Cost Saving by Upgrading of Evaporator Condensates and NF-/ RO Permeates (Cow Water) for Reuse in Dairy Processes

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2. Characteristics of dairy evaporator condensates (Cow Water)
3. Cow Water Treatment Options
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   2. BiopROtector + AC + UF
   3. BiopROtector + UF + RO
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1. who is Water, Waste and Energy

Our expertise in optimized resource management
Our field of activity: resourcing the world on a global scale

- **€22.3 billion** in revenue, **202,800** employees

**NORTH AMERICA**
Revenue: €1,899.8 million
Workforce: 15,785

**FRANCE**
Revenue: €11,303.6 million
Workforce: 65,990

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**REST OF EUROPE**
Revenue: €810.3 million
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**FRANCE**
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**UNITED KINGDOM**
Revenue: €1,988.4 million
Workforce: 14,396

**GERMANY**
Revenue: €1,968.8 million
Workforce: 12,915

**CENTRAL AND EASTERN EUROPE**
Revenue: €1,201.4 million
Workforce: 29,326

**SOUTH AMERICA**
Revenue: €242 million
Workforce: 16,343

**AFRICA / MIDDLE EAST**
Revenue: €874.4 million
Workforce: 12,540

**ASIA**
Revenue: €1,074 million
Workforce: 21,913

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approx. **10,000** employees in design / build / solutions for drinking water and wastewater treatment plants and for water-reuse.
2. Characteristics of dairy evaporator condensates (cow water)
2. What is cow water?

Condensate from **evaporation** of dairy products

- whole milk concentration
- skim milk concentration
- sweet whey concentration
- acid whey concentration

**Origin is milk**, not tap water

Fig 1: 4 effect falling film Evaporator
### 2. Typical characteristics of cow water

<table>
<thead>
<tr>
<th>Origin</th>
<th>milk FR (ZA)</th>
<th>Sweet whey (DE)</th>
<th>Acid whey (DE)</th>
<th>NF &amp; RO Permeates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conductivity [µS/cm]</td>
<td>10–15 (100)</td>
<td>8 - 40</td>
<td>30 - 120</td>
<td>20 - 500</td>
</tr>
<tr>
<td>TSS [mg/l]</td>
<td>2 – 3 (20)</td>
<td>2 - 3</td>
<td>2 - 10</td>
<td>1 - 3</td>
</tr>
<tr>
<td>COD [mg/l]</td>
<td>10 – 50 (100)</td>
<td>30 - 45</td>
<td>50 - 300</td>
<td>20 - 300</td>
</tr>
<tr>
<td>TKN [mg/l]</td>
<td>0 - 2</td>
<td>0 - 3</td>
<td>0 - 5</td>
<td>2-10</td>
</tr>
<tr>
<td>Ethanol [µg/l]</td>
<td>50 – 800 (5,000)</td>
<td>100 – 2,500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acetones [µg/l]</td>
<td>50 – 2,000</td>
<td>50 - 400</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOC [mg/l]</td>
<td>1 – 4 (15)</td>
<td>1 - 9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- strong tendency for bacterial growth (> 200,000 CFU/ml)
- strong concentration changes of constituents over time
- development of slimy byproducts
- volatile Organic Compounds (VOC) due to TOC and MO activity resulting in smell issues
3. Cow water treatment options
3. General treatment options for cow water 1/2

- **UV- Treatment**
  - MOs are reduced, but organics remain in the water
  - Cheap solution; for simple applications only, not sustainable

- **Chlorination with ClO₂ or NaOCl**
  - acceptable for low TOC values (< 3 ppm) only
  - possible formation of critical by-products (AOX, THM) *

- **hygienic Dairy RO (Polisher RO)**
  - short membrane lifetime (12-24 months), daily CIP
  - low Capex, high Opex
  - traces of TOC and NPN remain in the permeate
  - insufficient rejection of low molecular weight (< 100 Dalton) organic components (e.g. lactic acid, urea, some amino acids)
  - not suitable for acid condensates (products containing lactic acid)

*) stringent guidelines for production of baby nutrition
Low molar mass fractions in Polisher- RO permeate

TOC

[mg/l]

[ Dalton ]

molar mass

100

200

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3. General treatment options for cow water 2/2

- **BiopROtector (enhanced bio-treatment) + UF + standard RO**
  - Good removal of microorganisms and organics;
  - For lower amounts of COD (< 100 ppm)
  - Very good water quality, suitable for unrestricted process applications

- **BiopROtector + Activated Carbon + UF**
  - Good removal of microorganisms and organics
  - For lower amounts of COD (< 50 ppm)
  - Very good water quality, suitable for unrestricted process applications

