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Unintended consequences of water and energy conservation on microbial quality

Presented by:

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Water distribution systems in large buildings

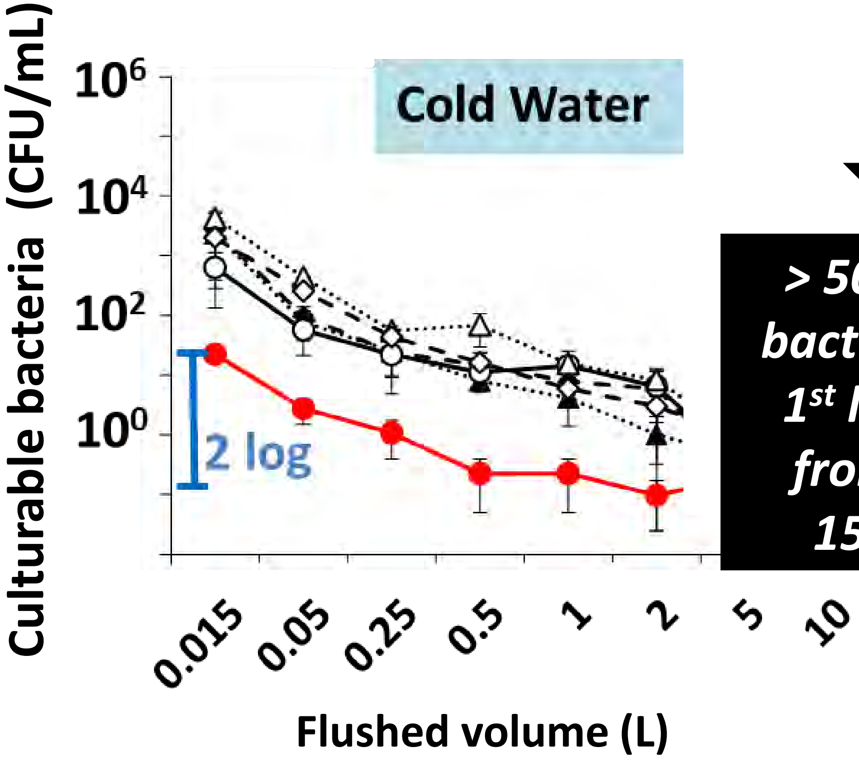
Favorable microbial growth conditions :

- ✓ Temperature (20 – 50 °C)
- ✓ Stagnation
- ✓ Small diameter = ↗ S/V
- ✓ Biofilm and amoeba
- ✓ Materials
- ✓ Dead legs
- ✓ Absence of disinfectant
- ✓ Renovation & construction

Reduced water consumption can result in:

