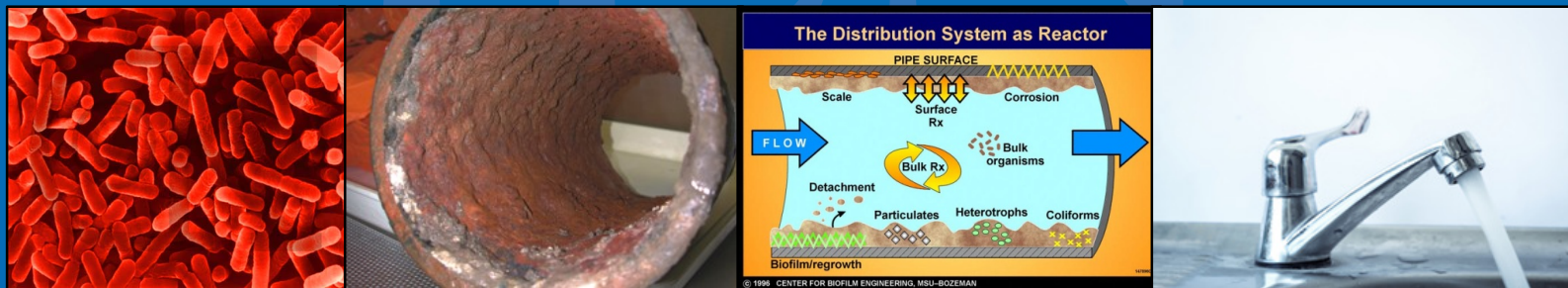


Water Quality and Microbial Dynamics in a Large Building Hot Water System and Managing Potential Risk Associated with *Legionella*

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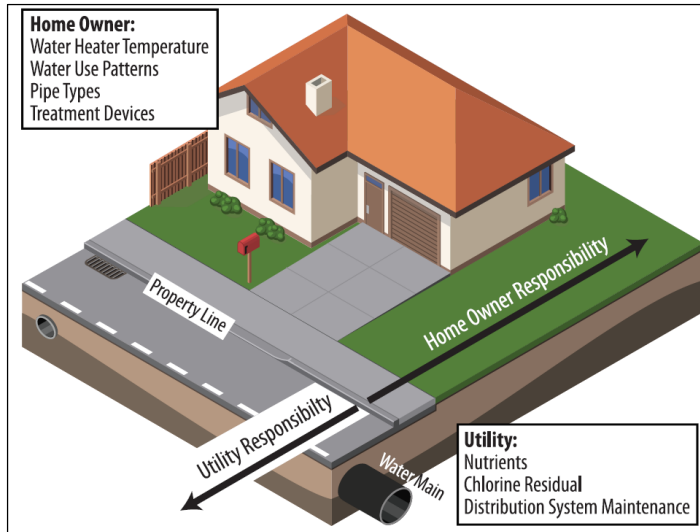


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Why Premise Plumbing?

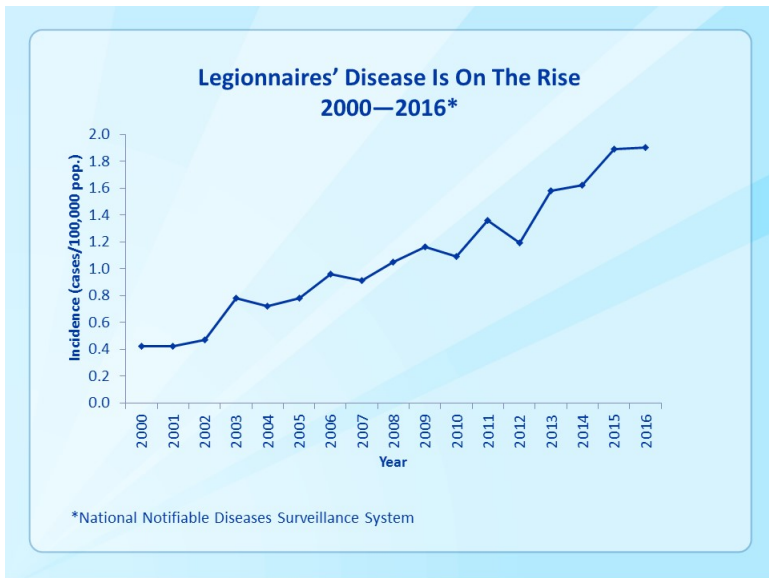
Premise plumbing (PP) includes that portion of the drinking water distribution system (DWDS) connected via the service line to houses and other buildings.



