Legionellosis: Breaking the chain of Infection

BACKGROUND

What is Legionellosis?

Legionnaires' disease first garnered public attention in 1976. After attending an American Legion convention at a Philadelphia hotel, 221 people became ill, with 34 dying of a mysterious illness. The U.S. Centers for Disease Control and Prevention (CDC) launched a major investigation, and in 1977 identified the responsible bacterium, naming it *Legionella*.

Infections caused by *Legionella* are called Legionellosis and have mild to severe effects. Two diseases caused by Legionella are Legionnaires' disease and Pontiac Fever. Legionnaires' disease is a potentially fatal pneumonia, whereas Pontiac Fever is more like a mild flu. While the disease and its cause are well known, the CDC reports that cases of Legionnaires' disease in the United States have grown by nearly 450 percent since 2000. This may be partly due to more infections, but also to aging population, increased awareness and testing, and other factors.

Symptoms for Pontiac Fever begin a few hours to three days after exposure and last about a week. Legionnaire's disease symptoms begin 2 to 10 days from exposure. They may include cough, shortness of breath, fever, chills, headaches, muscle aches, and gastrointestinal illness. Patients often require hospitalization. Fatality rate varies, but the overall rate in Europe is 12 percent according to the World Health Organization (WHO).

Inhaling contaminated, aerosolized water droplets less than five microns in diameter is the most common route of exposure. Showerheads and faucets, hot tubs, cooling towers, HVAC systems, water fountains, and other water systems create aerosols that transmit the bacteria. Those most at risk are people over 50 years old, current or former smokers, people with existing lung disease, and those with compromised immune systems.

Legionella Bacteria

Legionellae are common throughout the worldwide environment in water and moist soil. While there are numerous species and subspecies of *Legionella*, only a few cause infections, with the majority resulting from exposure to *L. pneumophila*.

Legionella prefers warm water for growth, over 20° C (77° F), but below 50° C (122° F). The optimum temperature is 37° C (98.6° F), which is body temperature and the temperature most hot tubs are set at. It multiplies in stagnant water, making facilities with intermittent flows attractive. Cruise ships, hotels, campsites, and schools are highly susceptible for this reason.

In nature, *Legionella* does not exist in quantities to cause disease. However, small amounts can enter the water distribution system. It can then multiply in the complex water systems of large buildings and other facilities to become infectious. In addition to those noted above, common locations for infection include hospitals, large office complexes, areas around cooling towers, and fountains.

The Importance of Biofilm

Microorganisms, including *Legionellae* can adhere to natural and man-made surfaces. As they colonize they form a biofilm, which helps protect them from temperature extremes or biocides.

Biofilms are extremely complex ecosystems and may consist of bacteria, algae, and grazing protozoa. Areas of slow water flow and stagnation encourage biofilm formation.

Water flowing past the biofilm provides nutrients and gas exchange, allowing *Legionella* to multiply. The biofilm provides stability, making it more difficult to physically remove *Legionella* and other pathogens, especially on surfaces with scale or corrosion. About 90 percent of the *Legionella* bacteria are in the biofilm versus the water stream.

Legionellae grown in biofilm are more resistant than those grown in the liquid phase. Research at the Montana State University Center for Biofilm Engineering has also found that as biofilms collect sediment or scale they become brittle and can break off in fragments. When these fragments are inhaled, they are more difficult for the body to clear than single bacteria.

As biofilm grows, protozoans can live within it. Protozoans are single celled animals, and include flagellates, ciliates, and amoebae. *Legionella* can infect an amoeba, a protozoan species, using the amoeba's internal materials as nutrients while gaining protection from the outside environment. *Legionellae* replicate within the amoebae, ultimately exploding and infecting other amoebae, then continuing to multiply.

To make things worse, *Legionella* that has grown within an amoeba may be protected from adverse conditions. Per a May 2013 article in the journal Virulence, "Cellular microbiology and molecular ecology of *Legionella*—amoeba interaction," when environmental conditions are unfavorable, amoeba can form into a cyst, protecting Legionella. The article also notes that "bacteria grown in amoeba have changes in biochemistry, physiology, and virulence potential" including better antibiotic and chemical resistance.

CHALLENGES

Industries and companies are responsible for minimizing risks posed by the growth of *Legionella* in their water systems thus preventing Legionellosis.

