentage of systems that would have exceeded compliance thresholds for different numeric disinfectant residual levels.
- Detectable states = systems from states requiring a detectable residual. Numeric states = systems from states requiring a numeric residual.
Total Chlorine Residual Levels in CWSs

Total Chlorine Only in Large Surface Water CWSs Below a Given Value

- **Systems Serving >17,200**
  - All Systems (n = 130)
  - Detectable States (n = 16)
  - Numeric States (n = 114)

- **Systems Serving ≤17,200**
  - All Systems (n = 1,726)
  - Detectable States (n = 291)
  - Numeric States (n = 1,435)

- The y-axes represent the percentage of systems that would have exceeded compliance thresholds for different numeric disinfectant residual levels.
- Detectable states = systems from states requiring a detectable residual. Numeric states = systems from states requiring a numeric residual.
Participant Discussion Questions on Disinfectant Residuals

• What data other than the Six Year Review Information Collection Requests and Unregulated Contaminant Monitoring Rule are available to inform pathogen or indicator occurrence at different disinfectant residual levels?

• What actions have water systems taken to meet numerical disinfectant residual requirements? What factors should water systems consider in determining the specific action(s) to take to increase disinfectant residual in areas of a system with low disinfectant residual levels?

• What data are available to assess disinfection byproduct formation or other water quality impacts resulting from increased disinfectant residual requirements?

• How do water systems assure that disinfectant residuals are being consistently maintained in the distribution system?
Participant Discussion Questions on Opportunistic Pathogens

• What actions or tools should be considered as a part of a comprehensive risk management framework for Legionella and other biofilm pathogens?

• What data or information are available to inform the water quality conditions under which Legionella occur or proliferate?

• Do the available data and analysis show that a specific disinfectant residual level reduces the public health concerns about Legionella and other biofilm pathogens in drinking water systems?

• What other measures have been shown to reduce the public health concerns about Legionella and other biofilm pathogens in drinking water systems?
How to Provide Input and Information

• Stakeholder engagements and meetings
• Docket ID Number: EPA-HQ-OW-2020-0486
• Dedicated e-mail inbox: MDBPRevisions@epa.gov
• EPA Potential MDBP Rule Revisions website: www.epa.gov/dwsixyearreview/revisions-microbial-and-disinfection-byproducts-rules
References

• CDC. 2020. *Legionella* (Legionnaires’ Disease and Pontiac Fever). [https://www.cdc.gov/legionella/about/history.html](https://www.cdc.gov/legionella/about/history.html)


• CDC. 2018. Clinical Features. [https://www.cdc.gov/legionella/clinicians/clinical-features.html](https://www.cdc.gov/legionella/clinicians/clinical-features.html)

References


References


