Translation into English of the technical paper 'Hohe Wasserqualität auch während Dürre' originally published in the German magazine 'Special IndustrieWASSER 01/22'

Membrane processes for efficient water use

High water quality even during drought

When water is scarce, less groundwater from deep wells is available to the industry. However, other sources can be tapped using membrane processes.

In a global perspective, water consumption has more than doubled since the 1960s. According to the World Research Institute, more than one third of the world's population is already directly affected by severe to extremely severe water stress. As the world's population continues to grow rapidly, the water situation is not expected to ease in the future. The Middle East and the southern part of Europe are particularly affected.

For Germany, the water situation is more relaxed. Since the 1990s, water consumption has been almost halved due to efficiency improvements and the decline in cooling water withdrawal from conventional power plants. According to the Federal Environment Agency in 2016, 12.8% of the available water in Germany is used.

Viewed regionally and especially seasonally, however, the situation is more critical. Due to changing climatic conditions, droughts are also being observed more frequently in Germany. The water quantities in the rainy months are no longer sufficient to replenish the groundwater bodies, so that the dryness of the overall soil continues to increase, reports the Helmholtz Centre for Environmental Research.

Impact of water scarcity on operational safety

The effects are already being felt today and, unfortunately, are no longer a rarity in Germany: falling water levels in wells are accompanied by restrictions on withdrawal rights. In this context, manufacturing industries are increasingly competing with the extraction of drinking water, more than 70% of which comes from groundwater. The political regulations for water usage will continue to increase: in 2021, the National Water Strategy was presented as a draft by the Federal Ministry for the Environment. The draft focuses on the prevention of water scarcity and avoidance of conflicts of use with the aim of providing everyone in Germany with high-quality water even in 2050.

In order to make the most efficient use of the increasingly scarce resource water, recycling technologies will be increasingly necessary in the future. Since it can be adapted very well to different water qualities, membrane technology is an essential part for this. If high-quality well water is scarce or no longer available, efficient membrane processes can provide process water from alternative sources. In the following, two examples show how well water can be replaced with the help of membrane processes and how a reliable water supply can be ensured all year round.

Process water from river water in chemical park

The operator of a chemical park in southern Germany was unable to continue to obtain the full volume of groundwater from deep wells that had been used for many decades due to a requirement imposed by the authorities. Until then, the supply of fully demineralized water was ensured via turbidity-free well water using a classic ion exchange system.

The plant concept developed by OSMO as an alternative which was installed in 2012 processes the river water previously used only for cooling to produce demineralized water. With the aid of an ultrafiltration plant, the river water is purified from particles and colloidal constituents and a filtrate with a residual turbidity < 0.1 NTU and an SDI < 3 is produced for the further desalination steps. A reverse osmosis plant serves as the main desalination stage upstream of the following ion exchange plant, which remains in place, and which removes about 95% of the dissolved constituent. In addition to hardness components and nitrate, process-critical silica compounds are also reliably removed. In addition, dissolved organic substances are retained which are not desired in the process water and lead to problems in the subsequent ion exchanger. The permeate produced by the reverse osmosis plant is then heated and fed to the existing ion exchange plant, which is the final residual desalination step. Pre-desalination of the river water by RO saves 95% of the regeneration chemicals sodium hydroxide solution and hydrochloric acid compared to the conventional ion exchange only process, which is another plus point for the operator considering current chemical prices.

Further developed solution approach

In addition to the use of surface water instead of well water or drinking water, the recovery of biologically treated wastewater can in many cases contribute to a reliable year-round water supply and reduce the amount of fresh water used in the process. Using ultrafiltration, similar to the technology developed for treating river water, the previously biologically treated wastewater is freed from particles and biomass. Due to their significantly higher solids tolerance, the membranes are operated in an out-in process with a continuous cross-flow. Other modes of operation have proven to be disadvantageous for this type of wastewater due to the high solids load.

