The Daireuse Process

Biological treatment of evaporator condensates (Cow Water) in combination with membrane technologies

Veolia implemented such a Daireuse process in a large dairy in Belgium:
This dairy upgrades up to 1,500 m³/d of evaporator condensate from concentration of milk or whey to potable water quality*, known as the "Daireuse" process.

* except from the contents of minerals (pH and solubility for calcite) all other limits of the German drinking water regulation are safely met.

Within the industry in general the dairies belong to the largest consumers of potable water, therefore the saving of water and water reuse approaches are of specific applicability for these factories. This paper describes an innovative process for upgrading of evaporator condensate from concentration of milk or whey to potable water quality*, known as the "Daireuse" process.

Veolia implemented such a Daireuse process in a large dairy in Belgium:
This dairy upgrades up to 1,500 m³/d of evaporator condensate from concentration of milk to potable water quality for replacement of drinking water in various applications in the dairy including CIP cycles and final rinses. The dissolved organic components of the condensates for example are minimized by a combination of biological and membrane processes to a TOC value of 0.2 mg/l only. The reverse osmosis process itself cannot nearly achieve such a low TOC value.

Water used for cleaning of production plants in German dairies is subject to the German Drinking Water Regulation (Trinkwasserverordnung 2001[1]). The local health authorities however may permit exceptions (changes in composition) for food processing companies if they are convinced that the quality of the water used does not negatively affect the healthiness of the final product.

The quality of the treated water from the Belgian dairy has been analyzed and assessed by the IWW (Rheinisch-Westfälisches Institut für Wasser). The IWW concluded[2] that the RO permeate is of a quality which does not raise any concern that the usage of this water could adversely affect the quality of the final food product. The process and operation is appropriate and sustainably save. The permissibility of a deviation according to §18 German drinking water regulation is therefore confirmed without any restrictions.

Author: Heribert Möslang, CTO, Veolia Water Technologies Deutschland GmbH, www.veoliwatertechnologies.de, contact: heribert.moeslang@veolia.com
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Therefore they had to start new ways of water management.

Condensates from evaporation of milk and whey contain low molar mass organic molecules, traces of lactic acid, alcohols, acetones, non-protein-nitrogen etc. Those components enhance microbiological growth (often associated with slimy by-products), create odors and cannot be removed completely just by a reverse osmosis process. These very small organic molecules are biodegraded by the innovative BiopROTector technology (carrier-based biological process) and converted to other components which then are separated easily by downstream membrane systems.

This allows a high water quality to be achieved with a very low content of TOC, comparable to drinking water also regarding the low potential for microbiological growth. In the present case the treated water is blended with drinking water, standardized and fed into the common dairy network for potable water.

2 PROCESS OVERVIEW

For upgrading of the condensates the Daireuse process has been applied, consisting of the following main process steps:

- BiopROTector: biological fluidized bed reactor and fixed bed reactor
- Ultrafiltration (UF)
- Reverse Osmosis (RO)

2.1 BIOPROTCTOR

The BiopROTector not only prevents biofouling in downstream membrane units but in combination with UF and RO it is also a key technology for producing high quality process water from evaporator condensates which is contaminated with dissolved organic molecules. The BiopROTector for this application is designed as a two-step process (see figure 1):

- Fluidized bed BiopROTector (A), to remove the bulk of nutrients (>75%) present in the feed water
- Fixed bed BiopROTector (B), a polishing step for further removal of remaining nutrients and reducing the biological activity of the feed water

In case of low contaminated water at typically COD (=RBOC**) levels < 10 mg/l and NH₄-N < 1 mg/l the fixed bed BiopROTector (B) is applied directly without pretreatment (A). It is able to reduce the concentrations COD and NH₄-N to levels where growth of a biofilm is minimized, thus producing high quality process water.

Backwash of the fixed bed BiopROTector is done typically once per month to get rid of surplus biomass and to keep the BiopROTector vital. The backwash procedure takes approx. 15-20 minutes.

