Understanding the Importance of Biofilm in Recreational Water

*Darla Goeres, Ph.D.*

Dr. Darla Goeres has been doing research at the CBE since 1997. She leads the Standardized Biofilm Methods Research Laboratory, where her primary research focus is the development and validation of methods for growing, treating, sampling and analyzing biofilm bacteria. Dr. Goeres is the Chair of ASTM Committee E35 and is an active participate in ASTM Subcommittee E35.15 where she is the technical contact for the five approved biofilm methods. She and her team have collaborated with the US EPA Microbiology Laboratory Branch on the development of biofilm efficacy tests. In her tenure at the CBE, Dr. Goeres has investigated the efficacy of biocides for use in health care facilities, homes, recreational water, oil fields, and manufacturing plants. In 2014 she had a Fulbright to do research and teach in Finland.

**Abstract**

Biofilm is defined as a cooperative community of microorganisms embedded in an extracellular polymeric substance (slime). Biofilm may consist of a variety of different microorganisms, including pathogenic bacteria. Biofilm is of particular importance to the recreational water community because once a biofilm is established, the bacteria become extremely tolerant to disinfection and the slime becomes challenging to remove from a surface. In addition to the health concerns associated with pathogenic bacteria in recreational water, the slime makes surfaces slippery and aesthetically displeasing. This presentation will explain what biofilm is, how it grows and what other industries are doing to control biofilm in their facilities.
Understanding the importance of biofilm in recreational water

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Center for Biofilm Engineering

OVERVIEW

Establishment of a field

4863 biofilm papers in 2016 (PubMed)
CBE research areas

- Biofilm control strategies
- Energy solutions
- Environmental technologies
- Health / medical biofilms
- Industrial systems & processes
- Standardized methods
- Water systems

Biofilm bacteria are a self-organized, cooperative community of microorganisms embedded in a matrix of extracellular polymeric substances.
Use our understanding of basic biofilm concepts to solve biofilm problems in industrial and medical fields.
Soap Dispenser Biofilms

Biofilms in Beer Draught Lines

Biofilms in Premise Plumbing
Biofilms in Recreational Water

- Earliest reference of biofilms in hot tubs was in 1978 by Sausker et al.
- In 1984, two papers describe how biofilms may protect bacteria and therefore increase resistance to disinfectants. (Favero 1984; Chandrasekar et al. 1984)
- In 1988, Price and Ahearn attribute the recolonization of P. aeruginosa in hot tub water to the presence of biofilms

PubMed search of biofilm and recreational water: 20 hits
### Field Survey: Bacteria in 7 Hot Tubs

<table>
<thead>
<tr>
<th>Hot Tub</th>
<th>Disinfectant (mg/L)</th>
<th>Biofilm CFU/cm²</th>
<th>Suspended CFU/ml</th>
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<tr>
<td>1</td>
<td>2.8</td>
<td>501</td>
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Fouled filter does not contaminate the bulk fluid until no chlorine is measured.

Free Chlorine Concentration (mg/L)

Suspended Cells (log₁₀ CFU/ml)
Fouled coupons do not contaminate the bulk fluid until no chlorine is measured.

Healthy Recreational Water

- Quality Water
- Microbiology
- Design
- Water Chemistry
- Training

Biofilm Strategies

- **Reduce/control** the biofilm (low level of efficacy)
- **Kill** the viable biofilm bacteria (high level of efficacy)
- **Prevent** biofilm
- **Remove** biofilm
Biofilm Remediation Strategies

- Brush
- Floss
- Mouth wash
- Dental visits

Biofilm Remediation Strategies

- Disinfection
- More aggressive disinfection as necessary (when pool is closed)
- Surface cleaning (mechanical and/or chemical)
- Complete system check-up & maintenance

Include Biofilm in the Conversation

- Pool operator training
- Guidance documents
- Disinfection testing & validation
- Client education
Collaboration = Success

Swimmers

Public Health

TRADE ORGANIZATIONS

Standard Setting Organizations

Regulators

Academics

Biocide Companies

Manufacturers

Standardized Biofilm Methods Laboratory

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