Processing Water - I Thought It Was Sanitary

Moderator: Josie Greve-Peterson PSSI Food Safety Solutions, United States

Organized by the Water Safety and Quality PDG

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Today’s Presenters

Josie Greve-Peterson  
PSSI Food Safety Solutions, United States

Josie Greve-Peterson is the Corporate Microbiologist for PSSI Food Safety Solutions where she develops and implements strategies and programs to mitigate food safety risks, which includes providing microbiological and technical support. Josie has a B.S. and M.S. degree in microbiology, more than 11 years of experience in the food industry in various quality management and food testing roles, and serves as Vice-Chair of the Dairy PDG.

Diane Walker  
Montana State University, United States

Diane Walker is a Research Engineer at Montana State University’s Center for Biofilm Engineering where she works with an interdisciplinary team of engineers, microbiologists and statisticians in the Standardized Biofilm Methods Lab (SBML), developing methods to grow, treat, sample and analyze biofilms for use by academia, industry and the regulatory agencies. Diane has degrees in biology, bio-resources engineering, and environmental engineering from MSU, and has worked with the SBML for more than 15 years.
Phyllis Posy has extensive experience working with city, state, federal and international governments, and stakeholders, bringing environmental, water and reuse technologies to market, and implementing them to improve water and food processing. She is President of Posy Global in Jerusalem, Israel, and Secretary of the Water PDG.

Neil Bogart is an Executive Area Technical Support Coordinator for the Food & Beverage division of Ecolab. Prior to Ecolab, he worked in food manufacturing in Quality and Regulatory and was a Food Safety Consultant specializing in food safety program development and sanitation systems. He is also a Chef. Neil holds a Food Science degree from Mississippi State University and his Le Cordon Bleu from Monroe County Community College.
Biofilms

Diane K. Walker
Research Engineer
Standardized Biofilm Methods Lab
Montana State University

IAFP Webinar | June 8, 2021
Biofilms are a self-organized, community of microorganisms embedded in a matrix of extracellular polymeric substances.
Free-swimming cells alight on a surface and attach
New genes are expressed to synthesize matrix polymers
Cells coordinate by exchanging signaling molecules
Quorum Sensing

PLANKTONIC

- Relatively low HSL concentration
- HSL secreted

BIOFILM

- Locally high HSL concentration
- Modified metabolism
- HSL secreted
- HSL receptors

© 2004 CENTER FOR BIOFILM ENGINEERING MSU-BOZEMAN
Pathogen Survival in Biofilm

Green is \textit{gfp} \textit{P. aeruginosa} PA01
Red is \textit{dsRed} \textit{E.coli} 0157:H7

Bacteria reproduce and form microcolonies.

Chemical gradients are established.
Cell-Cell Communication
Cells dissolve matrix and are released
Biofilms Impact...

- Teeth
- Oil Recovery
- Drinking Water
- Paper Manufacturing
- Medical Implants

- Cooling Water
- Food Processing
- Ship Hulls
<table>
<thead>
<tr>
<th>Static Biofilm</th>
<th>Drip Flow Biofilm</th>
<th>CDC Biofilm</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Shear</td>
<td>Low Shear</td>
<td>High Shear</td>
</tr>
</tbody>
</table>

