# Water Recovery using RO, Highlighting storage controls and usage

**Derek Pitman – Indigo FSL & Realco**
**Jon Tyrrell – Jon Tyrrell Consulting & Realco**

# Me!

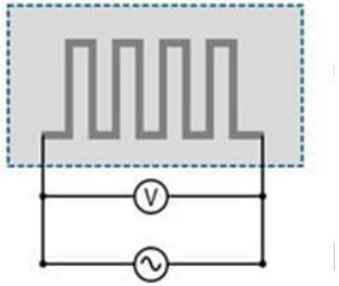
# Derek Pitman & Jon Tyrrell

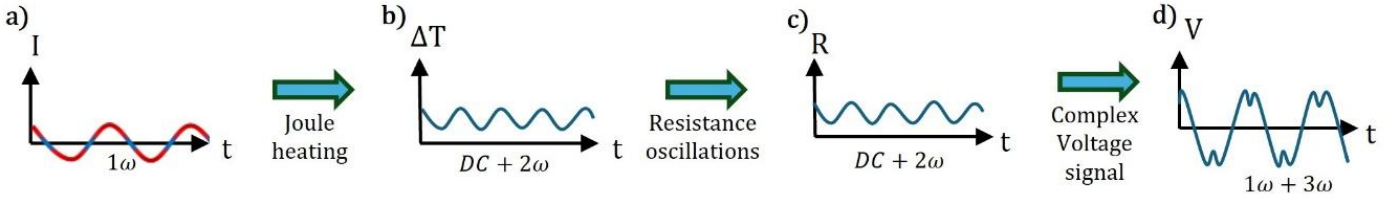
INDIGO Food Solutions

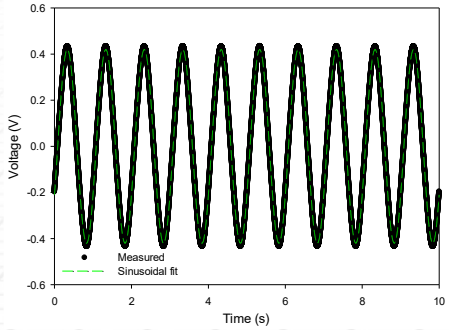
## Our “qualifications” to prepare and present this:

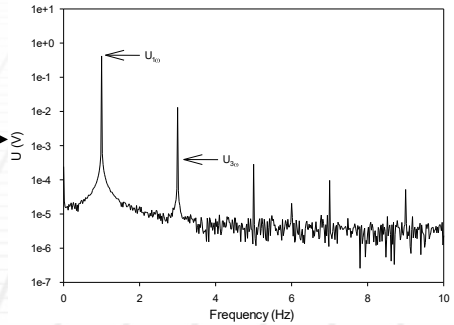
- ✓ Both studied Food & Dairy Technology at CCA, Reaseheath (albeit 10 years apart)
- ✓ Both worked for MMB / Dairy Crest in Production Management roles at various sites with a range of processes and products produced
- ✓ Both joined Detergent / Hygiene companies in Technical Account Manager roles
- ✓ Spent most of this with CCL, CCL Interchem & Pentasol, working primarily within the Dairy Sector and focusing on Membrane Plant Cleaning
- ✓ CCL were the most significant supplier of membrane detergents and support in the UK for over 20 years
- ✓ Also blood plasma and environmental applications
- ✓ Have visited and supplied many sites as part of this role

# Are you ready to start?






$$\acute{U}_{3\omega} = \frac{U_{3\omega}}{U_{1\omega}} = \frac{1}{2}\beta\frac{P}{l\pi\kappa}\left(-\frac{1}{2}\ln(\omega) + k\right)$$

*Developing a sensor to be located within a membrane to measure "fouling build up"*

**Mads Koustrup Jørgensen**
Associate Professor
Department of Chemistry and Bioscience

AALBORG UNIVERSITY
DENMARK

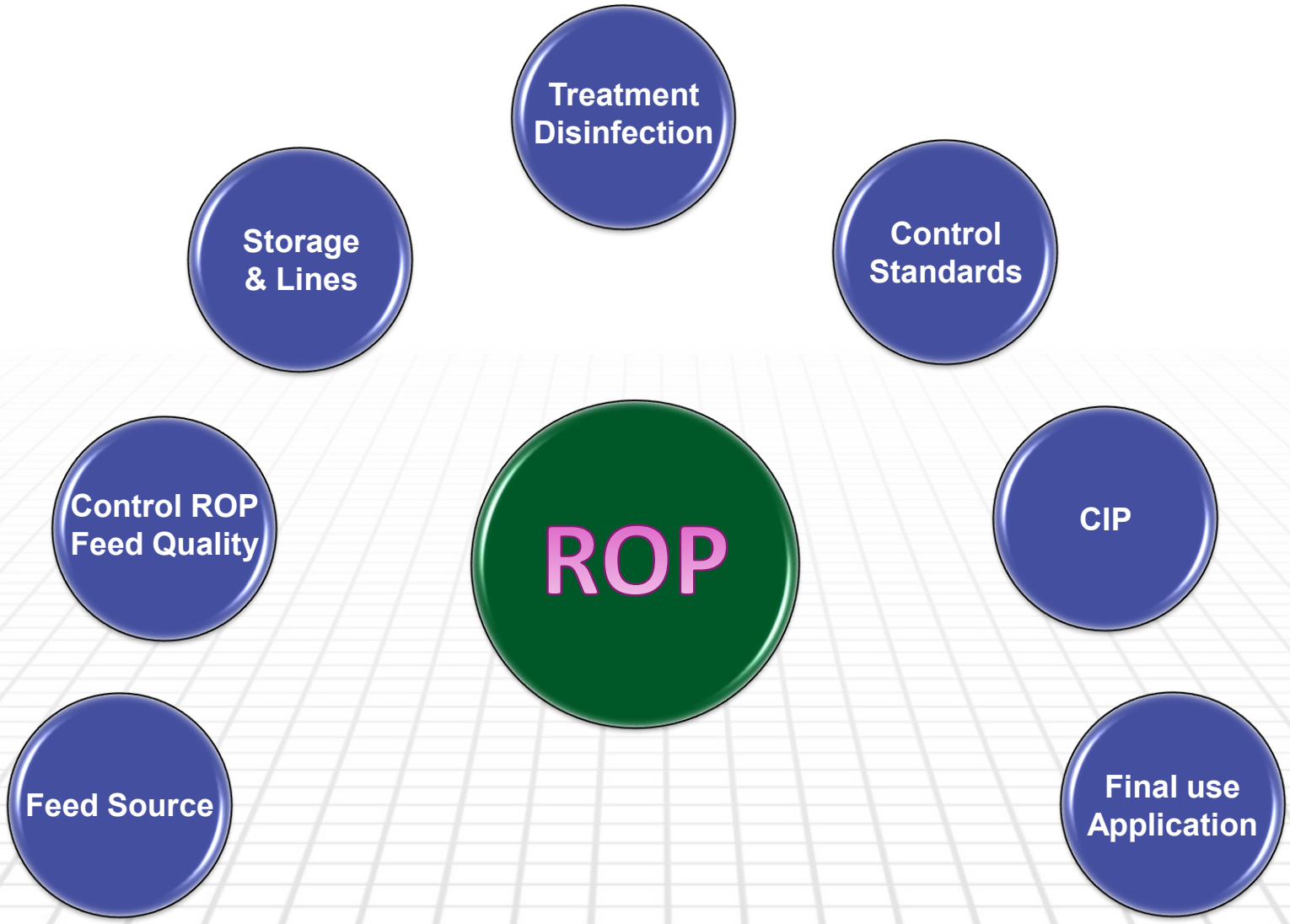
# The early days!

