BS8580 Water quality – Risk assessments for Legionella control – Code of practice

Scene setting: the need, key issues and progress

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Health Protection Agency

Legionellosis

1st recognised outbreak of "legionnaires' disease

58th state convention of the American Legion Dept. of Pennsylvania July 1976

Legionella: 34 years on

Type species *Legionella pneumophila*

At least 52 species described to date

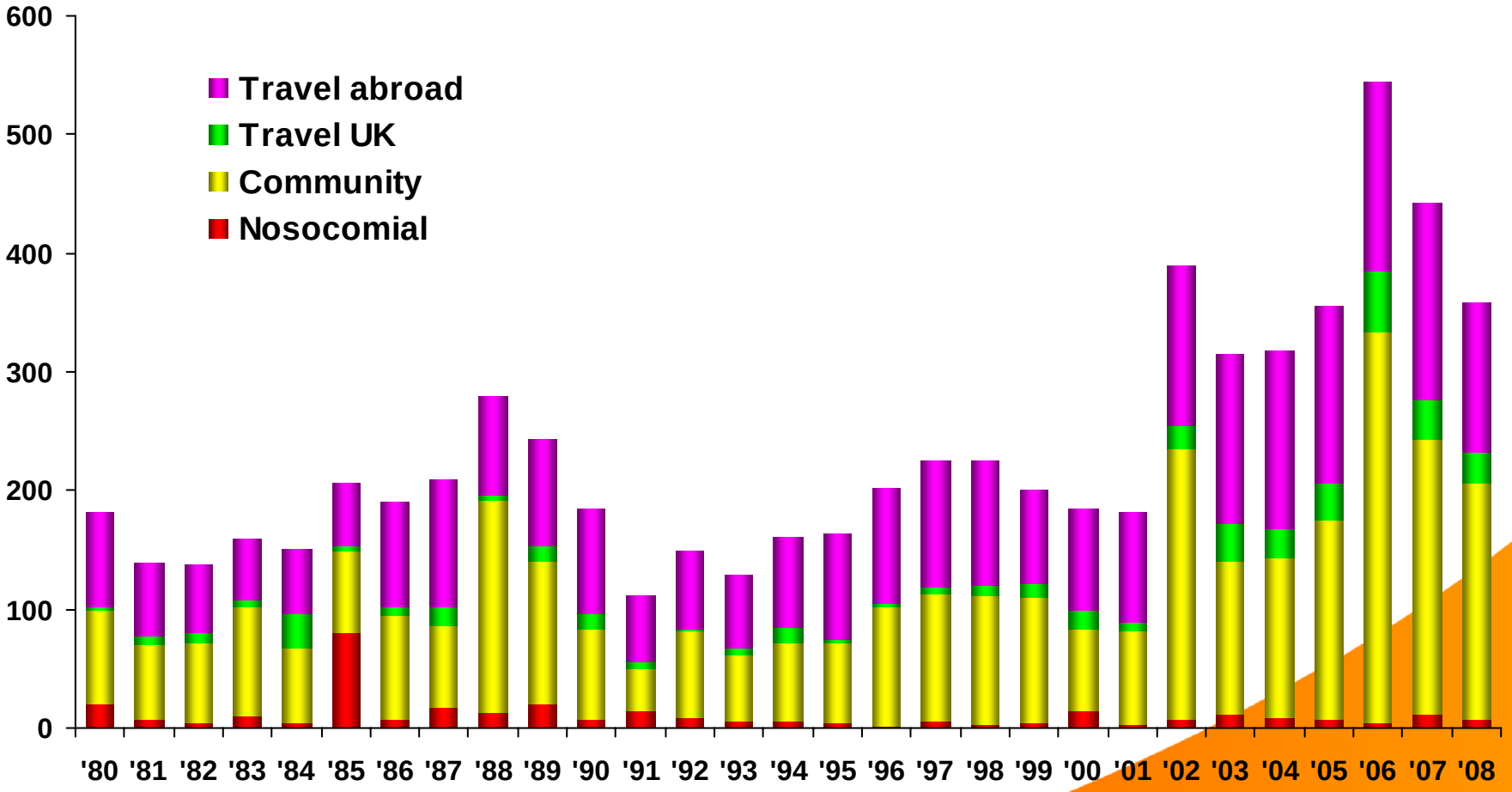
At least 20 species associated with disease in man

L. pneumophila of one particular subtype (serogroup 1 monoclonal subtype 3/1 [synonyms Pontiac / mAb2 reactive]) most common cause of outbreaks of legionnaires' disease worldwide (except some parts of Australia where *L. longbeachae* is most common cause)

