Evidence Shows Need To Address Pathogenic Bacteria in U.S. Drinking Water Systems

BY DARYN CLINE, MEMBER ASHRAE; SARAH FERRARI

Legionnaires' disease is on the rise. Unfortunately, efforts to prevent Legionnaires' disease to date have focused on building water systems rather than the municipal water supply. Building water systems are too far downstream to correct the problem, and, as a result, these efforts have been ineffective in curbing the incidence of legionellosis.

It is unrealistic to place on building owners and operators the burden and risk for providing pathogen-free water throughout buildings when the water delivered to their buildings contains *Legionella* bacteria. *Legionella* is commonly found in source waters (*Figure 1a*) and in the soil, and thus, if untreated at the municipal water treatment plant and in the distribution systems, the *Legionella* bacteria will necessarily find its way into buildings. More needs to be done by the municipal water suppliers to minimize *Legionella* bacteria in the drinking water supply before it can enter building water systems. Legionnaires' disease is the number one waterborne disease associated with potable water in the United States, and it is lethal; approximately 10% of those who contract the disease will lose their lives.

Minimizing water pathogen risks is a *shared* responsibility between municipal water suppliers *and* building owners. At present, however, regulatory efforts seek to put responsibility for all preventive measures on building owners and operators. Consider the following:

- Water management plans based on standards like ANSI/ASHRAE Standard 188, *Legionellosis: Risk Management for Building Water Systems,* or the Centers for Disease Control and Prevention's (CDC) toolkit, "Developing a Water Management Program to Reduce *Legionella* Growth and Spread in Buildings: A Practical Guide to Implementing Industry Standards," typically require testing for *Legionella* in building water systems.
- Current U.S. Environmental Protection Agency (EPA) regulations do not require municipal water sup-

Daryn Cline is director of environmental technologies for EVAPCO in Taneytown, Md. He is a member of the SPC 191, *Standard for the Efficient Use of Water in Building Mechanical Systems* committee, and was a member of the ASHRAE Guideline 12-2000, *Minimizing the Risk of Legionellosis Associated with Building Water Systems,* committee. Prior to retirement, Sarah Ferrari was the senior product development manager for evaporative condenser technology at EVAPCO in Taneytown, Md. She was member of SPC 188, *Legionellosis: Risk Management for Building Water Systems.*

pliers to test directly for *Legionella* bacteria in their water systems.

Water management plans are recommended and encouraged for building water systems, especially in high-risk buildings like hospitals and senior citizen housing. But water suppliers must also assume responsibility for providing pathogen-free water in the first place. Typically, after Legionnaires' disease outbreaks, water suppliers state that the water "meets all EPA regulations." This may be true, but that does not mean that the water is *Legionella*-free. As discussed below, EPA regulations are inadequate when it comes to requiring municipal water utilities to take actions to eliminate bacteria in the water supply.

A Paradigm Shift is Due

Because *Legionella* bacteria exist in nature and are common in source waters, measures can and must be used to minimize *Legionella* levels in the municipal water supply. This, in turn, would minimize the presence of such bacteria in our homes and buildings. There is, however, a fundamental flaw in the EPA rules used to control or regulate *Legionella* bacteria. The EPA does set a maximum contaminant level goal (MCLG) of zero for *Legionella*. The problem is that it is simply a goal.Therefore, it is *not* enforceable, so water utilities/municipal providers are not required to monitor for *Legionella,* nor are they required to take action to minimize its presence.

This column explores three recent studies that investigated the presence of *Legionella* in downstream water systems, including sediments in municipal drinking water storage tanks (MDWST) with 1 to 5 million gallon (3.8 to 19 million L) capacity, point-of-use cold water taps, and cooling towers. These studies show that the EPA's policies for controlling *Legionella* are not working.

Figure 1 uses these studies to illustrate the flaw in the EPA National Primary Drinking Water Regulations (NPDWR) and how this is putting additional stress on public and private systems downstream of treatment plants.

