**Satellite Treatment - Modern membrane bioreactor technology makes treatment integral to the collection system and enables**

** Ed Jordan*

**Treating wastewater for reuse has become a necessity for many communities as water supplies dwindle and water costs increase. Communities have found, however, that it is simply too expensive to run reclaimed wastewater through miles of distribution pipe from a centralized water treatment plant to the point of use.**

That's why satellite wastewater treatment plants are increasingly popular as a way to recycle wastewater for reuse. These sidestream treatment plants allow cities to tap into sewer systems - a practice sometimes called sewer mining - and treat sewage locally for reuse applications, such as irrigation. The treatment process actually becomes integral to the collection system.

The satellite plants cause minimal infrastructure disruptions, decrease the load on a main treatment facility and delay costly expansions or permitting. Additional savings are realized because the plant does not require the same redundant equipment as an end-of-the-line plant. Satellite plants often use membrane bioreactor (MBR) technology. MBRs produce high-quality effluent, typically have a small footprint and require only minimal operator attention.

**MBR technology**

A membrane bioreactor combines membrane filtration with biological activated sludge treatment to produce effluent that meets the most stringent state reuse standards. The membranes retain minute particles, bacteria and viruses in the wastewater, while solids remain in the biological treatment system.

Immersed membrane technology integrated with biological processes was introduced in the last 10 to 15 years as an alternative to conventional clarification, allowing municipalities and industrial plants to meet strict effluent requirements with smaller treatment plants that can handle higher reactor loadings and produce less sludge.

According to market researchers, the market for MBRs is still growing. Robert W. McIlvaine of the McIlvaine Co., a filtration forecasting firm, has noticed a 30 to 40 percent increase in MBR sales over the last few years. Within that number, MBR usage for wastewater treatment has increased by 60 percent. In the U.S. alone, sales are expected to reach nearly $100 million by 2010.

With low-pressure membranes installed inside a biological reactor system, there is no need for sedimentation, screening and media filtration to separate mixed liquor or suspended solids from treated effluent. Thus, the membrane filtration system replaces the clarifiers found in conventional activated sludge systems. MBRs also eliminate the need for return sludge pumping, polishing-effluent filters and maintenance associated with conventional clarification. This results in a much smaller footprint.

The MBR process is easily automated. A membrane monitoring system can continuously monitor and record important operational parameters, helping operators meet environmental requirements. An existing conventional plant can be retrofitted with a membrane system and afterward treat greater wastewater volumes in the same space, while producing higher-quality water.

**How does MBR work?**

There are different MBR processes on the market, but they all use a suspended-growth biological reactor and a membrane filtration system. The membranes, which may be flat-sheet or hollow-fiber, low-pressure microfilters, are immersed in an aeration tank in contact with mixed liquor, where the biological treatment process takes place.

Typically, a vacuum is applied to channel the water through the membranes. The membranes hold back the active biomass, thus eliminating the sludge settleability issues found with traditional clarifiers. This allows the biological process to operate at long sludge ages, typically 20 to 200 days, and at increased mixed liquor suspended solids (MLSS) concentrations of 8,000 to 14,000 mg/L on average. The high MLSS concentrations provide numerous process benefits, including stable operation, complete nitrification, and reduced biosolids production. High MLSS concentrations also reduce biological volume requirements, and associated footprint, to 20 to 30 percent of those required for conventional biological processes.

Immersed operation of membranes in a high-suspended-solids environment offers unique challenges and requires careful management of the membrane environment to prevent solids buildup and dehydration on the membrane surface. To prevent accumulation, continuous and uniform fluid transfer at the membrane surface is critical. For this reason, the MBR process includes an airflow that produces turbulence to scour the external surface of the membranes, carrying the rejected contaminants away from the membrane surface.

**Satellite MBR plants**

The MBR satellite, or package, plant consists of the biological process with integrated membrane filtration system, along with all ancillary equipment, which may include the backwash filtrate tank, air-supply system, membrane clean-in-place (CIP) system, instrumentation package, and integral controls.
Prefabricated steel tanks typically include pre-installed internals and skidmounted pumps and blowers to reduce installation time and onsite labor. The plant is generally pre-wired, piped, skidmounted and perhaps even factory tested before shipment to the site.

If a satellite plant needs to be taken offline, untreated water simply bypasses the MBR unit and flows directly to the main wastewater treatment plant downstream. The shutdown would affect only customers using reclaimed water produced by that particular plant, rather than all reclamation customers in the area.
Many equipment variations, configurations and options can be used with a satellite MBR plant. Equipment selection depends on effluent requirements, ease of maintenance and operation, power consumption, future expansion and capital cost.