## The early days of water recovery!

- ✓ RO permeate not polished
- ✓ Typically, higher processing temperatures of 20 - 30°C and higher water temperatures
- ✓ Single “recovery” silo with no rotation
- ✓ No CIP options for silos and distribution systems
- ✓ Basic or nil “disinfection” (PAA “slug” dosed)
- ✓ No “monitoring” or control of quality
- ✓ *“We are having micro issues with our WPC / RO whey conc.”*
- ✓ Less stringent final product micro standards
- ✓ Biofilm / biofouling / slime on silo walls and distribution systems
- ✓ Low water use areas such as pump water seal lines and separator operating water lines blocked with slime

# BIOFILM!

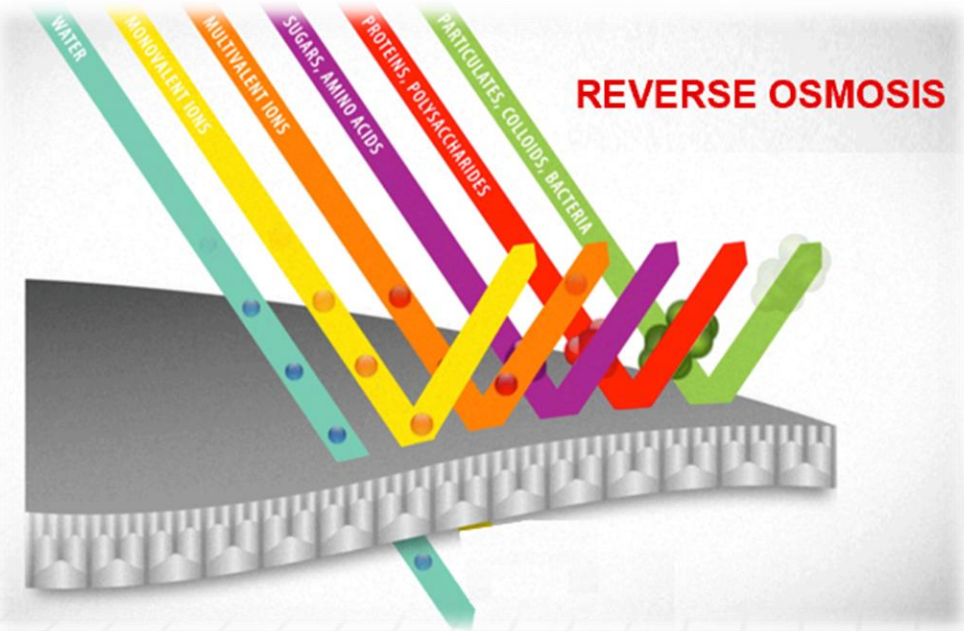
# Water Recovery using ROP



# What is an ROP?

- It is a Reverse Osmosis Polisher
- It is no different to any other Reverse Osmosis plant in its mode of operation
- It is used to maximise water quality prior to disinfection
- Using an ROP can remove 99.5% of remaining contaminants in the feed
- Counter-intuitively, running ROP's at lower baseline operating pressures (7-15 bar) can cause increased passage of organic and mineral loading into the permeate and higher conductivity
- Optimal baseline pressure range generally indicated at 15 – 25 bar

# RO Membrane “separation”




| | |
|---|---|
| Particle characteristic | Ionic |
| Milk system components | Ions |
| | Salts |
| | Lactose/derivate |
| Separation process | RO |
| | NF |