Fluid shear is important
Disinfectant efficacy depends upon how the biofilm was grown.
<table>
<thead>
<tr>
<th>Surface Material</th>
<th>Log Density ($\log_{10}$ CFU/cm$^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polycarbonate (left)</td>
<td>8.58</td>
</tr>
<tr>
<td>Stainless Steel (right)</td>
<td>7.89</td>
</tr>
<tr>
<td>Polypropylene</td>
<td>8.01</td>
</tr>
<tr>
<td>Borosilicate Glass</td>
<td>8.23</td>
</tr>
<tr>
<td>Surface Material</td>
<td>Log Density (log_{10} CFU/cm^2)</td>
</tr>
<tr>
<td>---------------------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td>HALAR (ECTFE)</td>
<td>7.40</td>
</tr>
<tr>
<td>PEEK</td>
<td>6.78</td>
</tr>
<tr>
<td>UHMWPE</td>
<td>7.09</td>
</tr>
<tr>
<td>ETFE</td>
<td>7.71</td>
</tr>
<tr>
<td>Ceramic</td>
<td>8.50</td>
</tr>
<tr>
<td>PVDF</td>
<td>9.25</td>
</tr>
</tbody>
</table>
Biofilm affords protection from antimicrobial agents
Movie: Alcohol/Quat blend (undiluted)
Movie: Phenolic disinfectant (1:16)
Movie: Chlorine (1:20)
Microbial Biofilms: Sticking Together for Success

Single-celled microbes readily form communities in resilient structures that provide advantages of multicellular organization.

- **Spore-like ultramicrobacteria** grow in right conditions
- **Planktonic bacteria**
- **Surface attachment:** Within minutes
- **Early biofilm formation:** Within minutes to hours
- **Outer cell layers** absorb antimicrobial attack
- **Fluid flow** delivers nutrients to colonies
- **Micro-environments** harbor different species or phenotypes
- **Proximity** promotes cell-cell signaling
- **Biofilms migrate:** Detachment, dispersal, rolling, rippling
- **“Dispersers”**
- **“Wall formers”**
- **Single species may differentiate for tasks**
Thank You!

Standardized Biofilm Methods Lab:
Darla Goeres
Paul Sturman
Al Parker
Kelli Buckingham-Meyer
Lindsey Lorenz (Miller)
Diane Walker

“See” you in Phoenix!
I thought it was Sanitary!

Processing Water: Assessing Risk for Biofilms in Food/Dairy Processing: Why and How?

Phyllis B. Posy
President, PosyGlobal
PosyGlobal

Leveraging 5 decades of experience answering the need for practical ideas that make things work better. Helping dairy companies turn water into a resource.
Context: Biofilm RA in a changing world

Step 1: Choose a focus

Step 2: Analyze your water supply

Step 3: Evaluate your vulnerability

Step 4: Develop/Evaluate strategies
Context: The World Has Changed

Customer requirements have changed

- Clean Label
- Different uses increase risk

Research:
- Lots of research: 9778 peer-reviewed pubs; 46 on specific Dairy Processing biofilm-related issues
- Before AND after pasteurization
- WGS can point a smoking gun!

Climate Change
- Temperature extremes; precipitation extremes
- More feed contamination
- Somatic cell counts rising require more antibiotics
- Gene transfer promoting resistance to treatments

Graph courtesy of Dan Vimont, director of the Center for Climatic Research
Context: Do you *REALLY* have to worry?

**Similarities with Standard RA:**
- Aggregate; data-based; action oriented

**Critical Differences:**
- MRA: compliance indicators; bacteria; additive; only amounts above the threshold carry real risk
- BF RA: interactive; cumulative; any amount carries risk slow operations; spoil product; cause loss

**Does current system address history or today?**

**Key directional questions: Are you**
- Relying on municipal water without further testing?
- Using coliform testing as the key indicator?
- Reducing time dedicated to cleaning/QA?
- Extended operational runs since the last HACCP Plan?
- Updating facilities regularly?
Context: Biofilm RA in a changing world

Step 1: Choose a focus
Step 2: Analyze your water supply
Step 3: Evaluate your vulnerability
Step 4: Develop/Evaluate strategies
Step 1: Pick a Corollary Goal/ Focus

Recognize your culture:
- Never have any processing lapses
- A little more chlorine will kill it all off….
- We had some occasional counts… nothing serious
- Climate Change won’t affect us
- If it is not completely broken, trying to fix it will make it worse
- Rinsing with lots of water will prevent biofilms

Dizzying array of tools

Understand your organization
- What would be meaningful?