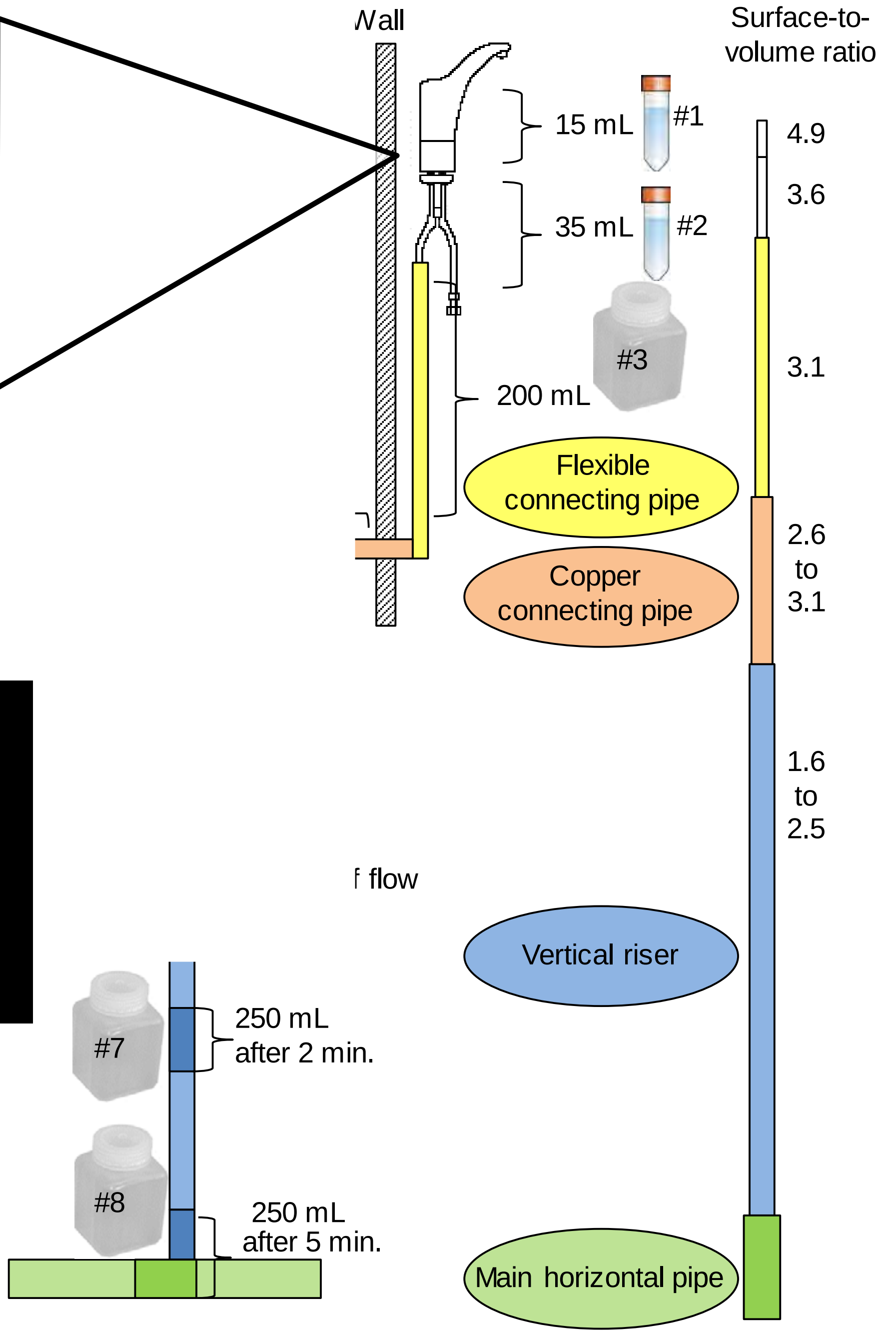
- ➢ ***Longer residence time***
- ➢ ***Lower flow = less turbulence***
- ➢ ***Drain plugging***
- ➢ ***Shorter flush at electronic taps***
- ➢ ***Prolonged stagnation***