# RO Membrane “Ageing”

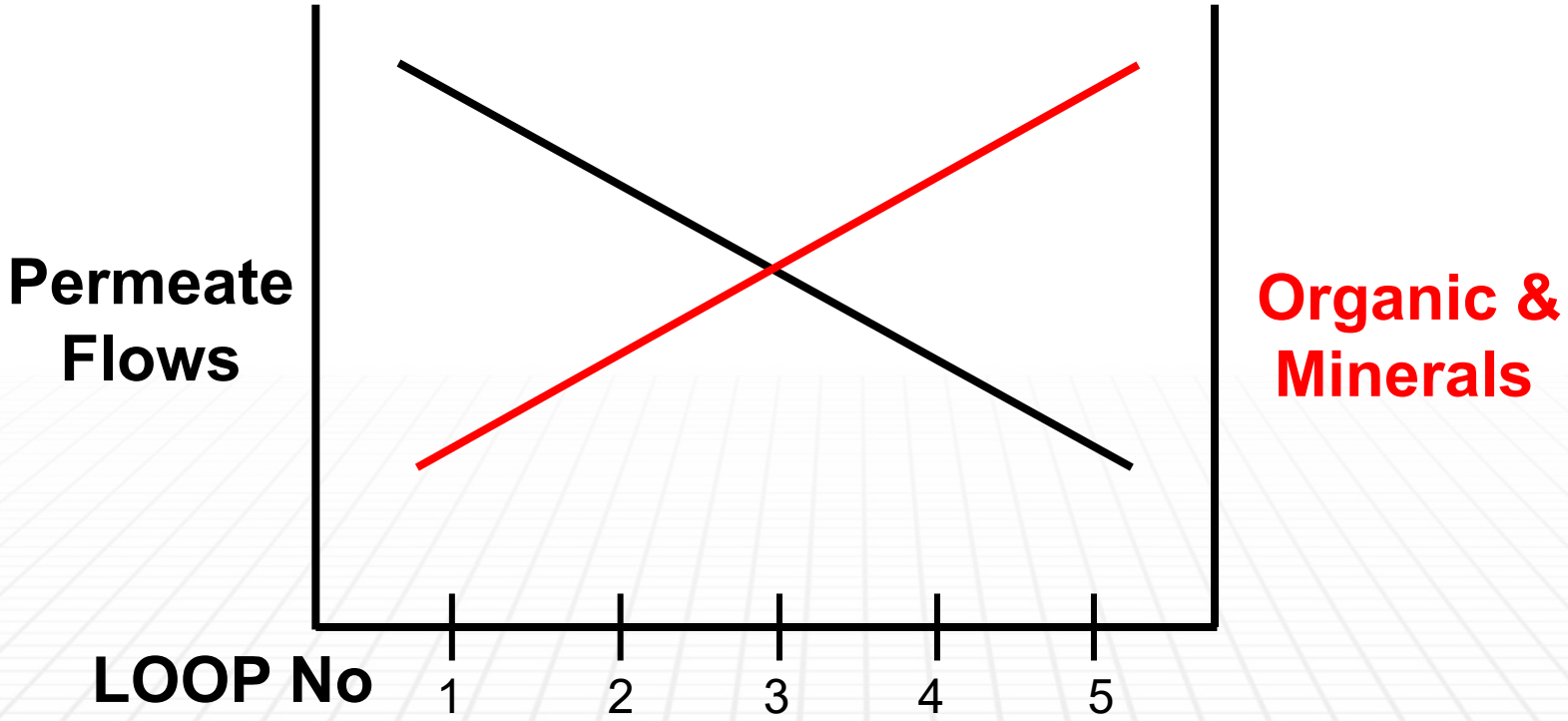
- ✓ Dairy Process streams categorised as “biologically active feeds”
- ✓ “Ageing” and physical damage allow passage / leakage of specific components that provide an ideal environment for micro growth and biofilm formation
- ✓ Organic - Lactose (major component in whey) and Nitrogenous compounds
- ✓ Minerals (salts) - Affect the ionic strength of the permeate. Impacts on bacterial adhesion to the membrane. Reduction in disinfection efficacy
- ✓ Accumulated irreversible fouling
- ✓ Physical damage can impact on cleaning effectiveness
- ✓ ATD Seals leakage
- ✓ Effect of operating pH, temperature and pressure on permeate quality

# Feed Source

- ✓ Green Inititiatives and Sustainability, resource availability and costs
- ✓ RO / NF permeate (typical cheese whey concentration combination)
- ✓ NF permeate (Whey UF for WPC, permeate to NF)
- ✓ RO permeate (skimmed milk)
- ✓ COW water (**C**ondensate **O**f **W**hey). Generic term applied to condensate from any Dairy Evaporation Operation
- ✓ WWT / Effluent – “standard” treatment plant. E.g. DAF, biotank, pH adjust + MBR & RO
- ✓ WWT / Effluent – solids removal, pH adjust, membrane process UF & RO (Axium)
- ✓ Prior to the ROP, treat all silos and lines as though the feed was product. **CIP capability a must!**

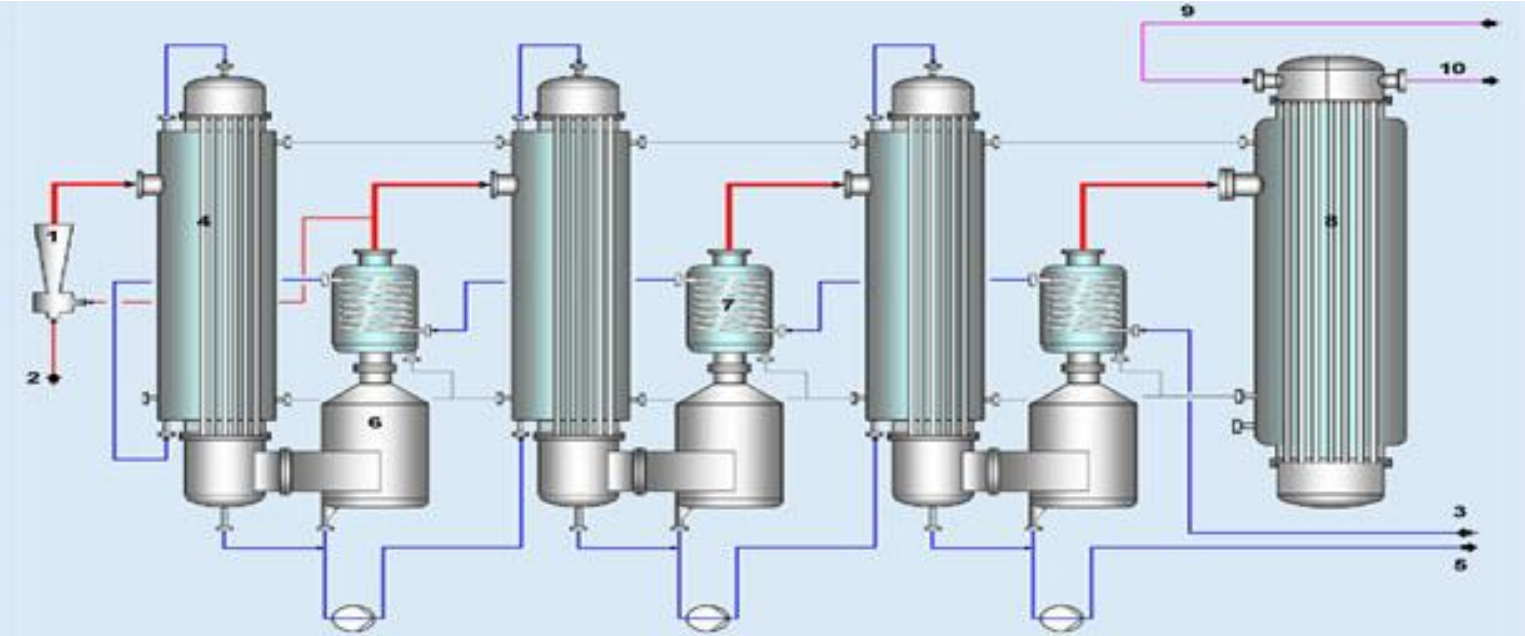
# RO Plant

## RO Plant Permeate Quality




- ✓ If all loops have new membranes, same number and spec in each loop, the total organic & mineral load will be the same from each loop
- ✓ Many sites would send final loop(s) to WWT
- ✓ Monthly conductivity monitoring of each loop
- ✓ Do you want to recover all loops for ROP feed?
- ✓ Critical to control the supply to the ROP with inline conductivity divert options