In hospitals a wider range of species has been found to cause disease

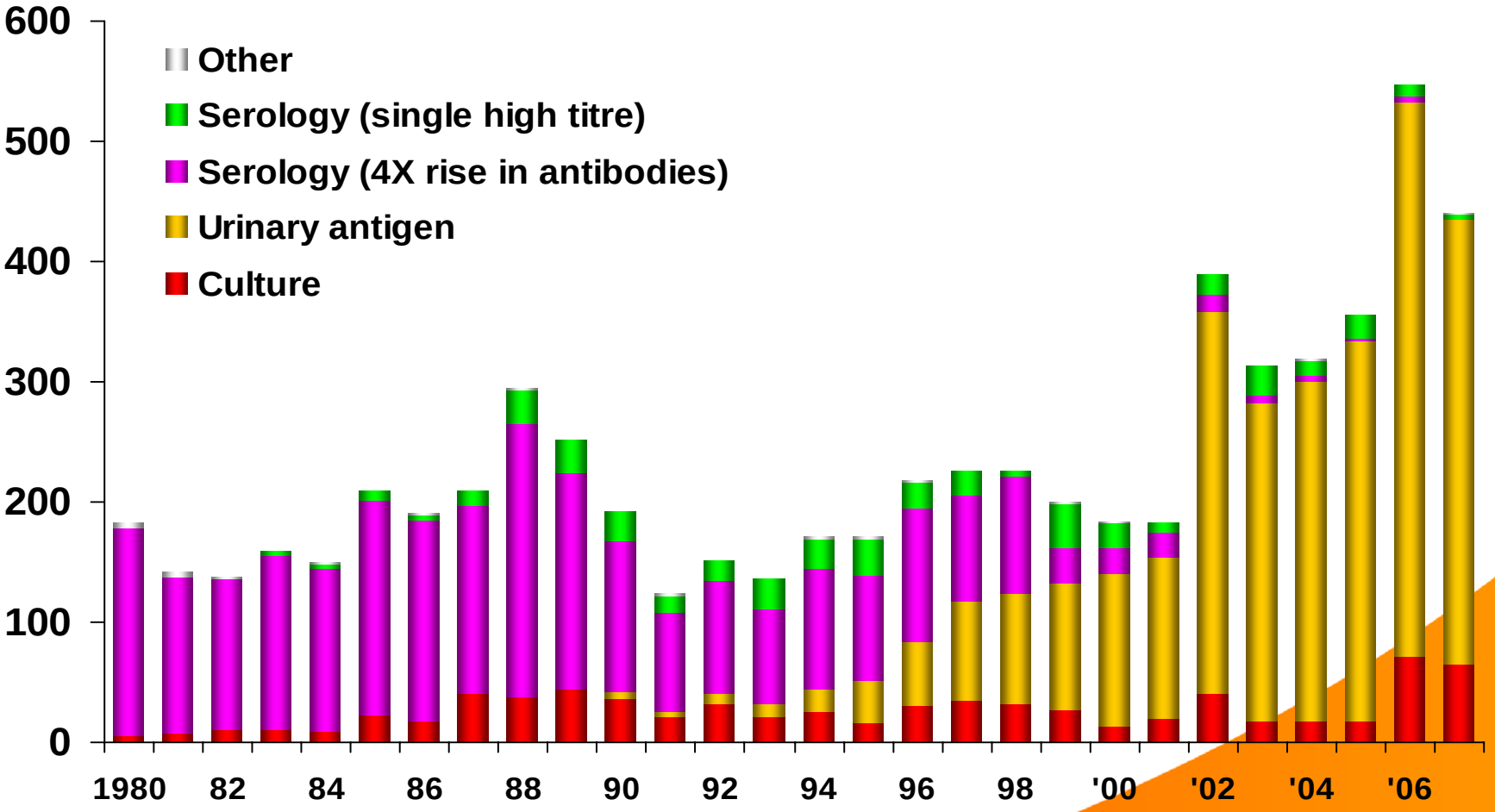
Bellevue-Stratford Hotel,
Broad Street, Philadelphia

Legionnaires' disease in England and Wales - Category of exposure 1980 - 2008



Data from HPA Respiratory Diseases Dept.

Main method of diagnosis



Data from HPA Respiratory Diseases Dept.

Key ecological facts

Widespread in natural aquatic environment

Thermal springs, rivers, lakes, streams, soils, sediments, groundwater, tropical rainforest canopy

Legionellae survive prolonged periods / indefinitely in water provided physico-chemical conditions are not adverse