These studies sampled sites across the nation and evaluated for *Legionella* using quantitative polymerase chain reaction (qPCR). The qPCR technique screens and quantifies selected microorganisms like *Legionella* and has the distinct advantage of being able to detect even low levels of the bacteria. It works by amplifying the specific sections of DNA being investigated and measures them in real time, giving researchers information on the type and concentration of DNA.

The samples tested positive for *Legionella pneumophila* and *Legionella pneumophila* serogroup 1 (the most virulent strain) in all studies. The results demonstrate that the current methods to control the spread of *Legionella* are inadequate to minimize the risk of infection in municipal water distribution systems, allowing contaminated and potentially lethal water to enter facilities 24/7/365.

The Three Key Studies

These three broad, independent studies were carried out by the EPA and the CDC to measure pathogen levels across the country in diverse drinking water systems: water storage tanks,[1] tap water,[2] and cooling towers.[3]

Looking at all three studies combined, approximately one-third of the drinking water samples tested positive for *Legionella pneumophila* at all three points along the drinking water distribution route *after* leaving water treatment plants. Notably, 20% to 28% of samples in each of the three studies were infected with *Legionella pneumophila* serogroup 1, the most lethal strain responsible for 90% of Legionnaires' cases.

The remarkable similarity of the results provides evidence that *Legionella* is present when it leaves the municipal source and can and does enter building systems where people are exposed.

Water Storage Tanks Study[1]

In 2015, the EPA published the results of a study carried out to determine the level of potential pathogens including *Legionella pneumophila* bacteria present in municipal water storage tanks (*Figure 1b*). Eighty-seven sediment samples were taken from municipal drinking water storage tanks (MDWSTs) in 18 locations in 10 states that spanned five regions: Northeast, East Coast, Midwest, South and West Coast, providing a diverse sample set.

These municipalities sourced their water from a mixture of 61% groundwater and 39% surface water. At all locations, the water in the tanks contained chlorine concentrations that met EPA regulations.

The water was completely drained from each tank before sediment collection was carried out using a sterile plastic spatula and bottle. A quantitative polymerase chain reaction (qPCR) analysis was performed on each sample.

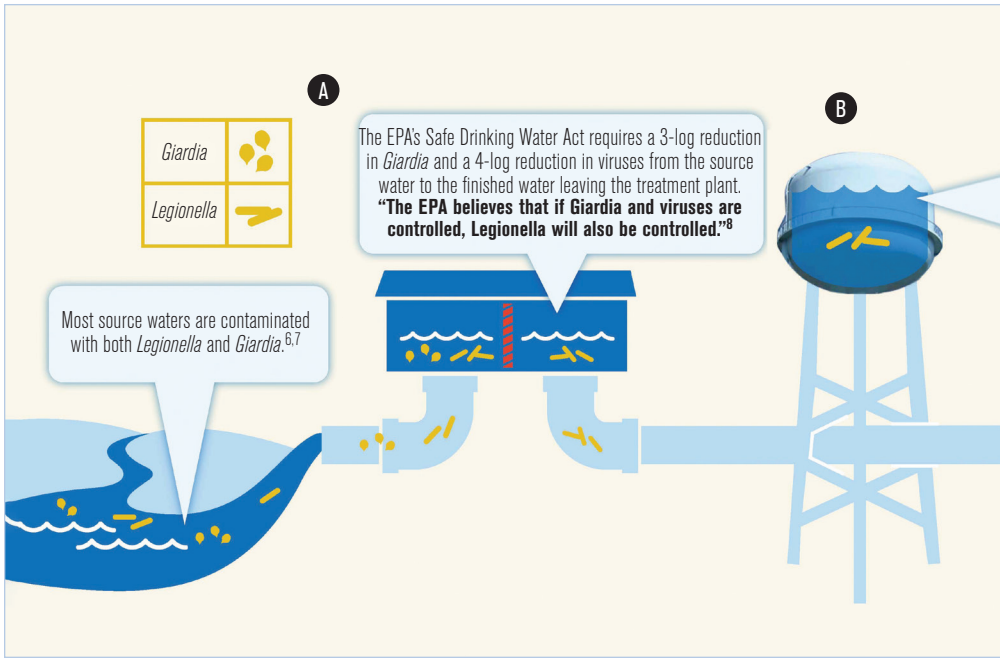
FIGURE 1 Widespread municipal water risks in the United States.