# Evaporator COW water




- ✓ 1st Effect – largest volume, highest temperature, lowest organic load, typically used for boiler water feed
- ✓ Middle effects – from vapour separation, lower volumes, higher organic loading as greater product carryover, lower temperature, higher micro loading
- ✓ Final Effect – highest organic loading, lowest volume
- ✓ Do you want to recover all effects (except 1st) for ROP feed?
- ✓ Critical to control the supply to the ROP with inline conductivity divert options

# Control Feed Quality to ROP

- ✓ Generally, conductivity is used as a simple check
- ✓ This is the first objective in ensuring that the polished water is of the standard required
- ✓ Membrane management strategy

# Control of ROP

- ✓ Conductivity monitoring of feed
- ✓ Critical to control the quality of the supply of polished water to the Treatment / Disinfection, storage & distribution system
- ✓ Inline conductivity alarm or divert options
- ✓ Monthly conductivity monitoring of each loop

# Treatment / Disinfection

- ✓ System capability / specification must be designed to provide the required micro kill with the **worst quality feed** - not only the best!
- ✓ We have seen many sites where the $ClO_2$ system is designed to operate with the polished water quality provided by new membranes, but as they age the system size is too small
- ✓ If the polished water feed quality is outside the design specification for the system, there is potential for micro growth and biofilm development. This applies to all disinfection options
- ✓ The disinfection system needs to be maintained as per manufacturer's / supplier's recommendations
- ✓ The polished water storage and distribution system should be designed to allow effective CIP (as per CIP COP) when required
- ✓ If ClO2 treated water is dechlorinated (SMBS) for use during RO plant cleaning, this CIP option is more important
- ✓ Required to provide residual disinfection in silos and distribution system

# Treatment / Disinfection

- ✓ System capability / specification must be designed to provide the required micro kill with the **worst quality feed -** not only the best!

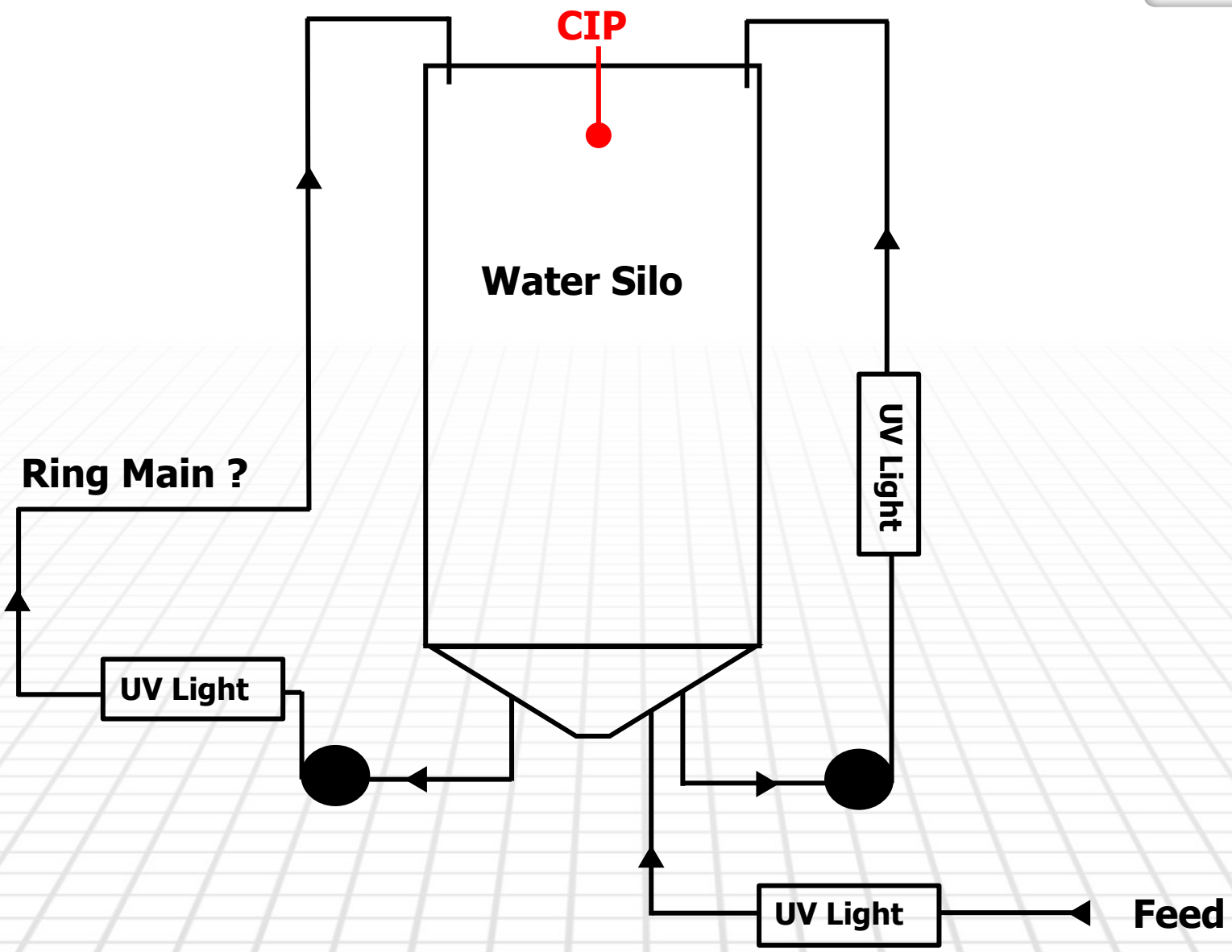
**NON CHLORINE**

- ✓ UV
- ✓ Ozone
- ✓ UV & Ozone combination

**“CHLORINE”**

- ✓ Chlorine Dioxide
- ✓ Chlorine (rarely used)