Define a corollary goal
- Intractable even nuisance problem
- Operational optimization
- Reuse water planning

Generate support for a serious risk assessment

Keep focus on the target and how the RA ties to it!
Context: Risk Assessment in a changing world

Step 1: Choose a focus

Step 2: Analyze your water supply

Step 3: Develop a Data Plan

Step 4: Make it a habit over the long term
Step 2: Analyze your water supply

- Depend on Municipal /WHO potable water?
- Differ with official FDA/FSMA position (as does the EPA)
- Can standards designed to make water safe for individuals be applied to food processing facilities?
  - US rules make no distinction between food manufacturing facilities and a single home: a service connection is a service connection.
  - A PWS serving 10 households and a large food processing/manufacturing facility has the same testing/monitoring requirements as a supplier that serves 11 households and no manufacturing facility.
  - PWS focus on Fecal e coli, will not indicate salmonella, listeria, bacillus or pseudomonads, masking biofilm, spoilage, even potential food safety risk.
  - Sampling, analysis and reporting timing mean that pipes would be inoculated and even product shipped before you can take action.

If you depend on external water sources without further testing/tracking you are at high risk for biofilms
Do Municipal Water Rules Protect Food Processing?

- What does the EPA say?

Meeting as part of preparation for a Symposium and a followup series of IAFP webinars

1. Senior EPA Rule and Implementation Managers

   - Food Processors should understand:
     - We protect drinking water; food processing is an off-label use
     - Our risk assessment does not take into account hazards that are reasonably likely to occur in a food production facility
     - High carbon environment of food processing premise plumbing is not in EPA purview
     - Premise plumbing pressure variations can make a big difference to microbial integrity
     - Impact of Backflows, cross connections and deadlegs in premise plumbing not considered
     - Timing is not on their side

   Speaker: Ewen Todd, Phyllis Posy, Dorothy Wrigley and Ewen Todd

   Convener: Phyllis Posy

This session will confront the generally accepted position that if water is good enough to drink, it is good enough to use for food processing. Speakers will analyze the data on whether/how the gap between EPA Drinking Water and FDA FSMA policies leave a hole in the middle that can compromise food safety and dialogue about solution models. The Revised Total Coliform Rule (RTCR, effective 4/2016) redefines the Safe Drinking Water Act criteria for fecal Escherichia coli as the exclusive indicator for compliance. It changes requirements for public notification when samples are positive in favor of triggered assessments (“find and fix”). Users could never know that microbiologically contaminated water was provided, except from the annual water quality report a year or more later. While impact on individuals drinking might be minimal, food processors, especially small and medium manufacturers relying on municipal water, could be contaminating their pipes and products. Municipal water can be used for processing (food contact or even ingredient water) without any risk assessment because FSMA specifically excluded municipal water users from requirements to address water in their written Food Safety Plans. In reality, not all municipal water is disinfected and public water suppliers must be compliant with treatment requirements only 95% of the time. Recent research in Minnesota and Wisconsin found EPA compliant water, when not disinfected, can be contaminated with Salmonella and other organisms of concern. Viable pathogens can infiltrate, through non-point sources or through the hydraulic action of high service pumps, and go undetected by EPA standard testing. Our current statistics do not capture the link between food outbreaks where the underlying transmission agent or amplification is in the “drinking water”. Here, EPA, FDA, and FSIS panelists discuss: How big is the hole in the middle and can it compromise food safety? What should we do about it?

Presentations:

- What is in Drinking Water that Could Matter: The Minnesota Virus Study
  Mark Borchardt, US Dairy Forage Research Center, USDA-Agricultural Research Service

- Do We Only Find What We Are Looking for?
  Vincent Hill, Division of Foodborne, Waterborne and Environmental Diseases Centers for Disease Control and Prevention

- Solutions Panel: Is There an Addressable Gap and What are Options and Models for addressing it?
  Moderator: Phyllis Posy
  Strategic Services & Regulatory Affairs Atlantium Technologies, Vice Chair Water Safety and Quality PDG
  EPA Perspective: Dr. Julie Javier
Does Groundwater-borne Illness Risk Meet EPA Standards?