- **Biosep + standard RO**
  - For higher amounts of COD (> 100 ppm)
  - Excellent removal of critical components incl. nitrogen components
  - Higher Capex, low Opex;
  - Very good water quality, suitable for unrestricted process applications

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3.1 Hygienic RO systems

- Easily cleanable components
- High quality material finishing Ra < 0.8 µm
- Specific welding and passivation requirements
- Hygienic equipment and installation design (EHEDG recommendations)
3.2 Biological treatment “BiopROtector”

- Biological treatment, combined with drinking water UF and RO
- Excellent process water quality
- Less cleaning of UF/RO
- Long membrane lifetime
- Biodegradation of organic carbon, e.g. lactic acid

* Depending on feed water conditions

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BiopROtector – principle operation

Influent biopROtector

Effluent biopROtector

Candle filter (CF) Replaced every 4 – 5 days

biopROtector

Candle filter

CF 5 µm

Without...

With!!
BiopROtector reference

- Capacity: 50 m³/h
- Startup July 2013
- 2-150 ppm COD in feed
- BiopROtector®: fluidized + fixed
- Ultrafiltration
- Reverse Osmosis
UFlex Ultrafiltration, after BiopRO

- Widely used Ultrafiltration System for drinking water production
- Certified membranes for drinking water applications
- Guaranteed bacteria and virus removal
- High recovery
- Long membrane lifetime
- Cost efficient in Capex and Opex
3.4 Biosep® - Membrane- Bioreactor (MBR)

- biological treatment, combined with submerged UF
- excellent biodegradation
- long membrane lifetime
- relatively low Opex
- robust process
- for heavily polluted cow water (CSB >> 50 ppm)
Standard – Sirion RO, post-treatment

- Widely used RO System for process water production
- Excellent effluent quality
- High recovery
- Long membrane lifetime
- Cost-efficient operation
4. Process Comparison
<table>
<thead>
<tr>
<th>Technology</th>
<th>Origin</th>
<th>COD = 0-10 ppm</th>
<th>COD = 10-50 ppm</th>
<th>COD = 10-100 ppm</th>
<th>COD = 50-500 ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Hygienic RO</td>
<td>Whole/skim milk, sweet whey</td>
<td>★ ★ ★ ★</td>
<td>★</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>2. Fixed bed BiopRO + UF + RO</td>
<td>Whole/skim milk, sweet whey</td>
<td>★ ★ ★ ★ ★</td>
<td>★ ★ ★</td>
<td>★</td>
<td>no</td>
</tr>
<tr>
<td>3. Fluidized &amp; fixed bed BiopRO + AC + UF</td>
<td>Fresh cheese, Acid whey</td>
<td>★ ★ ★ ★ ★</td>
<td>★ ★ ★ ★</td>
<td>★ ★ ★ ★</td>
<td>no</td>
</tr>
<tr>
<td>2. Fluidized &amp; fixed bed BiopRO+UF+RO</td>
<td>NF and RO permeate</td>
<td>★ ★ ★ ★ ★</td>
<td>★ ★ ★ ★ ★</td>
<td>★ ★ ★ ★ ★</td>
<td>no</td>
</tr>
<tr>
<td>3. Biosep+RO</td>
<td></td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
</tr>
</tbody>
</table>
5. Economics
5.1 Economical Considerations

- Permits for direct discharge of evaporator condensates to surface waters are not easily extended.
- Treatment of cow water required.
- Quality of Polisher RO permeates not good enough for unrestricted reuse in dairies (e.g. for CIP).
- Removal of low molar weight hydrocarbons and nitrogen allows direct replacement of drinking water in CIP loops; > 80% of condensates can be reused.
- Special permits might be required (dependent on country).
5.3 Typical Dairy Economics

Assumptions

- Drinking water Consumption: 2000 m³/d
- Condensate available: 1000 m³/d
- Possible reuse with Polisher RO: 400 m³/d
- Possible reuse with BiopRO: 765 m³/d

- Annual savings with Polisher RO: 186 k€
- Annual savings with BiopRO: 378 k€
- Amortisation with Polisher RO: 2.9 years
- Amortisation with BiopRO: 2.4 years
6. Summary
6. Summary

- Sustainable management and continuous increase in production require the re-use of water.
- Evaporator condensates are very suitable for upgrading to high process water quality.
- RO alone is not sufficient for removal of low molar mass (< 100 Dalton) hydrocarbons and N-components.
- BiopROtector & Biosep can convert those components in easily separable particles (microorganisms).
- Cost efficient processes are available with ROI < 3 years.
- A water self-sufficient dairy is no utopia any longer.
Nestle Dairy Lagos de Moreno, Jalisco, Mexico, Cero Agua