Impact of sta



Mixing Valve

> 50% of bacteria in 1st liter = from 1st 15 mL



Bédard et al. 2018

Examples of unintended consequences of water and energy conservation

Water consumption reduction

1) LEED designed school case study
2) Electronic faucets

Energy savings

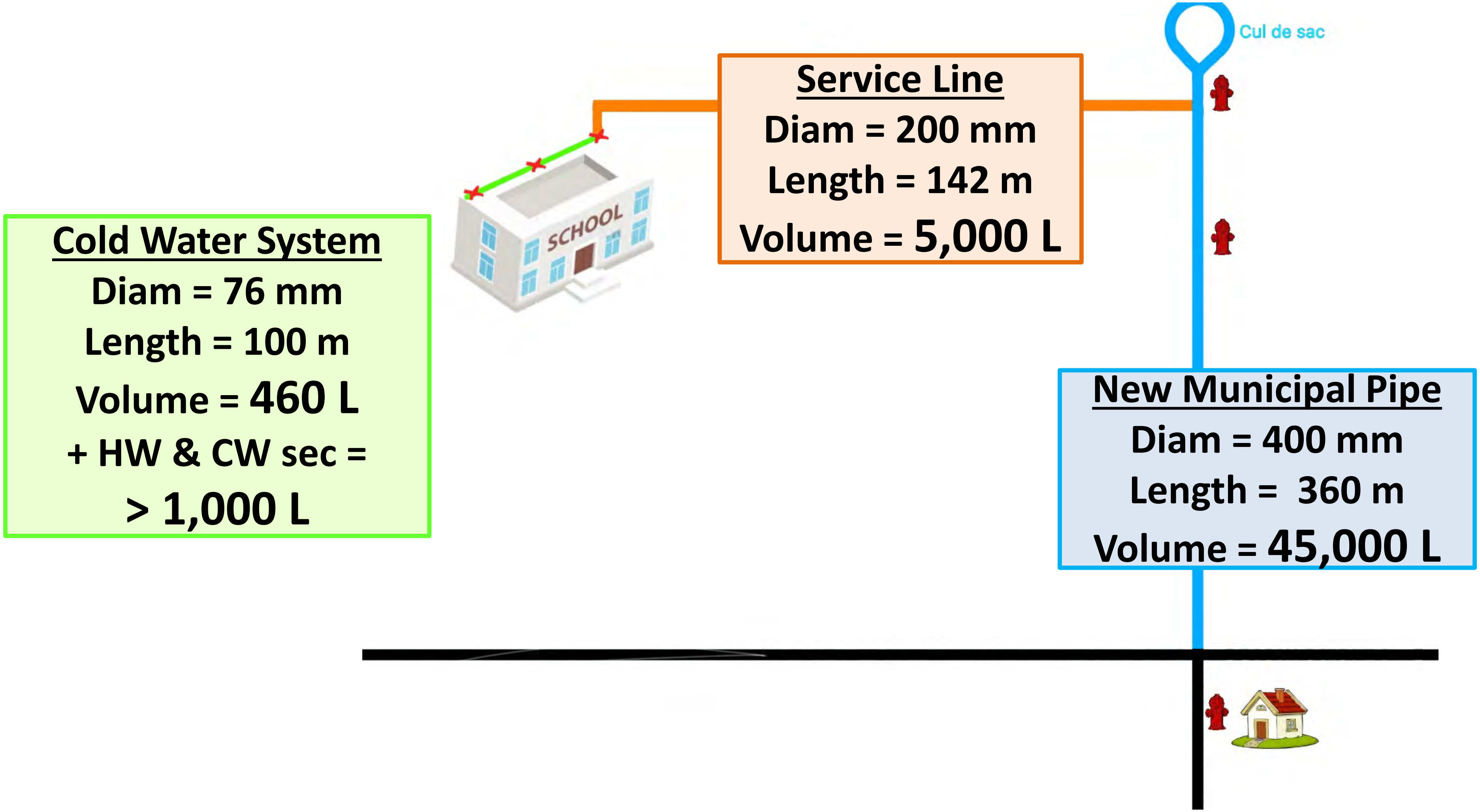
3) Reducing hot water temperature
4) Pre-heating hot water

1) Reducing water usage in LEED Designed Buildings – school case study

- **LEED design**
  - ♦ 4,7 L/min during daytime; 12 L/min peak flow
- **Built following plans from another school built earlier**
- **Detection of total coliforms at start of school – absence of residual chlorine**
  - ♦ Boiling advisory
- **Implementation of continuous flushing at tap (end of building system)**
  - ♦ 10L/min → chlorine residual of 0.15 mg Cl_2/L