• Acceptable EPA risk for waterborne disease is 1 infection in 10,000 people/year

• Assume every infection leads to an illness, then the acceptable illness rate is 0.0001 illness/person-year

• In the spring of 2006 the WAHTER Study measured 0.44 illness/person-year in children < 5 years old that was attributed to groundwater

• 4,400 times higher than EPA acceptable risk
Follows basic concept of the WATHER study

- 74% of the population relies on municipal groundwater
- 567 PWS do not disinfect; 243 community; 324 NTNC
- 82 wells in study – 14.7% of the systems
- All compliant – no e coli (none triggered the GWR)

Tested for: Human Enteric Viruses Adenovirus Group A –F; Enterovirus; Norovirus GI & GII; Hepatitis A; Human Polyomavirus; Rotavirus; Salmonella spp.; Campylobacter jejuni; Enterohemorrhagic E. coli (EHEC); Bovine Bacteroides; M3 Bacteroides-like; Bovine polyomavirus; Pepper mild mottle virus; Total coliforms and E. coli

66% wells positive for a target; 20% positive for salmonella;

Of those, 60% TCR positive but NONE positive for e coli
Is All Municipal Water Compliant?

Overall compliance gaps triggered April 2021

Compliance Advisory

- FY2020: 34% violated at least 1 standard
- 7% health violations (21 million people)
- Reporting violation are “cheaper” than a hit
- Many violations under the radar: 5% rule

Survey of Compliance in 2015 in 3 top dairy states

- State Detection Database used; survey of dairies/ farms and processors
- In one state, over 430 dairy facilities were in areas served by public water systems that had TCR detections, did not exceed 5%, so no violations:
  - Detections report pathways
- Second state, of 38 dairies; CCR reports showed half had detections
  - 3 had violations- so three get public notice a year later
- Third state, 54 dairies were listed as “public water systems” from 2012-2015: 18 had one or more hits/and/or violations.

Check: https://echo.epa.gov ; ewg.org/tapwater
Where does your water come from?
- Does your water supplier buy finished water or treat it?
- Ground Water or Surface? blend or use only one source?
- How much Defacto Reuse?
- Understand the treatment process!
- Does your system disinfect? With what? To what level?

Determine what percent of their output you get?

Where on the distribution system are you located
- Are you the end of the line?
- Are there sampling points nearby that will provide information?

Check on your state database for recent detections, violations; check your CCR
- Have been any in the past 18 months? Did you know at the time?
- Determine if there is a realistic way you can stay in the loop so you can – on a timely basis -- evaluate, monitor, verify issues and variability in your specific supply (esp. blending)
Step 3: Evaluate Your Vulnerability

- Develop a data plan
  - Speciate incoming water to create a benchmark
  - Check your QA data against FoodTracker (Thank You Cornell!!)

<table>
<thead>
<tr>
<th></th>
<th>Isolates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Listeria monocytogenes</td>
<td>14,561 isolates</td>
</tr>
<tr>
<td>Pseudomonas spp.</td>
<td>3,809 isolates</td>
</tr>
<tr>
<td>Vibrio parahaemolyticus</td>
<td>160 isolates</td>
</tr>
<tr>
<td>Streptococcus spp.</td>
<td>2,938 isolates</td>
</tr>
<tr>
<td>Streptococcus agalactiae only</td>
<td>1,233 isolates</td>
</tr>
<tr>
<td>Lactic acid bacteria</td>
<td>453 isolates</td>
</tr>
<tr>
<td>Salmonella spp.</td>
<td>14,928 isolates</td>
</tr>
<tr>
<td>Bacillus spp.</td>
<td>4,161 isolates</td>
</tr>
<tr>
<td>Paenibacillus spp.</td>
<td>2,502 isolates</td>
</tr>
<tr>
<td>Klebsiella spp.</td>
<td>634 isolates</td>
</tr>
<tr>
<td>Total isolates</td>
<td>88,599 isolates</td>
</tr>
</tbody>
</table>