In case of high contaminated water (this is the case here) the amount of oxygen in the water is insufficient to oxidize the COD and ammonia in the fixed bed BiopROTector. For those situations a two stage BiopROTector is designed, a fluidized bed with coarse bubble aeration (A) followed by a fixed bed unit (B).

With high amounts of nutrients in the condensate the bulk of the COD and ammonia is oxidized in the fluidized BiopROTector. The carriers are kept constantly in suspension by coarse bubble aeration.

ULTRAFILTRATION

The BiopROTector converts very small organic molecules into gases and microorganisms which can be separated easily with ultrafiltration technology. UF membranes separate quantitatively components with particle sizes > 0.05 µm. High quality hollow fibre UF membrane modules with certification for drinking water production are used.

In order to control membrane fouling a regular (typically daily) chemical enhanced backwash (CEB) cycle with low concentrations of chemicals is performed.

In addition to the CEB mentioned above, a recovery clean is applied from time to time (typically every 6 – 8 weeks) to fully recover the permeability of the membranes.

2.2 REVERSE OSMOSIS

For double security and for elimination of dissolved, non-biodegradable components a reverse osmosis unit is finally installed.

The RO permeate is similar to DI water (conductivity <= 50 µS/cm). Usually it is stabilized by addition of small amounts (0.3 mg/l) of chlorine dioxide and – depending on the application – blended with other water sources and standardized prior to reuse.

The RO concentrate (approx. 15 – 20% of the feed flow to RO) is still of high quality (COD lower than in RO Polisher permeate) and is typically utilized as process water for less critical applications (e.g. water for cooling towers).

The RO unit includes a cleaning-in place (CIP-) system for regular rinsing or service cleaning of the unit.

3 ECONOMICS

The Daireuse process is a combination of standardized units which are also used in other drinking water applications. To achieve a long service life pipework and tanks are made from corrosion resistant, high quality plastics. That’s why the equipment can be offered quite cost-efficiently. Also the operation costs for Daireuse systems are relatively low:

- Chemical cleanings are therefore quite low
- Chemical cleanings are mainly performed by using cheap basic chemicals (e.g. NaOH, H₂SO₄)

** Readily Biodegradable Organic Carbon: the fraction of organic components, in most cases present as volatile fatty acids, like acetic acid and propionic acid, alcohols, acetones, amino acids etc.
membrane lifetime is achieved. The membranes used for UF and RO are drinking water membranes which are manufactured in large quantities. Membrane replacement costs are therefore relatively low.

• Energy costs are low as well, achieved by applying high-efficient drinking water pumps and system configurations.
• High level of automation and operator-friendly process control unit minimize the requirements for operator attendance, keeping the costs for man-power low. At the same time the quality of the treated water is documented gapless by efficient monitoring.

4 WATER QUALITY
The quality of the treated water in the Belgian dairy was analyzed and assessed by IWW Mühlheim with regard to use as process water for CIP units in German dairies.

In Germany, such waters are generally subject to the drinking water regulation (Trinkwasserverordnung). If a dairy intends to use other waters than “drinking water” it requires an exemption from the competent health authority. Such an exemption may be granted based on §18 TrinkwV, if they are convinced that the quality of the water used does not negatively affect the healthiness of the final product. The IWW summarized their assessment as follows:
• The colony count (directly after RO, before disinfection) was slightly above the limit defined in the drinking water regulation. The RO permeate however is finally disinfected by addition of 0.3 ppm chlorine dioxide. Therefore there is no doubt that in the final application there is no measurable colony count anymore.
• The RO permeate is particle-free and low in TOC (0.21 mg/l). It is therefore very easy to disinfect.
• The pH and the solubility for calcite were below the limits. Both values however were typical for demineralized water and have no negative effect on the applications intended.
• All other parameters (107 parameters analyzed) were within the limits of the drinking water regulation
• The permissibility of a deviation according to §18 German drinking water regulation is therefore confirmed without any restrictions

5 LITERATURE

The Daireuse process is a combination of standardized units which are used also in other drinking water applications (photo: Veolia)