School case study

Water Infeed Pipes



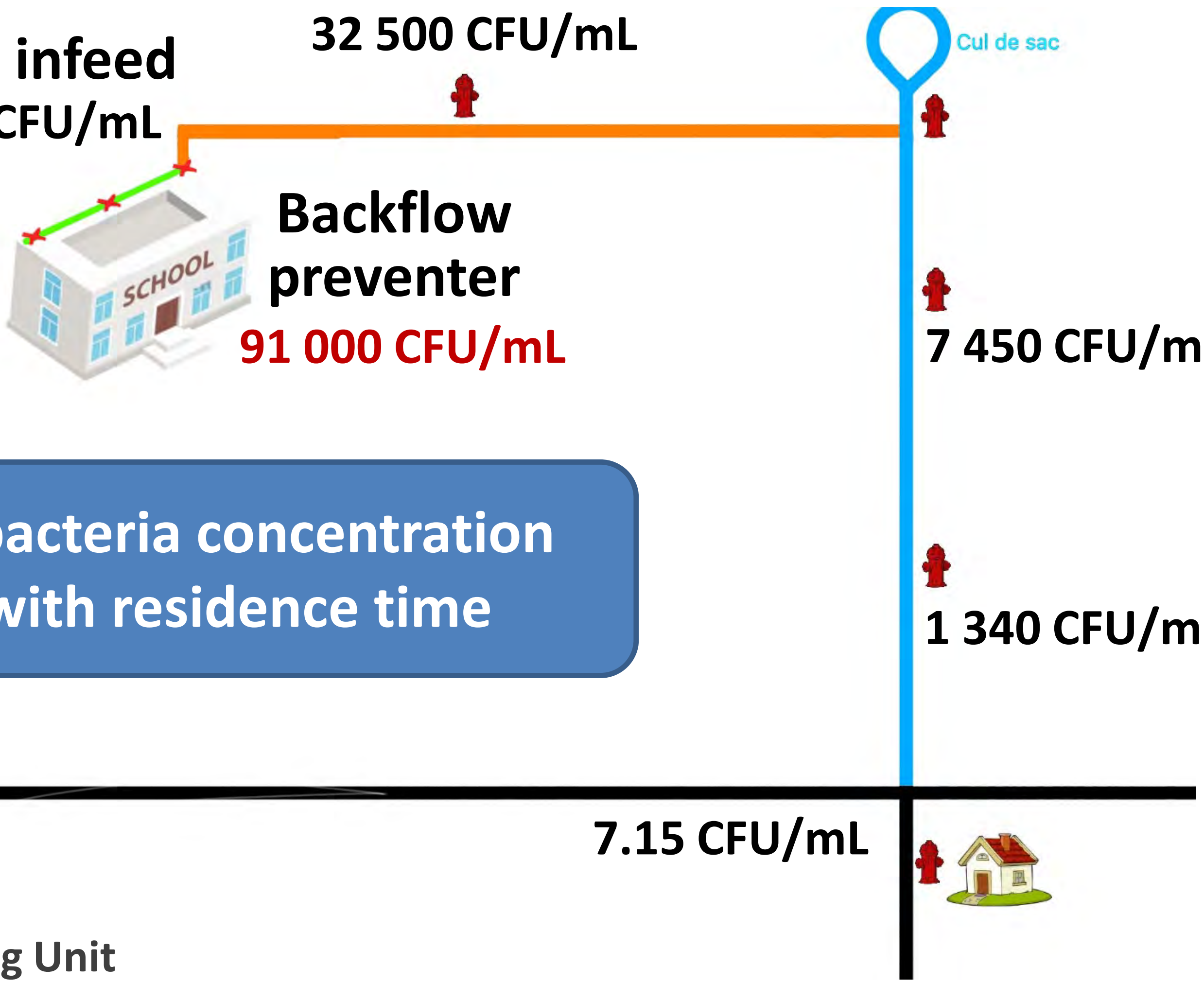
Service Line
Diam = 200 mm
Length = 142 m
Volume = 5,000 L

Cold Water System
Diam = 76 mm
Length = 100 m
Volume = 460 L
+ HW & CW sec =
> 1,000 L

