BIOFILMS IN WATER DISTRIBUTION

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Introduction

- The occurrence of bacterial growths in finished drinking water is not new.
- In 1930, the AWWA committee on water supply reported the problem of regrowth of "B. Coli".
- Bacteria could not be detected in the finished water at the point of entry; however, microorganisms were apparently multiplying in distribution pipelines.
- While water treatment and disinfection systems can remove most of the bacteria found in raw water, the water produced is not sterile, and low levels of bacteria do persist even in properly treated supplies.

- Bacterial growth in drinking water distribution systems makes monitoring for bacterial quality in the distribution system difficult.
- Growths of bacteria on pipe walls, called biofilms, also can provide a haven for potentially pathogenic bacteria.
- Biofilm is an organic or inorganic surface deposit consisting of microorganisms, microbial products, and detritus.

Description

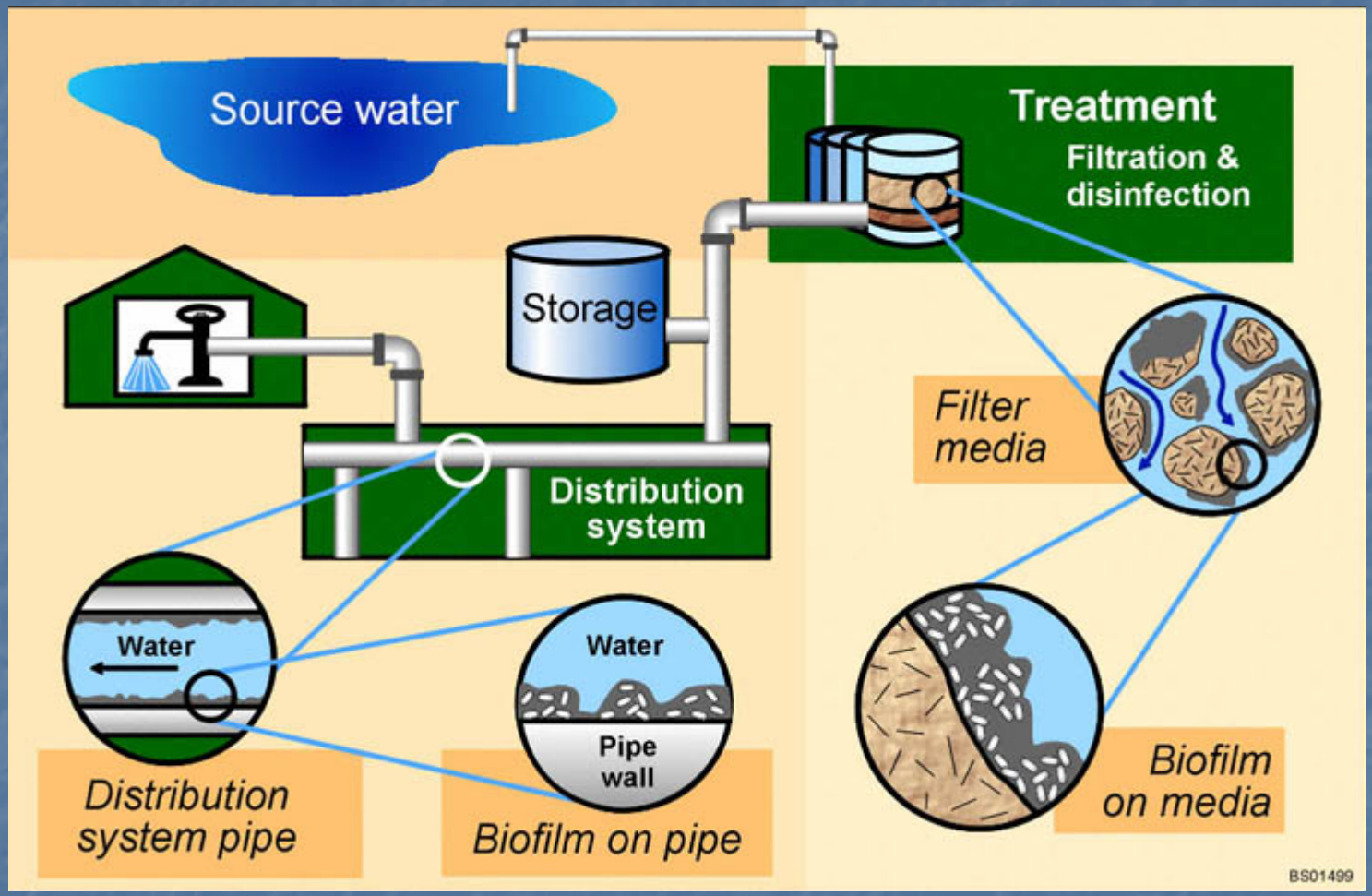
- What is a Biofilm?