# UV Installation



# Distribution circuit design

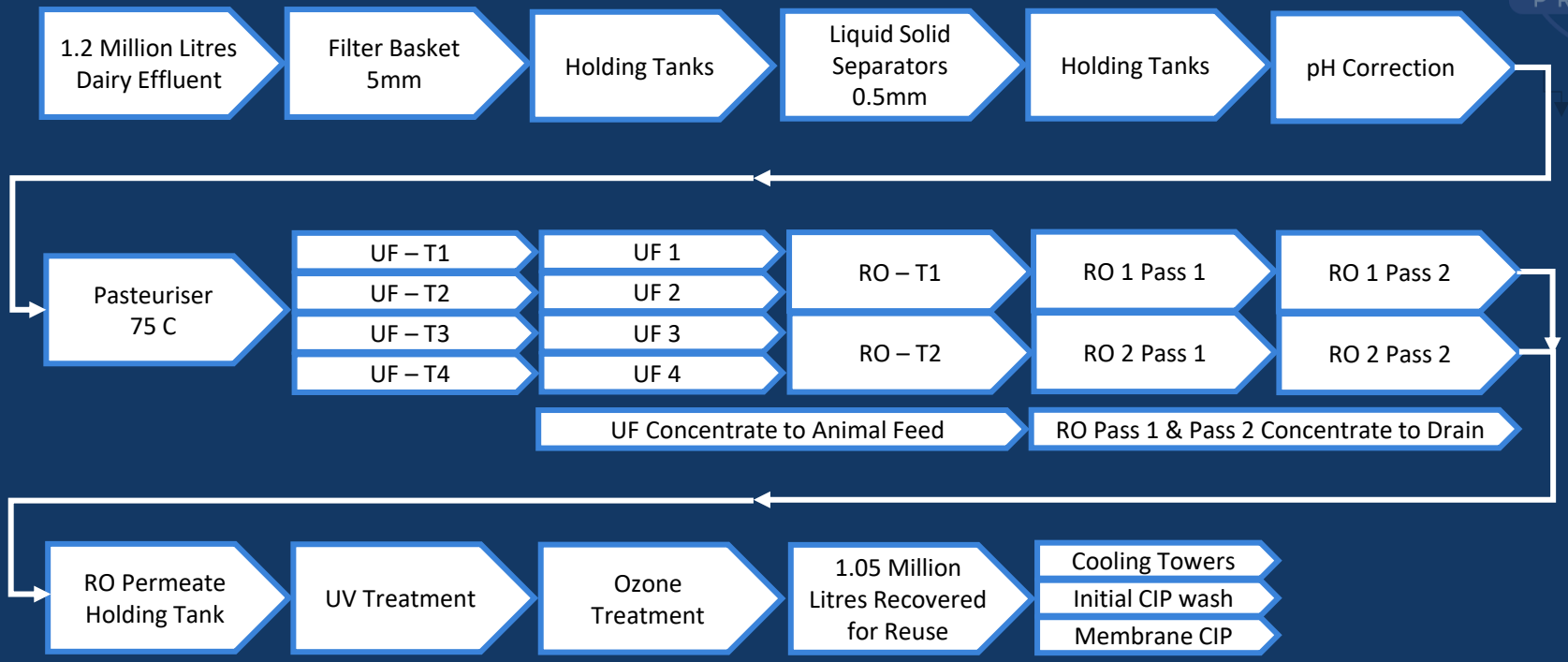
- ✓ Designed as per CIP COP with no dead legs and no significant changes in pipe diameter
- ✓ Possibly a ring main with additional “disinfection” option
- ✓ High level mains with droppers to dosing points (deadlegs?)
- ✓ No areas of low flow and small pipework diameters e.g. pump water seal lines and separator operating water
- ✓ All pipework to be on a CIP circuit


Engineering Effective, Innovative & Sustainable Process Solutions

# Axium Process – Dairy Effluent - Water Recovery for Re-use

Engineering Effective, Innovative & Sustainable Process Solutions

# Axium Process – Dairy Effluent - Water Recovery for Re-use

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# Final use options

- ✓ A separate storage and distribution system for ROP water – most common with specific applications
- ✓ Membrane plant cleaning and CIP:
- Some sites use for all including Final Rinse applications and others use for all except Final Rinse
- ✓ Hosepipes – in food production or external use
- ✓ Blending with site mains / bore hole water storage and distribution system – ROP water must be of correct quality to ensure no contamination of the site water system as this is unlikely to have a CIP option
- ✓ Potable water – these are the requirements

# Potable Water – a challenge!

- ✓ There are significant challenges in producing a "Potable Water" standard from Recovered Water Processes

It must comply with:

- ✓ The Drinking Water Inspectorate (DWI).
- ✓ The Water Supply ( Water quality )Regulations