New Municipal Pipe
Diam = 400 mm
Length = 360 m
Volume = 45,000 L

School case study

Finding the source of contamination



Water infeed
9 950 CFU/mL

32 500 CFU/mL

Remote point
75 500 CFU/mL

Backflow preventer
91 000 CFU/mL

7 450 CFU/mL

1 340 CFU/mL

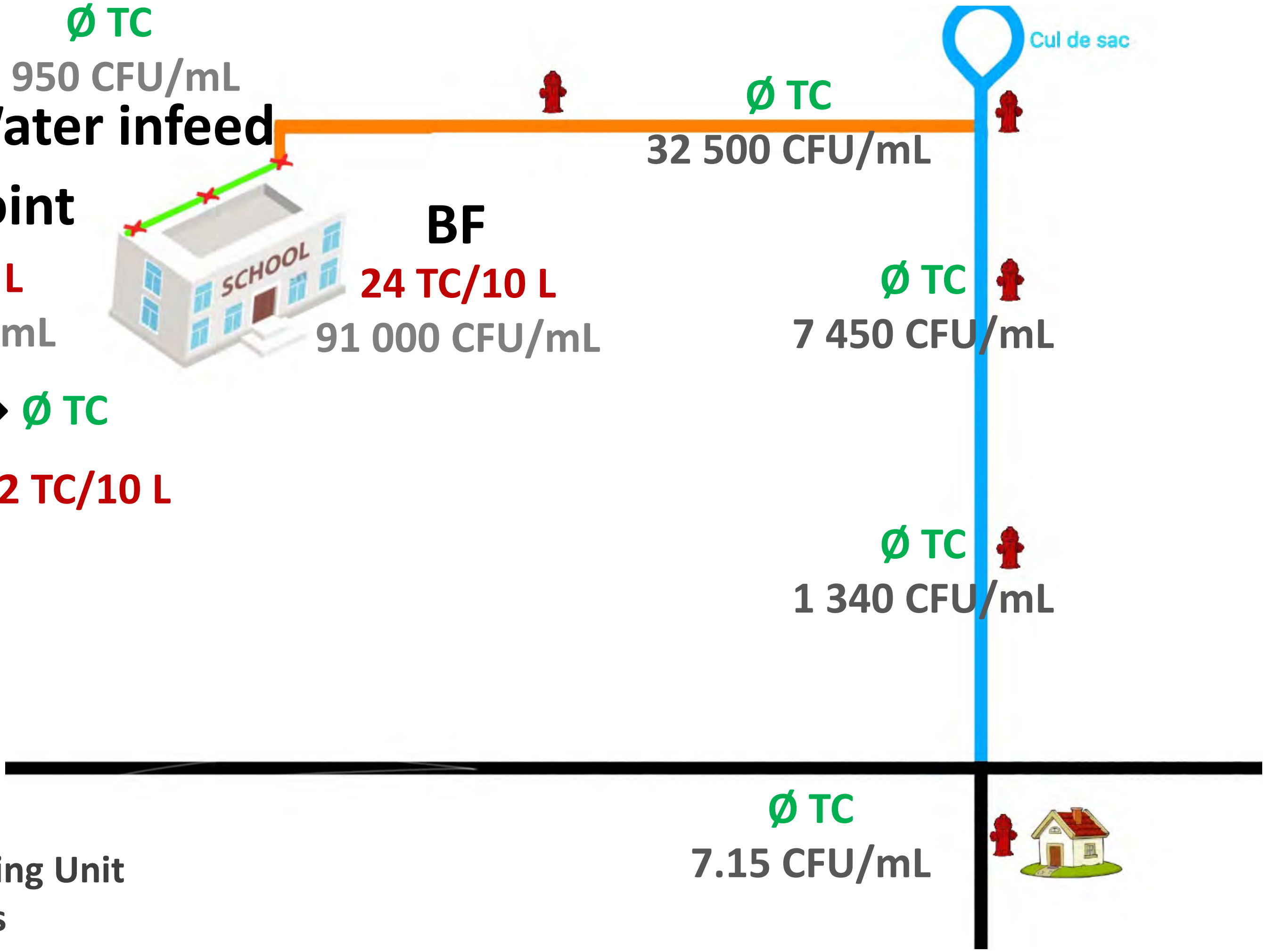
7.15 CFU/mL

Culturable bacteria concentration increase with residence time

CFU: Colony Forming Unit

School case study

Finding the source of contamination



Ø TC
9 950 CFU/mL

Water infeed

Remote point

111 TC/10 L
75 500 CFU/mL

BF

24 TC/10 L
91 000 CFU/mL

Ø TC
32 500 CFU/mL

Ø TC
7 450 CFU/mL

Ø TC
1 340 CFU/mL

Ø TC
7.15 CFU/mL

Flush with Cl_2 → Ø TC

48h stagnation → 2 TC/10 L

CFU: Colony Forming Unit
TC: Total Coliforms

School case study
Conclusions

- Reduced water consumption → need to scale down pipe diameters for green buildings
- Small change in water infeed configuration = important
- Separate service lines for fire protection and DW can help reduce pipe diameter and water volume for low DW usage
- Municipal main pipe dimensioned for long term new housing sector – impact on water age

Electronic faucets

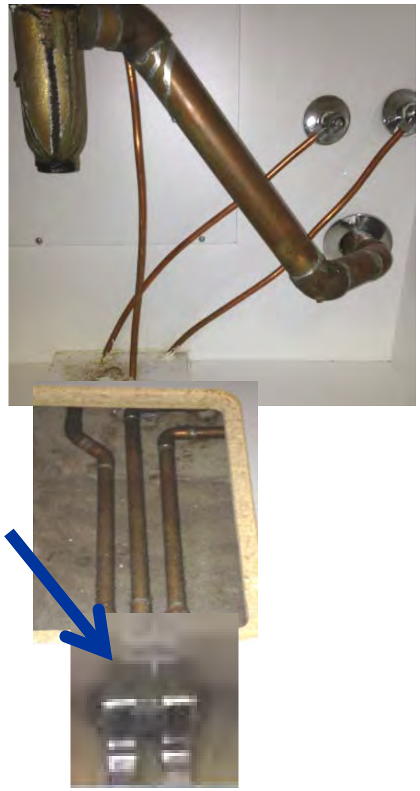
Higher prevalence?

Manual

One-lever

Two-lever

Foot-operated



Electronic

= Mixing zone location

Electronic faucets

Results : Electronic vs manual

Types of faucet	Nb sampled	Nb positive for *Pa*	% contaminated
E faucets	92	13	14%
	13	4	31%
Manual	90	13	14%
Pedal activated	14	4	29%

versus

Charron et al. 2015

Electronic faucets

Factors to consider

Electronic faucet = activation mode

Higher prevalence could be caused by <u>other features</u> not exclusive to electronic faucets:

- Shorter flow times → minimal flushing
- Low flowrates → laminar flow
- Frequent on/off cycles → hydraulic flow changes
- Temperature around 35°C → no hot water after mixing valve
- Materials in mixing valves → plastics, rubber, …

Examples of operating and design parameters to consider:

- Connecting pipe material
- Volume of stagnant mixed hot and cold water
- Water characteristics
- Faucet to drain alignment

3) Energy Savings:
Reducing Temperature

- ***Legionella pneumophila*:**
  - Waterborne pathogen - legionellosis
  - Transmission through inhalation or aspiration
  - Loss of culturability around 55°C, some strains can survive above 70°C
  - Hot water system is a known reservoir
- **Key measures to control *Legionella pneumophila* in hot water systems:**
  - Maintain elevated water temperatures throughout the system
  - Minimize stagnation through optimal water circulation

Reducing hot water temperature to save on energy?

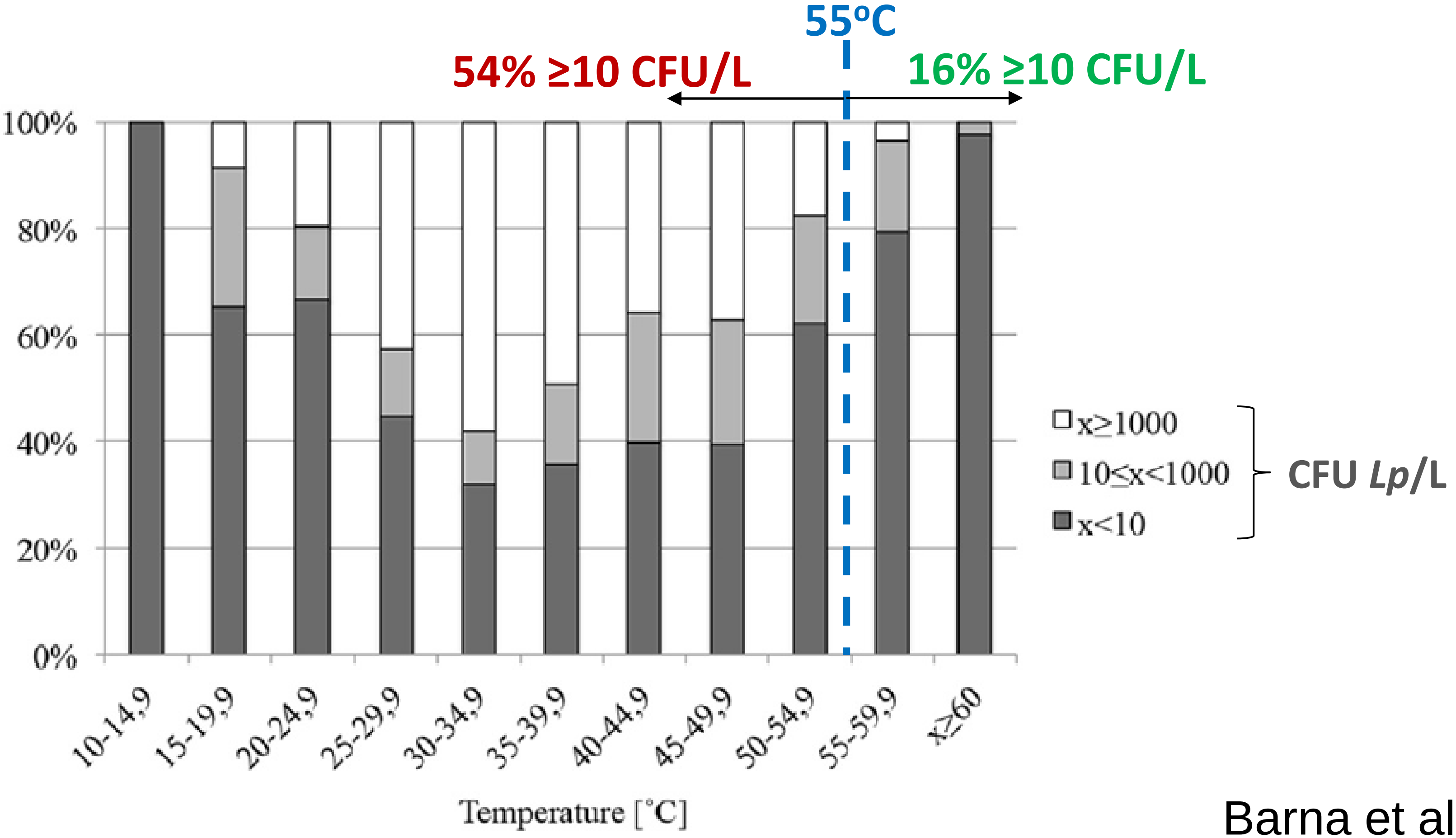
- **800-bed hospital in Lausanne, Switzerland**
- **HW temperature reduced to 50ºC for energy savings**
- **3 years of high positivity for *Lp* despite added onsite disinfection**
- **Increased temperature to 65ºC = reduced *Lp* positivity:**

