KOCH MEMBRANE SYSTEMS

A Koch Chemical Technology Group, LLC Company

California Facility Uses Advanced Membranes to Improve Wastewater Quality

Membrane Bioreactor Technology Is Energy Efficient and Reduces Lifecycle Costs

The City of Santa Paula, Calif. recently completed construction of the first water recycling facility built under California government code 5956 to encourage private investment aiding in solving public infrastructure needs.

The city selected the PERC Water / Alinda Capital team to design, build, operate and finance a 7.2 MGD peak day flow (10.4 MGD peak hour) membrane bioreactor facility that will allow Santa Paula to meet current and future wastewater treatment needs while complying with environmental standards. The city also expects the new facility to enable the use of recycled wastewater for irrigation.

Santa Paula chose Membrane Bioreactor ("MBR") technology because it combines biological wastewater treatment and membrane filtration into one unit process, producing a consistently high quality effluent in an extremely compact footprint. PERC Water selected the single header PURON™ membrane filtration modules from Koch Membrane Systems ("KMS") to incorporate into the MBR design because they are energy efficient and provide significantly lower lifecycle costs than other alternatives. The Santa Paula project is the first large MBR installation in North America to use the KMS PURON membrane filtration modules.

Aging Infrastructure Needed to Be Replaced

Santa Paula is a city 65 miles northwest of Los Angeles and in the rich agricultural Santa Clara River Valley. Surrounded by rolling hills, rugged mountain peaks, and orange, lemon and avocado groves, Santa Paula is sometimes called the "Citrus Capital of the World."

Santa Paula's wastewater treatment facility was constructed in 1939 and today serves about 30,000 residents. Hindered by failing infrastructure and dated technology, the facility was in violation of several discharge requirements issued by the Los Angeles Regional Water Quality Control Board ("RWQCB"), and had received more than 3,000 violations and fines in excess of $8 million. To comply with the increasingly stringent regulations, the city made several plant modifications but ultimately failed to achieve the operating requirements.

A consent judgment with the state issued in 2007 allowed the city to apply the fines toward a new wastewater treatment plant if the facility was completed and in compliant operation by December 15, 2010. Santa Paula opted to pursue a design-build-operate-finance strategy to construct a new state-of-the-art water recycling facility designed to meet the city's current and future wastewater treatment needs. The project was awarded to Santa Paula Water, a partnership of PERC Water and Alinda Capital, in May, 2008. The new facility is designed for 7.2 MGD

peak day flow (10.4 MGD peak hour) and 3.4 MGD average day flow capacity with the ability to expand to 4.2 MGD. The system was completed and in full operation in May 2010, seven months ahead of the December 15, 2010 deadline.

MBR Technology Chosen for Energy Efficient and Space Saving Features

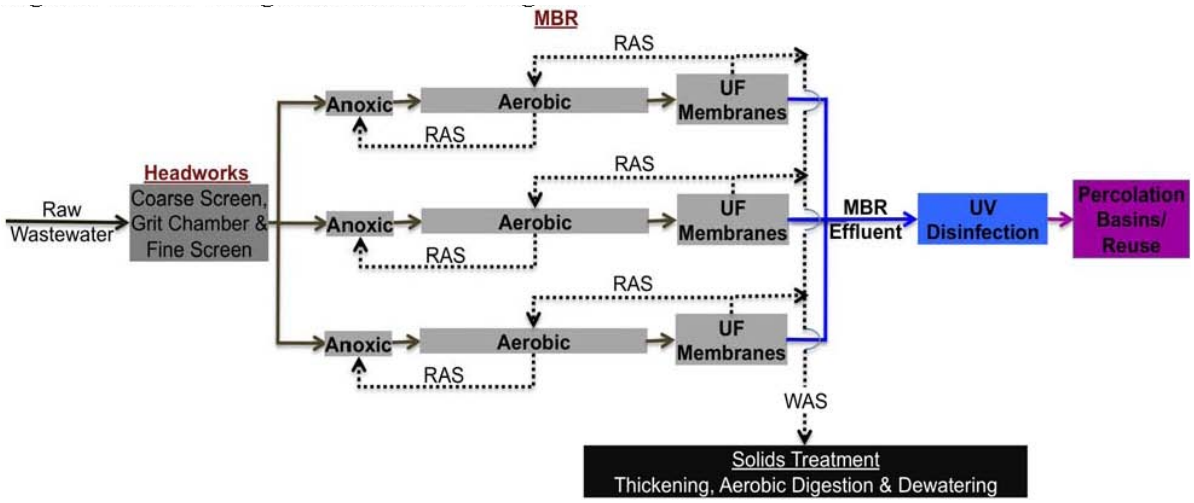
After a thorough assessment of the facility needs, Santa Paula Water chose MBR technology to provide advanced treatment process, increase plant capacity and reuse water for irrigation.

