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New Technology in Controlling and Removing Legionella from Water Systems

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Legionnaires Disease attracted worldwide attention. In July 1976, the American Legion convention was being held in Philadelphia. Numerous attendees came down with a mysterious disease that had never been reported before. There were 4,000 people at the convention, 221 contracted the disease and 34 died.

It was not until December 1977 that microbiologists were able to isolate a bacterium during an autopsy of the lung tissue of one of the legionnaires. The bacterium was named "*Legionella pneumophila*" (*Legionella* in honor of the American Legion, and pneumophila, which is Greek for "lung-loving").

Legionella pneumophila is a facultative intracellular pathogen, and is the causative agent of Legionnaires' disease and other pneumonias, especially in immunocompromised hosts. The Legionella bacteria infect, multiply within and eventually kill macrophages. The Legionella bacteria themselves avoid destruction by preventing the joining of the phagosome with lysosomes of the macrophage. They can also infect free-living amoebae, and are nearly ubiquitous in warm fresh water supplies (e.g., air-conditioning cooling towers). Research quickly established that Legionella pneumophila bacteria manifests in two forms, Legionnaires? Disease, which is a severe pneumonia illness with severe gastric symptoms, and Pontiac Fever, which is a mild influenza. The source of the infections was unknown, but the cooling system was considered to be the cause of the new disease.

The organisms classified in this genus are Gram-negative bacteria that are considered intracellular parasites. They grow well on buffered charcoal yeast extract agar, but it takes about five days to get sufficient growth. When grown on this medium, Legionella colonies appear off-white in color and circular in shape. Laboratory identification can also include microscopic examination in conjunction with a direct fluorescent antibody (DFA) test. Since the initial discovery many species have been added to the Legionella genus, but only two are within the scope of our discussion: L. pneumophila and L. micdadei.

It is estimated that upwards of 25,000 cases of Legionnaires disease have been contracted each year.[1] Only 1,000 cases of Legionnaires Disease are reported annually in the US. Annual worldwide deaths from Legionnaires Disease are estimated to be between 3,000 to 7,000. The exact number is difficult to pinpoint. Many elderly people die of this disease, but autopsies are not conducted to determine the actual cause of death. Because the symptoms are pneumonia and Legionnaires Disease are very similar and autopsies are not preformed on many elderly patients, the cause of death may be attributed to pneumonia instead of Legionnaires Disease. Many older adults have an extreme reaction to the Legionella bacteria and most of the deaths associated with Legionnaires Disease have been people over the age of 60.

Treatment for Legionnaires Disease has been antibiotics (erythromycin has been the most widely dispensed) which does not kill the bacteria. Erythromycin keeps Legionella bacteria from reproducing and allows the natural immune system to kill the infection. If the natural immune system is not able to destroy the infection, Legionnaires? Disease may contribute to the cause of death. Cipro is now the recommended antibiotic for this disease. It has proven much more effective than erythromycin, which correlates with the drop in deaths.

Studies were conducted to determine the rate of infection that allows transmission of the Legionella bacteria. High levels of Legionella bacteria (greater than 1,000 cfu/ml [colony forming units per ml]) were discovered with no associated outbreak. However, there have been outbreaks reported with only160 cfu/ml in potable water systems. Researchers have been baffled with these findings and had a difficult time trying to distinguish the true source of infections. The question has been whether the high level of colonies in the cooling tower or the lower level in the potable water source caused the infections. The cooling tower has a higher colonies count and less personal contact while the potable water source has a lower count with closer personal contact.

Researchers have also been mystified as to why some patients get Pontiac Fever and others get Legionnaires?Disease from the same bacteria[2]. No patients have died from Pontiac Fever. Healthy lung tissue is not removed for biopsy from patients that recover from an infection.

The Legionnaires Disease is and always has been linked to water borne infections caused by contact with a spray or mist from water contaminated with the Legionella bacteria or by ingestion of contaminated water. Legionella bacterium seems to be transmitted from cooling towers. The bacteria can be absorbed into the body by inhalation of aerosol mists of contaminated water, which transports the bacteria into the lungs.

Some members of the medical community are beginning to doubt that cooling towers are the main source of the Legionella bacteria. Their current theory is that the source of contamination is from hot water heaters and water tanks used to store potable water.

In studies of water systems, Legionella is found more often found in towers than in potable water sources. However, potable water it is usually associated with closer personal contact than cooling tower water. In several recent studies, Legionella bacteria has been found in approximately 28% of cooling towers and condensers. Studies have found 18% of hot water heaters in commercial buildings and 30% of residential water heaters were contaminated with Legionella bacteria. Both sources of Legionella have been traced to incidences of infection and deaths.

Legionella bacteria are commonly found in natural water sources. They inhabit ponds, streams, lakes, rivers, soil, mud and underground water. Legionella also can also colonize in many types of man-made water systems such as plumbing systems, hot water tanks, cooling towers, evaporative condensers of large air-conditioning systems and whirlpool spas.

Factors known to enhance growth of Legionella include the following:

1) Legionella thrive in water between temperatures of 68^o and 122^o F, with optimal growth occurring between 95^o and 115^{o}F. They will not multiply at temperatures below 68^{o}F, and cannot survive in water above 140^{o}F.

