BARCLAY
WATER MANAGEMENT

Waterborne Pathogen Disinfection and Remediation in Healthcare Facilities

Presented by:
Michael Castro

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Michael Castro, MPH, CWT
District Manager

- 23 years of experience
- Voting member of ANSI/ASHRAE Std. 188
- Committee member of ANSI/ASHRAE Std. 514
- Initiated Development of ASTM Std. D8422:
  - Intermittent Use Validation of POU Water Filters
- Certified Trainer for ASSE 12080 *Legionella* Water Safety & Management Specialist Program
- Co-authored a chapter entitled *Legionella: Causes, cases, and mitigation*

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Conflict of Interest and Disclosure of Financial Relationships

- Barclay Water Management, Inc. (current)
  - Provide water safety related interventions
  - Provide water safety consulting services
- Special Pathogens Laboratory (past)
  - Provided environmental laboratory testing
  - Provided water safety consulting services

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Learning Objectives

1. Understand different interventions used to mitigate *Legionella* and other waterborne pathogen challenges
2. Evaluate benefits, challenges and limitations to both **short-term** and **long-term** disinfection and remediation strategies
3. Understand how to evaluate and implement control measures (interventions) when conditions may allow *Legionella* growth
4. Discuss peer reviewed publications which support evidence-based performance claims

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Opening Questions

- Have you <u>already</u> evaluated your options if your facility has significant environmental *Legionella* colonization/contamination?
- Is the Water Management Program Team prepared to make swift decisions if a Legionnaires' disease case is associated with a facility?
- Have you considered the "other" waterborne pathogens and modes of transmission [specifically named by CMS]?
  - Pseudomonas
  - Acinetobacter
  - Burkholderia
  - Stenotrophomonas
  - nontuberculous mycobacteria
  - fungi
- Who knows what water disinfectant your hospital receives?

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Legionella Reservoirs in Building Water Systems

- **Potable Water**
  - Showerheads
  - Faucets
  - Ice Machines
- Cooling Towers
- Decorative Fountains
- Whirlpool Baths or Spas
- Misting Systems
- Dental Lines
- Humidifiers
- Water Fountains

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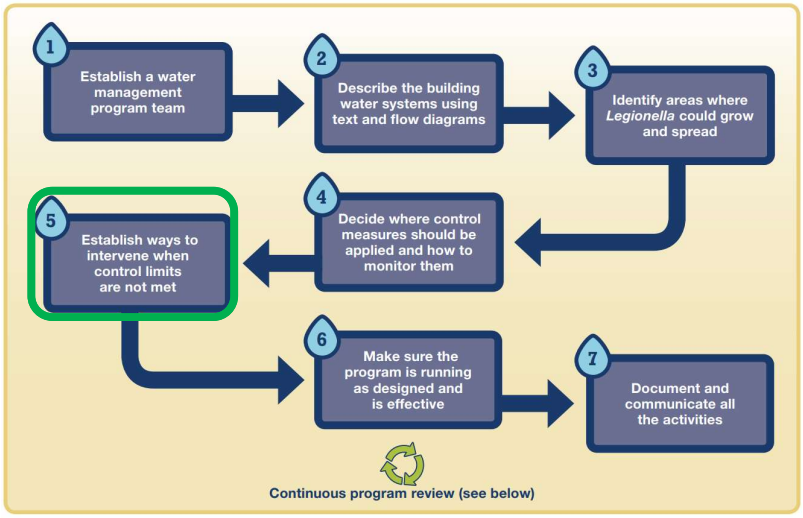
Water Management Program Interventions



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Water Management Program Validation

ENVIRONMENTAL GROUP
a division of Barclay Water Management, Inc.

LABORATORY REPORT

Hospital
123 Hospital Dr
New York, NY 10100

REPORT NO.: 125
SAMPLE DATE: 10-06-2022
REPORT DATE: 10-24-2022

#	Bldg	Floor	Room	Source	Hot/Cold	Draw	Temp °F	Identification	Final Result (CFU/mL)
1	BLDG A	Basement	Pharmacy Bathroom	Manual Faucet	Hot	First Draw	112	*Legionella pneumophila* serotype 1	49
2	BLDG A	Basement	BA-112	Manual Faucet	Hot	First Draw	102	*Legionella pneumophila* serotype 1	83
3	BLDG A	1st	Men's Restroom	Manual Faucet	Hot	First Draw	113	None Detected	ND
4	BLDG A	1st	Nurse's Station 6	Manual Faucet	Hot	First Draw	114	*Legionella pneumophila* serotype 1	51
5	BLDG A	1st	1A-106	Showerhead	Hot	First Draw	114	*Legionella pneumophila* serotype 1	28
6	BLDG A	2nd	Women's Restroom	Manual Faucet	Hot	First Draw	112	None Detected	ND
7	BLDG A	3rd	B3-101 Scrub Room	Manual Faucet	Hot	First Draw	116	*Legionella pneumophila* serotype 1	24
8	BLDG A	4th	Waiting Room Restroom	Manual Faucet	Hot	First Draw	116	*Legionella pneumophila* serotype 1	36
9	BLDG A	4th	4A-163	Shower Wand/Hose	Hot	First Draw	114	*Legionella pneumophila* serotype 1	19
10	BLDG A	5th	5A-134	Manual Faucet	Hot	First Draw	106	*Legionella pneumophila* serotype 1	72

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Water Management Program Validation

ENVIRONMENTAL GROUP
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LABORATORY REPORT

Hospital
123 Hospital Dr
New York, NY 10100

REPORT NO.: 123
SAMPLE DATE: 10-06-2022
REPORT DATE: 10-24-2022

#	Sample Name	*Pseudomonas aeruginosa* (CFU/100mL)
1	NICU Room 1	47
2	NICU Room 2	106
3	NICU Room 4	88
4	NICU Room 7	131
5	NICU Room 13	91

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What Happens Next?

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ASHRAE Guideline 12-2020

Managing the Risk of Legionellosis Associated with Building Water Systems

Table C-1 Performance Indicators for Water Management Programs for Potable Water Systems [a]

Calculated *Legionella*, CFU/mL [b]	Program Performance	Suggested Response
≤1 or not detected	*Legionella* growth appears well controlled.	Continue Program.
>1	Conditions may allow *Legionella* growth.	Implement the guidance in Section C5 [d].
Trending of Test Results over Time [c]	**Program Performance**	**Suggested Response**
10 to 100 fold increase	*Legionella* growth appears to be poorly controlled.	Implement the guidance in Section C5 [d].
>100 fold increase	*Legionella* growth appears to be uncontrolled.	Implement the guidance in Section C5 [d].

In **health care facilities** where **at-risk persons** are housed or treated and where ***Legionella* growth does not appear well controlled**, **consider implementing measures** from the healthcare facility's water management plan **to protect patients** from exposure to water aerosols while implementing the guidance in Section C5.