MBR systems increasingly are used in locations where water resources are scarce, reusable quality effluent is desirable, space availability is limited, and/or stringent discharge standards are in effect. These locations may include small communities, housing developments, commercial developments, resorts, hotels, malls, schools and golf courses. The MBR is also employed for industrial applications to recycle process water, reducing wastewater disposal costs and reducing water footprints.

The Santa Paula MBR facility has a compact design, with fully redundant headworks, conservative and efficient aeration design, biological foam spray system, hollow fiber membranes with incorporated aeration. Effluent from the system will discharge into evaporation/percolation ponds, and a portion of the water will eventually be used for irrigation.

Figure 1 provides a general illustration of the overall system.

Figure 1 – MBR Design Process Flow



The new water recycling facility is designed to produce an effluent that meets or exceeds all current environmental wastewater quality standards mandated by the U.S. EPA and the RWQCB. The MBR is designed to produce a finished effluent with biochemical oxygen demand and total suspended solids concentrations of less than 5 milligrams per liter (mg/L), total nitrogen less than 8 mg/L and turbidity less than 0.2 Nephelometric Turbidity Units.

Table 1 shows the facility's water quality results for October 2010.

Table 1 – Santa Paula Water Recycling Facility October 2010 Water Quality Results			
	Influent	Effluent Permit Requirements	Effluent Results
BOD	340	10	1.1
TSS	283	10	<1
Total Nitrogen	n/a	10	6.0

MBR Requires Careful Design to Meet Water Quality Objectives

An MBR is a biological process that combines secondary and tertiary treatment using a membrane filtration process. Because membranes are used to provide the necessary solids-liquid separation, MBR effluent is consistently high quality with low turbidity, low bacterial counts, and low TSS and NTU. The filtrate quality, in many instances, is suitable for feeding directly into a reverse osmosis (RO) process, if required in the future. An additional advantage of an MBR system is its compact footprint. This is achieved by replacing the secondary clarification process with membrane separation and by operating the biological process with higher mixed liquor suspended solids than conventional activated sludge systems.

Despite its advantages, using membranes for solids-liquid separation requires careful assessment of several critical design elements. **Table 2** shows these design requirements along with a brief overview of how they were handled in the Santa Paula Water project.

Table 2 – Unique MBR Design Requirements		
Design requirement	Why it is important	How Santa Paula Water addressed the requirement
Wastewater characterization	Confirms the design assumptions and ensures compliance with product warrantees	Independent laboratory performed the water quality assessments to ensure proper design and warranty compliance
Accurate estimates of peak flows	MBR facilities are even more susceptible to wet weather flows than conventional gravity solids-liquid separated plants	Flow hydrographs used to understand the peak hour flow rate and determine the time elapsed to produce the inflow volume. To reduce the peak wet weather flow that would need to be sustained, this design incorporated a 1.0 MG equalization basin to attenuate flow

Careful design of headworks	Headworks protect the membranes and minimize the accumulation of inert debris in the membrane tanks, and ensure reliable performance without requiring extensive maintenance	Facility designed with two gross solids removal processes ahead of the fine screens. Headwork process units were oversized to reduce the frequency of required maintenance and ensure consistent performance
Membrane equipment selection	Ensures reliability, compatibility with competing products, energy efficiency, and customer support	Hollow fiber membranes were selected for the solid-liquid separation to provide an energy efficient solution with separate membrane tankage for ease of maintenance and process control.
Biological foam control	MBRs provide a perfect trapping environment for filamentous bacteria that float and cause biological foaming, which can result in undesired loss of biomass and increased membrane fouling rates. *The PERC facility's unique covered aeration basin design made this issue a particular challenge*	Automated spray system designed to fit the roof design for each basin using the smallest practical nozzles, achieving full coverage spray of the water surface at the normal average operating level
Aeration design and operation	Special concern with the MBR process due to the increased mixed liquor suspended solids (MLSS) concentrations at which MBRs operate compared to conventional processes	Required airflow rates to maintain the aerobic zones at dissolved oxygen (DO) concentrations of 2 mg/L were determined using an α-factor of 0.45 and a standard oxygen transfer efficiency (SOTE) of 30 percent for the membrane aeration panels
Biological treatment concerns	MBRs may trap filamentous bacteria that floats and causes biological foaming events	Biological modeling simulations were performed using a modular, multi-purpose modeling environment used for the simulation of municipal and industrial wastewater treatment plants
Softened water requirement	Inorganic foulants can be a significant factor in MBR facilities when the wastewater contains high mineral or metal concentrations, causing increased operation and maintenance costs due to additional chemical cleans required to maintain design capacity	The design includes a reverse osmosis skid to provide sufficient softened water for the sprayer system, maintenance cleans and intensive cleans
Biological startup	Crucial to plant success and should be designed to minimize the startup period to quickly reach stable activated sludge process operating conditions and maintain overall membrane integrity and mitigate untimely membrane fouling	The biological startup process was modeled using GPS-X process simulator, while taking into consideration the system's physical constraints