Seasonal incidence in temperate zones

Require other aquatic organisms for growth

Grows in biofilms

Growth at 20 - 45°C

Optimum growth at 32 - 42°C

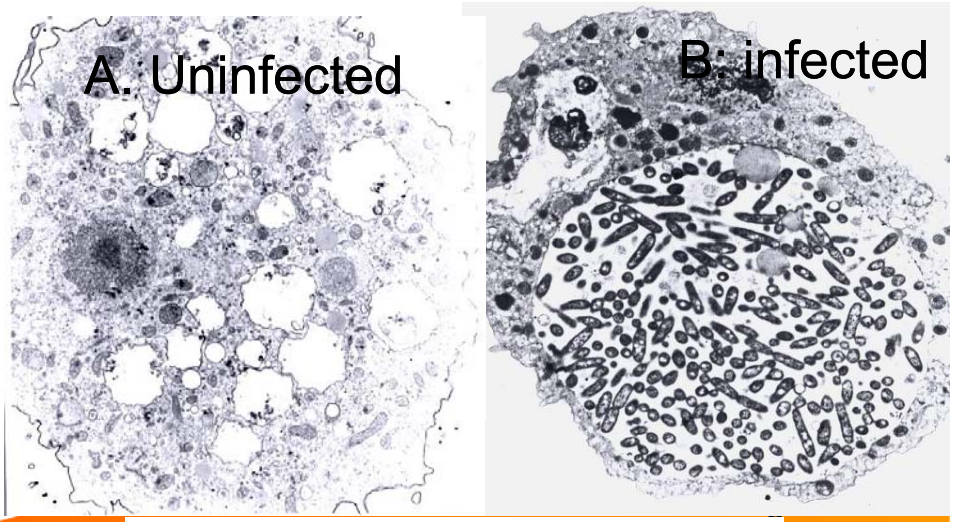
Most commonly isolated from water at 35 – 45°C

Legionellae and protozoa

Rowbotham 1980 *J. Clin. Path.* 33: 1179-83 first reported association of legionellae and amoebae

Subsequently shown to be associated with 14 species of amoebae, 2 species of ciliated protozoa, and one species of slime mold including: *Acanthamoebae* spp; *Hartmanella vermiformis*; *Tetrahymena pyriformis*; *Naegleria* spp

Growth is temperature dependent - at 20°C protozoa overcome infection and at 37°C legionellae proliferate



Electronmicrographs provided by Dr S Surman

Acanthamoeba polyphaga

Protozoa protect legionellae

Protozoan vegetative cells often more resistant to chlorine and other biocides than legionellae

Cysts are especially protective

***L. pneumophila* have been shown to survive inside amoebal cysts treated with 50ppm chlorine overnight**
(Kilvington & Price 1990 J Appl Bact 68: 519 - 525).

Cysts also can protect against drying and heat

Grows in association with biofilms

Consortium of different microorganisms growing in association

Rougher surfaces preferentially colonised forming microniches

Nutritional advantage

Polysaccharide matrix traps nutrients from environment

Cross feeding between different species can permit organisms to grow together that otherwise could not grow by themselves

Growing in consortium can permit growth over wider temperature range than individual strains could otherwise

Niches for bacteria with differing metabolic needs e.g. both aerobic and anaerobic bacteria can be isolated from the same biofilm

Biofilms are protective

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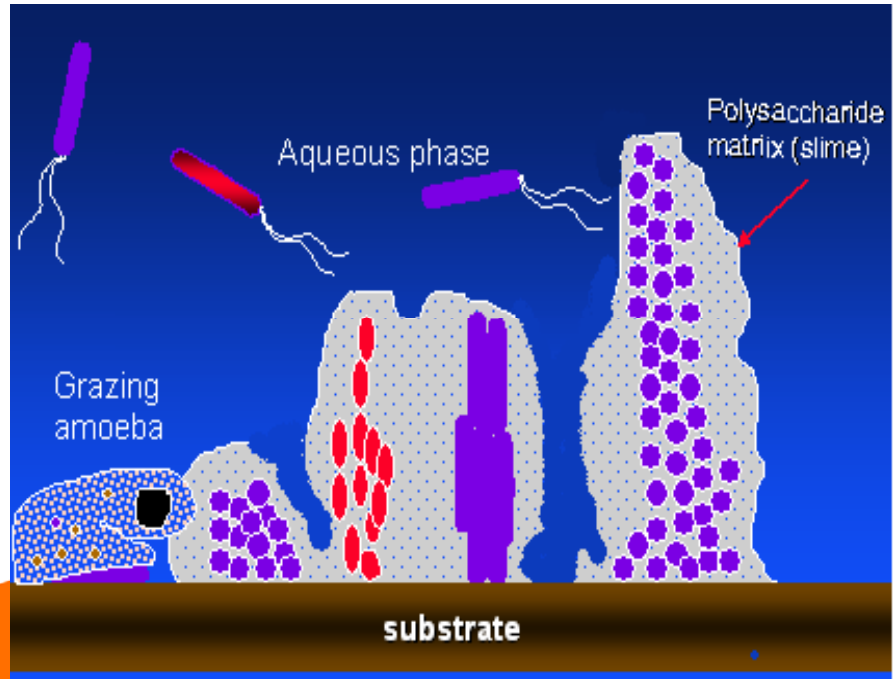
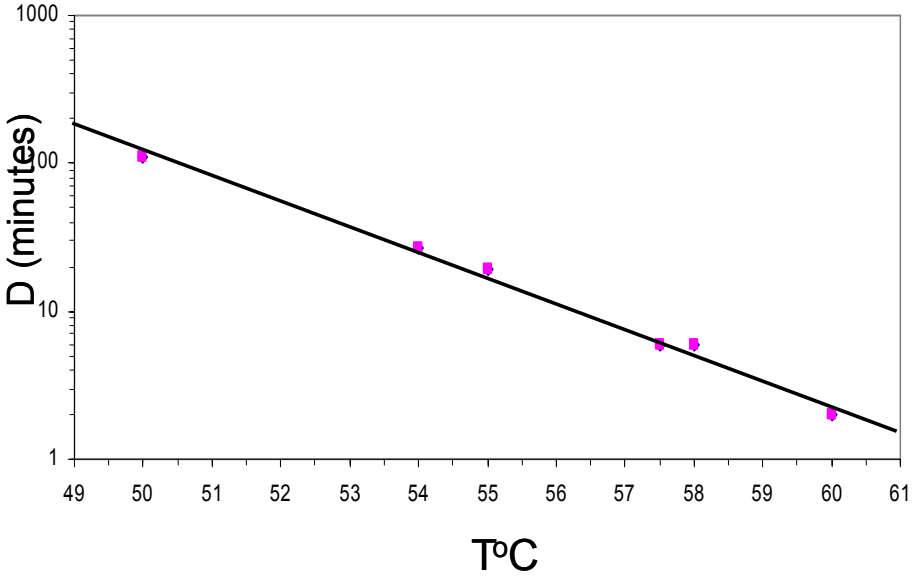
- Protects from sheer stresses / turbulent flow
- Can take up to 1000 x greater exposure to a given biocide concentration to kill an organism in a biofilm as it would to kill the same organism in water
- Organisms in biofilm are in a different, more resistant physiological state
- Can enhance temperature tolerance