2) pH - it grows within the range of 2.0 to 9.5,

3) Stagnation or low water turnover;

4) High microbial concentration including algae, amoebae, slime and other bacteria

5) Biofilm, scale, sediment, sludge, corrosion products (zinc, potassium, iron)

6) Organic matter

7) Some materials such as natural rubber fittings (may be a nutrient source)

Outbreaks of Legionnaires Disease have been traced to many types of water systems. Cases of Legionnaires' Disease has been linked with cooling towers, domestic hot water systems, showers, faucets, whirlpool baths, humidifiers, decorative fountains, and grocery store mist machines.

Current recommendations for the prevention of Legionella include the following[4]:

1) Twice yearly cleaning of towers, if possible

2) Regular dosages of biocides, very high dosages at times, intermittent feeding of oxidizing biocides in conjunction with another biocide

3) Constant feed of high levels of chlorine or bromine

4) Completely draining systems that are not in operation for three or more days

5) Treating systems with biocides or sodium hypochlorite before starting the equipment up

(Tower fans should be turned on only after treatment)

6) Side stream filtration for particulate removal

7) Detailed operation and maintenance records

8) Removal of scale and deposits

9) UV Treatment

10) Ozone

11) Silver and Copper Ionization

12) Dual Biocide - continuous feed and/or super chlorination

Today?s water treatment practices proposed by industry magazines and trade articles, are based upon controlling and preventing the growth of Legionella bacteria. The problem is that biological propagation and colonization in cooling water systems can be very rapid because there is warm water, oxygen and organic nutrients available. Biocides do not eliminate Legionella, but simply attempts to prevent the reproduction and to limit the growth of the number of colonies.

Recommendations for control of Legionella range from dual biocides fed continuously and/or in very high doses, side stream filtration, increased blowdown and lowering of cycles. Other recommendations call for the removing sites (scale or biological masses) for that may assist organisms to grow and develop colonies. Removing all sources of food for the organisms may inhibit the further growth of colonies.

The recent treatment theory is based upon removing **all** the places that the bacteria can hide out (ex. scale, organic deposits, masses of algae and amoebas, silt, and other contaminants), removing **all** the possible food sources, i.e. bacteria, algae, and other microbioata, and removing dirt and minimizing particulate matter. The organic matter is removed with the use of biocides. Food sources and particulate matter are removed with side stream filtration or treatment and cleaning of the tower as often as possible.

While chlorine and bromine have excellent inhibition properties, they both are very poor at removing organisms in water systems. When the halogen compound attaches itself to the cell wall of an organism, its effectiveness is severely limited and the halogen compounds do not have the ability to penetrate the cell wall of the Legionella bacteria.

UV light and ozone have been recommended for controlling Legionella and both have proven effective at high dosages in the laboratory, but the high cost of treatment and the cost of maintaining equipment with UV and ozone are drawbacks that have prevented both from being widely used. The results in the field have been not been as effective as in the laboratory..

Filtration to remove the bacteria has been recommended to be at most 0.45 micrometers. While this is effective in the laboratory, in the field it is not practical because the filters are back washing every few minutes. Filters large enough to work effectively would be cost prohibitive for most systems.

Most current biocides are based upon one or more of the following processes:

1) attaching to the cell wall of organisms and bursting the cell wall
2) surrounding the cell to prevent respiration and transpiration thus starving the cell
3) oxidizing the cell structure to destroy the cells

Legionella may be as difficult to kill as tuberculosis bacteria, which continues to be a persistent threat to public health. Due to the fact that Legionella is an intracellular parasite, the problem is two fold, how to invade the cell and attack the Legionella at the same time. Most biocides do not have the ability to penetrate and continue to attack after attaching itself to the cell wall. Most biocides are not active or aggressive enough to actually penetrate and attack the Legionella. The usual effect has been to kill the host organism and not the Legionella. The Legionella can then consume the host organism and then find a new host to invade.

A new type of agent has been developed that attacks the Legionella in a different way. Instead of attacking the cell wall, this agent works to remove the interstitial tissue of the cell. This is like removing the skeleton from your body. After the cell collapses, the oxidation process destroys the cells. This process has proven effective in the field as well as the laboratory. The basis for this new material is hydrogen peroxide, which alone has not been effective against Legionella. However, combined with other agents, it has proven to be effective in removing the Legionella bacteria in a single dosage.

This product has been effective at removing Legionella bacteria as rates as low as 400 ppm in slug dosages and a continuous feed rate of 25 ppm. Slug dosages have proven to completely remove the Legionella in a single treatment 80% of the time and 100% in two dosages in successive days. Cost of the material is much lower than conventional biocides while its effectiveness is superior.

Samples from cooling towers are drawn from the sump before testing in a certified independent laboratory. Dosages are determined and applied immediately after samples are drawn. After 24 hours, a second sample is collected in the same location in the sump and both samples are submitted to the laboratory for testing.

There are drawbacks of using this material. It is corrosive to tissue and is an oxidizer. The type of compound is similar in characteristics to sulfuric acid, but it does not fume. This cleaner is compatible with most treatments, is not corrosive to metals, does not add any solids to the tower water and does not increase TDS. There is no residue and no waste by-products. When the treatment breaks down, it converts to water. In use dilution, it is safe for fish to swim in, and may be safe enough for approval for potable water.

As this is new raw material, it has not passed EPA?s strict standards and is not EPA registered. No claims are being made about it effectiveness in killing any organisms, but it does show promise. Testing is currently under way for registration with the EPA.

Overall, this new technology seems to present a long awaited answer for the cooling tower industry. This technology also presents new applications for potable water, wastewater, lake and pond reclamation, agriculture, and many other uses.

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