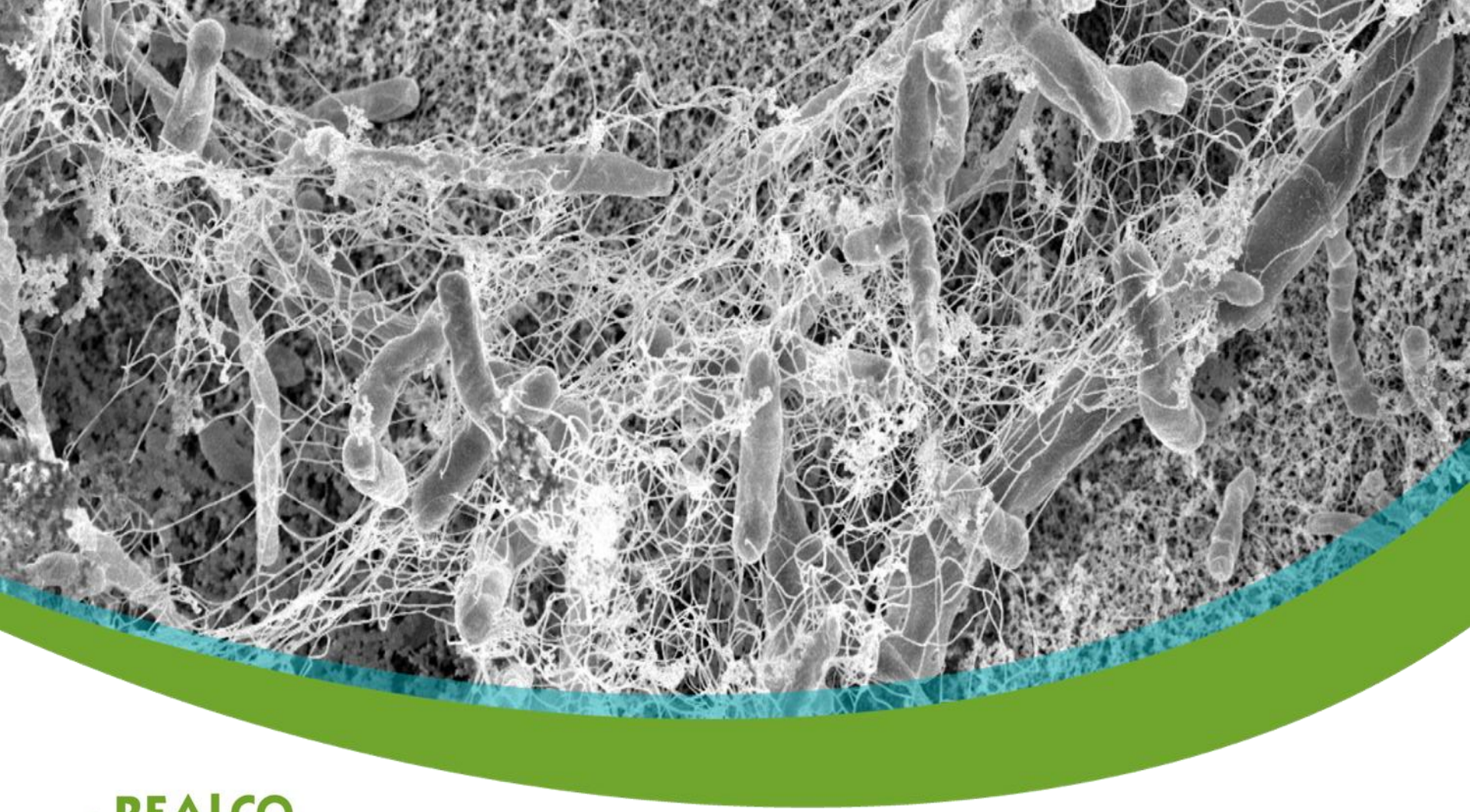
# Potable Water

## What is Potable Water?

- ✓ Safe for Human consumption, for cooking and drinking - Tasteless and colourless, odourless
- ✓ Safe to use for Personnel Hygiene. Safety showers / Eye wash.
- ✓ Contains low level contaminants, bacteria and dissolved solids. But levels that are not harmful
- ✓ Must be free from harmful bacteria and viruses
- ✓ Free from Pathogens which cause waterborne disease
- ✓ E.Coli, Enterococci & Total Coliforms Absent in 100 ml sample

# Key points

- ✓ Understand and control feed quality to the ROP. Impact of any changes?
- ✓ Treat ROP feed storage and pipework design as if product. CIP a must!
- ✓ Membrane management strategy for membrane plant supply to ROP
- ✓ Treatment / Disinfection to provide micro kill for worst quality feed
- ✓ Polished water storage and distribution system design
- ✓ Polished water storage and distribution system CIP option



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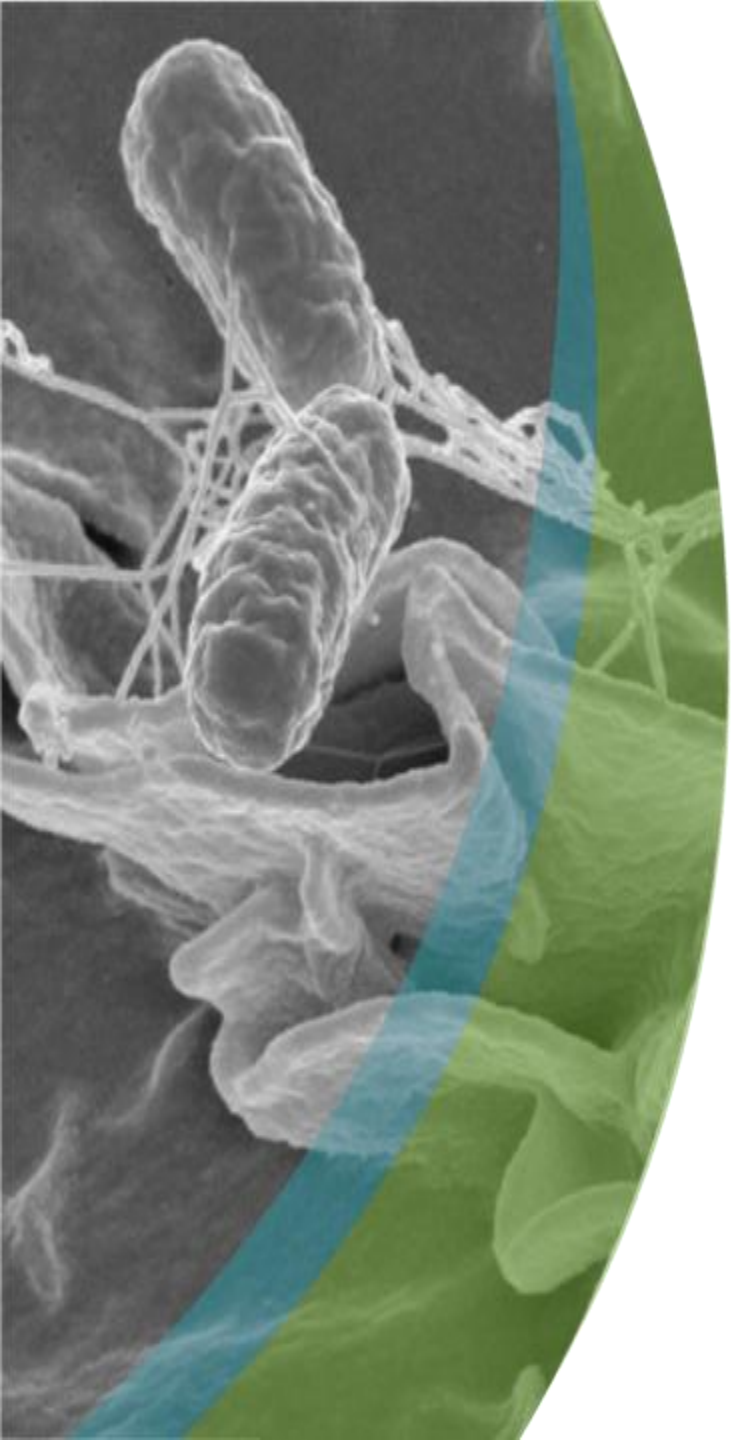
ENZYMES FOR LIFE

# Biofilms : definition, root causes and symptoms



# What is a biofilm ?

- = Source of **constant contamination** created by an **accumulation of bacteria** who develop a **protective matrix** made of organic polymers (EPS) polysaccharides, proteins, DNA, lipids, etc.
- = dominant environment for microorganisms
  - 99 % of bacteria's live in a biofilm
  - One biofilm can contain different types of bacteria's

# Which microorganisms can be found into a biofilm

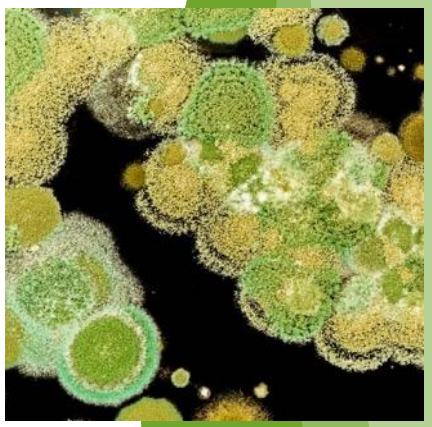
Some slime producers who build the biofilm matrix

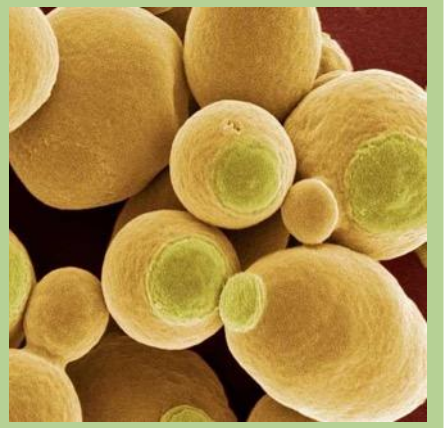
- *Bacillus cereus & mycoïdes*
- *Salmonella spp.*
- *Leuconostoc spp.*
- *Burkholderia spp.*
- *Campylobacter jejuni*
- *Cronobacter sakazakii*
- ***Listeria monocytogenes***
- ***Stenotrophomonas maltophilia***
- ***Staphylococcus aureus***
- ***Escherichia coli***
- ***Bacillus subtilis***
- ***Klebsiaella*** sp
- ***Burkholderia cepacia***
- ***Pseudomonas fluorescens***

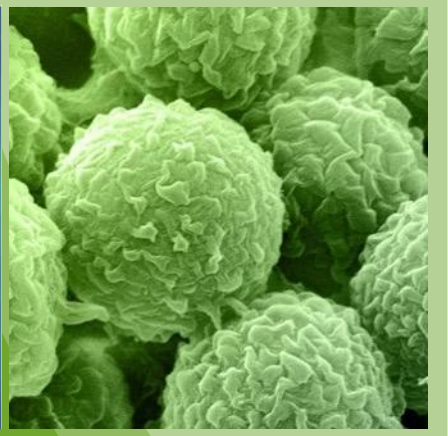
> Bacteria in bold are N-acétyl-glucosamine (PNAG) producers

Other microorganisms

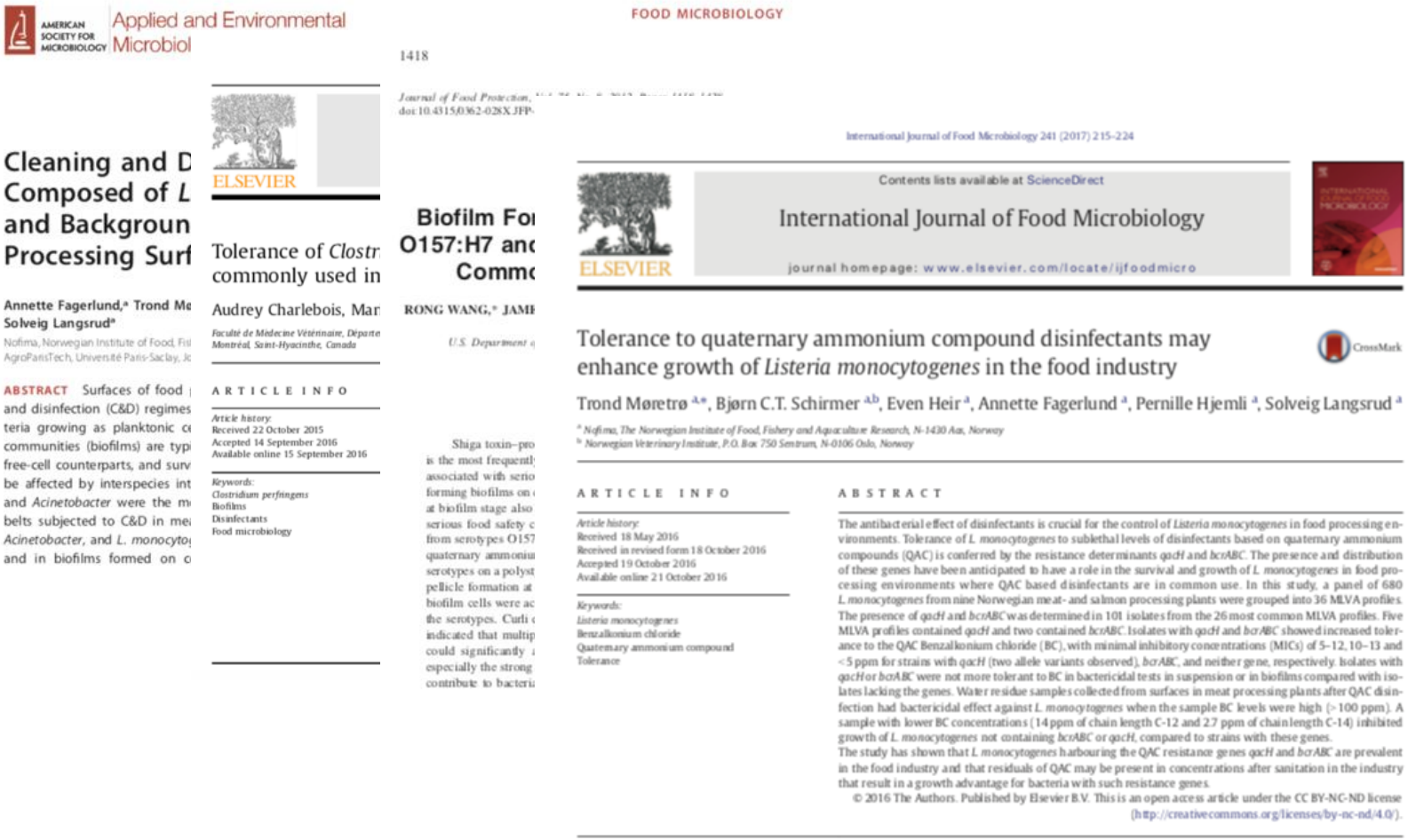
- Bacteria that do not produce biofilm matrix
- Viruses
- Phages
- Molds & yeast







