A Legionellosis Intervention
Timeline, treatments and efficacy of treatments

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Background Information
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• Originally this intervention, by CDC EHS-Net staff, involved one critical care facility (hospital).
  – It was extended to include a nursing home, in the same neighborhood, owned by the same healthcare group and using the same public water.

• Cases of legionellosis initially occurred in the hospital - -
  Very complex assemblage of hot water systems.

• Phased approach to treatment beginning with Heat and Flush – easiest and quickest treatment to implement.
Facility Layout & Disease Occurrence

Numbers in parentheses indicate other incidental locations of the case patient.
Initial Timeline – Dates, Cases and Locations.

- **2009**
  - April 19: Heat & flush in West
  - May 30: Heat & flush in CC
  - June 21: **ClO₂** installed in ER, CC, West & Tower

- **2010**
  - August 3: Heat & flush in CC
  - August 26: ClO₂ injection points added
  - October 6: Case #4 East, Case #5 West
  - January 19: Heat & flush in West
  - May 9: New ClO₂ injection points added
  - May 26: Case #4 East, Case #5 West

ER = Emergency room; CC = Critical Care; Tower = Main Building
Water Chemistry

- The city is served by a single surface reservoir source.
- Typical data leaving the water treatment plant from a July monitoring report:
  - pH = 8.6 – 9.4
  - Turbidity = 0.11 – 0.23 NTU
  - Chlorine = 1.4 – 1.7 mg/L
  - Total Organic Carbon = 1.29 – 1.79 mg/L
- A key concern regarding treatment is the alkaline pH levels. Sample data indicate pH up to 9.9.
Treatment Concerns - Chlorine

Chlorine & Hyperchlorination

- High pH range favors hypochlorite ion over hypochlorous acid.
- Hypochlorous acid is the effective disinfectant.
- In the pH range of 9.0 to 9.5 less that 10% of the chlorine exists as the disinfecting acid.
Treatment Concerns – Copper-Silver Ionization

- A 2002 Study by Lin, et al found that high pH impacted the effectiveness of copper-silver ionization.
  - Work done in a hospital with a pH range of 8.5 to 9.0;
  - Impact of water hardness (Ca\(^{2+}\) and Mg\(^{2+}\)), alkalinity (HCO\(_3^-\)) & dissolved organic carbon (DOC) was also studied;
  - Changes in the amounts of these parameters around neutral pH had no negative effect on treatment efficacy;
  - The effectiveness of copper ions was severely reduced at pH >9.0;
  - Precipitation of copper was suspected at pH>6.0;
  - Silver ions were not impacted with increased pH.
Chlorine Dioxide

- Highly soluble in water / 10 times more ‘soluble’ than chlorine
- Does not hydrolyze to a great extent and remains as a ‘dissolved gas’.
- Much less of a pH effect than chlorine: Good biocidal activity between pH 6.0 and 8.5 (USEPA).
- Reported to be effective between pH 5.0 and 10.0 (Lenntech).
- Lower temperature negatively impacts disinfection activity.
- USEPA targeted maximum of 0.8 ppm.
The Interventions
Later Timeline – Key Dates, New Case and Locations.

- **2010**: Hyperchlorination in East. In response to Case #4.
- **2011**: Updates and repairs to ClO$_2$ system West, Tower and CC. **System is one-year old.**
  - Cu-Ag installed in East as acute treatment.
- **2012**: Acute treatment Removed from East.
  - Cu-Ag installed West.
  - Cu-Ag re-installed East.

**April 3, 2012**: Tower ClO$_2$ Removed.
Tower - Percentage of Culture Positive Sites

Chlorine dioxide maintenance 1-12-11

Intervention begins 8-3-11

Copper Silver installed 10-12-11
East - Percentage of Culture Positive Sites

- Hyperchlorination 9-15-10
- Acute Cu-Ag installed 1-12-11
- Acute Cu-Ag removed 4-15-11
- Copper Silver permanently installed 2-28-12
- Intervention begins 8-3-11

SAMPLE DATE

Percentage of Positive Samples
Second Intervention Site

Nursing Home – Percentage of Culture Positive Sites

Hyperchlorination 12-17-10

Intervention begins 4-12-11

Copper Silver installed 4-19-11

Intervention ends 4-24-12

Percentage of Positive Samples

DATE

Example of Long-Term Results at St. Luke’s Home

Copper-Silver Concentrations and Percent Positive Legionellae Detected in St. Luke’s Home Hot Water Supply
Hospital Long-Term Treatment Summary

**Initial Treatment**

- WEST
- EAST
- ClO₂
- ClO₂
- Cu- Ag

**Final Treatment**

- WEST
- EAST
- ClO₂
- ClO₂
- Cu- Ag
- Cu- Ag
Conclusions
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1. Remediating facility water systems as a result of legionellosis may be a complex process & it can require long-term assessments in order to result in adequate control.

2. Chlorine dioxide had limited success in a complex hospital environment; this involved multiple buildings with multiple premise distribution systems.

3. Implementation of Cu-Ag ionization in certain buildings of the hospital and an entire nursing home helped control both *L. pneumophila* 1 and 6 and *L. anisa*.

4. The intervention showed that Cu-Ag could be effective in an alkaline pH environment in the range of 9.0 to 9.5.
On-Going Work
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• Due to the precipitation of Cu in alkaline environments, the risk of Cu corrosion should be examined.
  – As a result of this, and other, work industry has considered testing a silver electrode with minimal copper; status unknown.
  – Using CDC EHS-Net funds NYSDOH had done a preliminary assessment of metal deposition (i.e., Ag and Cu) and corrosion.
On-going Work

• We are completing an extensive review of the biocidal action & resistance mechanisms of Cu and Ag (and other metals) as it relates to:
  – Growth state (active growth vs. starving state)
  – Cellular energy needs
Recommendations

• The literature reports that both Cu and Ag resistance may develop over a three-to-four year period. Each facility should:
  – Be aware of the need for increased Ag (or Cu) to control legionellae;
  – Consider intermittent hyperchlorination to cause turnover of the entire microbial community.

• Reevaluate water quality data to determine the role of pH, free chlorine, temperature, dissolved oxygen etc. in reducing legionellae.
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Selected References