Speciate in Zones 3&4 before a vacation or break;
Generic gram neg?
How to Build a Data Plan

QA: MAP Micro trail for the last 2 years
- Incoming water variability
- Anomalies can mean persistence

MAP Maintenance – repeats/preventive -2 years
- Cooling/heating systems: pinhole leaks, joint fixes

MAP Engineering – go back 2 years; ahead 2
“Normal changes” can be opportunities
- Deadlegs often ignored in the rush to end

MAP Utilities: Water use volume; variability
- CIP the most constant, process critical
- By product/by time of day/by season
- Flowmeter, records point to gaps
- Power too!
To determine Vulnerabilities, ask your team:

**Consistency: cleaners & sanitizers evaluated/changed?**
- Chemicals may remove biological fouling
- Enzymatic cleaners better for residual elements
- Frequent changes will control biofilms more than consistency

**Any inherent risks in your specific products or process?**
- Storing water (fiberglass, temperature, with/without residual) vents?
- Ct time and pipe flow rates- will the chemicals really work?
- Pipe materials- some materials have natural pits
- Disinfection by products

**Have you reviewed your system for:**
- Cross-contamination possibilities: sequential use for diff products
- Water used in the packaging process
- Any special relevant incidents or factors?
Evaluate each process component

**In process contamination/cross contamination/backflow**

- Power anomalies
- GAC and other filters? optimum niches for microbial growth
- Untreated water hoses for cleaning?
- Water Storage tanks? especially without hepa filters; fiberglass in the sun
- Heat exchangers with pinhole leaks
- Ice chillers and cooling processes recirculate
- RO membranes foul; haven for biofilms; watch flux clean earlier

**Consider how dynamic your system is**

- Frequency of product or process changes?

**Post process contamination**

- Thermophilic and psychotolerant spores
- Flushes for post-pasteurization pipes
- Rely on sheer forces or volume to do the job? Vary!
- Any pre-rinse water used in later stages?
Is chlorine a silver bullet or simply overused?

In a study by the University of George on resistance of Listeria individual cells (planktonic) and biofilms to chlorine, 13 strains of Listeria were grown and exposed to a very high concentration of chlorine. Both individual cells and biofilms were resistant. Biofilms of each strain were grown on stainless steel coupons. The biofilms were exposed 60 ppm of sodium hypochlorite. When in planktonic culture, four strains were able to survive exposure to 40 ppm of chlorine, whereas four strains were able to survive 80 ppm of chlorine in at least one of three tubes. The remaining five strains survived exposure to 60 ppm of chlorine. Biofilms of 11 strains survived exposure to 60 ppm of chlorine.
Step 4: Find the right Strategies/Tools

- Key technologies come in various sizes/combos
- Coordinate with Corollary goal
- Chemicals may be useful for specific need/processes
  - Understand what they leave behind, potential impact
  - Change regularly to prevent resistance/assure efficacy
- Chlorine Dioxide/Ozone, other aggressive treatments
  - Consider potential product contact; worker exposure

Tools

- Remember your generator and power supply
- Filtration – new media/technologies invented daily
- Consider particle size, most resistant microbe
- Investigate synergies; treatment order may be important
Step 4: Pick the Tools

**UV: Inactivation/ disinfection for water**

- Non-validated tech: high risk
- Polychromatic cover broader spectrum, no regrowth
- Reliable flow meter; control;
- Pay careful attention to process limits: flow, water quality
- Computerized monitoring/tracking;
- Coordinate power
- Develop good startup/shut down process

**Validate, Verify and Document**

- Paper validation; real time verification
- Continual documentation; watch trends carefully
Risk is part of Life
Life is not a Lab

- Biofilms won’t disappear
- Don’t be afraid of new tech
- Start with peer reviewed lit; Translate your conditions
- Credible validation: base paper analysis on process limits
- Be alert to climate, environmental, water variability

Achieving Corollary goal will make the RA work

Pay for Service: more realistic cost comparison

Document from the beginning

- If it is not documented, it did not happen
Thank you for your attention!

