UNITED STATES OF AMERICA AND CANADA

MBR application will gain in popularity

The use of membrane bioreactors for municipal wastewater treatment in the USA and Canada is increasing for applications which require a high degree of treatment, and/or where site constraints limit conventional treatment processes. Most installations are less than five years old. Therefore, the design criteria for this technology are still in its infancy. In addition, until the last year, only one manufacturer offered this technology for municipal applications in the USA and Canada. As designs are optimized, the number of manufacturers increase, and costs reduce, the use of MBRs will gain in popularity.

Historically, membrane bioreactors have been limited to industrial and commercial applications in an attempt to generate high quality water which could be reused in gray water applications. However, throughout the USA and Canada, there are increasingly more stringent environmental regulations imposed to protect water resources and human health. To satisfy the stringent water quality criteria requires increasingly high levels of treatment with respect to nutrients as well as bacteria and viruses.

Many cities face the need to locate satellite treatment facilities to either supplement an existing treatment plant or to provide water at the point of reuse and avoid expensive pumping. Often times these satellite plants are located within existing neighborhoods where space is limited and aesthetics critical. Because of the exceptional effluent quality and its small footprint requirements, MBRs are being considered as a very viable treatment technology for reuse applications. However, current operation and maintenance (O&M) issues as well as high capital costs have limited their installations both in number as well as the size of the facility.

Current situation

Currently there are a limited number of MBR installations in municipal treatment applications. Because of high capital and O&M costs, MBR installations have not been used in plants greater than approximately 7.500 m³/d. In fact, most facilities are less than 3.000 m³/d. Within the US, there are about 24 municipal WWTP using MBRs, all of which use Zenon, Inc equipment. Within Canada, there are approximately nine installations.

It is accepted that fine screening, as low three mm, and grit removal is required to protect the membranes; however, not all of the design criteria are as well established. MLSS, SRT, and membrane flux rates are the key criteria for the design of the bioreactor. Initial commercial and industrial applications indicated design conditions using SRTs of 25 days or greater as well as MLSS concentrations up to 20 g/L. However, it has been determined through various pilot-scale facilities that operating at such high MLSS adversely impacts the flux rates and oxygen transfer. At MLSS concentrations of more 13 g/l limitations on oxygen transfer with fine bubble aeration systems led to ammonia breakthrough ('Investigating membrane bioreactor operation for domestic wastewater treatment: a case study'. A. Fernandez, J. Lozier and G. Daigger. WEFTEC 2000) but reasonable nitrification and denitrification. For full nitrification it was necessary to operate at around 10 g/l. Simultaneous nitrification and denitrification could be achieved by air/off at 6 g/l. Other systems use separate anoxic zones with recycle. The suggested MLSS concentration is between 8-12 g/l for most applications.

Operating at 25 days or greater SRT provides a stable biological system and minimizes sludge production, albeit not below that of a conventional extended aeration process. However, the desire to minimize facility footprint and to implement BNR has driven research to evaluate operations at shorter SRTs. Consideration has even been given to operating at very short SRTs to inhibit nitrification. However, reducing the SRT can increase fouling of the membranes which increases capital cost and potentially increases the number of membranes to accommodate a loss in flux rate. Second, many of the MBR applications are remote operation facilities and longer SRTs are better suited for unattended operation. And, third, without decreasing the MLSS concentration in conjunction with the SRT, there is a limit to the SRT reduction before HRT is adversely impacted. An MBR is basically an activated sludge facility and the same biological kinetics hold. Consequently, sufficient time must be present to treat the influent contaminants.

The selection of the appropriate flux rate is critical. Utilizing an aggressive flux rate can limit the capacity of the MBR either based on insufficient throughput capacity or based on a high recovery clean frequency which continuously takes membranes out of service. The flux rate is influenced by temperature and MLSS concentration; therefore, a universal flux rate cannot be given. One manufacturer suggests a flux rate of approximately 25 l/m²/h at 20°C at an average flow rate with a one to two day peak flux rates of 42-50 l/m²/h to accommodate peak flows. Conversely, other manufacturers contend that flux rates should not exceed approximately 17 l/m²/h at any time in order to minimize fouling and maintain a reasonable recovery clean frequency. In order to accommodate the lower flux rates economically, upstream equalization is

Lifting Zenon membrane section at the drinking water station of Collingwood (photo: DHV Water).

MBR installation of Key Colony Beach WWTP (photo: DHV Water).

aeration basins into the base of the membranes to provide scouring of the membranes. Vivendi Water/US Filter has a facility under construction in California. Kubota has only recently begun to market their equipment in the USA. They use a membrane plate. Mitsubishi has submitted their equipment for evaluation at the Aqua 2000 Testing facility in San Diego, California, but they have not yet actively marketed their equipment for municipal installations. Envirogen has industrial applications, but will most likely be in the municipal market soon. ¶

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recommended. Alternatively, membranes would be installed to accommodate the peak flow, and during average flows some membranes would remain out of service. The situation lends itself to satellite 'scalping' plants for water reclamation as these plants could be run at a constant flow rate.

The O&M issue of greatest importance is the membrane cleaning operation. With the high concentration of solids within the basin, there is a need for a high intensity scouring of the membranes to maintain operating flux rates. To date, membrane scouring is provided using aeration which results in an intensive energy consumption as well as high residual dissolved oxygen levels. This results in high power requirements as well as complications in the design of MBRs which must provide denitrification. Historically, a recovery clean operation involved removing the membranes from the basin and dipping them into a chemical bath of a chlorine or a citric acid solution at an interval between one and four months. The actual time is a function of operating conditions and wastewater characteristics. This process is labor intensive and poses undesirable safety issues for many facilities. As one can imagine, for a large facility, membrane cleaning would be required on a continuous basis requiring a dedicated staff.

Future outlook

The is a bright future for MBRs for municipal wastewater due to the need for cost effective, small footprint technologies which produce a very high quality effluent. Key issues in the design of the MBR systems which need further research are:

- SRT optimization, i.e. how low can it go without sacrificing flux rate;
- determination of BNR design criteria and configuration to consistently achieve low effluent phosphorus and nitrogen;
- and improvements in the membrane cleaning operation to reduce air scouring requirements and minimize chemical cleaning labor requirements.

As the design criteria become better established, and as more players enter the field, the costs will also come down. Currently, costs are still such that unless a microfiltration quality water is required, MBRs are not cost-effective even with the trade off of significantly less facilities, i.e. no final clarifiers, no filtration, and less disinfection requirements, unless there are significant site constraints. With cost reductions and improvements in the membrane cleaning operation, larger sized facilities can realistically consider this technology.

Parties involved

All MBR installations in the US and Canada to date utilize Zenon equipment. However, Vivendi Water/US Filter recently introduced their MBR design which combines the proven technologies of the Memcor CMF-S membrane with Jet Tech aeration and pumping equipment. The membranes are located in a separate basin and a MLSS/Air mixture is pumped from the