Typical uses for water recycled by the satellite plant are landscape irrigation, groundwater replenishment, cooling tower feedwater, and other nonpotable uses. Odor is generally not an issue, since wasted sludge from the MBR plants are ideally suited for a wide range of municipal and industrial wastewater applications including:

- Residential development projects (single dwelling, housing cluster or subdivision).
- Commercial development projects.
- Remote installations
- Emergency response wastewater treatment applications.
- Military bases and rapid infrastructure deployment.
- Sports facilities and parks.
- Schools, shopping centers and office parks.

**Satellite plants in the community**

Some municipalities have already taken advantage of satellite treatment. For example, The Lacey, Olympia, Tumwater and Thurston Country (LOTT) Wastewater Alliance in Olympia, Wash., has started a reclamation program that will use wastewater made available through existing local collection systems. Removal of wastewater from existing sewer lines takes the load off of the main end-of-the-line treatment plant.

The Hawks Prairie location for the plant will begin treating up to about 2 million gpd in 2006 for large users of reclaimed water. The program will save local communities hundreds of millions of gallons of drinking water each year and preserve valuable groundwater supplies.

The City of Kissimmee, Fla., is also interested in satellite treatment as a reliable way of reclaiming wastewater remotely. After Disney World opened nearby in 1971, Kissimmee and its neighbor, St. Gloud, experienced rapid population growth, which continues today. This growth, combined with the challenges of existing infrastructure and drought, have stressed the water supply, making water reuse a necessity.

A 50,000 gpm MBR satellite demonstration facility operated at one of the city's water treatment plants and provided high-quality reclaimed water with minimal operator attention. Although the city already reclaims more than 3 mgd of wastewater for irrigation, it has a long-term, growing need for more treatment and reclamation.

**MBR: The Process at work**

Membrane bioreactor (MBR) technology is a simple process that enables high-quality and high-volume treatment in a relatively small footprint. Here is an overview of how one specific MBR process works.

The packaged plant uses an immersed membrane bioreactor operating system. Wastewater is screened before entering the tank where biological treatment takes place. Aeration within the aerobic reactor zone provides oxygen for the biological respiration and maintains solids in suspension.

To retain the active biomass in the process, the MBR uses submerged polymeric hollow-fiber microfiltration membranes, housed in a separated membrane tank. The hollow fibers are bound together in modules, using a dual-potting system. By application of low vacuum to the insides of hollow fibers, the fully oxidized and nitrified water is filtered through the membranes.

Meanwhile, mixed liquor and air are pumped continuously into each membrane module fiber bundle. The resulting flow across the membrane continually scours the membrane surface, preventing solids buildup. Effluent characteristics are:

- Turbidity < 0.2 NTU.
- BOD (biochemical oxygen demand) < 5 mg/L.
- TSS (total suspended solids) < 1 mg/L.
- Nutrient removal as low as 5 mg/L total nitrogen and 0.5 mg/L phosphorus when required.

To ensure continuous fluid transfer at the membrane surface, the unit incorporates a fluid renewal system that provides both fluid transfer, in the form of mixed liquor, and air scour energy, through a two-phase jet.

The jet system is located at the bottom of each membrane module, introducing both air and mixed liquor from a separate aeration basin into the bottom of the module. The air bubbles blend with the mixed liquor and rise up through the membrane bundle, providing scouring energy to the membrane surface as well as fluidizing the membrane surface to prevent solids accumulation.

The two-phase jet introduces fluid consistently to all membranes in the system by dividing the membrane module into narrow fiber bundles that allow air and fluid to move up and between the individual membrane fibers. This continuous fluid renewal prevents liquid viscosity from increasing and fouling the membrane surface.

When modules are placed within the membrane tank into a complete system, the jet generates an overall upflow of fluid within the tank (mixed liquor is introduced into the bottom and overflows the top). This upflow of liquid parallel to the membrane surface creates a cross-flow pattern that prevents solids accumulation at the membrane surface and reduces air scour requirements.

The upflow of liquid also eliminates areas of conflicting currents that result in dead zones. Further created by the mixed liquor and air upflow is a flotation effect that moves grease, scum and other potential membrane foulants to the tank surface, where they are removed from the membrane environment.

The system also includes a solids distribution process whereby air and liquid are introduced into the two-phase jet, creating back pressure and even distribution of air and mixed liquor to each module in the membrane tank. Even distribution across the tank ensures consistent operating conditions for all membrane modules in the system.

An automated clean-in-place (CIP) operation allows the membranes to be chemically cleaned without lifting or removing the membrane module, disconnecting pipes and fittings, or using high-pressure hoses that could damage the membranes.

Because the membranes are isolated from the biological process, the sensitive biology is protected from strong oxidizing chemicals, such as chlorine or acid. The CIP process ensures that all membranes on a common suction header are cleaned together, preventing accelerated membrane fouling.

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