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CDC *Legionella* Toolkit (June 24, 2021, Version 1.1)

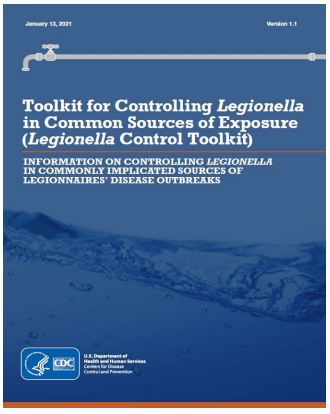
Figure 1. Routine *Legionella* testing: A multifactorial approach to performance indicator interpretation

Concentration indicates that *Legionella* growth appears:

Uncontrolled	Poorly Controlled	Well Controlled	
≥10 CFU/mL† in potable water	1.0–9.9 CFU/mL in potable water	Detectable to 0.9 CFU/mL in potable water	No *Legionella* detected in a single round of testing
OR ≥100 CFU/mL in non-potable water	**OR** 10–99 CFU/mL in non-potable water	**OR** Detectable to 9 CFU/mL in non-potable water	

Change in concentration over time indicates that *Legionella* growth appears:

Uncontrolled	Poorly Controlled	Well Controlled	
100-fold or greater increase in concentration (e.g., 0.05 to 5 CFU/mL)	10-fold increase in concentration (e.g., 0.05 to 0.5 CFU/mL)	*Legionella* concentration steady (e.g., 0.5 CFU/mL for two consecutive sampling rounds)	No *Legionella* detected in a single round of testing



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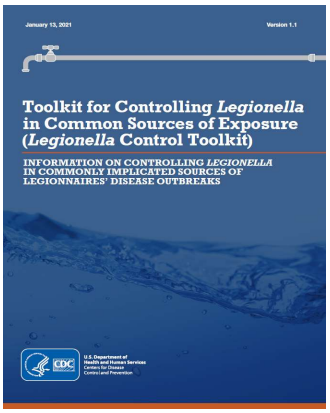
CDC *Legionella* Toolkit (June 24, 2021, Version 1.1)

- If Legionella growth does not appear well controlled in healthcare facilities…**consider implementing immediate control measures**…
- If the **root causes** of *Legionella* growth are not identified and controlled, ***Legionella* growth is likely to reoccur.**



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SAN DIEGO STATE UNIVERSITY

San Diego State Professor Dies of Legionnaires' Disease

Legionella can be found naturally in freshwater but can also grow and spread in human-made water systems like hot tubs, hot water tanks, decorative fountains and more complex water systems

By Christina Bravo • Published March 7, 2023 • Updated on March 7, 2023 at 3:06 pm

This undated image made available by the Centers for Disease Control and Prevention shows a large grouping of Legionella pneumophila bacteria (Legionnaires' disease). Most deaths from Legionnaires' disease are tied to hospital and nursing home showers, not outdoor cooling towers, new government figures released Thursday, Aug. 13, 2015 show. The germ spreads into the

A professor who was diagnosed with a rare case of Legionnaires' disease, died after a weeks-long battle with the severe form of pneumonia, San Diego State University officials said on Tuesday.

Dr. Michael J. Buono, a professor of SDSU's the School of Exercise and Nutritional Sciences with a 40-year career at SDSU, died on March 4, three weeks after he was hospitalized with Legionella pneumonia, the university said.

https://www.nbcsandiego.com/news/local/san-diego-state-professor-dies-of-legionnaires-disease/3181301/

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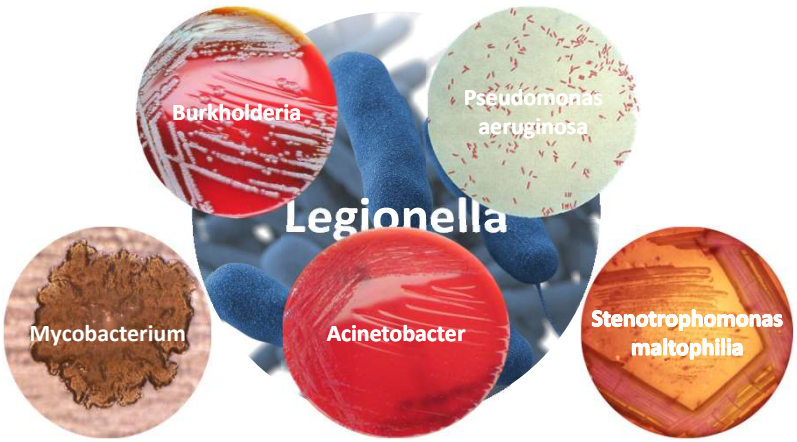
It's Not Just About Legionella Anymore



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Other Waterborne Pathogens in Healthcare

- ***Pseudomonas aeruginosa*** [1, 2]
  - ~51,000 healthcare-associated *P. aeruginosa* infections occur in the US annually resulting in ~400 deaths per year. 13% are multidrug-resistant
  - Infants with *P. aeruginosa* infections showed crude mortality rates of 18 to 100% (mean = 62.7%)
- **Nontuberculous Mycobacteria (NTM)** [3]
  - Oregon Study: 35.1% died in the 5 years following respiratory identification
  - ~85,000 people in the US currently suffering from NTM infection

1: https://www.cdc.gov/hai/organisms/pseudomonas.html;
2: Jefferies, J. M., Cooper, T., Yam, T., & Clarke, S. C. (2012). Pseudomonas aeruginosa outbreaks in the neonatal intensive care unit – a systematic review of risk factors and environmental sources. Journal of Medical Microbiology, 1052–1061; 3: https://ohsu.pure.elsevier.com/en/publications/mortality-after-respiratory-isolation-of-nontuberculous-mycobacte

