More milk and "milky water" – less tap and waste water

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UNIVERSITY OF COPENHAGEN

Outline

- Reuse of “water”: Why bother with the risk?
- Water definitions
- HACCP for reuse
- Current projects
- Examples of water qualities observed
- Growth potential in RO treated whey
- Research needs?

Environmental responsibility

- **At company, national and international level**

UN: 2030 agenda for sustainable development (September 2015).

Target 6.3: Increase recycling and safe reuse of water

Target 6.4: increase water-use efficiency across all sectors

EU: Sustainable production: Circular economy package (Dec 2015)

Denmark : Growth plan on food (2014), Growth plan on water, biology and environment (2014)

Issues	WHY do it? Drivers	Barriers
Environmental	water scarcity in some areas Discharge problems due to environmental impact	
Economical	Increasing costs for fresh water Increasing costs for wastewater discharge	Payback times Difficulties in estimating the true cost of water
Legislative	Optional use of alternative water qualities possible Possibility of lowering requirements without resulting in significant health risks Strict wastewater discharge regulations	Standards versus guidelines Obtaining knowledge, documentation and training both for industry and regulators Regulations are too strict and not flexible
Technological (Treatment)	Availability of technically feasible purification processes Commercialisation of recovered by-products	Lack of guidelines for process water treatment Demanding procedures for quality control of processes Lack of easy access to evaluate different methods
Water quality assessment	Need for reliable methods Need for safety and quality assurance	Choice of relevant parameters and methods Relevance of DW indicators for safety, processing, shelf life etc. Real-time monitoring
Social	Water scarcity	Negative perception of “reused water”
Food industry	Economy, environmental responsibility	Major effort, much testing, Safety flaws may jeopardize the whole company

Definitions of reuse (national and international) can be an issue

Terminology used by DHI

- Reduce: reductions by better management
- Renew: More water efficient processes
- Reuse/recycle: Non-treated water use in same process (recycle?) or less demanding proces (reuse?)
- Reclaim: after use of reclamation technology/water treatment
- Return: waste water

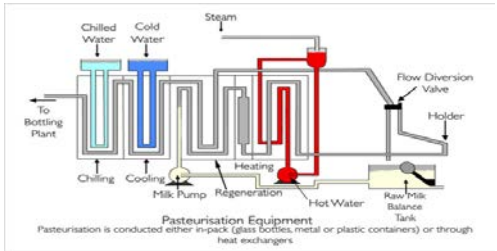
Codex Alimentarius 1999

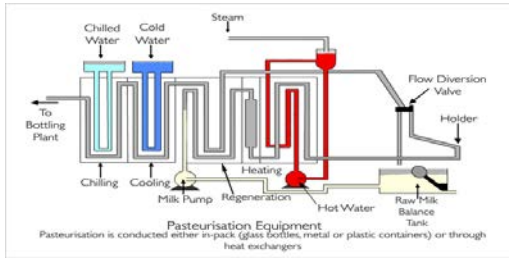
- **Reuse:** The recovery of water from a processing step, including from the food component itself, its reconditioning treatment, if applicable and its subsequent use in a food manufacturing operation.
- **Reconditioning:** The treatment of water intended for reuse by means designed to reduce or eliminate microbiological, chemical, and physical contaminants, according to its intended use.
- **Recycled water:** Water, other than first use or reclaimed water that has been obtained from a food manufacturing operation and has been reconditioned when necessary such that it may be reused in a subsequent food manufacturing operation.
- **Reclaimed water:** Water that was originally a constituent of a food, has been removed from the food by a process step, and has been subsequently reconditioned when necessary such that it may be reused in a subsequent food manufacturing operation.
- **Reused water:** Recycled and reclaimed water.

Establishing the documentation

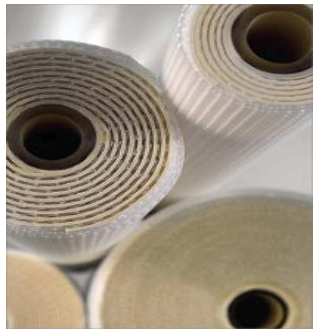
1. **Identification of the criteria for potable water that are relevant** → **National Guide**
2. **Hazard analysis & validation** → **National Guide (generic) + local confirmation/ adaptation**
   - Microbiology
   - Chemistry
3. **Controls, indicators & technology** → **National Guide (generic approach)**
   - Risk categories
   - Monitoring systems
   - Verification procedures
4. **Daily operation** → **Local implementation**
   - HACCP plan
   - Verification plan

Generic vs. specific? Example from text: permeate from membrane filtration. Are our data from AFI/DP representative ??