Current delineation of public versus private responsibility with respect to the DWDS (Adapted from “Pathogens in Premise Plumbing” by Water Research Foundation 2014, *AWR*, 24(1):24).

- ❖ Public health data shows that a significant fraction of the nation’s **waterborne disease outbreaks** are attributable to PP systems.
- ❖ It is important to understand the characteristics of these systems which amplify the **potential public health risk** relative to the DWDS.

Why *Legionella*?



In the United States, reported cases of Legionnaires' disease have grown by nearly four and a half times since 2000. (From the National Notifiable Diseases Surveillance System (CDC) <https://www.cdc.gov>).



Legionella pneumophila

It is unclear whether this increase represents:

- artifact (due to increased awareness and testing)
- increased susceptibility of the population
- increased *Legionella* in the environment
- or some combination of factors

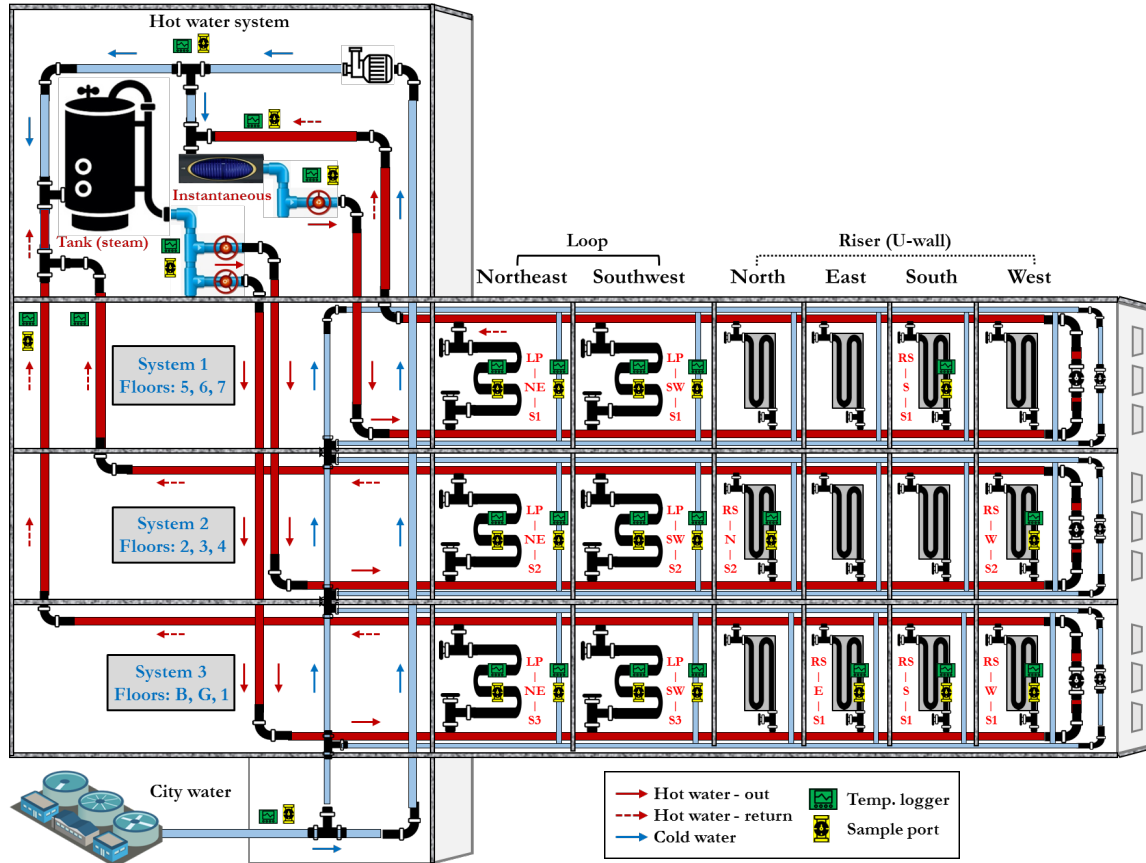
Objective

The current research examined the Bacterial population in a 40-year-old large building using NGS technology and culture-dependent assays to:

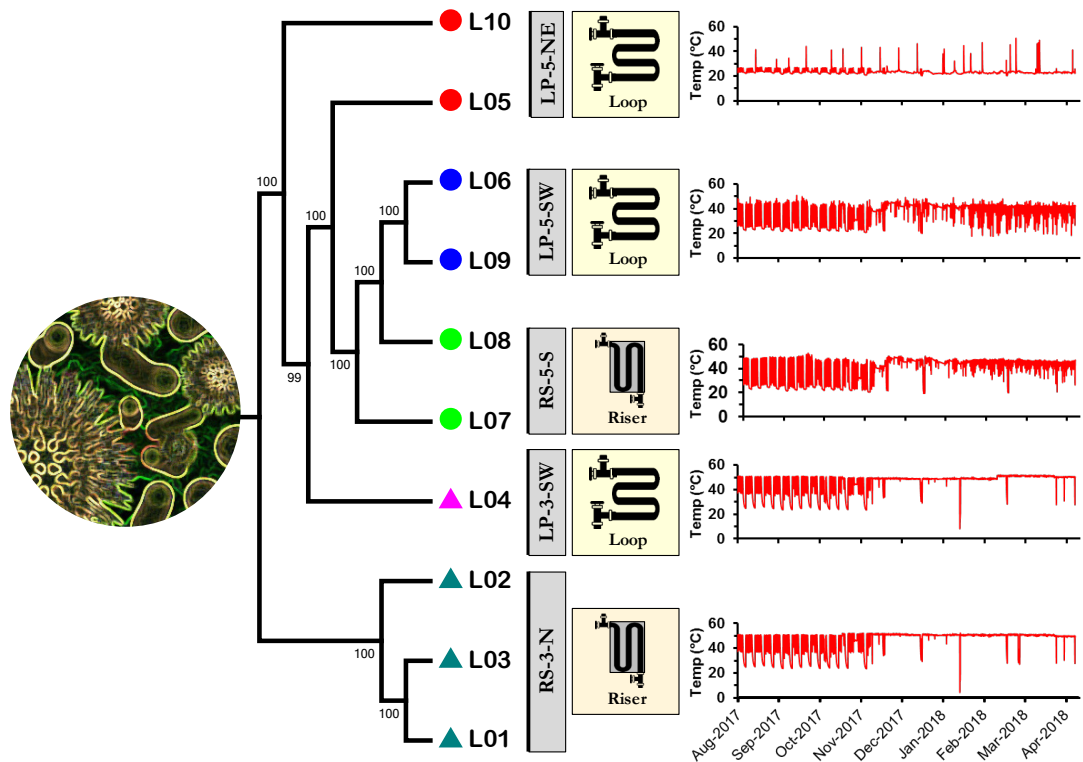


- Determine the extent to which the microbial community structure varies temporally and spatially within the build environment drinking system.
- Detect and enumerate waterborne pathogens in the hot water system.
- Perform genome-wide analysis of *Legionella pneumophila* serogroup I.