Regulatory Landscape

Regulations for preventing Legionellosis are difficult to encapsulate. The United Kingdom was a leader in this respect, implementing a stringent Code of Conduct after a major outbreak in the 1980's. *The European Technical Guidelines for the Prevention, Control and Investigation of Infections Caused by Legionella Species* is used as referral document throughout Europe. While individual countries may have different specific requirements, each has required methods to minimize risk, control *Legionella* growth, and document actions taken.

Guidelines in the United States (U.S.) are issued by the CDC, but there are currently no regulations. Some states or cities have adopted sections of the guidelines as law. Affected industries have implemented standards supported by the CDC, which offers a toolkit called *Developing a Water Management Program to Reduce Legionella Growth and Spread in Buildings: A Practical Guide to Implementing Industry Standards*. Other countries, like Indonesia, are now considering regulations for the control and prevention of Legionellosis.

Water Safety Plans

The guidelines above include development of a written Water Safety Plan (WSP) or water management program for each affected facility. Companies must perform a survey and risk assessment, looking at every link in the causative chain for Legionellosis. Once the risk assessment is complete they must address all the applicable issues. Other items in the WSP include training requirements for employees, documentation, and procedures to follow if an outbreak occurs. Each WSP is unique to its facility.

Items required in the WSP may include maintaining cold water taps below 15° C (59° F) and above 50° C (122° F), flushing stagnant lines, adding disinfectants, and preventing corrosion and biofilm buildup.

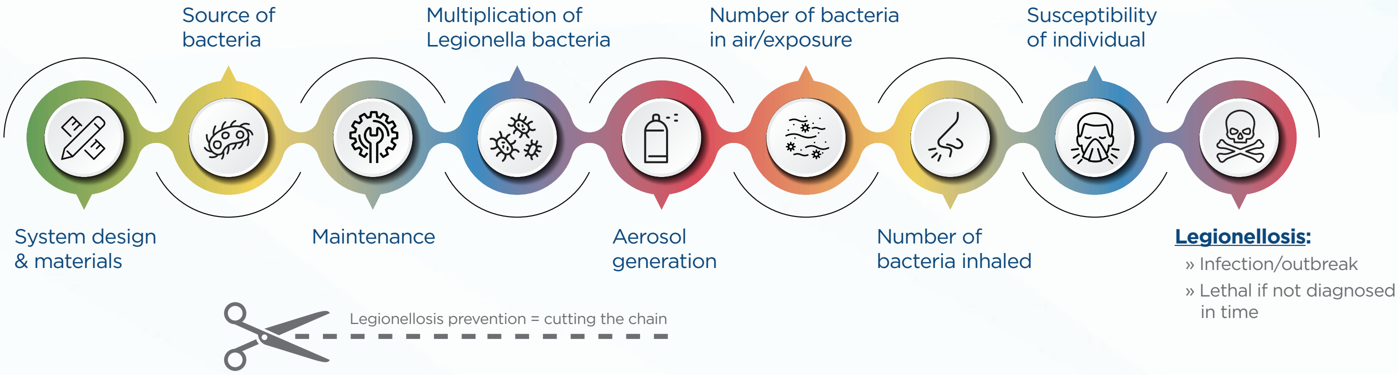
Breaking the Causative Chain

While regulations, standards, and guidelines for preventing Legionellosis have been in effect for over 30 years, the number of outbreaks continues to grow. Recent U.S. cases include a July 2018 outbreak resulting in 22 people with Legionnaire's disease and one death. In August 2018, an outbreak in New Hampshire left 14 people sick and one person deceased. In Italy, a July 2018 outbreak with 26 cases claimed three lives.

Clearly, the challenge of preventing this deadly disease is still ongoing. Each link in the causative chain must be addressed. Companies must find and cut the chain at its weakest link.

