MBR Technology for Wastewater Reclamation in Rural Areas

Antonia von Gottberg, Koch Membrane Systems, Wilmington, Mass
Darren Lawrence, Koch Membrane Systems, Aachen, Germany
Christoph Kullmann, Koch Membrane Systems, Aachen, Germany

Membrane bioreactors (MBR) with submerged membrane modules have set the standard for the next generation of biological wastewater treatment plants as they offer two main advantages; a significantly improved effluent quality and a substantially smaller footprint. Aside from the major application in industrial wastewater treatment, there are also many municipal applications where MBR technology is being implemented. One example is the Bega Valley Sewerage Program (BWSP) in Australia that includes state-of-the-art MBR plants.

Bega Valley is located on the southeastern coastline of New South Wales (NSW). It includes the towns of Cobargo, Wolumla, Kalaru and Candelo. The capacity of the valley's wastewater treatment systems was being stretched by urban growth, as well as seasonal population increases during the holiday period. Some unsewered villages in the valley were at risk for environmental and public health issues caused by discharge from septic tanks.

In order to maintain Australia's Environment Protection Authority compliance and to enhance environmental outcomes, the Bega Valley Shire Council developed the Bega Valley Sewerage Program, which includes the installation of new pressurized sewage collection systems coupled with membrane bioreactor (MBR) treatment plants in the towns of Cobargo, Wolumla, Kalaru and Candelo (BVSP, 2004-2006). The Cobargo MBR plant was commissioned in July 2006, and the remaining three plants will follow in 2007.

The entire program is designed to keep capital and operating costs at a minimum and to produce a very high-quality effluent for reuse. Reclaimed water from the MBR plants will be used in an irrigation scheme on public facilities such as the Cobargo Showground, Wolumla Recreation Reserve, Candelo Showground and the Sapphire Coast Turf Club, replacing potable water as the primary source. In future, reclaimed water may also be used for toilet flushing, as well as to provide a vehicle wash down facility.

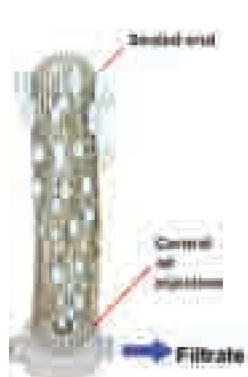

Figure 1: Membrane bundle

Membrane Bioreactors

In an MBR, ultrafiltration membrane modules are submerged in the activated sludge to combine the biological step and the solid-liquid separation into a single process. Since the membrane acts as a barrier, this improves the effluent quality. Additionally, the membrane barrier eliminates the secondary clarifier and allows the activated sludge to be more concentrated. This reduces the volume requirement for biological tanks, thus saving space and construction costs. Overall, the MBR process reduces footprint significantly compared to the combination of wastewater treatment followed by sand filtration or ultrafiltration. The footprint savings due to the wastewater treatment plant alone can be as much as 50 percent, and since the additional tertiary filtration steps there are additional footprint savings.

Example of MBR Technology

There are many different configurations of MBR technology. One example that optimizes both membrane and module design is the PURON™ submerged hollow fiber UF module from Koch Membrane Systems (KMS), of Wilmington, Mass. The patented module is designed to avoid the clogging and sludging that is an issue with some MBR module designs offered today. The module features hollow fiber membranes with a pore size of approximately 0.05 micron. The lower ends of the membrane fibers are fixed in a header while the upper ends are individually sealed and are free to move laterally as shown in Figure 1. All solids and particulates remain on the outside of the fibers while permeate is sucked out of the inside of the fibers by means of a vacuum

The fibers are arranged in bundles and are submerged vertically into the activated sludge. To maintain the filtration rate of the membrane modules, air scouring is carried out at regular intervals. An air nozzle is integrated into the center of the bundles to apply the air for scouring purposes. The central arrangement of the air nozzles inside the membrane bundles reduces the energy consumption, since the air is injected at the place where the risk of sludging is highest. The module design ensures that even hairs and fibrous compounds will be removed reliably from the system, so that a coarse prescreen can be used, thus improving capital and operating costs. A special added feature of these membranes is their enormous mechanical strength. This mechanical strength is provided by a braid inside the membrane material.

The individual fiber bundles are connected in rows. Several of the rows are mounted into a frame made of stainless steel to form a module as shown in Figure 2. The free moving fibers combined with central aeration ensure stable filtration during plant operation, long membrane life, and low operating costs by reducing the need for energy, cleaning and maintenance.

Bega Valley

Bega Valley Shire is located approximately 450 miles south of Sydney and is the largest local government in coastal NSW with a population of over 30,000. The villages of Cobargo, Wolumla, Kalaru and Candelo


Figure 2: Membrane Module

are located in the Bega Valley, and are described below. These villages were unsewered and were experiencing challenges related to septic tank effluent discharge.

Cobargo

Cobargo is a rural, residential settlement located in the north of the Bega Valley Shire. The landscape is dominated by foothills and valleys on the coastal hinterland. Surrounding agricultural land is dominated by dairy and beef grazing. The village has a permanent population of around 400 people and also has a small holiday population during peak tourist periods. The village has a busy commercial area located on both sides of the highway.

The previously used septic systems consisted of absorption trenches, transpiration beds and aerated systems that were considered to be ineffective for the number of households serviced in the area and the soil type.

Wolumla

Wolumla is a small rural village to the south of Bega. Wolumla is located on rolling hills on the coastal hinterland and has been predominantly cleared for beef, dairy and sheep grazing. The township has a permanent population of around 380 people and also has a small holiday population during peak tourist periods. The township is predominantly low density urban housing with a small commercial area located on the main street including a hotel and general store. Like Cobargo, Wolumla currently relies on septic systems.

Candelo

Candelo is a small rural residential settlement located on the coastal hinterland approximately 12.4 miles southwest of Bega Valley. The village has a permanent population of about 350 people. A small commercial area is located on the main street. Dairy and beef properties are located along the Candelo Creek floodplain and extend into the rolling hills surrounding the village. Candelo also currently relies on septic systems.

Kalaru

Kalaru is a small rural, residential settlement located in the Bega Valley Shire on the far south coast of New South Wales. The township has a permanent population of about 300 people with a considerable increase in population during peak holiday periods. The township consists of mainly low density housing and contains a large caravan park, which caters for both holiday accommodation and permanent residences. The surrounding landscape consists of fairly flat topography on a floodplain and a number of swamps and wetlands. Surrounding agriculture is dominated by dairy and beef grazing with smaller market gardens and horse studs on rural residential properties closer to the town center. Kalaru also currently relies on septic systems that are considered to be ineffective due to the number of households serviced and the soil type.

> Overall, the MBR process reduces footprint significantly compared to the combination of wastewater treatment followed by sand filtration or ultrafiltration. The footprint savings due to the wastewater treatment plant alone can be as much as 50 percent, and since the additional tertiary filtration steps there are additional footprint savings.

Bega Valley Sewerage Program

The Bega Valley Sewerage Program is an alliance formed between Tenix Alliance and the Bega Valley Shire Council to upgrade five existing sewage treatment plants and install greenfield sewerage systems for five villages in the region (Stone, 2005). The program includes updating the existing plants to Biological Nutrient Removal (BNR) facilities and installing new pressurized sewage collection systems coupled with membrane bioreactor (MBR) treatment plants in the towns of Cobargo, Wolumla, Kalaru and Candelo. The program also includes the operations and maintenance of the new and existing sewage treatment plants for ten years, with an option for Council to extend the agreement for a further five years. All collection systems will remain the responsibility of Council.

Water Reuse

The program as a whole is designed to keep capital and operating costs at a minimum and to produce a very high quality effluent for reuse. The reclaimed water from the upgraded existing plants will be used for golf courses adjacent to the plants, and at a nearby dairy farm. Reclaimed water from the MBR plants will be used in an irrigation scheme on public facilities such as the Cobargo Showground, Wolumla Recreation Reserve, Candelo Showground and the Sapphire Coast Turf Club, replacing potable water as the primary source. In future, reclaimed water may also be used for toilet flushing and to provide a vehicle wash down facility.

Bega Valley MBR Plants

The four MBR systems are identical, resulting in significant cost savings for the Bega Valley Shire Council and the community. Each system is designed for 800 people equivalents or an annual average flow of 180 m^3/day (47,000 gpd). The maximum daily flow is 300 m^3/day (80,000 gpd) and the peak hourly flow is 360 m^3/day (95,000 gpd).

