Design for Legionella Control in Buildings – Post COVID Recovery

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Client: CBCL Ltd.

Objective

Determine the best treatment option(s) and management plan to reduce and maintain low levels of *Legionella spp.* after a campus shutdown.

Legionella spp.

- Found naturally in the environment and engineered water systems, such as premise plumbing and piping infrastructure.
- *Legionella pneumophila*: subspecies of bacteria capable of causing Legionnaire's disease and Pontiac fever.
- Proliferates in stagnant water and biofilms.
- No level of *Legionella spp.* is considered safe, therefore, no max allowable concentration (MAC) is outlined in provincial drinking water standards.
- During the Covid-19 building shutdowns, water remained stagnant, which favoured the growth of *Legionella spp.*
- Buildings reopening experienced elevated *Legionella spp.* levels.

Figure 1: Cross-sectional view of pipe containing biofilm

Design Process

- Shock treatments used in combination with continuous treatments were analyzed using the AHP decision framework to determine the best treatment option for this design.

The priority parameters used in this decision analysis consisted of:

1. Effectiveness
2. Campus Compatibility
3. Adaptability
4. Industry Familiarity
5. Safety
6. Supply Availability

Table 1: AHP score of shock and continuous treatment types

Shock Treatment	AHP Score	Continuous Treatment	AHP Score
Thermal Shock	0.251	Copper Silver Ion	0.284
Hydrogen Peroxide	**0.205**	**Sodium Hypochlorite**	**0.282**
Hyperchlorination	0.159	Thermal	0.239
Chlorine Dioxide	0.170	Point of Use Filtration	0.121
Monochloramine	0.151	UV	0.072
Ozone	0.063		

The analysis resulted in the selection of:

- Hydrogen peroxide (HP) as the initial shock treatment.
- Sodium hypochlorite (NaOCl) as the continuous treatment with the potential to incorporate thermal treatment.

- Engineering judgement was exercised with the analysis to select NaOCl based on industry familiarity.
- These shock and continuous treatments will be applied through a portable modular unit.
- Standard operating procedures (SOPs) were created for the *Legionella spp.* control design process.

Final Design

- A modular treatment unit was designed as a rapid intervention system for when *Legionella spp.* levels in the system exceed 10,000 GU/L. A set protocol will discourage further use of the campus water, and the treatment unit will be dispatched.
- The high dosage initial shock treatment of HP is intended to kill existing *Legionella spp.* and remove biofilm. As this disinfectant degrades in the system, the continuous treatment of NaOCl is required as a residual to prevent the re-growth of *Legionella spp.*

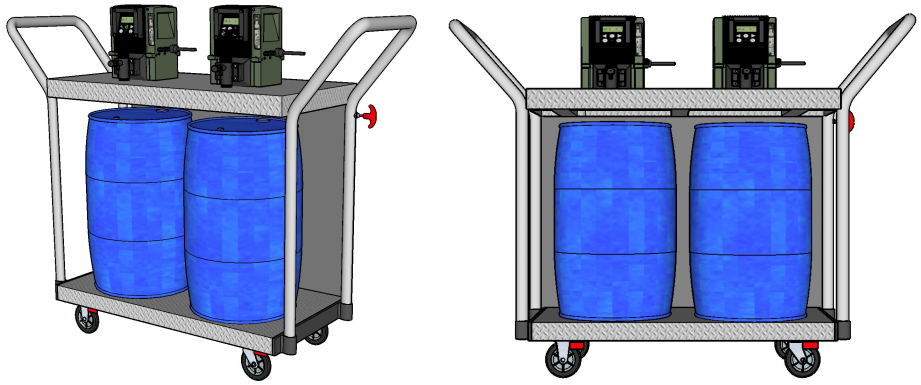

Figure 2: Modular Treatment Unit

SOP-01

- Locate the most distal point source and take a swab of the faucet, and grab samples of the water.
- Conduct DNA extraction, qPCR assay and GeneCount Q-16 analysis to quantify *Legionella pneumophila* presence.