A Source water contaminated with pathogens.

B *Legionella* in municipal drinking water storage tanks.

C 29% of cold-water taps contain *Legionella pneumophila*.[2]

D Potable cooling tower makeup water is frequently contaminated with *Legionella pneumophila* from public water supplies.



Statistical analyses were done to establish correlations between *Legionella*, *Acanthamoeba* and temperature as well as other independent variables like total organic carbon (TOC), total organic matter (TOM), particle size and pH. These variables were recorded at the time of sampling for use in the analysis.

The results of the study indicated that *Legionella* bacteria were present in 66.7% of the samples; *Legionella pneumophila* was present in 33% of samples; and *Legionella pneumophila* serogroup 1 was present in 28% of the samples. In contrast, *Escherichia coli* (commonly known as *E. coli*) and *Giardia* were undetected. This shows that while efforts to control *E. coli* and *Giardia* work, the efforts to control *Legionella* do not. Another important finding: there was a significant correlation between *Legionella* and *Acanthamoeba*. *Legionella* bacteria will amplify and increase its virulence inside amoeba. This further supports a relationship between the two, so the detection of *Acanthamoeba* may be used as a potential indicator of *Legionella* contamination.

The results of this nationwide study, the first of its kind, demonstrate that *Legionella* that is present in the municipal water system will continue to survive in drinking water storage tanks in addition to surviving in large buildings' plumbing systems. This reinforces the need for anti-*Legionella* measures at the water treatment plant and distribution system—before the water gets to water storage tanks where it will then be passed on to buildings and homes.

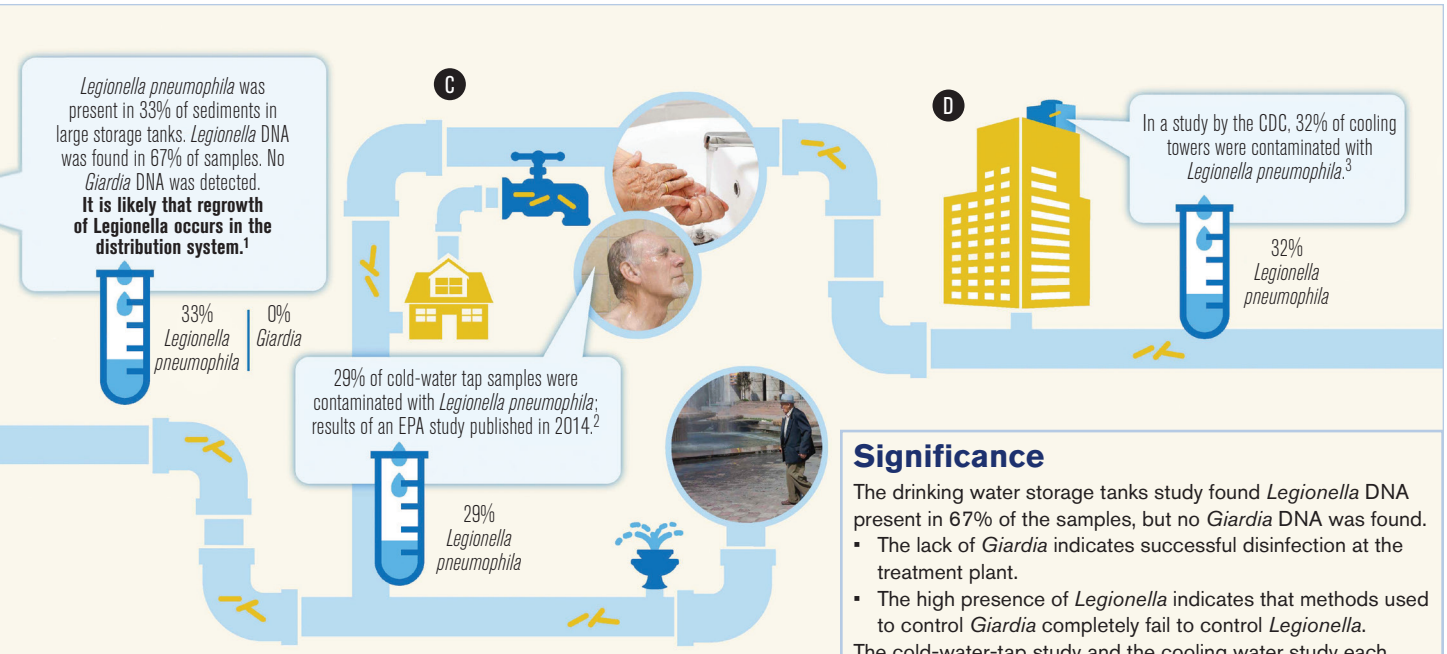
Cold Tap Water Study[2]