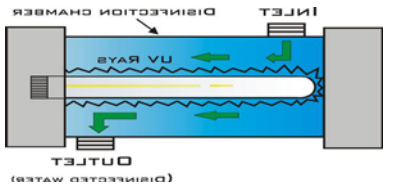
UF



RO

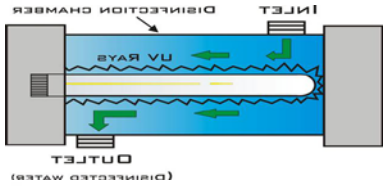
ROP

UV



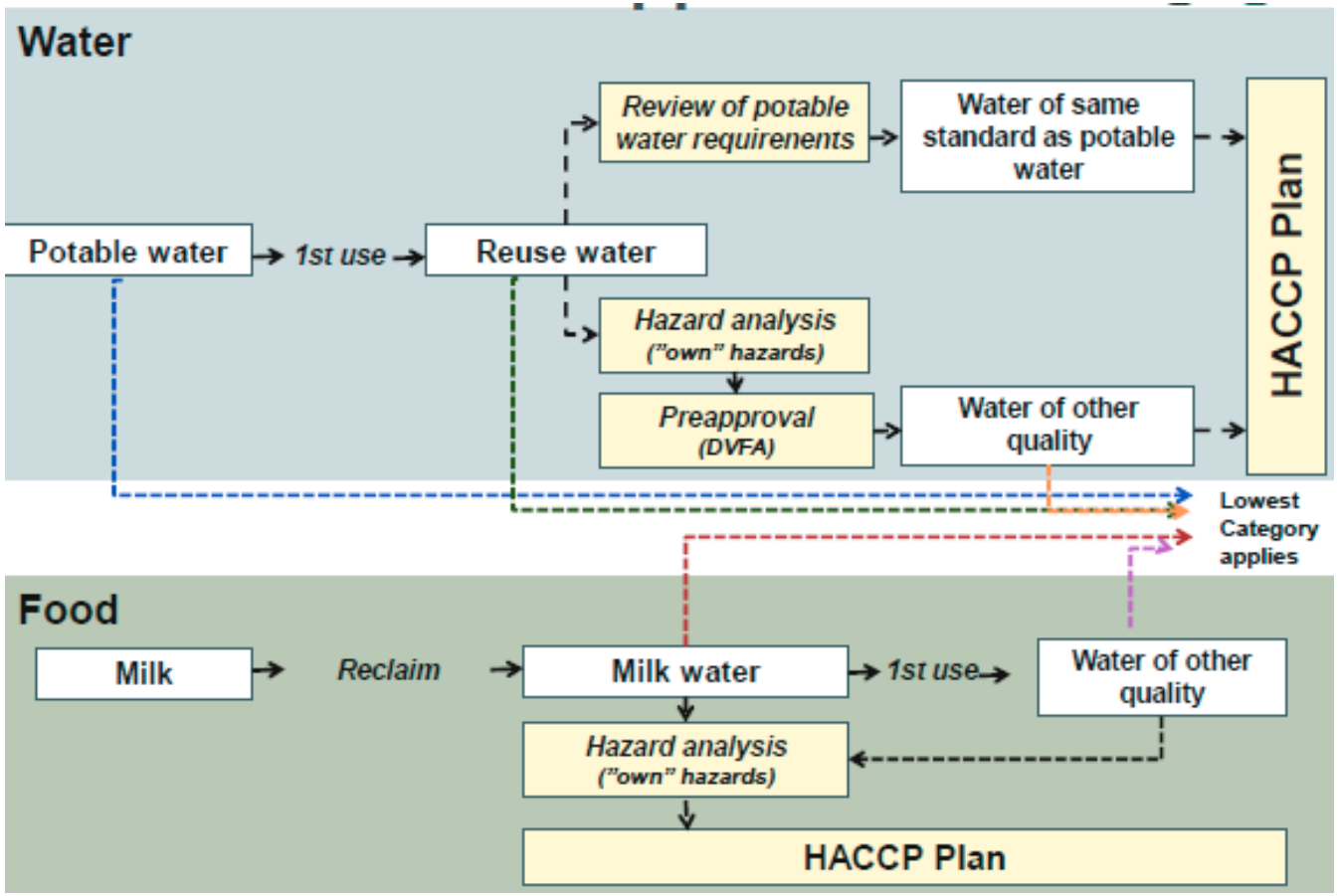
Tank storage

UV



For our purpose:

- Any water used for direct contact should be treated like an ingredient, i.e. using HACCP
  - Approach generic but HACCP should always be specific



Using HACCP is not new

ELSEVIER

Food Control 13 (2002) 315–327

FOOD CONTROL

www.elsevier.com/locate/foodcont

Application of HACCP to water reuse in the food industry

Sandra Casani *, Susanne Knøchel

ELSEVIER

Available online at www.sciencedirect.com

SCIENCE DIRECT®

Food Control xxx (2005) xxx–xxx

FOOD CONTROL

www.elsevier.com/locate/foodcont

Water reuse in a shrimp processing line: Safety considerations using a HACCP approach

Sandra Casani [a,*], Tommas Leth [b], Susanne Knøchel [a]

Journal of Food Protection, Vol. 68, No. 4, 2005, Pages 801–807

Comparison of Methods for Assessing Reverse Osmosis Membrane Treatment of Shrimp Process Water

SANDRA CASANI, TINA B. HANSEN, JAKOB CHRISTENSEN, AND SUSANNE KNØCHEL*

ELSEVIER

Water Research 39 (2005) 1134–1146

WATER RESEARCH

www.elsevier.com/locate/watres

A discussion paper on challenges and limitations to water reuse and hygiene in the food industry

Sandra Casani[a,*], Mahbod Rouhany[b,1], Susanne Knøchel[a]

Re.1: Which criteria for potable water are relevant?

Result of the review

Microbiological criteria for potable water		
	Measurement for:	
Total plate count 22 °C	General bacteriological quality	
Total plate count 37 °C	Need of treatment	
Coliforms	Contamination of the water system	Interrelated
E. coli	Contamination of the water system	
Additional criteria (pending the validations)		
Specified pathogens	Safety	

Why drinking water criteria are not enough. Potential pathogens not related to *E.coli:*
Staphylococcus aureus, Listeria monocytogenes, Bacillus cereus, Chronobacter sakazaki, Clostridium botulinum, Aeromonas hydrophila and more

Other “non-food safety” microbiological challenges overlooked??

- Fermentation problems: **phages**
- Food quality problems: **spoilage bacteria**
- Process issues: **microbiological fouling (**decreased flow, corrosion, low heat transfer, friction)
- Work health problems: ***Legionella***

Current project

REWARD 2014-2019

Mejerier på vandvognen

REWARD - "REuse of WAteR in the food and bioprocessing inDustry"

Af Søren Balling Engelsen, Pro
Københavns Universitet, Frans
Professor, Fødevarevidenskab,
Mogens Havsteen Jakobsen, Pr
Danmarks Tekniske Universite
Fødevarevidenskab, Københavı
Professor, KemiTeknik, Danma
Renzo Akkerman, Professor, De
München

17.8 Mio

4.5 Mio

0.5 Mio

0.5 Mio

0.5 Mio

Emphasis on online/real-time monitoring of water quality or cleaning efficiency using spectroscopy and chemometrics