PURON Membrane Filtration Modules Selected for Energy Efficiency and Ease of Operations

PERC Water turned to Koch Membrane Systems' PURON membrane modules as a cost-effective and energy-efficient solution to meet the RWQCB's stringent discharge requirements. PURON membrane modules produce high-quality effluent that meets stringent water reuse and recycling requirements while significantly reducing the treatment system footprint, installation cost, and manpower commitment, all key requirements for the Santa Paula site.

According to Juergen Nick, PERC Water's vice president of design and engineering, "The water recycling technology we are employing in the Santa Paula Facility sets the industry bar to help control and minimize operational energy costs within the smallest environmental footprint possible. As membrane scouring and biological aeration account for nearly half of the facility's power consumption, PERC Water chose to employ the most energy-efficient air production and usage systems on the market . . . Koch Membrane Systems' PURON membranes. In total, 24 PSH-1500 modules were installed, making it one of the largest MBR installations in North America."

PURON modules are energy-efficient, with the lowest energy demand of all commercially available MBR modules. The system is easy to operate, with features that are designed to provide significantly lower lifecycle costs, including a single header design that provides better solids management in the module, braided fibers to reduce the risk of fiber breakage, and highly effective air scouring that virtually eliminates sludging.

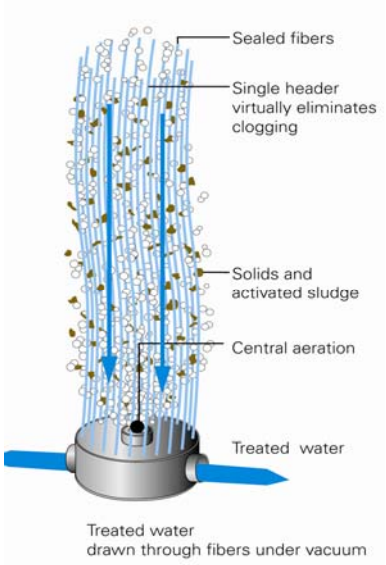


Figure 2 – PURON MBR Module Design

An important advantage of the patented PURON module is the use of a single header with reinforced hollow fibers that are fixed only at the bottom. The sealed upper end of the fiber is allowed to float freely. The free floating tip design eliminates the build-up of hair and fibrous materials that typically clog the upper ends of membrane fibers in MBR module designs that employ both top and bottom headers.

Solids and particulates, including bacteria, are retained by the membrane and remain on the outside, while permeate is drawn through the membrane to the inside of the fibers. The outside-to-inside flow pattern provides optimal solids management and a high flow-rate. **Figure 2** illustrates the single header design of the PURON module's fiber bundles.

The Santa Paula facility includes the larger 1,500 m^2 PURON module, which simplifies design, operation and retrofit of large-scale MBR plants. The improved submerged membrane module features greater packing density, lower energy costs for aeration, and simplified installation while providing even greater compatibility with other commercially available systems.