Legionella and temperature

Decimal reduction times (D, minutes) of *L. pneumophila sg. 1* at different temperatures



D = time to kill 90% of a population

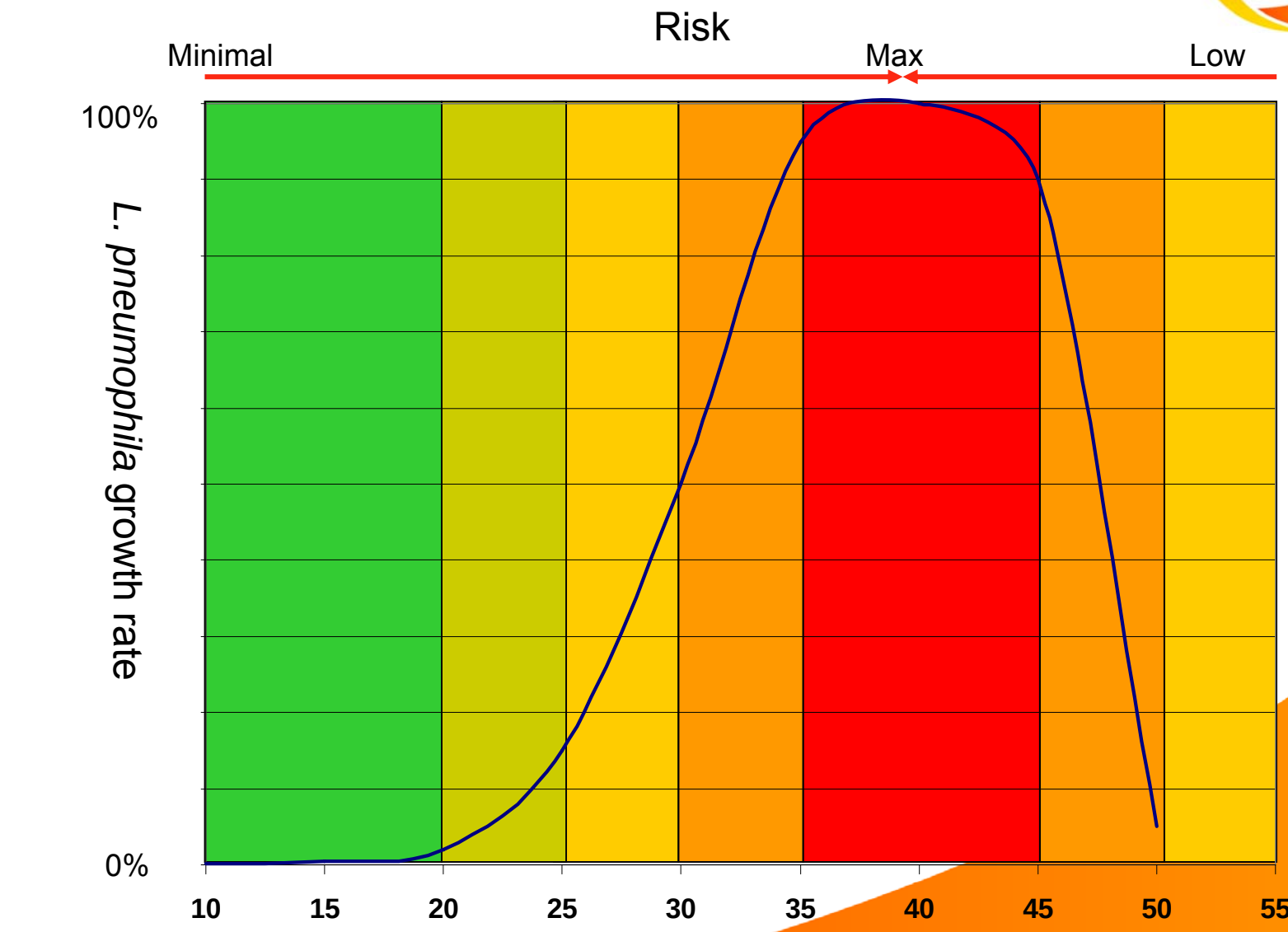
Data from Dennis *et al.* 1984 *J. Appl. Bacteriol.* **56:**349 – 350 and Schulze-Robbecke *et al.* 1987 *Schriftenr. Ver Wasser Boden. Lufthyg*. **72**: 86 – 89