Each plant includes prescreening with 3 mm perforated plate screens followed by a biological treatment system with nitrification and denitrification. The UF membranes are submerged in the mixed liquor and used to separate the treated wastewater from the suspended solids. Figure 3 shows a three-dimensional graphic of the plant. Each plant has a footprint of approximately 66 x 49 feet.

Each system includes 2 modules of 235 m^2. The membrane modules are type PSH 500 C2-8 and were supplied by KMS. A photograph of one of the modules that was installed at Bega Valley is shown in Figure 4.

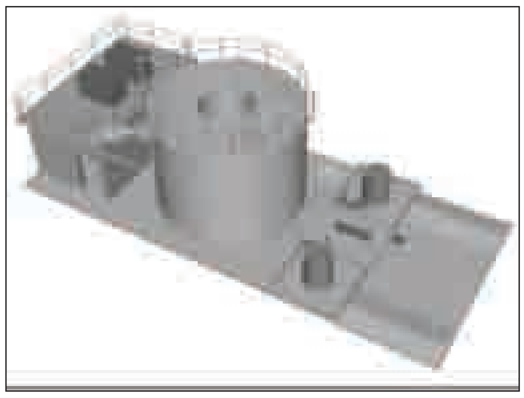

Figure 3: Sewage Treatment Plant

Cobargo

The Cobargo MBR plant was first to be commissioned in July 2006. The three other plants of Wolumla, Kalaru and Candelo will be commissioned in 2007. The plant at Cobargo is shown in Figure 5. Figure 6 shows the membrane tanks during normal operation.

Application of MBRs for Rural Areas

There are a several reasons why MBR technology can be an appropriate choice for rural areas. MBR systems provide excellent water quality without the risk of upsets that can occur with a secondary clarifier. Additionally, an MBR system can operate with minimal supervision but still guarantee high water quality appropriate for reuse. Many MBR systems in remote areas are designed with a SCADA system, allowing remote access to the data and then with an operator visiting the plant on a daily or weekly basis to perform checks, do routine maintenance and top up chemical tanks. MBR systems are modular, and so can be designed to easily accommodate additional future demand.

Figure 4: Membrane Module installed at Bega Valley

MBR systems occupy approximately half the footprint of a more conventional wastewater treatment plant, and are therefore less visible to the community. If desired, an MBR system can be installed so that it completely blends into the landscape. For example:

- In a farming community the MBR could be installed inside a building that looked like a barn.
- In a park, the MBR building could be partially underground with landscaping over the building so that the building is not obvious other than at access points.
- In a small town, the MBR could be installed inside a building that looked like a typical house in the town.

Many rural areas derive income from tourism. MBR technology supports this by providing a system that is less intrusive to the environment, and by providing high quality water. Some rural communities have selected MBR technology to provide high quality water for discharge in order to maintain the quality of their streams, rivers and lakes. MBR effluent can also be recycled to provide additional water to the community to ensure sufficient water resources to cope with the additional water requirements of the tourist season. MBR effluent is reused today for irrigation of golf courses and parks and for toilet flushing in hotels. The Village of Cloudcroft, NM is currently constructing an MBR system that will be part of an indirect potable reuse scheme to provide additional potable water to the village, which has 750 permanent residents and a transient population that can exceed 2,000 people at the weekends and during the summer tourist season (Howe, 2007).

Figure 5: Cobargo MBR Plant

Figure 6: Cobargo Membrane Tanks

Conclusions

The MBR systems supplied as part of the Bega Valley Sewerage Program are helping several small communities reduce the risk of environmental and public health issues related to discharge from septic systems. `Additionally, the MBR effluent is high enough quality to be recycled, thus providing additional water resources to the communities.

The first MBR system at Cobargo has been running for almost one year, and the other three systems will be commissioned in 2007.

MBR systems are appropriate for many rural areas because they require minimal supervision, can be designed to blend into the landscape, and provide high quality effluent for recycling.

References

Bega Valley Sewerage Program (BVSP), Website: www.bvsp.com.au ©2004-2006.

Howe, K. J., E. Livingston, A. T. Hanson, S. E. Cabaniss, B. M. Thomson, D. Chen. "Indirect Potable Reuse Using Membrane Bioreactors and Reverse Osmosis", Proceedings, AWWA Membrane Technology Conference, March 18-21, 2007.

Stone, W., C. Truscott, and D. Searle. "Alliance Project Delivery – Bega Valley Sewerage Program Background" Water Journal, Australian Water Association. December 2005.