Build Environment (drinking water system)

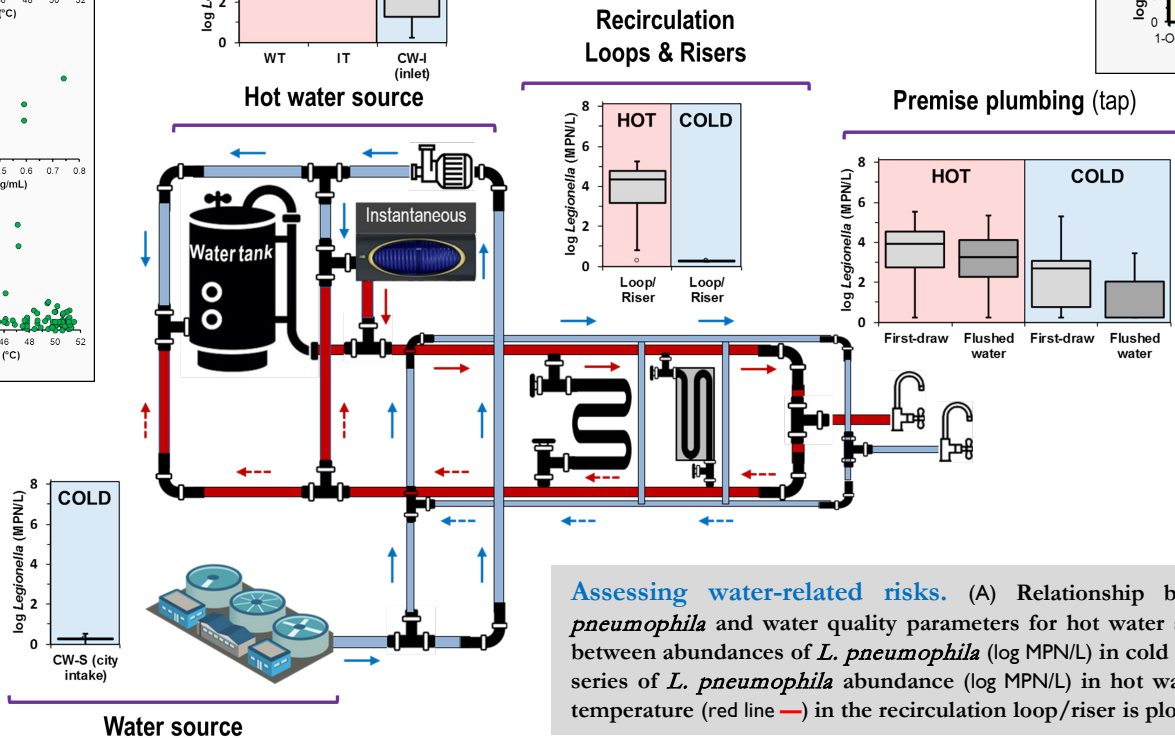
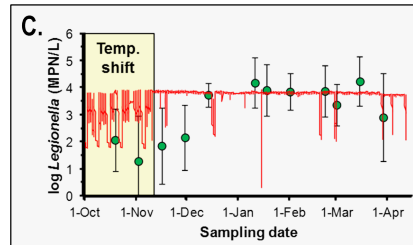
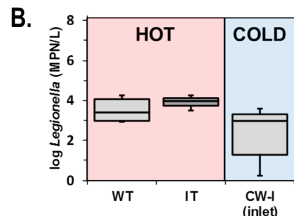
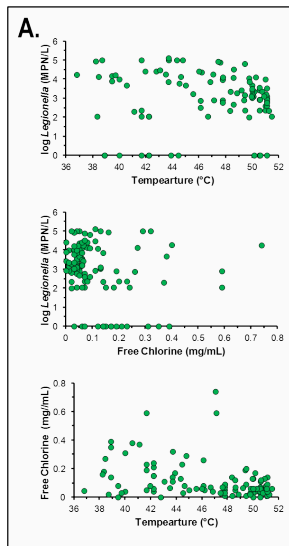


Microbial Community



Community profile. Cluster analysis of 16S rRNA libraries based on Jensen-Shannon dissimilarity. Samples were identified by room location and grouped in their corresponding hot water systems.