  Biofilms are formed in distribution system pipelines when microbial cells attach to pipe surfaces and multiply to form a film or slime layer on the pipe. They are dynamic microenvironments, encompassing processes such as metabolism, growth, and product formation finally detachment, erosion, or sloughing of the biofilm from the surface.

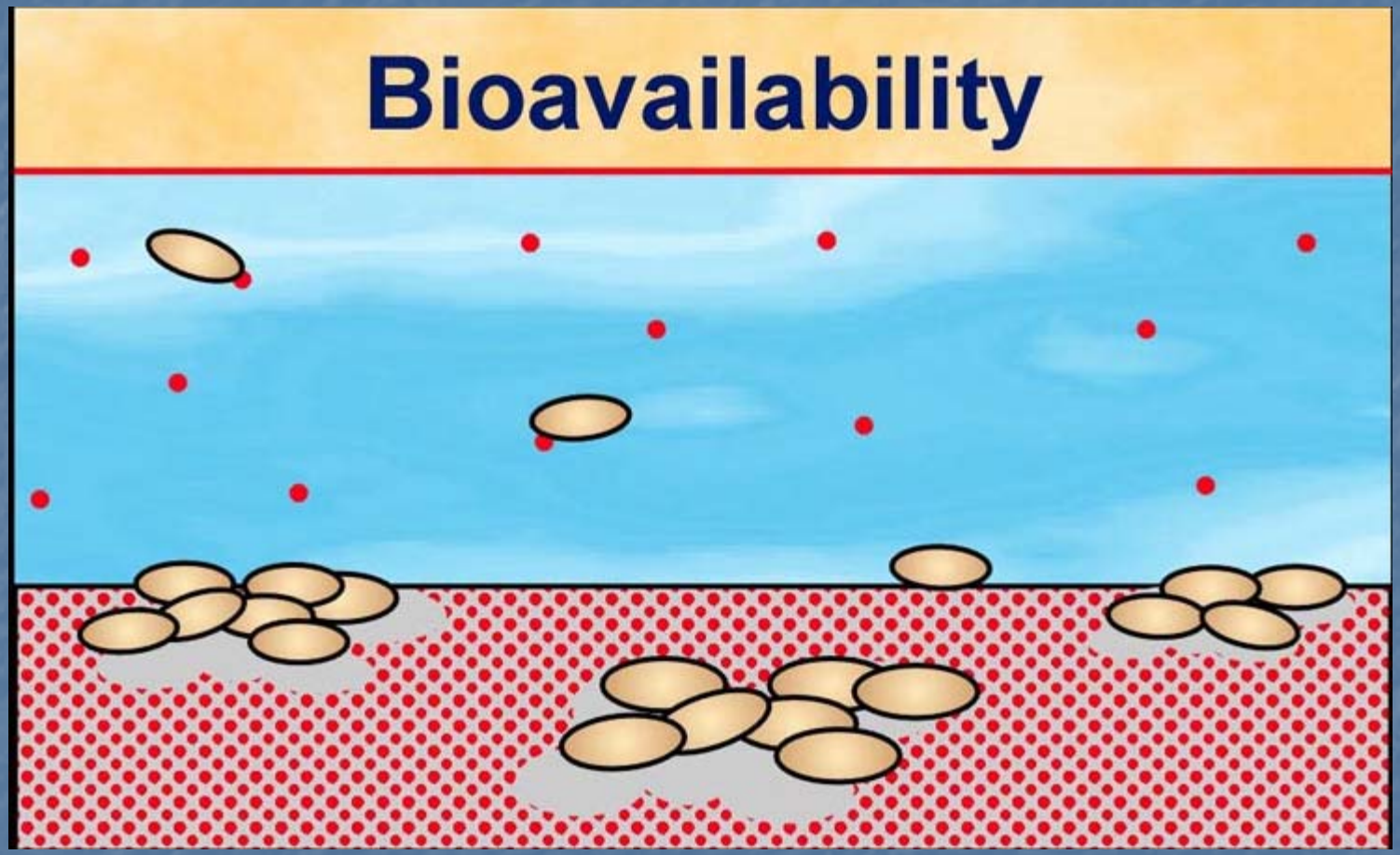
- The biofilm may grow until the surface layers begin to slough off into the water, and the pieces of biofilm released into the water may continue to provide protection for the organisms until they can colonize a new section of the distribution system.
- Macromolecules tend to accumulate at solid-liquid interfaces, creating a favorable environment in other-wise nutrient-deficient situation.
- A high flow rate in the system can transport tremendous quantities of nutrients to fixed microorganisms, even when nutrient concentration in the water is low.

