Hospitals, Water Systems and Microbiological Contamination Risks

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Pharmig
Introduction

- Risks of contaminated water systems
- Types of water and water uses
- Microbiological concerns
  - Biofilms
- Design of water systems
- Treatment of water systems
- Microbiological monitoring:
  - Bioburden
  - Pathogens
  - Endotoxin
- Discussion points
Risks of contaminated water systems

- Water with a high bioburden or specific pathogens:
  - Patient risk,
  - Healthcare worker risk,
  - Water system damage (biocorrosion),
  - Bad publicity,
  - Economic burden (downtime and prolonged treatment time).
Hospital water systems

- Types of water:
  - Mains water
  - Filtered water
  - Purified water (reverse osmosis)
- Water in hospitals is used for a variety of uses:
  - Haemodialysis,
  - Decontamination washers,
  - Clean sterilizer reuse,
  - Cleaning surgical instruments,
  - Floor cleaning,
  - Analyser equipment,
  - Boiler room to provide steam services.
Microbiological concerns

- Three types of microbial concern:
  - Excessively high levels of bacteria.
  - Presence of specific pathogens (‘objectionable’ microorganisms such as *Pseudomonas aeruginosa*).
  - Bacterial endotoxin.
Microorganisms in water

- Dual problem:
  - Microorganisms grow in water;
  - Water spreads microorganisms easily.
- Most microorganisms have two ‘lifestyles’:
  - Planktonic: freely floating in water
  - Sessile: attached to a surface
  - Main type: Gram-negative bacteria
- Microorganisms attach to surfaces by secreting a sticky polymer.
  - This can lead to biofilms forming.
Biofilms #1

- Microorganisms adhere to a surface by secreting DNA, protein and carbohydrates (extrapolymeric substances called a glycocalyx).
- Eventually leads to a biofilm
Biofilms #2
Biofilms #3

- A biofilm is a complex community which contains a great variety of microorganisms.
- Once formed biofilms are very hard to remove: slimy outer layers become resistant to disinfection and heat.
  - Lead to a ‘sludging’ effect, the mass continuously ‘secretes’ matter and microorganisms into the passing water: a steady level of contamination.
  - Far more bacteria in a biofilm than there are free floating.
Designing good water systems
Supplied water

- Supplied water (mains or potable water) will contain a mix of different types of microorganisms.
- The initial stages of water treatment e.g. chlorination help to control the numbers of microorganisms.
- Water is distributed through a network of pipes.
  - Temperature of the water in pipes is important.
  - Main risks are below 55°C in hot water pipes and above 20°C in cold water pipes = Pseudomonads.
Water system design #1

- A good water system design keep microorganisms in the planktonic state; a poor water system leads to biofilms, because of:
  - Downtime.
  - Poor design e.g. water flow too slow or in the wrong direction.
  - Poor finish to pipes (e.g. interiors not polished and smooth)
  - Presence of ‘deadlegs’ (lead to stagnant water).
Water system design #2

- Other design factors:
  - Water pressure: low pressure can lead to microorganisms adhering to a surface.
  - Pipe material: composition of pipe controls the types of chemicals released into the system and affects the types of bacteria that can colonise the surface.
    - Smooth internal surfaces
    - Continuous movement
    - Avoidance of areas where water can remain stagnant.
  - Pipe age: older pipes can be prone to wear and tear.
  - Physical integrity of pipes: breaks or leaks in pipes can lead to low water pressure.
  - Unclean storage tanks.
Point-of-use

- Certain types of materials used for flexible hoses pose greater opportunities for microbial colonisation than others.
  - Synthetic rubber based components (EPDM rubber) = less good.
  - Polyethylene = good
- Point-of-use filtration (using 0.2 μm pore filters)
  - Expensive
  - Masks problems?
Some best practices
Best practice examples

- Segregation of clean and dirty equipment.
- Avoiding sink ‘splashback’.
- Regular flushing of taps.
- Using handrubs as well as hand washing.

Also consider:

- Regular removal or cleaning or descaling or replacement of the water outlets, hoses and thermal mixing valves.
Treating contaminated water systems
Treatment

- Treatments include:
  - Filtration at point-of-use
    - Useful, but does not address the cause
  - Heating the system
    - Ideally requires steaming
  - Chemical treatment
    - Such as chlorine or ozone.
  - Removal and replacement of pipework
    - Last resort.
Treatment

- The most common and effective treatment is chlorine.
  - Chlorine inhibits the growth of most bacteria.
  - But, can cause corrosion and toxic by-products.
  - Alternative is chloramine (NH₂Cl).
Treatment

- Caution:
  - The method undertaken to remove one pathogen can lead to conditions which lead to the proliferation of another.
  - For example, chlorine can eliminate *Ps. aeruginosa* BUT *Mycobacterium avium* is relatively resistant to chlorine.
Microbiological monitoring

Purpose and objectives
Objectives

- Microbiological concerns:
  - What is the composition and activity of the microbial communities living within a water system?
  - What influences these communities?
  - What levels of control need to be achieved?
  - If something goes wrong, such as an increase in counts, what measures need to be taken to return a system back into control?
Microbiological monitoring

- What do you want to test for?
  - Pathogens
    - Presence or absence of any specific pathogens
  - Numbers of microorganisms against set-limits
    - Total numbers of microorganisms present per millilitre or per 100mL;
  - Endotoxin (e.g. haemodialysis units)
    - Levels of bacterial endotoxin (grades of ‘highly’ purified water).
Pathogens

- **Water system risks:**
  - *Pseudomonas aeruginosa.*
    - Likes low nutrient environments, such as water systems.
  - Other opportunistic pathogens, such as *Burkholderia cepacia,* *Ralstonia picketii,* *Stenotrophomonas maltophilia,* *Sphingomonas* sp., *Acinetobacter* sp., *Enterobacter* sp., *Serratia* sp.
Pathogens #2

- **Specific risks:**
  - *Legionella pneumophila.*
    - The causative agent for legionnaires’ disease and Pontiac fever.
  - *Mycobacteria,* such as *Mycobacterium avium.*
    - Involved with several clinical cases, and can cause pulmonary and lymphatic disease.

- **Rare but possible:**
  - Coliforms, especially *Escherichia coli.*
    - Indicator of faecal contamination. Relatively unlikely.
Defining an 'objectionable microorganism' is undertaken by way of risk assessment.

- Risk of causing patient harm:
  - Age and health of the patient,
  - Whether the patient is immunocompromised,
  - More susceptible to infection: elderly people, young children, cancer patients, pregnant women, and people with chronic illness.
- Whether the microorganism is antibiotic resistant.
Pseudomonas aeruginosa #1

- To detect *Pseudomonas aeruginosa*, selective media containing cetrimide (cetyl trimethylammonium bromide) is required.
**Pseudomonas aeruginosa #2**

- *Pseudomonas aeruginosa* it is expected that no isolates will be detected.
  - Low level be detected (<10 colony forming units per millilitre of water examined), the risk is normally regarded as medium and a review should be undertaken.
  - If 10 or more colonies are isolated, the use of the water system should be discontinued and action taken.
Total numbers

- **General consensus:**
  - R2A agar at low temperature for a long period of time
- **Importance of trending**
  - Examinations for:
    - Low and high use
    - Seasonality (e.g. low use at public holidays)
    - Changes following maintenance

Total numbers

- Mains water should not exceed 30,000 CFU/100mL.
  - As per WHO.
- Purified water should not exceed 10,000 CFU/100mL.
  - As per European Pharmacopeia.
- In reality, alert and action levels are set much lower.
Trend chart

Causes of contamination

- Special causes are local, sporadic problems such as the poor management of a particular water outlet in a process area.
- Specific to a:
  - A certain process
  - A certain outlet
  - A certain method of sanitisation, etc.
- Common causes are problems inherent in the system because of:
  - The nature of the system
  - The way the system is managed
  - The way the process is organised and operated
  - E.g. biofilm
- They can only be removed by:
  - Making modifications to the process
  - Changing the process
Rapid methods

- Flow cytometry
  - More accurate count
  - Detection of VBNC
- Process
  - Cells stained with fluorescent dyes
  - Cells passed through glass capillary
  - Laser shone
  - Analyser differentiates stained microbial cells from other (non-stained) particles
Endotoxin

- Endotoxins
  - Produced from Gram-negative bacteria when they undergo lysis.
  - LAL (Limulus amoebocyte lysate) test.
    - The principle of the LAL test is a reaction between lipopolysaccharide and a substance (“clottable protein”) contained within amoebocyte cells derived from the blood of the Horseshoe Crab.
  - ‘Safe level’ = <0.25 EU/mL
Sampling

- Importance of aseptic technique.
- Sterile containers
  - Mains water: containing sodium thiosulphate.
- When to sample?
  - In order to maximise the recovery of free floating planktonic bacteria it is important that water samples are taken:
    - During a time of no use (at least two hours since the point was last used); or
    - During a period of low use.
Discussion points (1 of 2)

- Is water system contamination a concern?
- Is the monitoring of water systems for endotoxin important?
- What makes for an objectionable microorganism? What types of organisms are looked for?
- What types of agars and incubation conditions are used for pathogens and for general bioburden testing?
Discussion points (2 of 2)

- How are alert and action levels set?
- What types of water treatments work best?
- What are the main water system design concerns?
Thank you

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