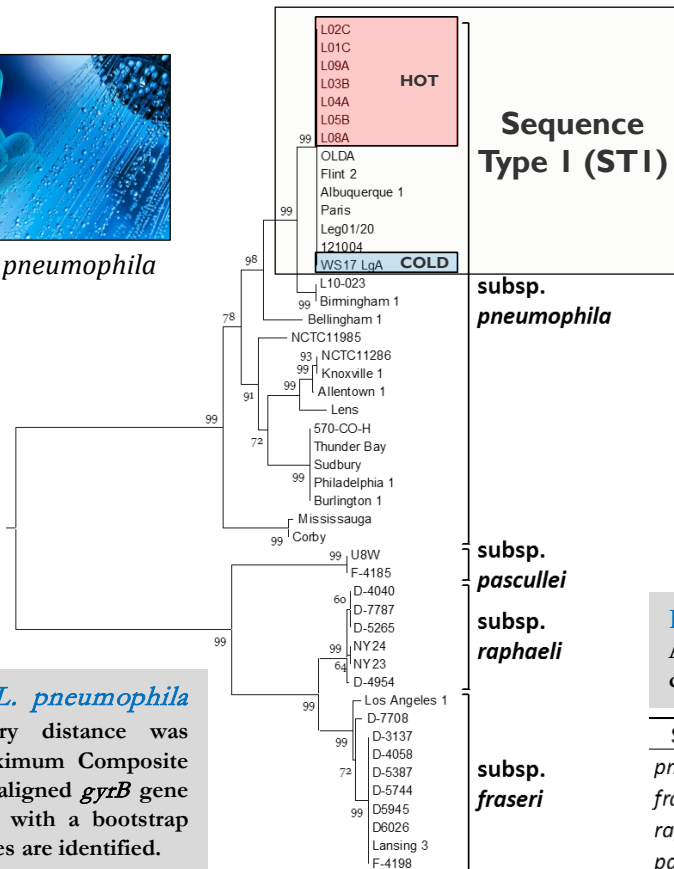
Water Risk Assessment



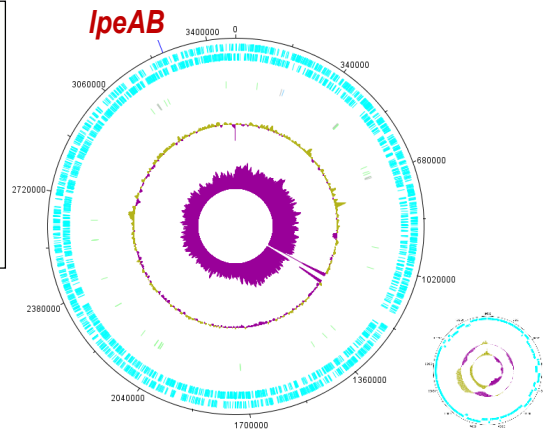
Genomic Characterization of *L. pneumophila* Isolates



Legionella pneumophila



Phylogenetic tree of *L. pneumophila* subspecies. Evolutionary distance was computed using the Maximum Composite Likelihood method of 48 aligned *gyrB* gene sequence (≈2.4kbp); nodes with a bootstrap value ≥50% of 500 replicates are identified.



Presence of the *lpeAB* genes encoding a macrolide efflux pump, which appears to be specific to ST1.

Identification *L. pneumophila* subspecies.
Average nucleotide identity (ANI) values (in %) calculated for each *L. pneumophila* subspecies.

Subspecies	Isolates	<i>fraseri</i>	<i>raphaeli</i>	<i>pascullei</i>
<i>pneumophila</i>	99.96	91.70	91.39	90.63
<i>fraseri</i>	91.86	---	96.49	93.52
<i>raphaeli</i>	91.24	96.49	---	93.72
<i>pascullei</i>	90.55	93.52	93.72	---

Conclusions



- Exploratory analysis of the water community (16S rRNA-encoding gene) showed clustering of samples based on **section/zones** in the hot water network.
- Variations in waterborne and opportunistic pathogen populations (*Legionella*, *Mycobacterium* and *Pseudomonas*) were observed among **section/zones**.
- First draw samples showed the highest (↑) counts of HPC and *Legionella* with a decrease (↓) in disinfectant residual and temperature. HPC and *Legionella* tended to decline (↓), and the temperature and disinfectant residual increased (↑) with flushing.
- The *Legionella* population was dominated by *L. pneumophila* subsp. *pneumophila* and identified as **serogroup 1** by agglutination and genomic analysis.
- The presence of *LpeAB* was correlated with **reduced sensitivity to azithromycin** (i.e. macrolides) in previous studies, which appears to be specific to **Sequence Type I**.

1913
Officers of the U.S. Public Health Service set up the Stream Pollution Investigation Station in Cincinnati, operating under a Congressional Act of 1912.

1921
Development begins on the application of the 1948 Water Pollution Act; the station is renamed the Cincinnati Environmental Health Center, authorized to protect water quality for fish and aquatic life, conduct research on water pollution and water treatment in pollution control.

1948
With the passage of the 1948 Water Pollution Act, the station is renamed the Cincinnati Environmental Health Center, authorized to protect water quality for fish and aquatic life, conduct research on water pollution and water treatment in pollution control.

1953
The Center moves to a new laboratory building on Columbia Parkway, later to be dedicated as the Robert A. Taft Sanitary Engineering Center.

1966
The Taft Center establishes a reputation for its work in wastewater treatment, water supply control, air pollution, radiation, and food protection for the Public Health Service.

1970
The Federal Water Quality Administration, National Air Pollution Control Administration and 13 other federal units merge to create the U.S. Environmental Protection Agency.

1972
The legislation for the Federal Water Pollution Control Act of 1972 is enacted, later to be amended and renamed the Clean Water Act.

1975
President Gerald R. Ford dedicates the National Environmental Research Center in memory of its first director, Martin Luther King Jr. in Cincinnati.

1979
EPA's Test and Evaluation Facility (TEF) opens on the grounds of the MBL Creek wastewater treatment plant in Cincinnati.

1980
The National Environmental Research Center is renamed the Andrew W. Bisselbach Environmental Research Center in memory of its first director (from 1971-1975).

1993
The 1991 exacerbation of the Clean Water Act and the 1993 Milwaukee Corporation's outbreak of illness in a decade of research in disinfection, treatment and method development for microorganisms, pathogens, organisms.

2002
EPA creates the National Homeland Security Research Center in Cincinnati to protect human health and the environment from effects of biological, chemical and radiological contamination due to homeland security events.

2003
EPA announces an initiative for additional research and development for cost-effective technologies to help small systems meet the new arsenic standard and provide technical assistance to compliance costs.

2007
EPA initiates the Aging Water Infrastructure research program to develop innovative technologies for the operations, maintenance, and replacement of aging and failing drinking water and wastewater systems.

2011
EPA and the U.S. Small Business Administration announce the federal launch of a water technology innovation cluster, new known as the Cincinnati, Dayton, northern Kentucky and southeastern Indiana region.

2012
EPA funds research to support the goals of the water technology cluster. All of the projects have strong partnerships with regional companies, utilities or universities.

2013
EPA recognizes and celebrates the 100th anniversary of federal water research in the greater Cincinnati region.

Water Research IN CINCINNATI

100 YEARS 1913 - 2013

Questions?