***Lp* +**	**50ºC**	**65ºC**
Water	**73% (285/388)**	**31% (30/97)**
Biofilm	**56% (98/175)**	**33% (63/191)**

Blanc et al. 2005

Impact of temperature and heat loss

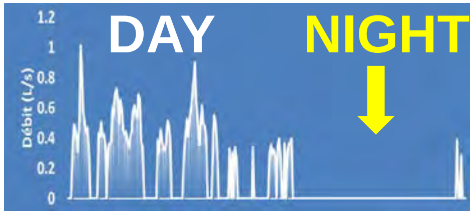
- **7-year study in 114 buildings**
- **Over 60% of buildings colonized by *Lp***

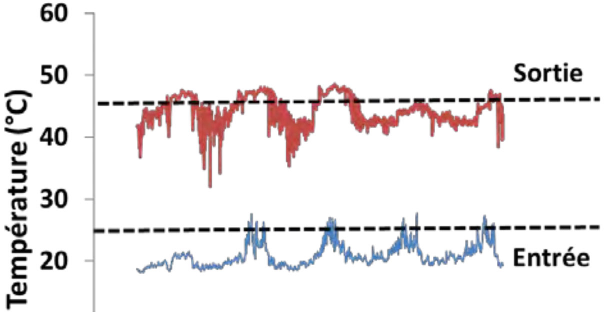


Barna et al. 2016

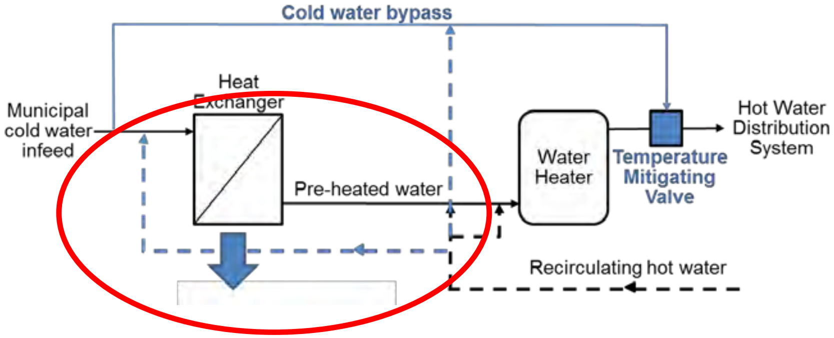
4) Energy Savings: Pre-Heating Hot Water