The 1,500 m^2 module is particularly significant because it was specifically designed for large-scale MBR projects. Features such as an optimized permeate extraction manifold and air supply

lines reduce the number of piping connections during installation. For additional flexibility, the new product line enables users to easily retrofit the advanced PURON technology into systems with comparably sized modules. **Figure 3** shows how the module works**.**

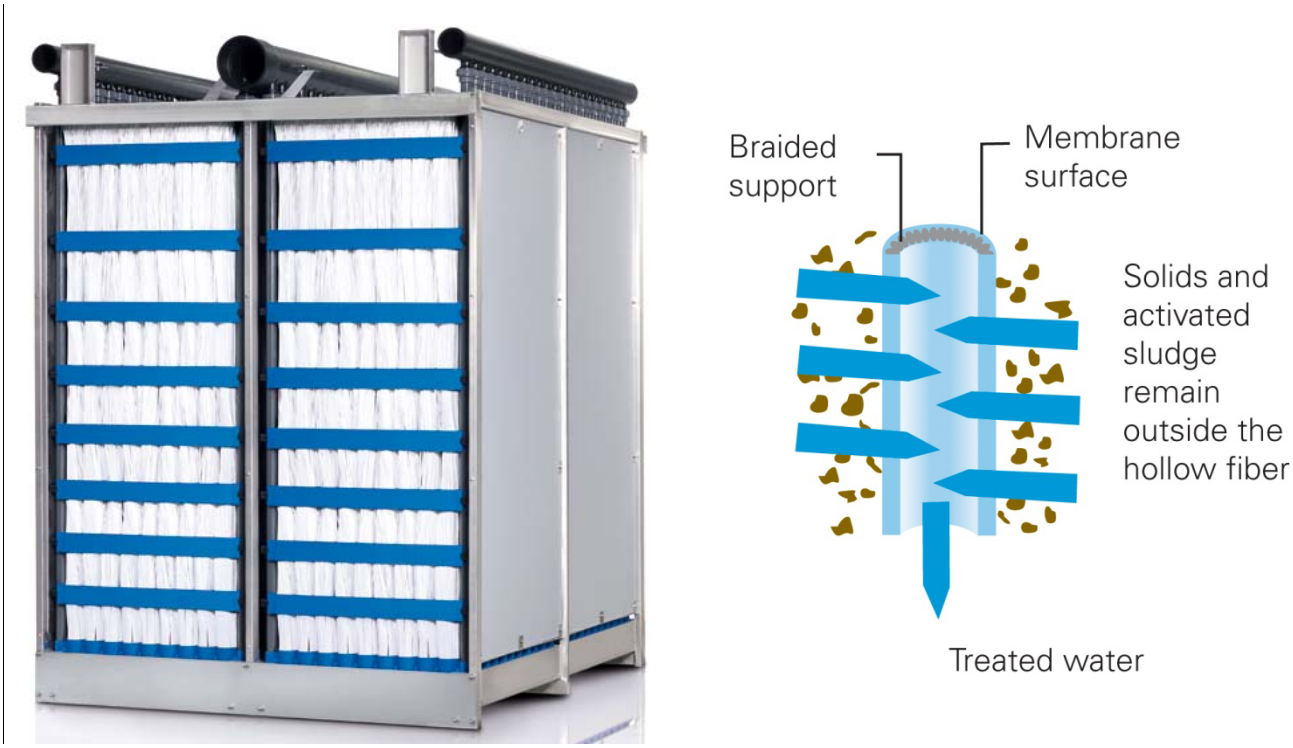


Figure 3 – Overall Design of the 1500 m² Module

In addition, to simplify membrane cleaning and maintenance, the central aeration system and the bottom header have been redesigned. The new aeration system reduces the flow rate during air scouring, resulting in a decrease in air usage by up to 20 percent over the original design.

PERC Water's innovative design uses five acres less land than would be required by a conventional wastewater treatment facility. The plan includes a recycling education center, where local students can learn how water recycling facilities function. In its first few months of operation, the power consumption of the plant was only 4.4 kWh/1000 gallons treated. The consumption is based on power used by all processes throughout the facility including digestion, building power, MBR Process, UV System, RO System etc. As flows increase, it is expected that the power consumption per thousand gallons will further decrease.

With the equipment selected for this facility, Santa Paula's MBR promises to be one of the most energy-efficient MBR installations in the world.

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About Koch Membrane Systems (KMS)

Koch Membrane Systems, Inc. is a global leader in membrane filtration technology and engineering support for close to half a century. KMS offers a wide range of products and engineering services which span industrial applications in food and life sciences, industrial processes and water & wastewater. As a designer and manufacturer of state-of-the-art membrane elements as well as complete membrane systems, KMS is specified for some of the most demanding applications. KMS offers comprehensive process engineering design, piloting and field service expertise. With an install base approaching 20,000 systems throughout the world, KMS is setting the standard as a comprehensive solutions provider for membrane technology. KMS is proud to be the Water Technology Company of the Year 2010.

For more information on Koch Membrane Systems and its full line of membranes and accessory products, visit www.kochmembrane.com, or contact: