Status of Bacterial Monitoring

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Microbial Contaminants

• Coliforms – *E. coli*
  • Standard for microbial quality of water
• Emerging Contaminants
  • Contaminant Candidate List 4
    • *Campylobacter*
    • *Helicobacter*
    • *Legionella*
    • *Mycobacterium*
    • *Salmonella*
    • *Shigella*
    • *E. coli O157*
Mycobacterium Associated Common Clinical Syndromes

- Pulmonary infection
- Lymphadenitis
- Otologic infection
- Skin and soft tissue infection
- Catheter-associated infection
- Disseminated infection
- 25% to 50% of individuals with AIDS will get *Mycobacterium* infection
Mycobacterium

- Relatively resistant to disinfection including chlorine
- Multiply in water that is essentially devoid of nutrients
- Recovered from surface, ground & waste waters
- Recovered from aerosols associated with water sources.
- Incidence increasing
  - 1983–1996: 1.8 to 7.7 per 100,000 (CDC 1999)
  - 1997–2003: 1.9 to 9.0 per 100,000 (Marras 2007)
- <20 to 10,400 CFU per day can be ingested
  - If water has mycobacteria concentration ranging from 0.01 to 5.2 CFU/mL
Nontuberculous Mycobacteria in Tap Water

- **A Study conducted in the U.S.**
  - No of distribution system: 8
  - Water treatment: 2 to 4 log reduction in mycobacteria in raw waters
  - No of sample collected: 583 (528 water; 55 biofilm)
  - Positive for NTM: 15%
  - Concentration of NTM: 10 to 700,000 CFU/L

- **A study conducted in Australia**
  - No of sites: 384 (189 summer & 195 winter)
  - Positive: Summer 40.21% (76/189); Winter 82.05%(160/195) (BMC Microbiology.2013. 13:89)

- **A Study conducted in the U.S. in 2011**
  - Public/private system: 19/27 positive
**Legionella – An Emerging Threat**

- More outbreaks than any other microorganisms
- EPA Candidate Contaminant List 3 & 4
- Human – Lung infection – pneumonia outbreaks
  - 8,000 to 100,000 cases annually
  - Fatality rates 5% to 30%
- Also know to infect and proliferate in
  - 13 species of amoeba
  - 2 species of ciliated protozoa
- Prevalent in environmental water
  - How does it transport in subsurface environment?
Legionella Physiology

• Single genus family containing over 50 species

• Heterotrophic, gram-negative, non-encapsulated, aerobic, differentially motile

• Highly pleiomorphic forming cocci, baccili, and filaments

Weekly Gram-negative rod
Legionella

- Relatively resistant to disinfection including chlorine
- Survive and multiply in water that lacks nutrients
- Recovered from surface, ground & waste waters
- Recovered from aerosols associated with water sources
- Incidence increasing
Legionella in the US Waters

- CDC MMWR Report 2009-2010
- 19/33 drinking water
- 7/12 non-recreational water

2000–2014: 286% increase in reported cases of Legionella per 100,000 population in the U.S.
**Legionella in Arizona Waters**

**Tap Water**
- Central AZ water meter biofilms
  - 72 meters sampled from two municipalities
  - 0% and 26% PCR positive for *Legionella*, 16% for Lp
- Two large buildings periodically sampled
  - Common contamination up to 100 CFU/mL *Legionella*
- Apartment water heater
  - 42 °C, Extremely high microbial load
  - $3 \times 10^4$ CFU/mL, present after flushing and superheating

**Recycled Water**
- West Valley water reclamation facility pond culture positive for *Legionella*
- East valley reclaimed ground water recharge basin
  - TP secondary and tertiary effluent
  - Both culture negative and PCR positive
  - PCR signal substantially stronger for secondary
- *Legionella* detected by PCR in 3/3 plants
Verde & Salt River watersheds

https://streamflow.watershedconnection.com/Map
USGS Weather stations

- 1: Verde River near Scottsdale, AZ
- 2: Salt River below Stewart Mtn. Dam

These locations are upstream of Granite Reef.

USGS Weather Stations

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Arizona canal & the distances between each sampling location

Granite Reef
E. coli averages for all 13 sampling sites

E. coli concentrations for 1 sampling site in Verde River

E. coli averages for 6 sampling sites in Arizona canal
Total coliform in central Arizona source waters 2016 – 2018
E. coli in central Arizona source waters
2016 – 2018
Mycobacterium in central Arizona source waters 2016 - 2018
Comparison of coliforms, *E. coli* *Mycobacterium* & *Legionella* in central Arizona source waters 2016 - 2018
Summary

• A 4-year database of bacterial occurrence in AZ source waters developed. Some key finding are:
  • Total coliforms occurrence in 2017-2018 has followed trend observed in previous years
    • Higher concentration during summer months
    • 100% samples/sampling sites tested positive
  • *E. coli* and coliforms concentrations fluctuated from month to month; however, for each month all sampling sites showed similar trend.
  • *E. coli* or coliform concentrations are not good predictor of *Mycobacterium* and *Legionella* in the surface waters
  • Mycobacteria detected between 1 to 2 log with few incidents of >3log
    • Drinking water treatment process can remove 2 to 4 log of Mycobacteria
  • *Mycobacteria* and *Legionella* occurrence data highlight the emerging CCL microbial challenges in central Arizona source waters.