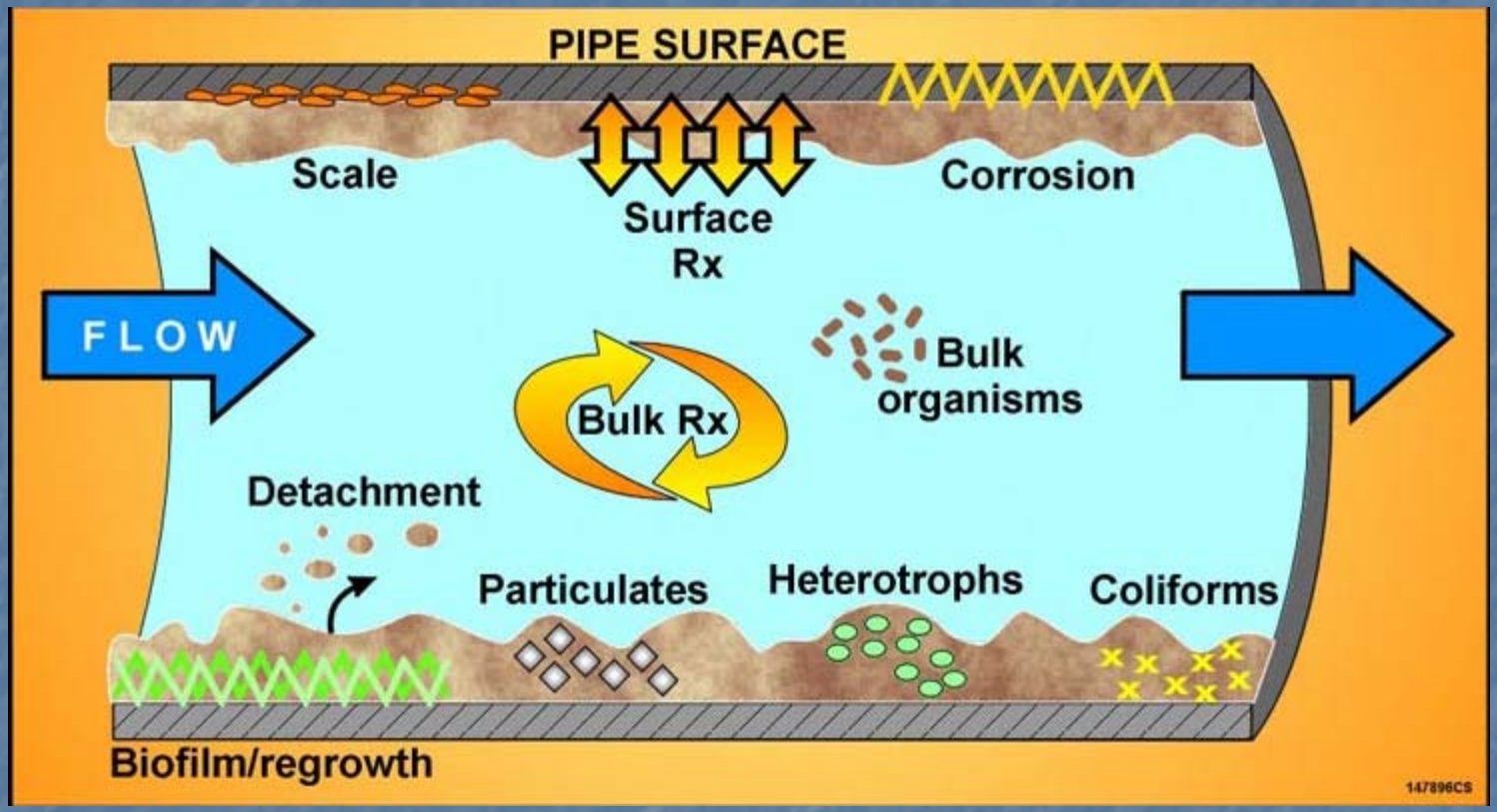
- Production of EPS (extra cellular polysaccharides) helps to anchor attached bacteria; EPS also may be a factor in nutrient capture.