STAGNATION + TEMPERATURES + SURFACE





+ CONTAMINATED WATER



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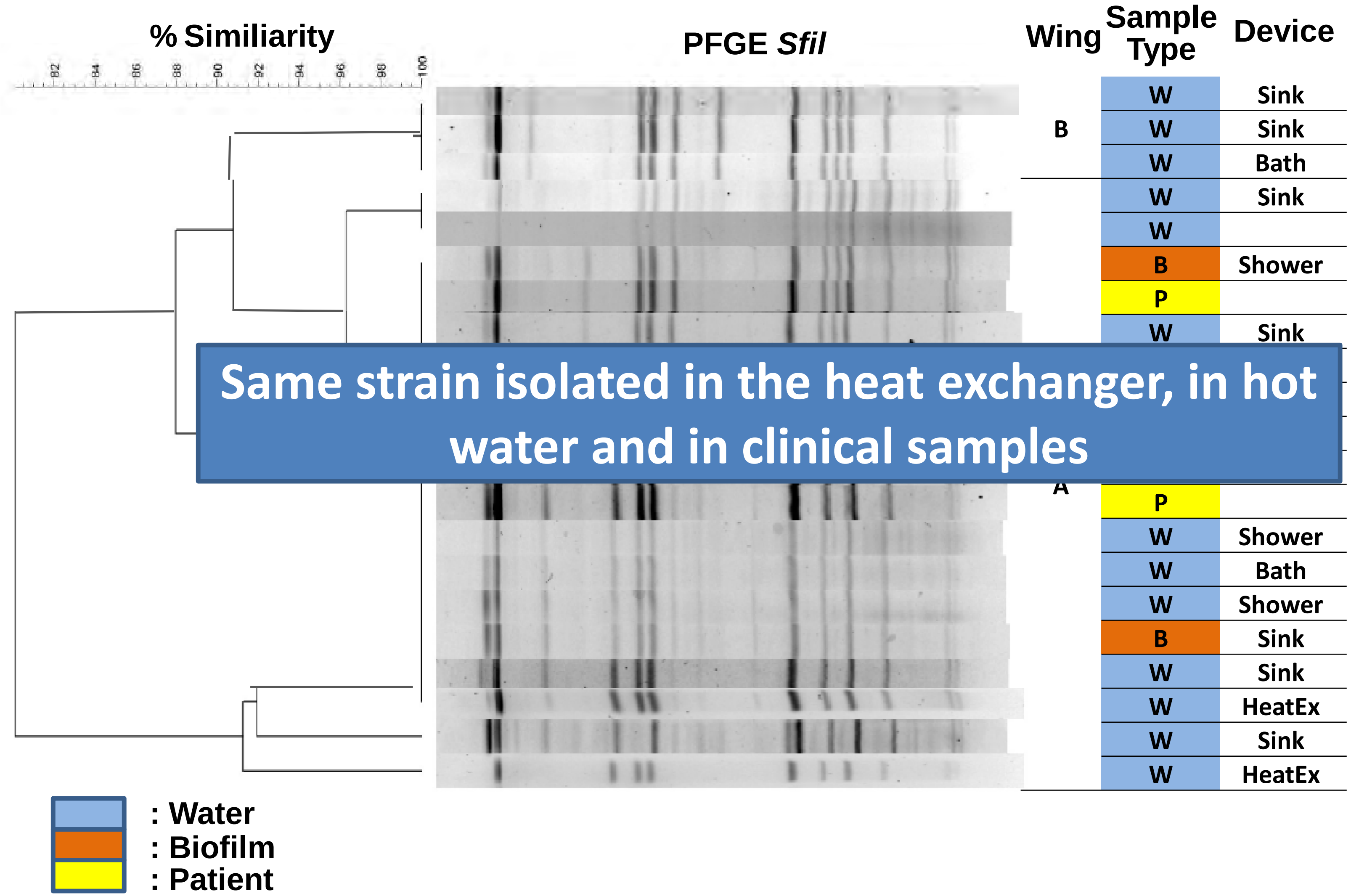
Description du prélèvement	Résultats *L. pneumophila*	
	Culture (UFC/L)	qPCR G/L)
Frottis 1ère plaque		sitif
Frottis plaque centrale		sitif
Frottis dernière		< LD
Frottis e		Positif
F	++	Positif
E	510	4600
E angeur	88 000	85 000
Eau p ge de l'échangeur	5 000	22 000

DANGER

Bédard et al. 2016

Pre-heating water

Strains relatedness



Wing	Sample Type	Device
B	W	Sink
	W	Sink
	W	Bath
	W	Sink
	W	
	B	Shower
	P	
	W	Sink
A	P	
	W	Shower
	W	Bath
	W	Shower
	B	Sink
	W	Sink
	W	HeatEx
	W	Sink
	W	HeatEx

🟦 : Water
🟧 : Biofilm
🟨 : Patient

Same strain isolated in the heat exchanger, in hot water and in clinical samples

NSERC INDUSTRIAL CHAIR ON DRINKING WATER

CREDEAU

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