LEGIONELLOSIS

The Causative Chain



SOLUTION

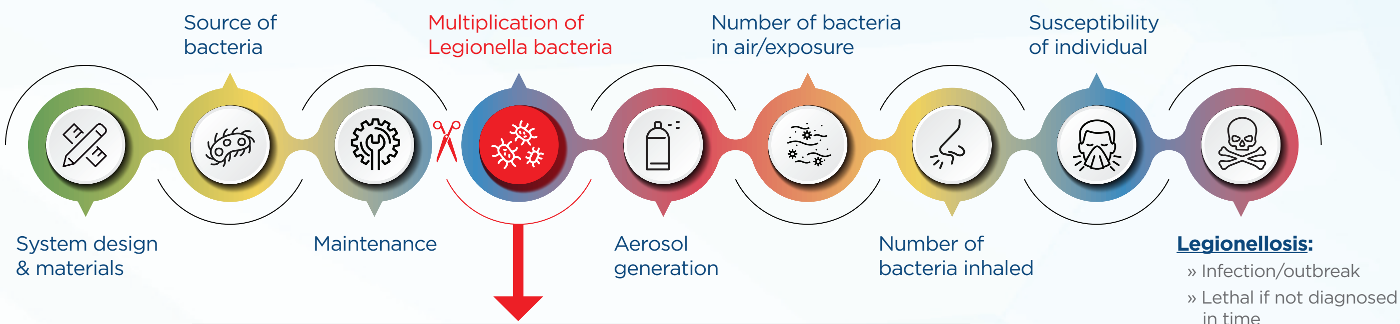
In order to cause infection, *Legionella* must be allowed to multiply and gain sufficient numbers. By controlling and minimizing Legionella proliferation, facility owners greatly reduce the risk of an outbreak.

Biofilm hosts the clear majority of *Legionella* in a water system—about 90 percent as noted previously. Also, *Legionella* grown in biofilm is more resistant to control methods. Heavy biofilm growth also supports amoebae, in which Legionella can strengthen and grow to the point of great multiplication and explosion.

By controlling the formation of biofilm, the causative chain of Legionellosis can be broken.

LEGIONELLOSIS

Breaking the Causative Chain



Jenfitch expertise helps to minimize/control Legionella multiplication by:

1. Prevention of biofilm formation
2. Enhance Legionella killing effectiveness of oxidizing halogen based disinfectants
3. Expertise on oxidizing Biocides effectively killing LP

Biofilm prevention and removal should be part of a general microbial control program. Stopping the multiplication of Legionella does the same for other pathogens. For example, Naegleria fowleri, the "brain-eating amoeba," or Salmonella, which causes 1.2 million gastrointestinal illnesses in the U.S. each year, could be reduced.

Jenfitch is one of the world's leading water treatment companies, with a presence in Canada, Mexico, Australia ,Korea, California Texas and Florida. Our team collectively has hundreds of years of industrial water treatment experience. With a deep understanding of Legionella and other pathogens, we are experts in controlling the multiplication of waterborne bacteria.

Biofilms are very complex, dynamic systems. Preventing and removing them requires a high level of expertise. Many of our employees have worked in the industrial water industry and understand the systems where Legionella growth occurs.

The Power of JC 9465

Reducing the Risk of Legionellosis

We also keep up with regulations on a worldwide basis, and have been developing several methods using biofilm monitoring and mineral oxychloride chemistry to control legionellosis. Using ORP to control biological growth, we can eliminate legionellosis in less than 4 hours in most systems.

Detecting Biofilm is the first step in prevent it from forming in your system. While there are several models in the marketplace that claim to detect biofilm as its forming, a new system developed and marketed by Aquanomix called, "CANARY", has the ability to detect a monolayer of bacteria in your water system. The sensitivity of this unit makes it ideal for monitoring deposits that hinder heat transfer and the development of biofilm in your system. Once you have detected a biofilm forming, you need a powerful treatment program. Jenfitch, Inc. has developed a powerful treatment program that is cost effective and simple to use. It was developed to eliminate harmful biofilm buildups in your system.

Chart No.1 indicates the higher the voltage the quicker disinfection occurs. JC 9465 has demonstrated quicker disinfection as a single oxidant and has been proven highly effective in a variety of applications, where chlorine alone failed, including biofilm, paper, cooling water, food and beverage, utilities, and oil and gas.