- Bacteria embedded in EPS matrices are protected from disinfectants by a combination of physical and transport phenomena.


Source water
Treatment
Filtration &
disinfection
Storage
Filter
media
Distribution
system
Water
Water
Pipe
wall
Distribution
system pipe
Biofilm on pipe
Biofilm
on media
BS01499

Bioavailability

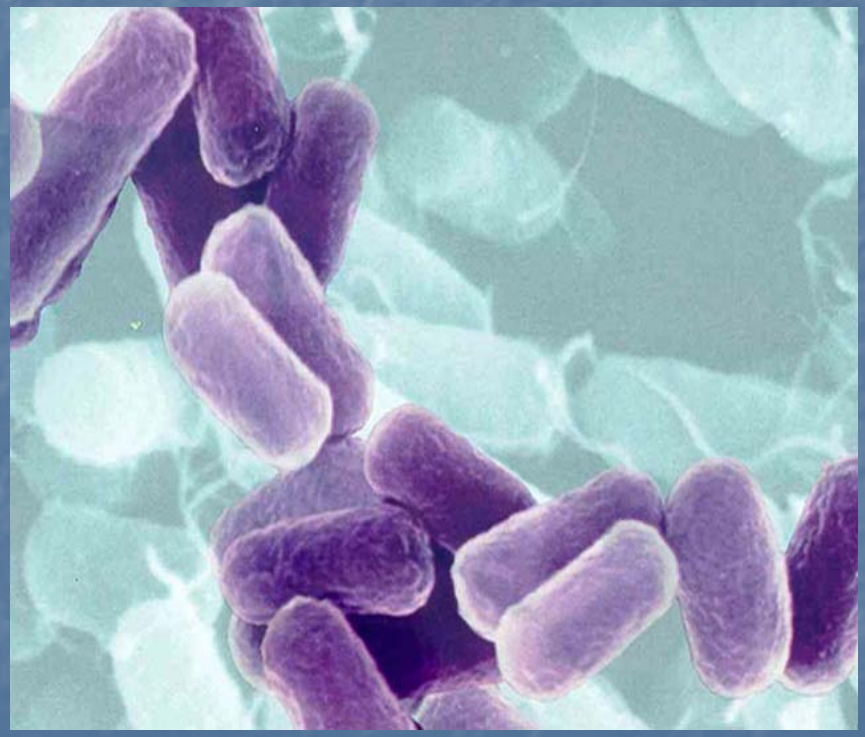



PIPE SURFACE
Scale
Surface Rx
Corrosion
FLOW
Bulk organisms
Bulk Rx
Detachment
Particulates
Heterotrophs
Coliforms
Biofilm/regrowth
147896CS

What Kinds of Microorganisms Make Up the Biofilm?