Detectable in waters up to ~55ºC

Basis of control in hot and cold water systems

- Circulate hot water at 60°C so that water at tap reaches at least 50°C within 1 minute.
- Cold should be less than 20°C within 2 minutes of turning on tap

Water temperature, growth rate and risk



Factors Encouraging Colonisation (Biofilm Formation) in Artificial Water Systems

Nutrients for microbial growth - sources

Dissolved or suspended in supply water

Dirt entering system

Construction materials (natural > synthetic > steel > copper)

Stagnation / slow water movement – leads to sedimentation

Tanks, pressure vessels, hot water storage vessels, dead / blind ends, low flow

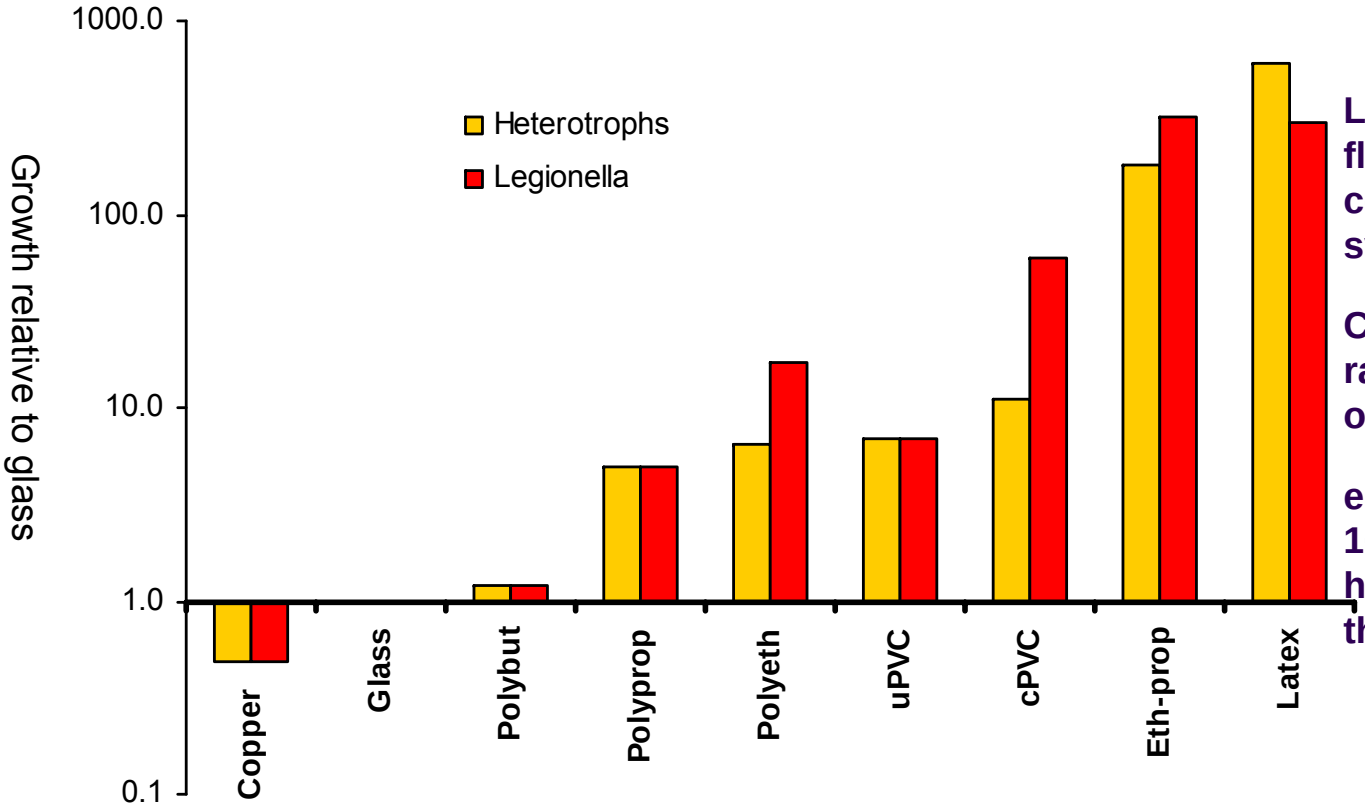
Difficult to clean (poor design)

High surface to volume ratio

Physico-chemical conditions

Temperature 30°C - 45°C, scale & corrosion

Growth on different plumbing materials relative to glass (=1)



Legionella and supporting flora were grown in continuous culture model systems.