Chart No.1

ORP Level (mV)	CFU/100 ml of Water
+200	300
+300	36
+400	3
+600	0*
+800	0**

*Water Disinfection
**Water Sterilization

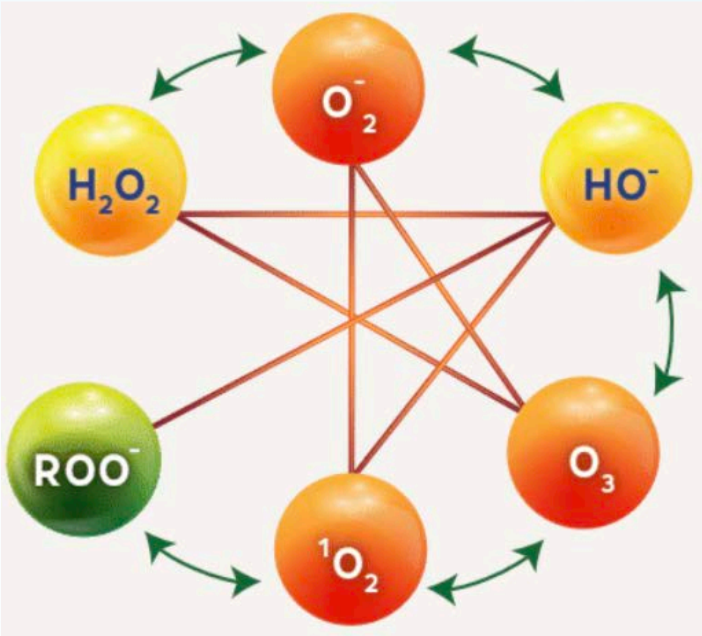
Using our mineral oxychloride chemistry to control biofilm and prevent legionellosis is the most recent development of technology for treating system contaminated with legionellosis. However, to understand how the mineral oxychloride chemistry works, you need to understand ORP and how to use ORP to achieve a 6-log reduction in less than 10 seconds in your water system. "ORP" refers to "oxidation-reduction potential (as measured in millivolt)." In Chart No. 2, we use the electrochemical voltage (Ev) of various disinfectants to express their reactivity in a water solution.

Chart No.2

REAGENT NAME	FORMULA	ELECTROCHEMICAL POTENTIAL (Volts)
Fluorine	F^2	3.06
Mineral Oxychloride	$M_xO_yCl_z$	2.8–2.9
Hydroxyl Radical	OH^-	2.8
Oxygen Ion	O^-	2.42
Ozone	O_3	2.07
Hydrogen Peroxide	H_2O_2	1.78
Perihydroxil Radical	HO_2	1.7
Chlorine Dioxide	ClO_2	1.57
Hypochlorous Acid	HOCl	1.49
Chlorine Gas	Cl_2	1.36
Oxygen (Molecule)	O_2	1.23
Hypochlorite Ion	OCl^-	0.94
Sodium Hypochlorite	NaOCl	0.94
Hydroperoxide Anion	HO_2^-	-0.88
Superoxide Radical	O_2^-	-2.4

Ozone is a known disinfectant for treating water. It can achieve a 6-log reduction in less than 10 seconds. Ozone has an Ev of +2.07 mV and sodium hypochlorite has an Ev of +0.94 mV. Hydroxyl radical ions have an Ev of +2.8 mV and JC 9450/JC 9465 has an Ev of +2.8 mV(Refer to chart No.2). What this means is hydroxyl radical ions, a member of the reactive oxygen species (ROS), has more energy to reacts faster with microorganisms than sodium hypochlorite. Mineral oxychloride chemistry generates a very high concentration of hydroxyl radical ions and singlet oxygen ions that can achieve a 6-log reduction of legionellosis in less than 10 seconds. In a study conducted the Ozone Institute they validated the concept of "a higher positive millivolt in solution will decrease the activity of microorganisms in that solution."

Controlling Legionella. JC 9465 is a new mineral oxychloride chemistry that is NSF approved, EPA registered as a biocide and USDA Organic Registered for use in applications requiring organic products only. In a study conducted by Special Pathogen Lab (PA) using JC 9465, they confirmed that controlling the ORP range above +700 mV effectively achieved a 6-log reduction of legionellosis in less than 10 seconds. JC 9465 is a mineral oxychloride chemistry that mimic nature's ability to generate a very high concentration of ROS in the form of hydroxyl radical ions and singlet oxygen ions. JC 9465 is a chemical that is more effective than chlorine. In Chart No.1, we see that electrochemical voltage is a method used to determine the strength of an oxidizing biocide. Ozone which a common and well-known oxidant is 2.07 volts, sodium hypochlorous acid (HOCL) is 1.36 volts, and JC 9465 is 2.7 volts-2.8 volts which indicates more energy for quicker disinfections. For more information on this technology please visit our website, www.jenfitch.com



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