Chemometrics and Intelligent Laboratory Systems 144 (2015) 39–47

Contents lists available at ScienceDirect

Chemometrics and Intelligent Laboratory Systems

journal homepage: www.elsevier.com/locate/chemolab

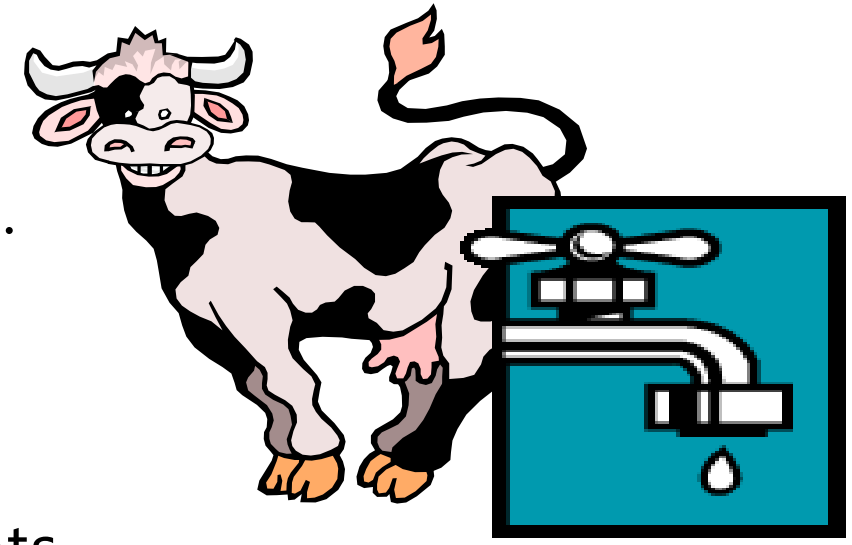
Protein residual fouling identification on UF membranes using ATR-FT-IR and multivariate curve resolution

Jannie K. Jensen *, José M.A. Rubio, Søren B. Engelsen, Frans van den Berg

University of Copenhagen, Faculty of Science, Department of Food Science, SPECC Section, Rolighedsvej 26, DK-1958 Frederiksberg C, Denmark

REWARD Microbiological safety and quality: whey water

- 1.Quantitative and qualitative mapping of microbiome before and after RO treatment.
  - Which microorganisms, how many?
- 2. Growth and biofilm forming potential of recurrent isolates in permeate.
  - Do they grow?
- 3. Growth of relevant pathogens in permeate.
  - Can pathogens/spoilers grow?
- 4. Critical limits for time/temperature.
  - What is max. storage time?
- 5. Relationship between on-line measurements and microbiological levels.
  - How to monitor quality real-time?



DRIP: another large project on water savings

DRIP
Water efficient industrial food production

19 partners – DKK 98m – 5 years

Positive contribution from authorities

Technology

AQUAPORIN
LiqTech INTERNATIONAL
GRUNDFOS
ALFA LAVAL
DSS
ULTRAQUA UV DISINFECTION SYSTEMS
SIEMENS
Cabinplant Precise by nature

Food

Arla
DANISH CROWN
HKSCAN
Member of TripleNine Group TripleNine Fish Protein
Carlsberg Danmark
LANDBRUG FØDEVARER

9 factories

Knowledge

CBS
TEKNOLOGISK INSTITUT
DTU
DHI

Ministry of Environment and Food of Denmark
Danish Veterinary and Food Administration

Ministry of Environment and Food of Denmark
Environmental Protection Agency

Ministry of Environment and Food of Denmark
Nature Agency

Innovationsfonden
FORSKNING, TEKNOLOGI & VÆKST I DANMARK

DRIP: dairy focus on process water
(CIP, cleaning of floors, tanks, trucks - no sanitary water, no rain water)

- Definition ?
  - CIP water problems related more to chemical residues
  - Floor cleaning/Truck cleaning/ Wheels potential for wider range of chemical and microbiological contamination
    - Treatment efficiency (which compounds, which organisms?)
  - How far can we safely upgrade this?

DRIP
Water efficient industrial food production

Innovationsfonden
FORSKNING, TEKNOLOGI & VÆKST I DANMARK

Microbiology on product water in REWARD until now

- *Isolation and identification of microorganisms in UF- and RO permeate*
  - Large variations in levels in UF permeate. RO and ROP below drinking water criteria
  - Culturing found mainly Bacillus and Lactococcus in UF while metagenomic analysis found mainly streptococci and lactics. Populations in RO/ROP seem random
  - Discrepancy between methods could partly be due to poor DNA recovery from spores
- *Growth potential of isolates in ROP permeate*
  - Some RO isolates can grow in RO and ROP permeates
- *Biofilm formation of isolates in RO and ROP permeate*
  - Some isolates can form biofilm in RO permeate on plastic as well as steel surfaces
  - Filamentous yeast found on several membranes
- *Growth of pathogens in ROP permeate*
  - *Listeria* negative, *Bacillus* vary, more to be tested

A request: Help us to know more about microbiological membrane fouling !

Therefore contact me skn@food.ku.dk if you observe biofilm and poor performance so we may get samples of the filters. We are interested in samples and your info on:

- Date of sampling
- Type of filter
- Reason for replacement
- Where the problem is in the production line
- What is filtered
- Temperature, daily usage time, and age of filter
- Cleaning regime