Counts are expressed as a ratio relative to the counts on glass (=1)

e.g. there was approximately 10 X the growth of aerobic heterotrophs on cPVC as there was on glass.

Conclusion: higher flexibility of plastic generally correlates with increased support for growth

Poor quality Flexible hoses

Materials grow Legionella but also they get damaged during installation and reduce flow

Damage/distortion was identified after the hoses were removed

How does one catch it? – aerosol formation

Inhalation of air containing the *Legionella* bacteria (aerosol)

Rarely by aspiration (water going down the "wrong way") of water containing *Legionella* bacteria

NEVER from someone else

Aerosol

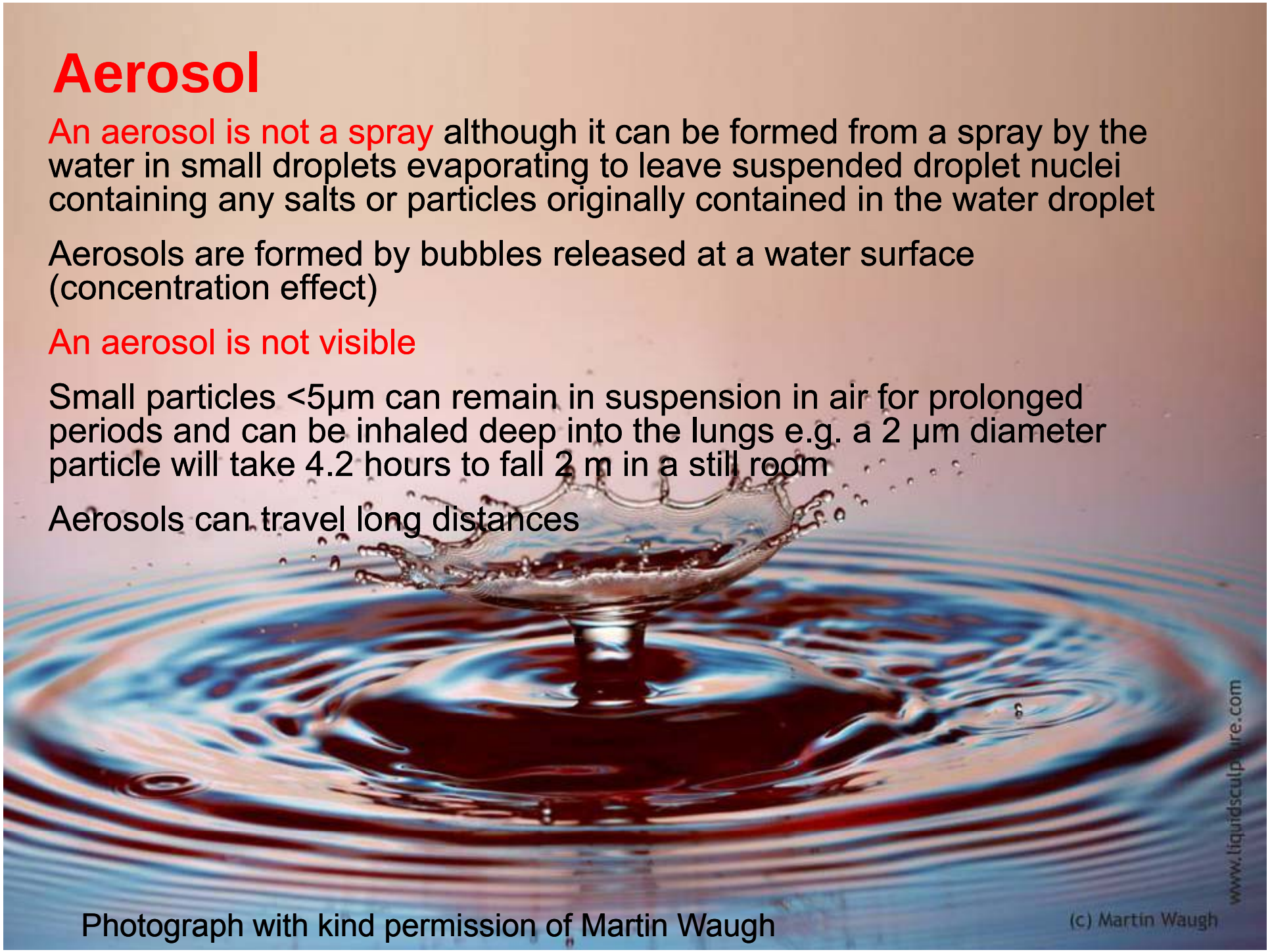
An aerosol is not a spray although it can be formed from a spray by the water in small droplets evaporating to leave suspended droplet nuclei containing any salts or particles originally contained in the water droplet