The next key study on *Legionella* levels is the cold water tap study undertaken by the EPA aimed at determining whether *Legionella* was present in cold water used by the general population. This is important because, out of the 6,868 cases of Legionnaires' disease reported in 2009–2010, only 2.6% were outbreak events, while the remaining 97.4% were sporadic.[4,5]

As with the storage tank study, samples were taken from diverse regions across the United States. Between January 2009 and December 2010, the EPA took a total of 269 samples from 68 residential and commercial locations in 25 states, one territory and one federal district.

Researchers sampled cold water from 29 kitchen sinks, 21 bathroom sinks, 17 drinking water fountains and one refrigerator water dispenser. Of the 68 taps sampled, 66 were from municipal supplies. Samples were taken after taps were allowed to run for 15 seconds to ensure that the supply was from the potable water supply and no hot water was included. No site had secondary water treatment (although the refrigerator had a filter).

A qPCR analysis was carried out and tests were performed to determine levels of *Legionella pneumophila* and *Legionella pneumophila* serogroup 1 (again, the most disease-causing variant). Twenty-nine percent of samples



Significance

The drinking water storage tanks study found *Legionella* DNA present in 67% of the samples, but no *Giardia* DNA was found.

- The lack of *Giardia* indicates successful disinfection at the treatment plant.
- The high presence of *Legionella* indicates that methods used to control *Giardia* completely fail to control *Legionella*.

The cold-water-tap study and the cooling water study each yielded almost identical percentages of *Legionella pneumophila* and *Legionella pneumophila* serogroup 1 contaminated samples as the storage tank study.

- **The remarkable similarity of the results provides evidence that the regrowth occurring in the distribution system is a fundamental step in the chain of transmission, allowing infiltration into buildings where people are exposed.**

tested positive for *Legionella pneumophila* and 20% were positive for serogroup 1 (*Figure 1c*).

Cooling Tower Study[3]

The last key study took place in 2016, when the CDC examined samples taken from 196 cooling towers located in most of the climate zones of the United States as defined by the National Oceanic and Atmospheric Administration (NOAA). Using real time qPCR testing, *Legionella* bacteria was detected in cooling towers located in each of the eight regions tested.

TABLE 1 Summary data of studies.