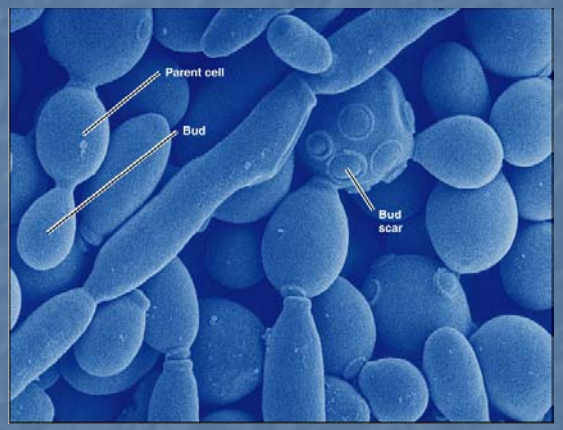
- Bacteria

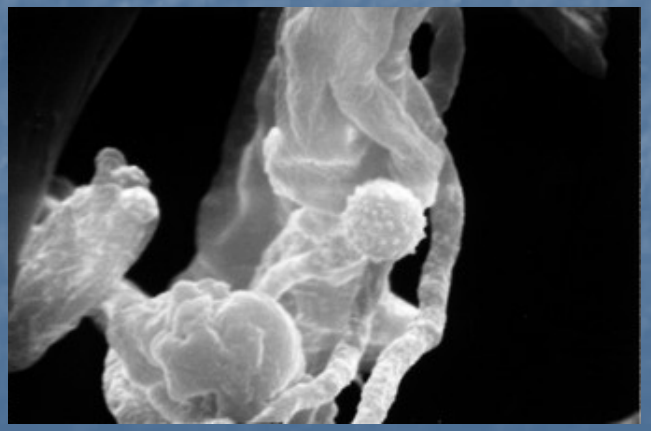
  The predominant coli form species generally include Enterobacter cloacae, Klebsiella, Citrobacter freundii and Enterobacter agglomerans.



- Fungi

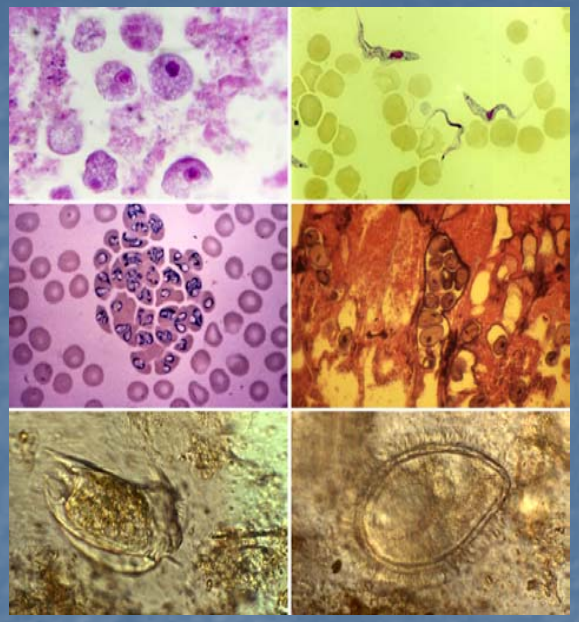
Fungi which include yeasts and molds can be found in finished water and can colonize and multiply in the pipe system. The primary concerns for fungi in drinking water are taste and odor complaints.





- Protozoa

Biofilms in potable water systems may contain a variety of nonpathogenic protozoa and other invertebrates.



Factors that favor biofilm growth

- Hydraulic Effects
- Nutrient Availability

  Carbon

  Nitrogen and Phosphorus
- Other Sources of Nutrients
- Disinfection Residual Concentrations
- Corrosion
- Sediment Accumulation

Discussion

How to Recognize a Biofilm Occurrence

1. Detection of Breakthrough Contamination
2. Detection of Biofilms
   - Characteristics of Biofilm Problems
   - Examination of Pipe Surfaces
   - Measurement of Nutrient Levels
   - Corrosion
   - Examination of Hydrodynamics

Biofilm Control Strategies

Comprehensive Distribution System Maintenance Program

- Regular flushing
- Pigging
- Pipe replacement

Reservoir Maintenance

- Rinse prior to use
- Limit retention times
- Maintain adequate residuals
- Keep covered

Corrosion Control

- Use chemical inhibitors
- Adjust pH

Appropriate Disinfection Practices

- Increase free chlorine residual
- Use alternate disinfectant

Reduced Nutrient Levels

By using:

- Activated carbon filters
- Mixed carbon/sand filters
- Biologically activated filters

Best Available Technologies to Meet the Total Coliform Rule

- Wellhead protection program
- Maintenance of disinfectant residual in the distribution system
- Proper distribution system maintenance
- Filtration and/or disinfection

Conclusion

- The water supply and distribution plays an important role in the Distribution System Monitoring and biofilm control strategies. It is always beneficial to have a thorough monitoring as it provides a historical data, which can help to detect changes in bacterial quality problems and also the sources of contamination. The risk of developing a biofilm problem is reduced by practicing good pipe maintenance and regular flushing of distribution lines.

THANK YOU