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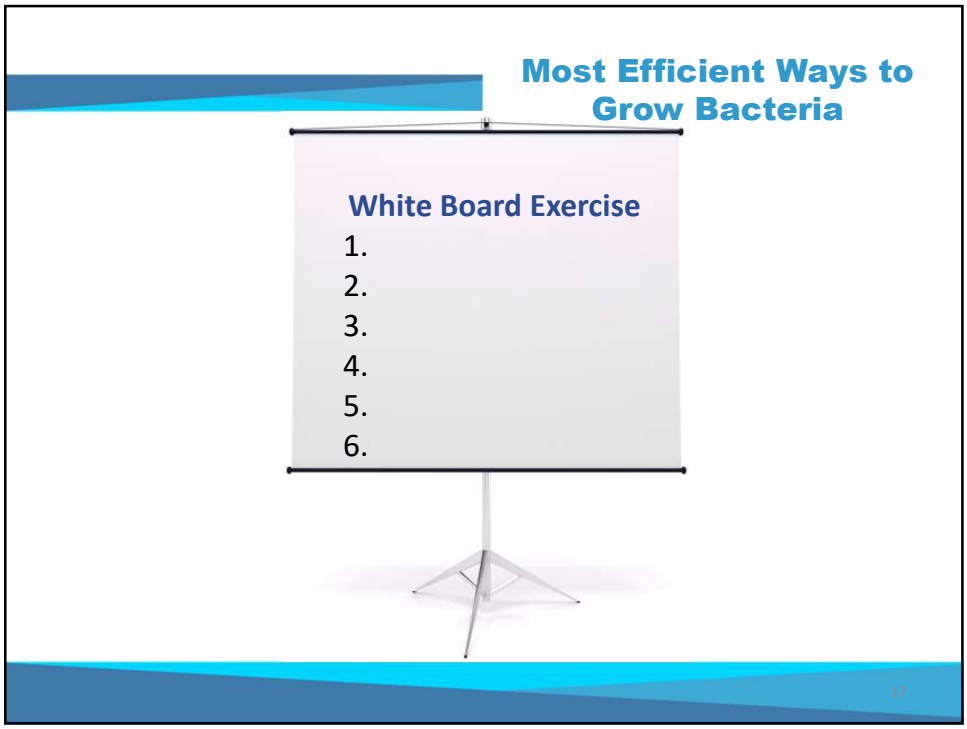
Most Efficient Ways to Grow Bacteria
White Board Exercise
1.
2.
3.
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5.
6.
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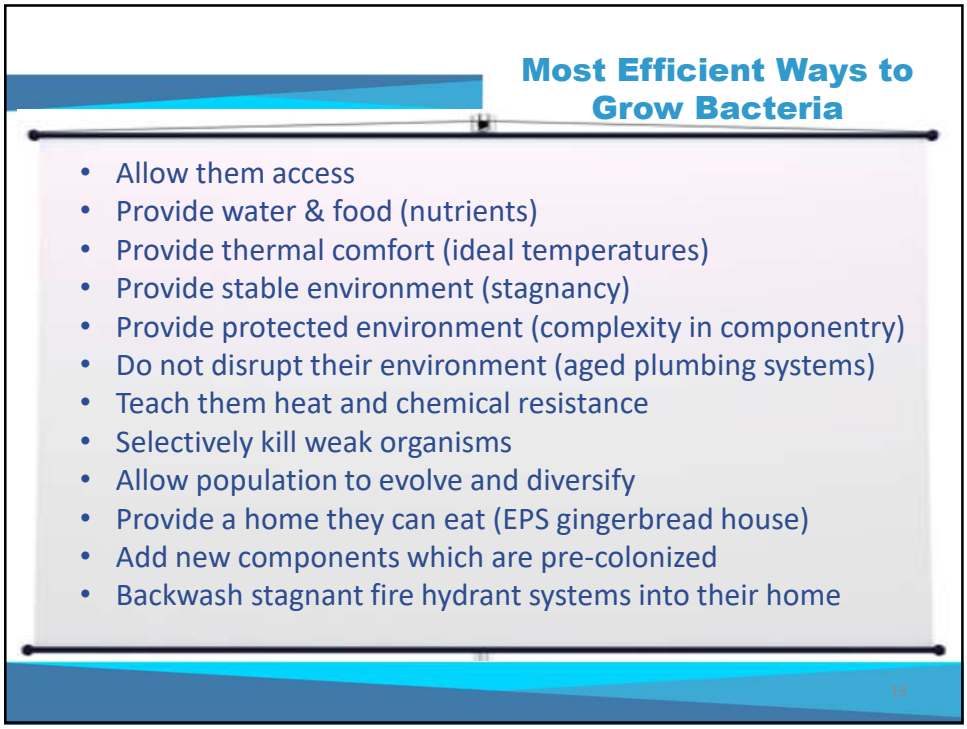
Most Efficient Ways to Grow Bacteria
• Allow them access
• Provide water & food (nutrients)
• Provide thermal comfort (ideal temperatures)
• Provide stable environment (stagnancy)
• Provide protected environment (complexity in componentry)
• Do not disrupt their environment (aged plumbing systems)
• Teach them heat and chemical resistance
• Selectively kill weak organisms
• Allow population to evolve and diversify
• Provide a home they can eat (EPS gingerbread house)
• Add new components which are pre-colonized
• Backwash stagnant fire hydrant systems into their home
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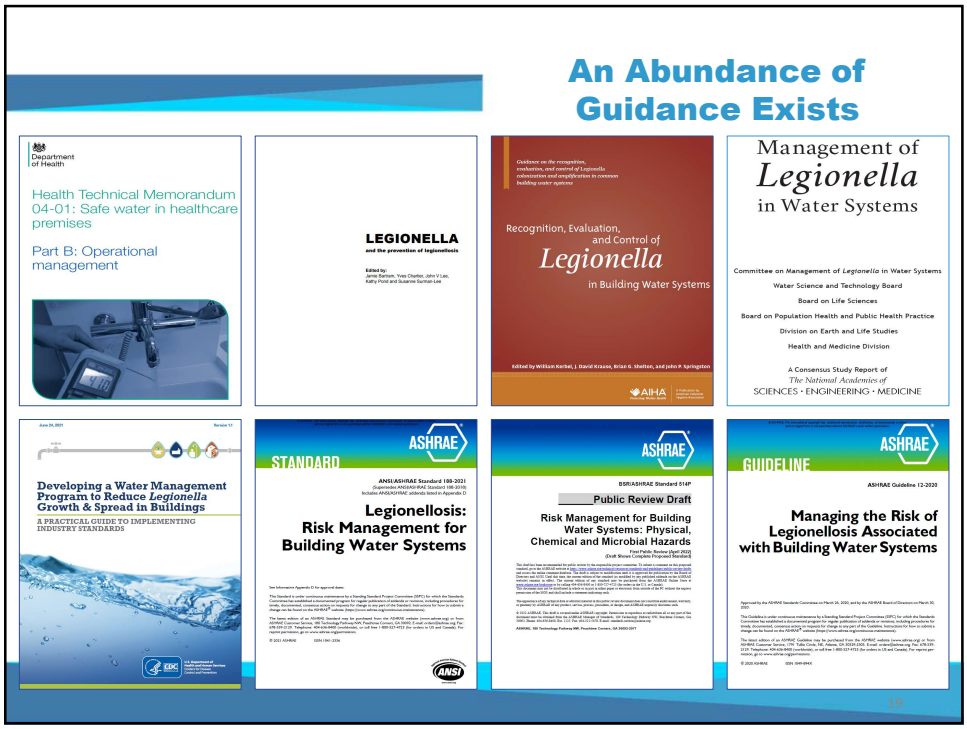

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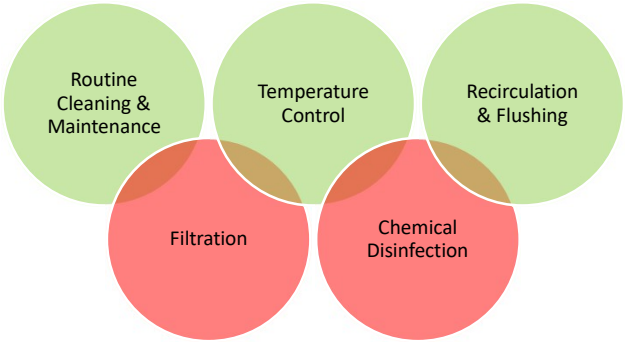
Limit Amplification by Bundling Interventions



- Keep it clean
- Keep it hot
- Keep it cold
- Keep it moving
- Keep residual chemistry

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Keep it Hot & Keep it Cold

- **Benefits:**
  - **Prevent** *Legionella* **multiplication**
  - **Maintain** biofilm **stasis**
  - Prevent heat loss or gain with insulation
- **Obstacles:**
  - Heating rapidly **depletes** many **disinfectant residuals**
  - **Capacity of water heaters** is inappropriate to deliver high temperatures
  - **Scalding** & **plumbing code** requirements
  - Increased corrosion
  - Decreased equipment life
  - Cold water main may be warm already

*Flemming, P.-C. (2016). Executive Summary: Results of the Collaborative research project "Biofilms in Drinking Water Installations". Duisburg, Germany: University Duisburg-Essen.

