Controlling Biomass Quantity, Quality at MBR Plant Requires Accurate, Real-Time MLSS Measurement

By Bob Dabkowski

During periods of high flows, operators at the Dundee, MI, wastewater treatment plant had experienced significant difficulties maintaining proper solids levels in the plant's MBR tanks, increasing the potential for clogged membranes and expensive manual cleaning. By adopting real-time monitoring of MLSS concentrations, the plant now has effective early warning of excessive solids build-up and the critical process control information necessary for making quick, accurate adjustments.

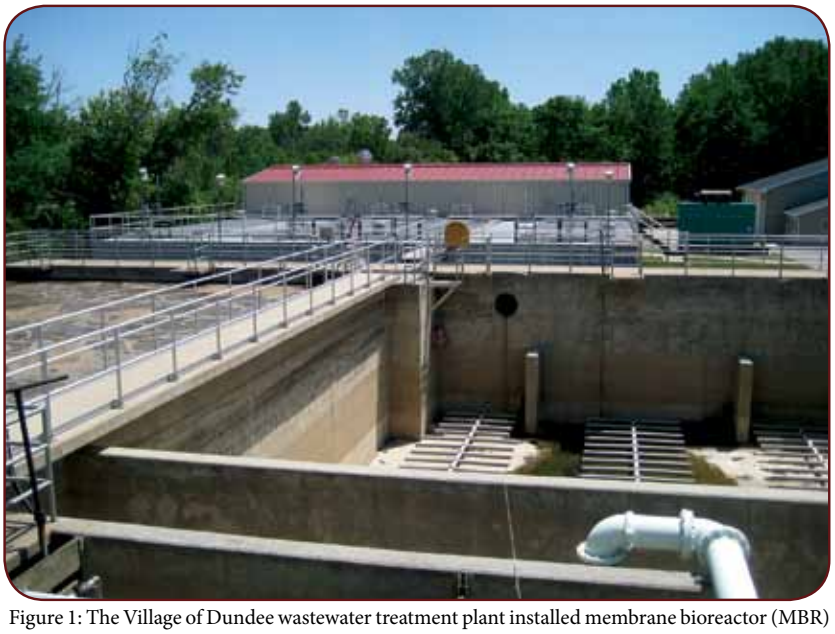

Figure 1: The Village of Dundee wastewater treatment plant installed membrane bioreactor (MBR) technology in 2005, using much of the existing plant, including the conversion of sequential bioreactors (SBRs) to biological process basins for the new system.

When the Village of Dundee wastewater treatment plant's new NPDES permit lowered discharge limits significantly, primarily on BOD and ammonia-nitrogen, the facility was already in need of expansion due to area growth. To meet these and anticipated future treatment needs, membrane bioreactor (MBR) technology was installed in 2005 using much of the existing plant, including the conversion of the facility's sequential bioreactors (SBRs) to biological process basins for the new MBR system.

The upgraded and expanded 1.5 mgd plant is designed for 3.0 mgd peak daily flow. Current average daily flow to the plant is 850,000 gpd.

Following grinding, grit removal and screening, flows enter pre-aeration tanks before proceeding to four 60,000-gallon MBR tanks. MBR, in concept, is simply an activated sludge plant with the final clarification stage replaced by a membrane filtration system. The separation of the sludge from the treated effluent is implemented directly in the aerated biological reactor rather than by gravity using large clarifiers. The solids removal efficiency of the membrane allows the sludge to be contained in the system at mixed liquor suspended solids (MLSS) concentrations up to five times higher than possible in conventional activated sludge plants. This results in a system which can treat the water as efficiently as a system with a much larger footprint.

High Flows Bring High Percent Solids

For the Dundee plant, high solids concentrations in the MBR reactors prompted the necessary adoption of advanced instrumentation for continuously monitoring MLSS levels.

"For example, when we have high flows to the plant, we can have what we call 'thickening' or 'dewatering' events in our MBR tanks," said Plant Superintendent Dave Rigel. "There are a number of reasons for these events, including flow splitting issues plus an insufficient amount of return activated sludge during peak flows. During these events, mixed liquor suspended solids get out of balance and solids content in the MBR tanks can rise upwards of 20,000 mg/L to 30,000 mg/L, and higher."

The membranes continue to permeate water during these events, thereby continuing to increase sludge thickness in the MBR tanks.

"We've had solids levels in our tanks rise to as high as 4.5 percent," Rigel said. "The membranes are not designed for that high a percent solids in the mixed liquor. When this happens, the thickened sludge clogs the membranes. It doesn't degrade the life of the membrane fabric itself, but it will become plugged and require increasing levels of suction to pull the water out."

The problem was exacerbated by the fact that Rigel and

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Figure 2: The plant's four MBR tanks are covered. The solids removal efficiency of the membranes allow the sludge to be contained in the system at mixed liquor suspended solids concentrations up to five times higher than possible in conventional activated sludge plants.

the plant's two operators run the treatment facility from 7 a.m. to 3:30 p.m. Monday through Saturday. The remainder of the time the plant runs unmanned.

"If a thickening event in one of our MBR tanks started at 4:00 in the afternoon, it would simply worsen until we came in the next day, and then we had to really scramble." Plus, Rigel said the only method the plant operators had for determining the current sludge thickness in the reactors was solely visual. "There are two hatches over each tank and we had to go by just visual inspections to check the status and see if our process adjustments were thinning out the solids inside the tank or not."