Due to the small pore size of 0.01 µm, bacteria and also most of the viruses are retained very efficiently, which means that the filtrate has very good hygienic properties. Since the solids are deposited on the membrane during filtration, cyclical backwashing is necessary. These are carried out fully automatically during operation. In order to prevent biological contamination, sodium hypochlorite is dosed several times a day during the backwashing process, which is also fully automatic. No other chemicals such as coagulants are required for the ongoing operation of the ultrafiltration plant.

Due to the sometimes high COD and salt loads in the wastewater, further treatment of the filtrate is usually necessary. Specially designed reverse osmosis systems are used for this purpose. As in conventional reverse osmosis systems, the feed water is pushed through a membrane under pressure, producing a very high-quality permeate that can be re-used at many points in the manufacturing process. Due to the high salt loads, especially from lime, precipitation of mineral compounds - so-called scaling - is to be expected in the concentrate. To prevent this, specially adapted high-performance antiscalants are used, which can ensure reliable plant operation even under difficult conditions. The important thing here is that both systems must be optimally matched to each other.

For optimum process design, OSMO offers the possibility of piloting the wastewater on site under real conditions using a container plant consisting of an ultrafiltration and reverse osmosis stage. Important process adjustments can thus already be determined in the piloting phase, which later enables safe plant operation and rapid commissioning.

Process water from wastewater in paper production

A large paper mill in northern Germany produces high-quality wood-free paper. The responsible use of water as a resource is of particular importance in the company's objectives. The strategic goals specify a 30% reduction in wastewater volume and a 40% reduction in COD load for all paper and pulp producing mills in the Group for the year 2030 compared to the reference year 2008.

The wastewater from the paper mill already passes through a very efficient wastewater treatment

process upstream of the membrane plant: After mechanical cleaning with screens and save-alls, the wastewater is biologically treated in two "Moving Bed Bio Reactors" (MBBR) and then fed to an aeration tank with surface aerator. In the secondary clarifiers, most of the biomass is separated from the clarified water by sedimentation. Downstream cloth filters remove further suspended solids before the clear water is discharged into the Emsden River. Since mid-2018, the operator has diverted a partial flow of up to 150 m³/h and fed it to the process water treatment plant. In the first step, the effluent is treated by an ultrafiltration stage. The UF filtrate is further treated by a subsequent reverse osmosis plant, which, in addition to desalination, also decolorizes the water. The permeate obtained meets the high demands required for the production of bright white fine paper. The permeate is 100% reused in the process and replaces part of the well water to protect the groundwater body.

It is noteworthy that the quality of the RO permeate is higher than that of the well water mainly used. The concentrate produced at the ultrafiltration stage - about 10 - 15 m³/h - is added to the return sludge to the biology. This recirculation further reduces the COD load of the wastewater, as is known from MBR technology. The concentrate produced at the reverse osmosis stage is discharged to the Ems River with the remaining clear water from the wastewater treatment plant.

In addition to the saving of well water, there is another positive effect for the customer - at least in the cold months: Due to the increased temperature level of about 30 °C, a considerable amount of heat energy can be fed back into the process. At a permeate flow rate of 80 m³/h, this corresponds to a recirculation of about 1.67 MW of thermal power.

With the process water treatment system, the paper manufacturer was able to reduce the production-specific wastewater volume from 2.7 m³/t (paper) to around 2.0 m³/t (paper) and fresh water consumption from 3.8 m³/t (paper) to 3.1 m³/t (paper). This saves 650,000 m³ of well water per year. The installed plant technology clearly demonstrates the possibility of using water from alternative water and wastewater resources, which can also be transferred to other industrial operations.

Decision-maker facts

- Water scarcity is a growing problem for the industry in Germany: due to declining groundwater levels, the extraction of well water is increasingly limited.
- With suitable treatment methods, surface water and even wastewater can be considered as alternatives.
- Membrane technologies such as ultrafiltration and reverse osmosis can provide the quality required for process water. Translation into English of the technical paper 'High water quality even in drought' originally published in the German magazine 'Special IndustrieWASSER 01/22'The recirculation and treatment of wastewater in the process reduces both freshwater requirements and wastewater emissions.