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ELSEVIER

Water Research

Volume 149, 1 February 2019, Pages 460-466

Role of hot water temperature and water system use on *Legionella* control in a tertiary hospital: An 8-year longitudinal study

Laura Gavaldà [a], Marian Garcia-Nuñez [b c d], Sara Quero [b], Carmen Gutierrez-Milla [a], Miquel Sabrià [b c e]

- Hot water temps dramatically drop to ambient in 20 min.
- *Legionella* is significantly higher at POU if **not used daily**.
- **Weekly flushing** of taps and showers **is not enough** to minimize *Legionella* colonization.

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Keep it Moving (recirculation & flushing)

- **Benefits:**
  - Reduces **water age**
  - Delivers fresh water & disinfectant
  - Mechanical friction **scrubs biofilm**
  - Removes some accumulated sediment
- **Obstacles:**
  - **Cost** of water & labor
  - Difficult to flush **sensor faucets**
  - Potential pressure challenges
  - Studies show **daily flushing is required** (weekly is not enough)

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Corrective Action: Remediation Options

Short-Term Disinfection Options

- Chemical Shock / Hyper-halogenation (chlorine)
- Point-of-Use Microbiological Filters (widespread use)
- Thermal Disinfection/Superheat & Flush
- Flushing

Long-Term Disinfection Options

- Sodium Hypochlorite (chlorine)
- Copper/Silver Ionization
- Chlorine Dioxide
- Monochloramine
- Ozonation / Ultraviolet Disinfection
- Point-of-Use Microbiological Filters (targeted deployment)

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How Do We Select the Best Intervention?

When to Consider

- Water temperature
- Incoming chemistry
- Supplemental chemistry
- Efficacy against biofilm
- Third-party publications
- Alarming, data & trending
- Corrosion/metallurgy

What to Consider

- EPA permitting requirements
- Cost (capital & operational)
- Footprint
- Service requirements
- Manpower requirements
- Safety features
- Other bundled interventions used

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Corrective Action: Short-Term POU Filters

- ≤0.2-micron, disposable microbiological filter
- Creates a physical barrier between plumbing & occupants
- Immediate & effective
  - Validated to retain >9-log bacteria (*B.diminuta*)
  - FDA-cleared to aid in infection control
- Often used as long-term intervention in high-risk units
- Source is not eliminated

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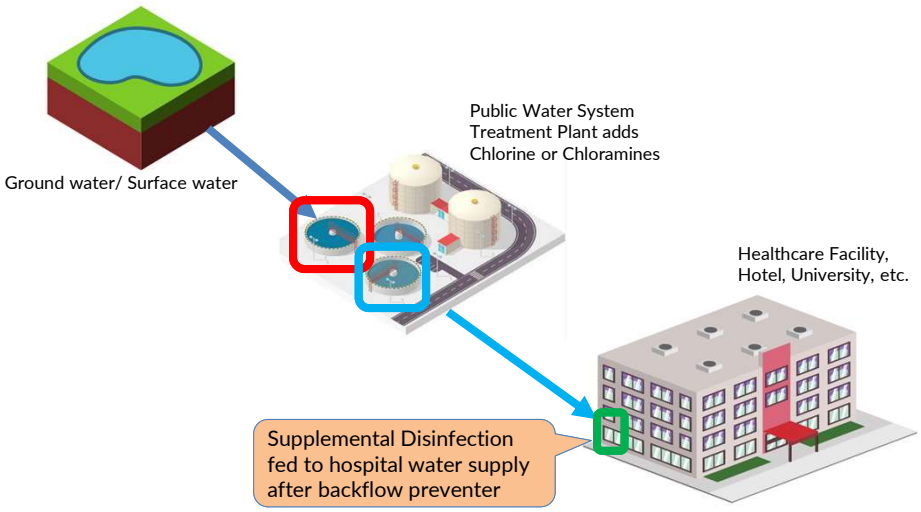
Primary, Secondary & Supplemental Disinfection



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When is Supplemental Disinfection Considered?

- Poor temperature control or heavy organic load
- Inadequate disinfectant at the point-of-use
- Amplification of *Legionella* within complex plumbing systems
- Case of Legionnaires' disease

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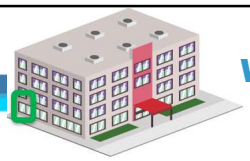
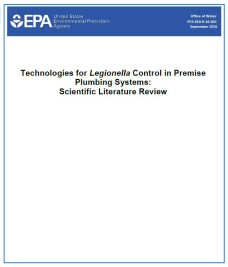


Why Add Supplemental Disinfectant?

- **Multiple studies:** "**support maintaining a chloramine residual** in the premise plumbing system in the range of 1 to 2 ppm as an effective means for **containing biofilm growth, minimizing *Legionella* colonization and preventing outbreaks**."
- "Within healthcare facilities such as hospitals and nursing homes the **potable water supply is the most common source of [*Legionella*] exposure**."
- **San Francisco study by CDC/Health Department:** "Our study demonstrated that ***Legionella* colonization** in a plumbing system **was effectively eliminated by** monochloramine [**supplemental disinfection**]. Hospitals or other facilities colonized with *Legionella* spp. might control *Legionella* growth and prevent disease transmission by adding [a supplemental disinfection] to their potable water system."



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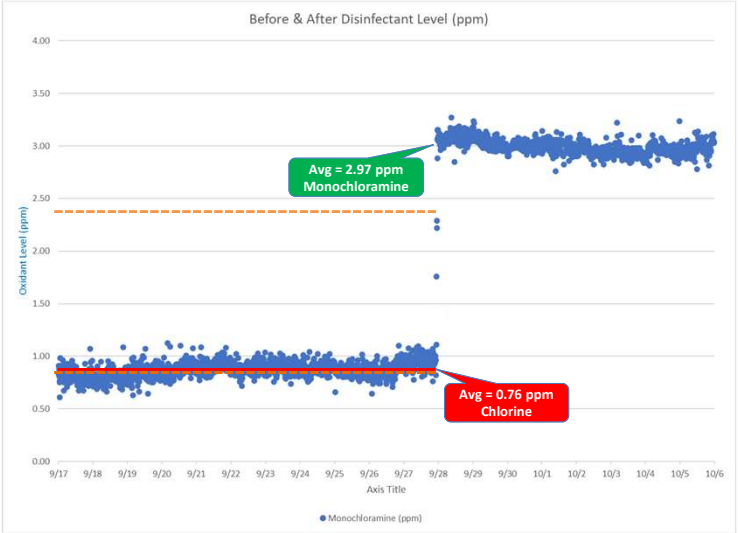
Why Add Supplemental Disinfectant?



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WATER MANAGEMENT

Cold Water: A Relative Term

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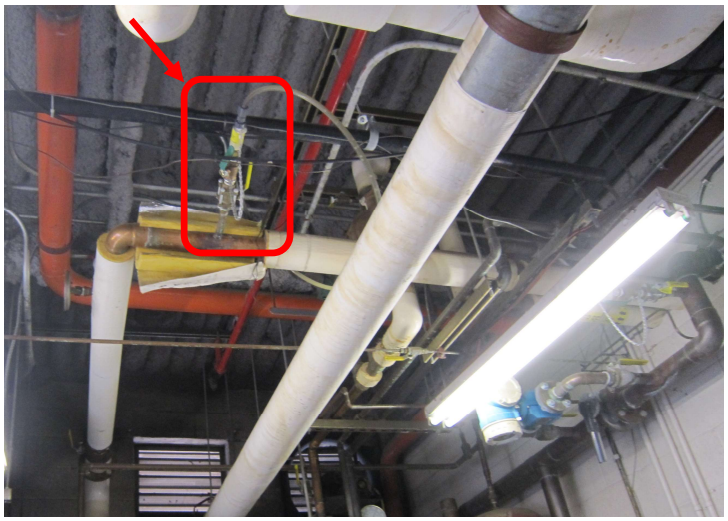
Overhead Neat Chemical Injection



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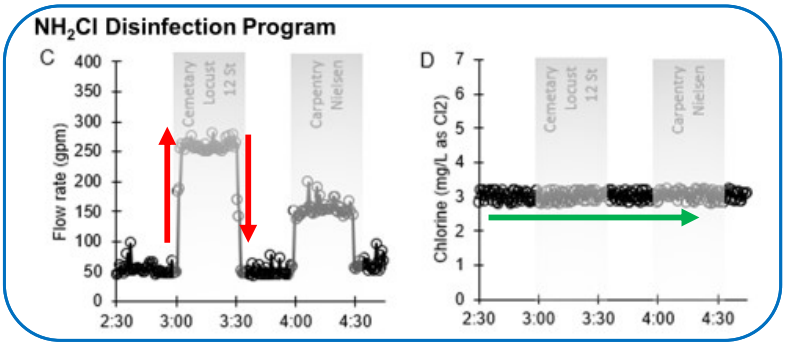
Response to Variable Flow



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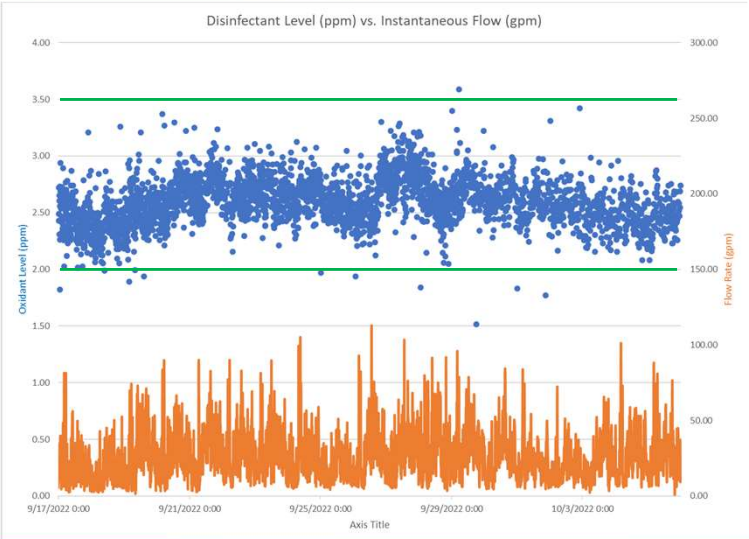
BARCLAY WATER MANAGEMENT

Response to Variable Flow



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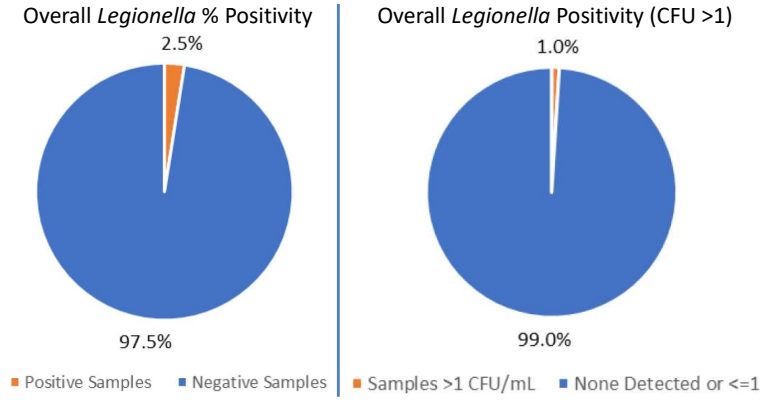
Efficacy of Intervention



- 10,432 *Legionella* cultures taken on 50 systems
- 261 (2.5%) Positive *Legionella* cultures
- 102 (1%) Positive *Legionella* cultures > 1 CFU/mL

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EPA Permitting

- Strict regulations in many states to permit systems
- Regulations vary widely state to state & county to county

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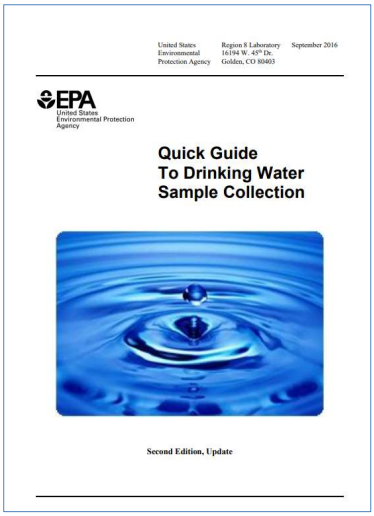
Permitting Requirements

- **Revised Total Coliform Rule** ✓
  - Absence of Total Coliform
- **Lead & Copper Rule** ✓
  - Lead <0.015 ppm in 90% of samples
  - Copper < 1.3 ppm
- **Stage 1 and Stage 2 Disinfectants and Disinfection Byproducts Rules** ✓
- **Other reports may be required**
  - Nitrite/Nitrate Testing ?


United States Environmental Protection Agency Region 8 Laboratory 16194 W. 45th Dr. Golden, CO 80403 September 2016

EPA United States Environmental Protection Agency

Quick Guide To Drinking Water Sample Collection

Second Edition, Update

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Monitoring Requirements

EPA Permitting Requirement	Frequency	Chlorine	Chlorine Dioxide	Monochloramine	Copper-Silver[1]	Ozone
Absence of Total Coliform	**Monthly**	●	●	●	●	●
Lead <0.015 ppm[3] (in 90% of samples)	**Bi-Annual**	●	●	●	●	●
Copper < 1.3 ppm[3]	**Bi-Annual**	●	●	●	●	●
Chlorite <1.0 ppm	**Daily**		●			
Chlorine Dioxide <0.8 ppm	**Daily**		●			
Total Chlorine <4.0 ppm	**Monthly**	●	●	●	●	●
Bromate <0.010 ppm	**Monthly**					●
TTHM <0.080 ppm[2]	**Quarterly or Annual**	●	●	●	●	●
HAA5 <0.060 ppm[2]	**Quarterly or Annual**	●	●	●	●	●

[1] *often not regulated/permitted*
[2] *based on locational running annual averages of samples collected from last 4 quarters*
[3] *lead and copper sampling can be reduced to annual or to every 3 years if levels are low enough*

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Things to Consider with Supplemental Disinfection

Best Good OK

Consideration	Chlorine	Chlorine Dioxide	Monochloramine	Copper-Silver
Treat both cold and hot water	Best	Best	Best	OK
Cold feed able to maintain disinfecting levels in hot	Good	OK	Best	N/A
Capital equipment cost	Best	OK	Good	Good
EPA permitting requirements (if permitted)	Best	OK	Best	Best
Corrosion challenges	OK	OK	Good	Good
Polymer/elastomer compatibility	OK	OK	Good	Best
Short-term remediation without water shutdown	OK	OK	Best	Best
Speed of efficacy	OK	Good	Best	Good
Biofilm penetration	OK	OK	Best	Good
Liquid chemistry or precursor required	OK	OK	OK	Best
Taste & odor	OK	Best	Best	Best
Manpower requirements	Best	OK	Best	Good
Total cost of operation	Best	OK	Good	Good
Simplicity of install/disinfectant generation	Best	OK	Good	Good
Stability/distal persistency	OK	OK	Good	Best
Efficacy over wide range of pH	OK	Good	Best	Good
Disinfectant byproducts	Good	OK	Good	Best

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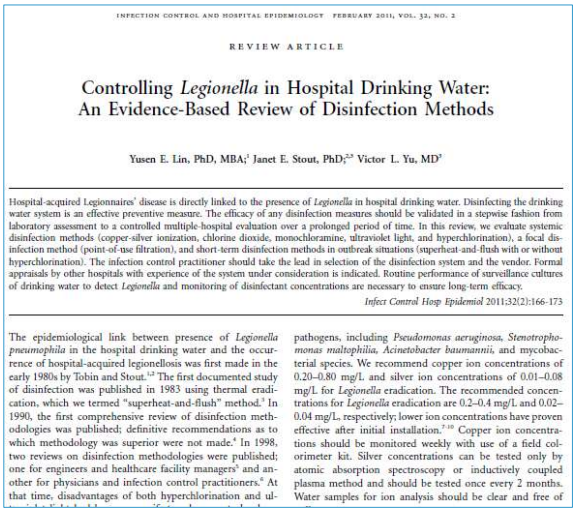
Publication Review



INFECTION CONTROL AND HOSPITAL EPIDEMIOLOGY FEBRUARY 2011, VOL. 32, NO. 2

REVIEW ARTICLE

Controlling *Legionella* in Hospital Drinking Water: An Evidence-Based Review of Disinfection Methods

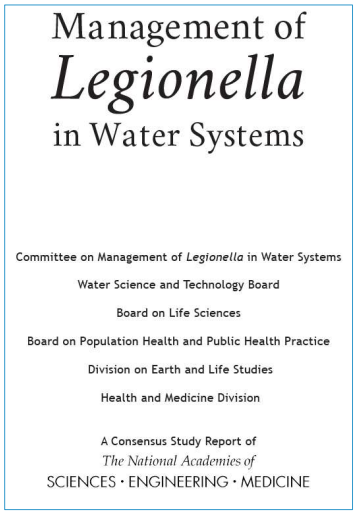
Yusen E. Lin, PhD, MBA;[1] Janet E. Stout, PhD;[2,3] Victor L. Yu, MD[3]

Hospital-acquired Legionnaires' disease is directly linked to the presence of *Legionella* in hospital drinking water. Disinfecting the drinking water system is an effective preventive measure. The efficacy of any disinfection measures should be validated in a stepwise fashion from laboratory assessment to a controlled multiple-hospital evaluation over a prolonged period of time. In this review, we evaluate systemic disinfection methods (copper-silver ionization, chlorine dioxide, monochloramine, ultraviolet light, and hyperchlorination), a focal disinfection method (point-of-use filtration), and short-term disinfection methods in outbreak situations (superheat-and-flush with or without hyperchlorination). The infection control practitioner should take the lead in selection of the disinfection system and the vendor. Formal appraisals by other hospitals with experience of the system under consideration is indicated. Routine performance of surveillance cultures of drinking water to detect *Legionella* and monitoring of disinfectant concentrations are necessary to ensure long-term efficacy.

Infect Control Hosp Epidemiol 2011;32(2):166-173

The epidemiological link between presence of *Legionella pneumophila* in the hospital drinking water and the occurrence of hospital-acquired legionellosis was first made in the early 1980s by Tobin and Stout.[1,2] The first documented study of disinfection was published in 1983 using thermal eradication, which we termed "superheat-and-flush" method.[3] In 1990, the first comprehensive review of disinfection methodologies was published; definitive recommendations as to which methodology was superior were not made.[4] In 1998, two reviews on disinfection methodologies were published; one for engineers and healthcare facility managers[5] and another for physicians and infection control practitioners.[6] At that time, disadvantages of both hyperchlorination and ul-

pathogens, including *Pseudomonas aeruginosa*, *Stenotrophomonas maltophilia*, *Acinetobacter baumannii*, and mycobacterial species. We recommend copper ion concentrations of 0.20–0.80 mg/L and silver ion concentrations of 0.01–0.08 mg/L for *Legionella* eradication. The recommended concentrations for *Legionella* eradication are 0.2–0.4 mg/L and 0.02–0.04 mg/L, respectively; lower ion concentrations have proven effective after initial installation.[7-10] Copper ion concentrations should be monitored weekly with use of a field colorimeter kit. Silver concentrations can be tested only by atomic absorption spectroscopy or inductively coupled plasma method and should be tested once every 2 months. Water samples for ion analysis should be clear and free of



Management of *Legionella* in Water Systems

Committee on Management of *Legionella* in Water Systems

Water Science and Technology Board

Board on Life Sciences

Board on Population Health and Public Health Practice

Division on Earth and Life Studies

Health and Medicine Division

A Consensus Study Report of

The National Academies of

SCIENCES · ENGINEERING · MEDICINE

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Free Chlorine (Sodium Hypochlorite)

Benefits:

- Extremely easy to access, install, and feed
- Used in drinking water for over 100 years
- Inexpensive

Challenges:

- Highly corrosive to piping
- Requires on site chemistry
- Creates disinfection byproducts (TTHM/HAAs)
- Highly reactive (must feed to both hot and cold)
- Poor biofilm penetration
- Requires extended length of time to reduce *Legionella*
- In studies, less effective than monochloramine and chlorine dioxide against *Legionella* bacteria as measured by CT
- Impact taste and odor

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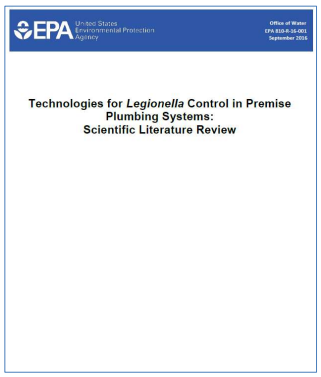
Efficacy of Chlorine

- **Lin et al., 1998a:** Relatively high doses of chlorine (2–6 ppm) were needed for continuous control of *Legionella* in water systems.
- **Muraca et al. (1987):** Chlorine was more effective at a higher temperature (109.4 °F) compared to 77 °F, but decayed faster at higher temperatures.
- **Kim et al. (2002):** Association with protozoa may explain why chlorine can suppress *Legionella* in water systems but cannot usually prevent its regrowth.



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Chlorine Dioxide

Benefits:

- Effective against *Legionella* and other types of bacteria
- Effective over a wide range of pH levels
- Little Impact on taste and odor

Challenges:

- Extremely corrosive to piping
- Cold water application requires extended length of time to reduce *Legionella*
- Degrades quickly (especially in hot water systems)
- Separate feed system required to control hot and cold water
- Tight control band (maximum dosage limit of 0.8 ppm; 1.0 ppm chlorite)
- Penetrates biofilm more effectively than Sodium Hypochlorite; but less effectively than Monochloramine
- Creates disinfection byproducts (chlorite and chlorate)
- **Daily chlorite monitoring usually required on permitted systems**

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Chlorine Dioxide

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Chlorine Dioxide

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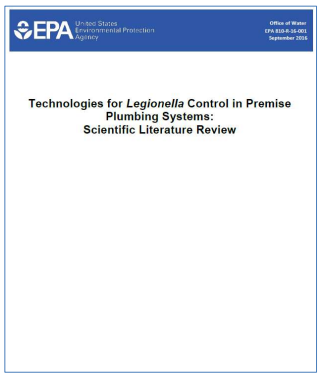
Efficacy of Chlorine Dioxide

- **Loret et al. (2005):** "Biofilm thickness was reduced to <5 µm with chlorine dioxide and several other disinfectants, as compared to a measured biofilm thickness of 13–35 µm in the untreated pipe loop."
- **Mustapha et al. (2015):** Laboratory study found that L. pneumophila was not inactivated at shock disinfection levels. At 4 ppm, L. pneumophila could be detected using cell culture, but at 6 ppm, no bacteria were detected.


EPA United States Environmental Protection Agency

Office of Water
EPA 810-R-16-001
September 2016

Technologies for *Legionella* Control in Premise Plumbing Systems:
Scientific Literature Review

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Chlorine Dioxide: Email from California EPA

To Kinderman, Liz <ekinderman@barclaywater.com>

Cc Souza, Kurt <Kurt.Souza@waterboards.ca.gov>

From Wednesday, June 1, 2022 2:57 PM Bcc

Using chlorine dioxide is very serious when it comes to proper operation and potential for public health issues, I would recommend against it.

Thanks,

Kurt Souza
California EPA
State Water Resources Control Board
- Division of Drinking Water
Asst. Deputy Director

Send

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Copper-Silver Ionization

Benefits:

- No precursor chemistry used
- Copper and silver work synergistically to produce higher inactivation rate
- Copper destroys cell wall permeability, silver interferes with synthesis of proteins and enzymes
- Non-enforceable Maximum Contaminant Level (MCL); Only Secondary MCL

Challenges:

- **Only applied to Hot Water**
- No direct, online measurement of residual available (i.e. no Cu-Ag probe)
- Must use laboratory analyses to test for Cu-Ag (delay in treatment adjustment)
- No traceability for Cu-Ag treatment levels throughout the day
- pH restriction of 8.0; high pH waters may pose precipitation challenges
- Specialized maintenance: cleaning/replacement of plates (uses strong acid)
- Tight control limits: 1.3 ppm Copper, 0.1 ppm Silver

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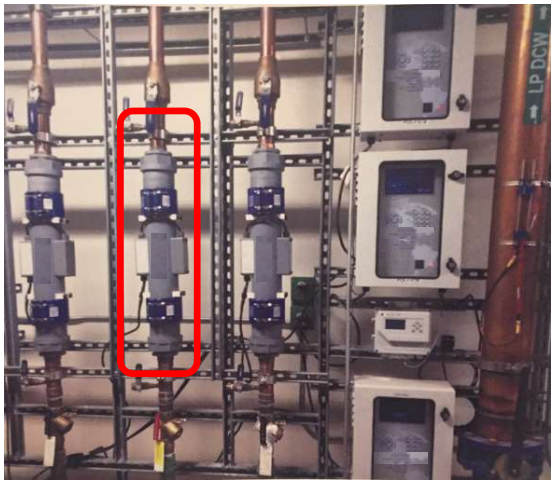
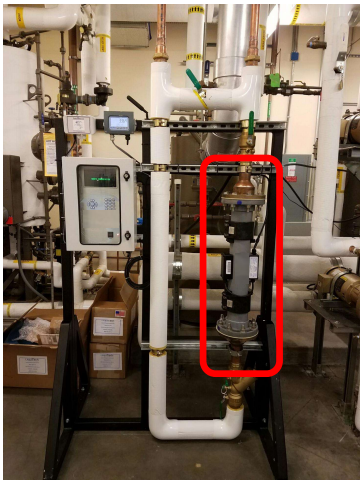
Copper-Silver Ionization





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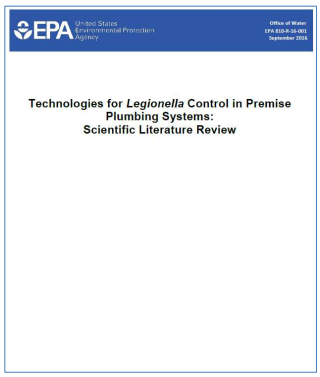
Efficacy of Copper-Silver Ionization

- **Dziewulski et al. (2015):** CSI efficacy demonstrated for inactivating both L. pneumophila and L. anisa under alkaline water conditions (pH 8.7–9.9). Positivity reduced from 70% to <30%.
- **Demirjian et al. (2015):** Outbreak at a Pennsylvania hospital – 23 of 25 locations sampled for *Legionella* culture were positive, while the mean copper and silver ion concentrations were measured at or above the manufacturer's recommended levels for *Legionella* control (0.30 and 0.02 ppm, respectively).
- **Chen et al. (2008):** Copper-silver ionization reduced positive L. pneumophila samples from 30% to 5%. Finally, after 11 months, positivity reduced to 0% after increasing Cu-Ag concentrations.


EPA United States Environmental Protection Agency

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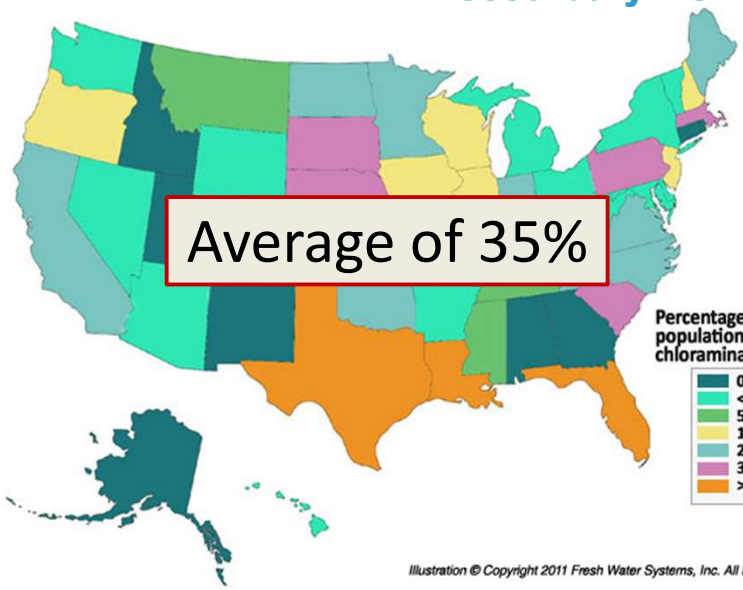
USA Monochloramine Secondary Disinfection



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Monochloramine

Benefits:

- Rapidly effective against Legionella bacteria (CT) and biofilm penetration
- Stable in both hot and cold water systems
- Persists well within complex plumbing systems
- Treatment translates to hot water by feeding only cold water main
- Less corrosive than free chlorine or chorine dioxide
- Like free chlorine, used in drinking water for over 100 years
- Reduced disinfection byproducts compared to chlorine
- Remediation can be performed without service interruption (<4.0 ppm)

Challenges:

- Proper ratio of precursor chemicals must be used
- Concerns exist for dialysis and fish tanks
- Concerns with free ammonia when fed improperly

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Monochloramine

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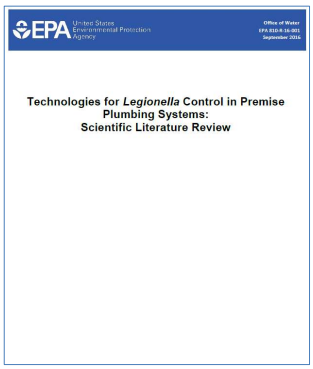
Efficacy of Monochloramine

- **Coniglio et al. (2015):** One year of monochloramine used following 100% colonization of two hospital hot water systems (*L. pneumophila* serogroups 3 and 6) showed no *Legionella* detected in all samples (except during one month when the generator failed for 15 days). Ammonium, nitrite and nitrate levels did not exceed their limits during the study.
- **Baron et al. (2015):** Treatment with monochloramine resulted in reduced total bacteria count, as well as reduced species diversity, compared to a control (untreated) hot water.
- **Duda et al. (2014):** Significant reduction in *Legionella* at distal sites after a monochloramine generation system was installed in a hospital hot water system, replacing a copper-silver ionization system. Monochloramine levels ranged from 1.0 to 4.0 ppm.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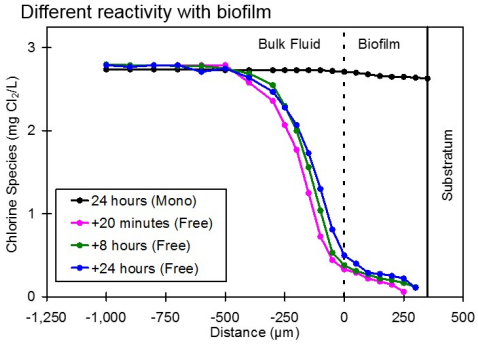
Efficacy of Monochloramine

Monochloramine vs Free Chlorine
Biofilm Penetration

- Monochloramine → complete penetration
- Free chlorine → penetration depth stabilizes
- Different reactivity with biofilm



Lee, W. H.; Wahman, D. G.; Bishop, P. L.; Pressman, J. G., Free chlorine and monochloramine application to nitrifying biofilm: comparison of biofilm penetration, activity, and viability. *Environ. Sci. Technol.* **2011,** *45*, (4), 1412–1419.

- For equivalent chlorine concentrations, monochloramine shown to penetrate biofilms 170 times faster than free chlorine
- Even after subsequent application to a monochloramine-penetrated biofilm, free chlorine penetration was limited

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Efficacy of Monochloramine

Legionella Colonization Prevention in Ice Machines

Querry AM, Pasculle AW, Dudek E, Crouse J, Sundermann AJ, Young L, Tatar J, Troesch A, Meduho E, Wozniak J, Muto CA

University of Pittsburgh Medical Center – Presbyterian Hospital, Pittsburgh, Pennsylvania

Conclusions:

- Manufacturer/specified ice machine cleaning and descaling guidelines were associated with the highest colonization rates and could lead to increased *Legionella* hospital acquired infections.
- POU filters had a lower rate of colonization, but changing all filters within 31 days is challenging. Manual interventions have the ability to work, but need to be strictly followed and maintained.
- Continuous disinfection with Monochloramine was most effective as preventing *Legionella* colonization and was easiest to maintain.

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Ice Machine Filtration

A bacterial infection killed three patients at Brigham and Women's. Here's how it got in.

Story by Jessica Bartlett • Monday

An infectious disease clinician working closely with the cardiac surgery department had an inkling something was off. It was 2018, and she mentioned to colleagues at Brigham and Women's Hospital the unusual occurrence of a suspicious bacteria, which had popped up several times in the last year and a half. The rare bacteria, Mycobacterium abscessus, can sometimes cause hospital-acquired infections, often from contaminated water. But the number of times hospitalized patients had tested positive for it struck her as odd.

- "the hospital discovered the culprit: a water purification system feeding an ice and water machine on the cardiac unit."
- "experts did find high levels of mycobacteria from ice and water machine samples… DNA extracted from the machine samples was an exact match to a gene in the patient outbreak."

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https://www.msn.com/en-us/news/us/a-bacterial-infection-killed-three-patients-at-brigham-and-women-s-the-culprit-a-water-purification-system/ar-AA18ikZo

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Ice Machines in Healthcare

- Cleaning and maintenance
- Temperature control
- Flushing
- Filtration
  - Particulate
  - Carbon/taste (??)
  - Microbiological
- Sanitization

Ice Machine Image shared with Kind Permission from Follet Ice, 2019

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Quick Takeaway

I'm an Infection Preventionist. What can I do?

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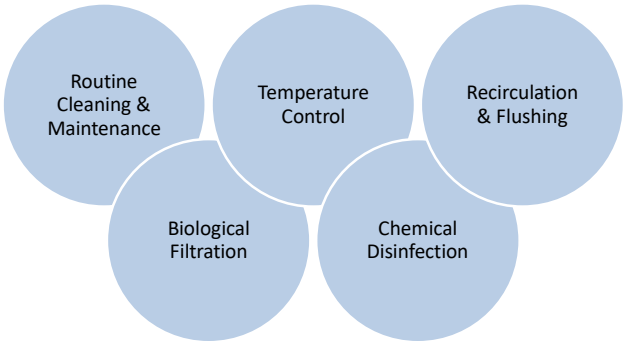
Quick Takeaway



- Keep it clean
- Keep it hot
- Keep it cold
- Keep it moving
- Keep residual chemistry

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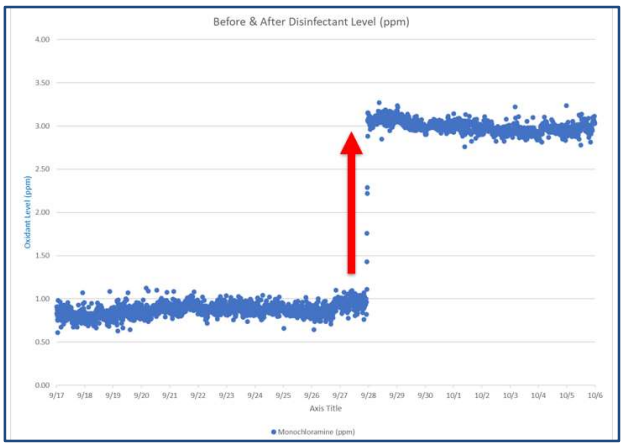
Being Proactive



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Efficacy Against Other Waterborne Pathogens

Water Research 189 (2021) 116656

Contents lists available at ScienceDirect

Water Research

journal homepage: www.elsevier.com/locate/watres

A comprehensive evaluation of monochloramine disinfection on water quality, *Legionella* and other important microorganisms in a hospital

Darren A. Lytle[a,*], Stacy Pfaller[a], Christy Muhlen[a], Ian Struewing[b], Simoni Triantafyllidou[a], Colin White[c], Sam Hayes[a], Dawn King[a], Jingrang Lu[b]

After treatment with monochloramine:

- ***Legionella*** culture decreased from 68% to 6% positivity after monochloramine addition
- **Pseudomonas aeruginosa** demonstrated large and significant decrease
- ***nontuberculous Mycobacteria*** by culture were significantly reduced from 61% to 14%

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Thank You!!!

Questions?

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mcastro@barclaywater.com

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