			% SAMPLES qPCR POSITIVE			% LOCATIONS qPCR POSITIVE
Subject Reservoir	Locations Sampled	Total Samples	*Legionella spp.*	*Legionella pneumophila*	*Legionella pneumophila* serogroup 1	*Legionella pneumophila* serogroup 1
Municipal Drinking Water Storage Tank Sediments	18	87	67% (58/87)	33% (29/87)	28% (24/87)	Not Provided
Cold Water Taps	68	269	Not Provided	29% (77/269)	20% (53/269)	47% (32/68)
Cooling Towers	196	196	84% (164/196)	32% (63/196)	20% (39/196)	20% (39/196)

Legionella-positive samples were cultured and further tested for specific DNA. Of 196 samples tested, 32% were positive for *Legionella pneumophila* and 20% were positive for *Legionella pneumophila* serogroup 1. **The test results are almost identical to the tap water study, which is not surprising since cooling towers use tap water as their fresh, potable makeup water source (*Figure 1d*).**

Results and Significance

The similarities between results from the three studies indicate that when *Legionella* bacteria are not addressed at the water treatment plant or in the distribution system, they will be present in the drinking water distribution supply with the potential to contaminate *all* water outlet sources after entering the building water supply. (*Table 1*).

The results of this study should be very concerning to homeowners, commercial building owners, and facility managers of hospitals and hotels. **The conclusion drawn from this study is that the supply of fresh potable water entering their buildings is not consistently free of pathogens. This is not surprising considering the weak antimicrobial efforts used at the water treatment plant and in the drinking water distribution system.**

Controlling *Legionella*

Legionella bacteria inhabit all types and varieties of water sources, including lakes, streams and groundwater[6] (*Figure 1a*). Other types of bacteria like *E. coli* are also present in these same sources, as are viruses like norovirus and rotavirus, as well as parasites like *Giardia Lamblia*[7]. The public expects that water treatment plants adequately combine filtration and chemical treatment to kill these and any other waterborne pathogens. This trust, however, may be misplaced.

The Safe Drinking Water Act (SDWA) is the federal law that governs water treatment to ensure it is safe for human consumption. The National Primary Drinking Water Regulations (NPDWR) are the standard for treating drinking water and are legally enforced by the EPA. Yet, nationally, there's a concerning divergence between theory and real accomplishment.

The EPA's NPDWR provides that 99.9% of the *Giardia* parasite must be removed or inactivated from the municipal supply. There is no stated limit, however, for concentrations of *Legionella*. The expectation is that the treatments to remove microbes like *Giardia* will also result in the removal or inactivation of *Legionella*, but the studies suggests otherwise.[8] As the three studies demonstrate, the current municipal water treatment measures are ineffective in neutralizing and inhibiting *Legionella*, and instead allow various bacteria and other pathogens to enter the distribution system and to pose health risks to the public.

Also, the presence of *Legionella* without the presence of other pathogens like *Giardia* demonstrates that although treatment is effective for one pathogen, it does not eliminate *Legionella*, as assumed in the EPA's National Primary Drinking Water Regulations.

Recommendations

The key takeaway is that it is imperative that the National Primary Drinking Water Regulations be revised to require testing for *Legionella* bacteria and also require remedial actions as needed. Federal regulations *must* be modified to ensure that *Legionella* bacteria is dealt with at the water treatment plant and through the water distribution system, rather than making it the sole responsibility of the downstream users to remove and limit the growth of *Legionella* bacteria. These measures would then complement targeted downstream efforts to curb *Legionella* growth, such as ensuring that disinfectants are at proper levels when the water is entering the buildings.

There are new statewide efforts that represent good examples of how this could work in practice. For example, Illinois recently modified their EPA regulations to include raising residual chlorine levels to ensure a continuing antimicrobial effort as the water makes its way through the system. The same regulations require water turnover in storage tanks to address stagnation, and the elimination of dead ends in water distribution systems. Louisiana and Pennsylvania have passed similar measures, and New Jersey is considering joining this group. These efforts must be supplemented with effective measures at the municipal water treatment facilities to remove *Legionella* further upstream, closer to the source.

All the studies mentioned in this column support the fact that *Legionella* bacteria are widespread, and if not controlled will result in greater numbers of *Legionella*-related cases and outbreaks. Therefore, a focus on efforts to better control pathogens in the public water supply upstream by strengthening EPA requirements is the rational approach to addressing the increased threat of waterborne pathogenic bacteria-related disease cases in the future.

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