# Resistance of micro-organisms to cleaning and disinfection treatments



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Cleaning and D
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and Backgroun
Processing Surf

Annette Fagerlund,[a] Trond Mø
Solveig Langsrud[a]

Nofima, Norwegian Institute of Food, Fis
AgroParisTech, Université Paris-Saclay, Jo

ABSTRACT Surfaces of food
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ELSEVIER

Tolerance of *Clostr*
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Audrey Charlebois, Mar

*Faculté de Médecine Vétérinaire, Départe*
*Montréal, Saint-Hyacinthe, Canada*

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Biofilm For
O157:H7 and
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RONG WANG,* JAME

*U.S. Department*

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Tolerance to quaternary ammonium compound disinfectants may enhance growth of *Listeria monocytogenes* in the food industry

Trond Møretrø [a,*], Bjørn C.T. Schirmer [a,b], Even Heir [a], Annette Fagerlund [a], Pernille Hjemli [a], Solveig Langsrud [a]

[a] *Nofima, The Norwegian Institute of Food, Fishery and Aquaculture Research, N-1430 Aas, Norway*
[b] *Norwegian Veterinary Institute, P.O. Box 750 Sentrum, N-0106 Oslo, Norway*

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Tolerance

ABSTRACT

The antibacterial effect of disinfectants is crucial for the control of *Listeria monocytogenes* in food processing environments. Tolerance of *L. monocytogenes* to sublethal levels of disinfectants based on quaternary ammonium compounds (QAC) is conferred by the resistance determinants *qacH* and *bcrABC*. The presence and distribution of these genes have been anticipated to have a role in the survival and growth of *L. monocytogenes* in food processing environments where QAC based disinfectants are in common use. In this study, a panel of 680 *L. monocytogenes* from nine Norwegian meat- and salmon processing plants were grouped into 36 MLVA profiles. The presence of *qacH* and *bcrABC* was determined in 101 isolates from the 26 most common MLVA profiles. Five MLVA profiles contained *qacH* and two contained *bcrABC*. Isolates with *qacH* and *bcrABC* showed increased tolerance to the QAC Benzalkonium chloride (BC), with minimal inhibitory concentrations (MICs) of 5–12, 10–13 and < 5 ppm for strains with *qacH* (two allele variants observed), *bcrABC*, and neither gene, respectively. Isolates with *qacH* or *bcrABC* were not more tolerant to BC in bactericidal tests in suspension or in biofilms compared with isolates lacking the genes. Water residue samples collected from surfaces in meat processing plants after QAC disinfection had bactericidal effect against *L. monocytogenes* when the sample BC levels were high (> 100 ppm). A sample with lower BC concentrations (14 ppm of chain length C-12 and 2.7 ppm of chain length C-14) inhibited growth of *L. monocytogenes* not containing *bcrABC* or *qacH*, compared to strains with these genes.
The study has shown that *L. monocytogenes* harbouring the QAC resistance genes *qacH* and *bcrABC* are prevalent in the food industry and that residuals of QAC may be present in concentrations after sanitation in the industry that result in a growth advantage for bacteria with such resistance genes.

# Biofilm EXPERT

DETECT

CHARACTERIZE

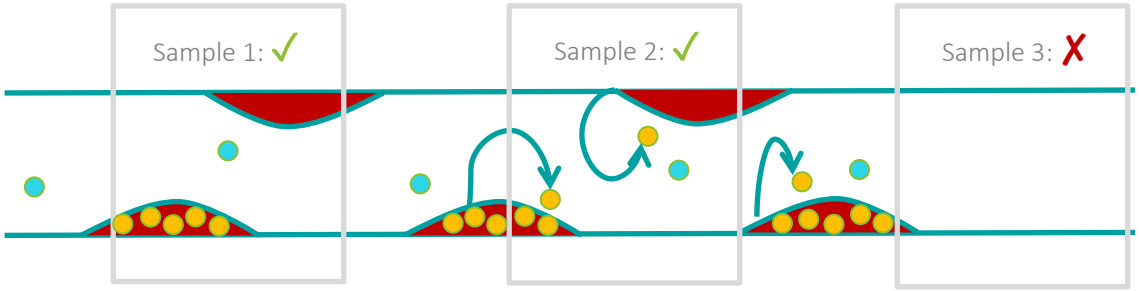
TREAT

PREVENT

1 — 2 — 3 — 4

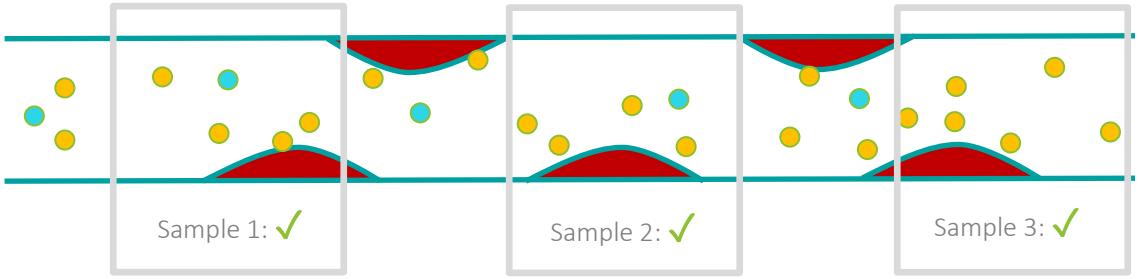
# CIP reliable sample – Circulate Biorem CIP 3G @ 2%

Without enzymatic treatment




Consideration of planktonic bacteria only!!

With enzymatic treatment




Consideration of all bacteria

# Thank You

Derek Pitman +44 7780 460490
derek@indigofsl.co.uk
derek@realco.be

Jon Tyrrell +44 7522 420986
Jontyrrell.consulting@btinternet.com