Aerosols are formed by bubbles released at a water surface (concentration effect)

An aerosol is not visible

Small particles <5μm can remain in suspension in air for prolonged periods and can be inhaled deep into the lungs e.g. a 2 μm diameter particle will take 4.2 hours to fall 2 m in a still room

Aerosols can travel long distances



Photograph with kind permission of Martin Waugh

Aerosol formation

Water drops falling onto a hard surface

Bubbles rising to the water surface and bursting

Rain

Running a tap

Running shower

Flushing a toilet

Spraying plants

Humidifiers

Water running over pack of cooling towers

Wave formation

What is a potential source of legionella infection?

Any system / device where the temperature of some or all of the water in it can be between 20°C – 45°C. - in practice anything that doesn't have sterile water in it

AND there is a possibility of the water being aerosolised and inhaled or in rare cases aspirated during normal operation or maintenance

NB history has shown that systems that have been perceived as potential risks usually are eventually shown to be responsible for an outbreak e.g. air scrubbers; vehicle washes; jet washes

Potential sources

Anything with water in it that achieves the right temperature sometimes – can include closed systems

Recognised sources

- **Wet cooling systems**
- **Domestic hot and cold water systems**
- **Spa pools**
- Humidified display cabinets for meat and vegetables
- Indoor fountains
- Natural spas / hot springs
- Humidifiers
- Respiratory therapy equipment
- Air scrubber
- Effluent (sewage) plant
- Compost
- Air scrubbers
- Water pressure jet cleaners
- Vehicle washes
- Cutting fluids

Other potential sources

- Irrigation equipment
- Whirlpool baths and therapy pools
- Whirlpool footbaths
- Sprinklers and outdoor water features
- Carpet cleaners
- Solar / geothermal heating

And so on

Chain of Causation

Contamination of water system	Incoming supply, dust / dirt entering system
↓	
Amplification	Physico-chemical conditions, nutrients, design (stagnation), water treatment, maintenance
↓	
Transmission	Aerosol generation, atmospheric conditions
↓	
Exposure and inhalation	Proximity to source, length of exposure
↓	
Host susceptibility	Underlying disease, smoking, age, sex

Legislation applicable to Legionella control

Health & Safety at Work Act 1974

Management of Health & Safety at Work Regs 1992

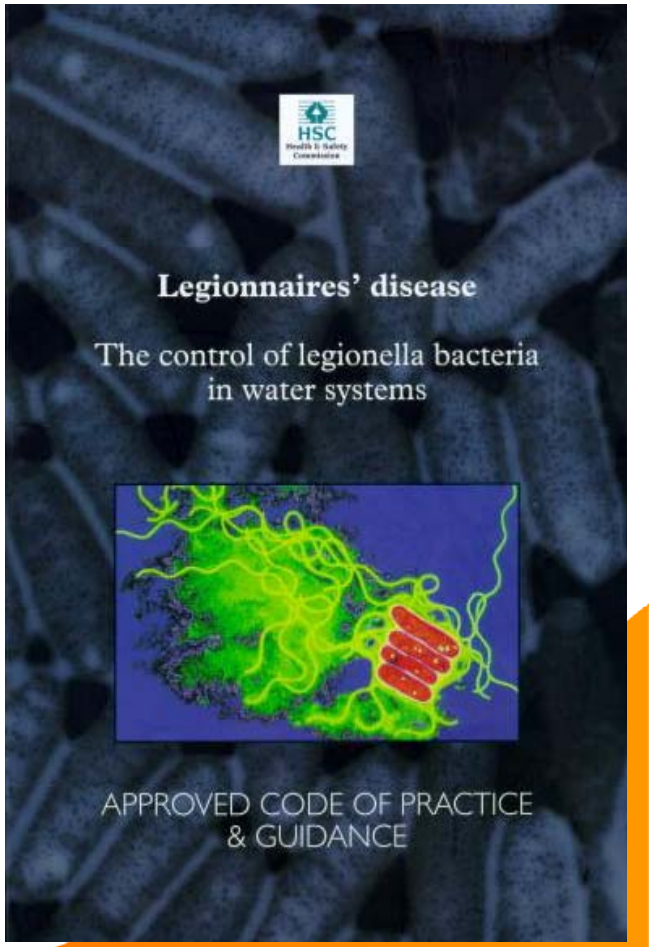
Control of Substances Hazardous to Health Regulations 1994