If sludge exceeds 4.0 – 4.5 percent solids in the MBR tanks, it can plug the membranes to the point where they must be pulled from the tanks and manually cleaned, which is a significant and costly task.

"Our plant does not have a system in place for pulling the membranes out of the tanks," Rigel said. "We have a 'double stack' system, with 11 membrane cassettes on the bottom of each tank and 11 on the top. Each of those cassettes contains 200 flat-panel membranes, so in our four tanks combined there are a total of 17,600 flat-panel membranes. It's a major deal and a very costly procedure to manually pull the membranes out and clean each one. We must contract this work out, and a crane must be rented in order to pull the cassettes out."

Since start up in 2005, Rigel said MBR tanks have had to be taken out of commission three times.

"Last time, the cost for pulling the membranes from two tanks was approximately $15,000. Plus, we were down an MBR tank – they're cleaned one at a time – so, our plant's treatment capacity was down 33 percent for an extended period."

Real-Time MLSS Measurement

In August 2008 the plant installed online sensors in each MBR tank to provide continuous, real-time MLSS measurements. The new sensors have provided plant operators with an effective early warning system of rising solids levels in the MBR tanks. Installation of the probes has also eliminated the reliance on simple visual assessment of sludge by providing the instantaneous process control information necessary for operators to maintain solids content in the tanks below critical levels.

The new suspended solids analyzers, Hach Solitax sc units, use dual-beam infrared scattered light photometers and receptors to monitor the mixed liquor concentration. The dual, infrared light technique eliminates color interference, minimizes calibration, and improves accuracy, and self-cleaning capability prevents erroneous values. Wastewater treatment facilities can use the units to measure suspended solids up to 150 g/L in plant influent, filtrate/centrate, mixed liquor, final effluent, and primary, digested, and thickened sludge.

Real-time monitoring of MLSS concentrations in the MBR basins has allowed Dundee plant operators to more consistently maintain target MLSS limits during periods of high flows.

Figure 3: To prevent problems with solids content in the MBR tanks rising to excessive levels, the plant installed Hach SOLITAX sc sensors in each tank to provide continuous, real-time MLSS measurements.

Unlike conventional systems, Solitax sc sensors are immune to shifts in color of activated sludge caused by variations in through-flow volume, climatic fluctuations, or other unexpected events.

"Now we look at a computer screen to see what the MLSS levels are in each basin, 24 hours a day. Knowing the MLSS concentration at all times allows us to have better control of biomass quantity and quality, to better respond to variations in influent flow and load."

Operators set high MLSS level alarms for each of the probes.

"When mixed liquor suspended solids rise to the tank's alarm target level – 20,000 mg/L, for example -- our SCADA system calls us at home and we come in and adjust the effluent valves on whichever tank that is experiencing the problem to direct more flow to it and flush that thickened sludge out. One of us can be here in 15 minutes to start adjusting valves to prevent the sludge from reaching over 2.0 – 2.5 percent solids."

Pro-Active Process Control

Operators now have the process control information they need to make proper adjustments during this critical period.

"If the probe is telling us that sludge is starting to thicken in MBR tank #4 for example, we'll be sure that tank's effluent valve is open all the way, and we will partially close down the effluent valves to number 1, 2 and 3 MBR tanks," Rigel said. "That way, much of the mixed liquor will be directed into the thickened number 4 tank to help thin out the solids. Once we've made our adjustments, we then look at our SCADA screen and check the progress we're making based on what the Solitax probe is telling us. The probe readings are critical in helping us evaluate the actions taken during these events."

Rigel said the plant has had no operation or maintenance issues with any of its Solitax probes and said sensor calibration is easy with a simple correction factor procedure to measure suspended solids. The probes have also shown excellent correlation to laboratory analysis.

"Once a week we pull a mixed liquor sample and compare the lab result to what the probe was reading at the time the sample was taken, to verify accuracy. The probes are consistently within around one percent of the lab test," he said. "In fact, the probe readings are so reliable we simply take the percentage of volatile solids in our pre-aeration tank and apply that number to the probe readings to determine the total pounds mixed liquor volatile suspended solids in the system, for calculating sludge age. We do this rather than perform a mixed liquor volatile suspended solids test on each individual MBR. It's a big time saver."

Maintenance, Downtime Prevented

The adoption of online MLSS measurement has allowed plant operators to consistently and significantly reduce the duration and severity of thickening/dewatering events in the MBR basins, thereby preventing the necessity for membrane removal and cleaning.

Figure 4: Hach sc100 controllers continually read the on-line SOLITAX probes and communicate this data via 4-20mA signals to the plant's SCADA system. The controllers also have built-in dataloggers along with calibration and verification points, alarm history, and instrument setup changes for up to six months.

"In the first nine months the probes have been installed, I estimate the plant has saved at least $40,000, which is roughly the cost to remove and clean the membranes if all four tanks went down," Rigel said.

"Continuous MLSS measurement has allowed us to prevent sludge in our MBR tanks from reaching four percent solids on several occasions, so far. For our plant, accurate online MLSS measurement is critical, and not having this capability would be very costly." **ms**

About the Author:

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