Please address any reactions, comments and questions to:

**Phyllis Butler Posy, President**

**Phone:** +1 347 220 8397, +972 54 665 1071  
**www.PosyGlobal.com**

**FSMA:** PCQI; FSVPQI  
**Skype:** Phyllis.Posy
REAL-LIFE MYTHS & COMMON MISTAKES

Food Manufacturing Biofilms

Neil Bogart – Executive Area Technical Support Coordinator

JUNE 8, 2021
MYTHS & MISTAKES

Water Hammering & Excessive Processing Vibration

My system has hammered for as long as I have been here.

- What is the excessive pressure doing at connections?
  - Could it be creating niches?
ATP Verification

I swabbed my equipment after the post rinse and got counts.

- Plausible
  - Inadequate rinsing times
  - Biofilms in processing water
    - PM of water header
    - CIPable water header
    - Water nozzles
    - Flex hoses
  - UV inactivates, but ATP can still be picked up
MYTHS & MISTAKES

Mechanical Action - Turbulent Flow

Chemistry alone will remove a biofilm

- False: Biofilms can survive saturation with disinfectants.
  - Mechanical action is needed to completely remove a biofilm
- Biofilms attachment to the surface is based off the environment
Dead Leg Rules

- Any drops or unused portion of any length of piping has the potential for the formation of a biofilm and should be eliminated if possible or have special sanitizing procedures.
Preventative Maintenance Program

Insufficient preventive maintenance

Elastomers

Torque requirements

- PTFE (Teflon)
- Viton
- EPDM
- Buna-N

### Typical Applied Torque Settings

<table>
<thead>
<tr>
<th>Gasket Material</th>
<th>Torque (in-lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silicone</td>
<td>25-30</td>
</tr>
<tr>
<td>EPDM</td>
<td>30-44</td>
</tr>
<tr>
<td>PTFE &amp; PTFE Blends</td>
<td>50+1</td>
</tr>
</tbody>
</table>

1. Consult clamp manufacturer for maximum allowed torque settings.
MYTHS & MISTAKES

Preventative Maintenance Program

i-Clamp® Gaskets could fail for reasons causing leaks, strain and ultimately blow. To the right are reasons why a gasket would what to look for lining gaskets us line.
MYTHS & MISTAKES
Smooth Surfaces - Stainless Steel Surface
Photos of a stainless steel surface ($R_z = 0.8$)
Smooth Surfaces - Stainless Steel Surface

2B Finish

- This is achieved by cold rolling, heat treating and pickling, along with the application of a light rolling at the end in order to achieve a smooth and reflective sheen. Considered the most widely used surface finish, 2B is the basis for most polished and brushed finishes. Most stainless-steel grades 304, 304L and 316L come in a standard 2B finish.

Pit Free Dairy (PFD)

- These types of finishes use an intense polishing method to eliminate any unseen pits, scratches or imperfections. Eliminating these imperfections early could also make the finished product easier to clean without the need to use harsh chemicals to eliminate the bacteria that develops.

I washed my system with a procedure that should have killed the biofilm, but my micro counts went up. How could this be?

- Plausible
  - An established biofilm can take numerous washes with the correct 4X4 process to completely remove an established biofilm.

Questions?

Questions should be submitted to the presenters via the **Questions section** at the right of the screen.
Contact Information

• dianew@montana.edu
• phyllis@posyglobal.com
• neil.bogart@ecolab.com
• jgrevepeterson@pssi.com
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June 29   Connecting Processing Systems to Optimize Productivity and Reduce Waste While Achieving Higher Compliance
This webinar is being recorded and will be available for access by IAFP members at www.foodprotection.org within one week.

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