SOP-02

- Determine volume of HP solution required for 12-hr shock treatment to be dosed at 25 mg/L.
- Measure chlorine concentration of main water line to calculate the volume of NaOCl solution needed to dose the building for the two-week continuous treatment at 4 mg/L.

SOP-03

- Defines the components of the modular unit and how to operate the pumps for both shock and continuous treatments.

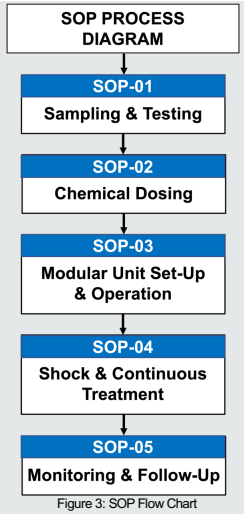

Figure 3: SOP Flow Chart

SOP-04

- Initiate HP shock treatment and conduct a five-minute flush at all taps to be repeated four times throughout the 12-hr shock treatment.
- Initiate NaOCl continuous treatment and measure chlorine levels throughout the two-week treatment to ensure the 4 mg/L MAC is not exceeded.

SOP-05

- Ensure water is suitable for use after treatment process and recommend follow-up testing to ensure that *Legionella spp.* levels are in control.

Design Considerations

- Existing distribution system
- Size and weight restrictions
- 15-gallon chemical barrels
- Pump compatibility with chemicals

Case Study

- D-Building on Dalhousie University's Sexton Campus was used as a case study to provide a framework of the *Legionella spp.* treatment process that can be applied to a variety of building types.
- *Legionella pneumophila* was quantified at the most distal tap through sampling and analysis to produce SOP-01.

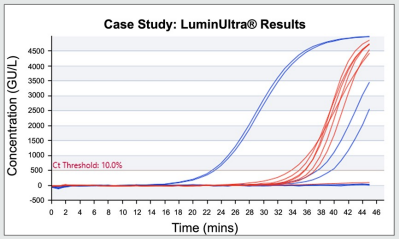

Figure 4: LuminUltra® Results

- The results indicated presence of *Legionella pneumophila*, below the 10,000 GU/L threshold.
- SOP-02 was created to determine the shock and continuous treatment dosing parameters for the modular unit.

Table 2: Calculated parameters for pump input

Chemical	HP	NaOCl	Units
Contact Dose	631	47484	mL
Flow Rate	7.0	1.2	mL/min

- These parameters are used in SOP-03 and SOP-04 to initiate treatment.
- SOP-05 was developed to ensure the building continues to maintain low levels of *Legionella spp.*

Economic Analysis

- Testing
  - LuminUltra® Test-Kit
  - Benchtop centrifuge
- Dosing
  - TTI-3000 Colorimeter
  - Chemicals
- Modular Unit
  - Dolly
  - Pump components
- **Total Capital Cost**
  - **$27,026.08**

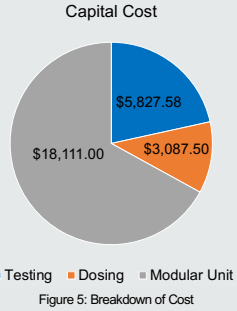

Figure 5: Breakdown of Cost

Conclusion And Recommendations

- HP and NaOCl selected as the shock and continuous treatment type via AHP decision analysis, and a modular unit was designed to apply both treatment types.
- Treatment unit with concise SOPs for testing, dosing, treatment, and monitoring, for effective management of *Legionella spp.* was developed.
- Recommend the treatment unit be constructed and tested in a controlled building environment to verify operational performance and efficiency.

References

- Papagianeli, S. D., Aspridou, Z., Didos, S., Chochlakis, D., Psaroulaki, A., & Koutsoumanis, K. (2021). *Dynamic modelling of Legionella pneumophila thermal inactivation in water*. Water Research, 190, 116743. https://doi.org/10.1016/j.watres.2020.116743

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