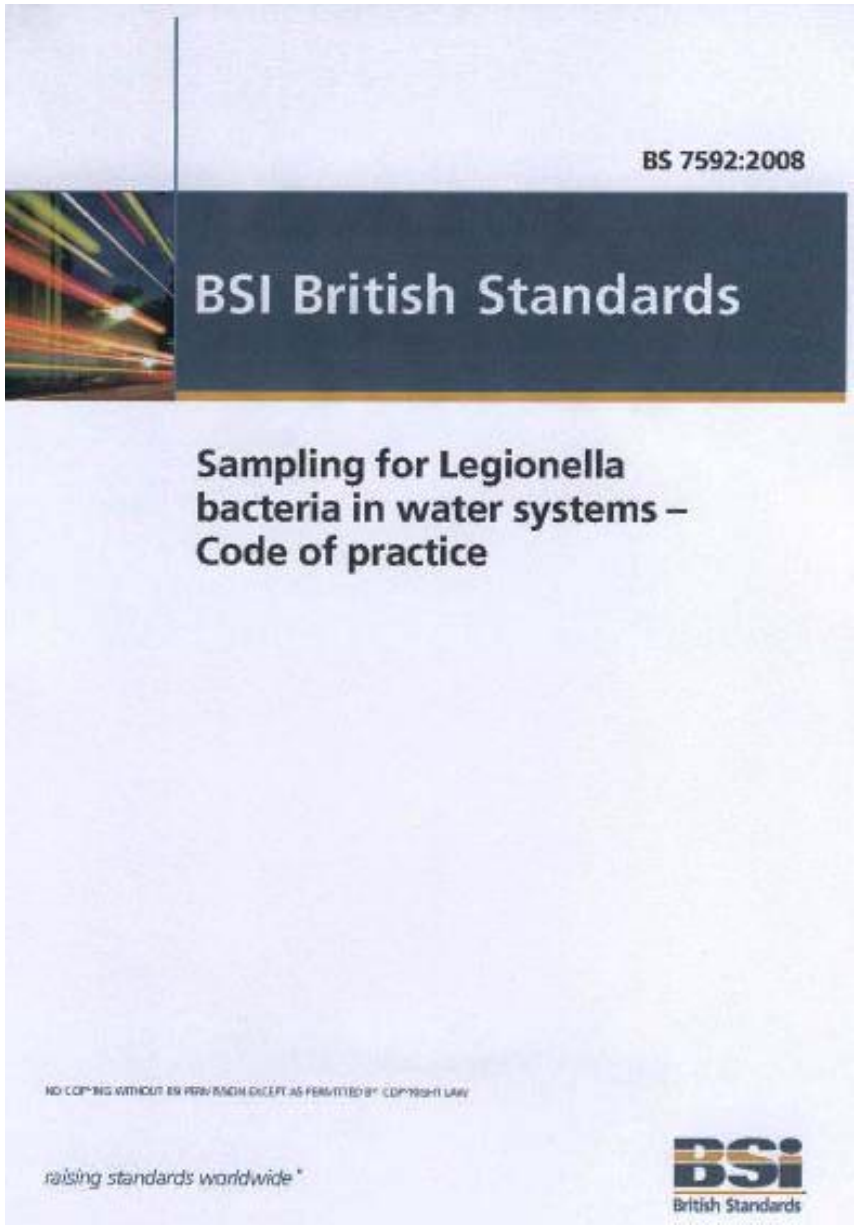
Notification of Cooling Towers Regs 1992

HSC Approved Code of Practice & Guidance 2000 "Legionnaires' disease The control of legionella bacteria in water systems" L8

Water Supply (Water Fittings) Regulations 1999. Statutory Instrument SI 1999:1148

Compliance with the last two should control most other microbial risks





BS 7592:2008 Sampling for *Legionella* Bacteria in Water Systems- Code of Practice

with its own Webpage on the BSi Website

www.bsigroup.com/bs7592.

Purpose of BS for Legionella Risk Assessment

Improve consistency of risk assessments

Facilitate risk assessment of novel risk systems

Improve compliance with law

Public Health Protection

Facilitate accreditation for risk assessment

Encourage development of international standard

Development so far

Work begun June 2009

Target audience

Scope

Excludes natural systems and preparation of scheme of control

Initially based on Water Management Society Document

Scoring system? - rejected

Guidelines v Code of Practice

Current structure

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8 Risk assessment reporting

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Appendices

Informative appendices

Annex A (informative) Issues to be considered during a risk assessment

Annex B (informative) Hot and cold water systems

Annex C (informative) Cooling towers and evaporative condenser systems

Annex D (informative) Fire suppression systems

Annex E (informative) Risk assessment of vehicle wash systems

Annex F (informative) Fountains and water features

Annex G (informative) Spa pools

Annex H (informative) Checklists

Annex I (informative) Equipment

Issues to be considered in a risk assessment – the Chain of Causation

Contamination of water system	Incoming supply, dust / dirt entering system
↓	
Amplification	Physico-chemical conditions, nutrients, design (stagnation), water treatment, maintenance
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Transmission	Aerosol generation, atmospheric conditions
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Exposure and inhalation	Proximity to source, length of exposure
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Host susceptibility	Underlying disease, smoking, age, sex

Next stages

Public comment finishes 31 May 2010

Revise document to accommodate comments where appropriate

Publish autumn