Arber
Water, Wastewater & Reuse Engineers

WATER WASTEWATER REUSE NEWS
SUMMER 2005

The new location of
Richard P. Arber Associates
Colorado office:
198 Union Boulevard, Suite 200
Lakewood, CO 80228
Phone: 303.831.4700
Fax: 303.831.0290
Website: www.arber.com

inside

Membrane Bioreactors (MBRs)

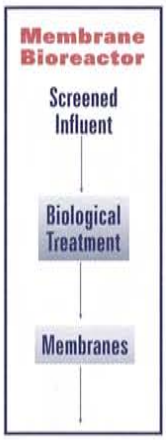
Membrane bioreactors are becoming more popular for wastewater treatment in the United States. Strict discharge requirements and limited water resources have made membrane systems attractive in a number of applications, including industrial and domestic wastewater treatment. Historically, the major disadvantage of membrane systems has been cost-effectiveness.

Membrane cassettes in MBR tank.

Introduction

Municipal governments in the United States face a number of challenges when it comes to treating and disposing of wastewater. Increasingly strict discharge limits to streams and rivers require a higher level of treatment from wastewater service providers. In some areas, the lack of water resources requires that wastewater be reused to reduce demand on the potable water system. These challenges are testing the limits of wastewater treatment technology.

The membrane bioreactor (MBR) is a new treatment technology that has shown promise in addressing these challenges. MBR systems couple activated sludge biological treatment with microfiltration or ultrafiltration membranes. They are capable of producing a high quality effluent that can be discharged to sensitive bodies of water or reused for a number of non-potable uses. MBRs have been successfully used for treating domestic and industrial wastewater over a large range of flow rates. The question remains, are they cost-effective when compared to conventional wastewater treatment technologies?



Conventional vs. MBR Treatment

Conventional wastewater treatment refers to methods that are commonly used in the United States for treating domestic and industrial wastewaters to meet effluent limits. These methods have been used for a number of years at many different locations, and their limitations are known.

MBR systems are composed of two primary parts: the biological unit responsible for the biological removal of the waste compounds and the membrane module for the physical separation of the treated wastewater. These systems have been arranged in two fashions: integrated and recirculated. Integrated systems have membranes internal to the bioreactor. The driving force is achieved by pressurizing or creating negative pressure on the membrane side. Recirculated systems have membranes external to the bioreactor. Mixed liquor is pumped through the membrane and a portion is returned to the bioreactor. Several different membrane configurations are commercially available. These include tubular, plate and frame, and hollow fiber.

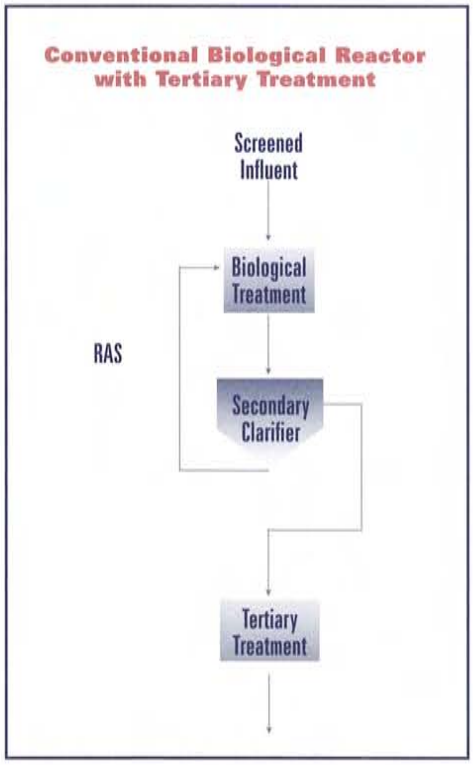
The treatment trains for conventional treatment and MBRs are substantially different. For example, the treatment train may consist of screening, grit removal, aeration basins, secondary clarifiers, and UV disinfection. Modifications to the aeration basins may

Continued inside.

enhance biological removal of nitrogen and phosphorus. Tertiary filtration, in the form of media or membranes, can be added for phosphorus removal and non-potable reuse.

The MBR treatment train consists of screening, grit removal, fine screening, flow equalization, and membrane bioreactors. Fine screening down to 2-mm openings is required to remove fibrous material that has proved problematic to membrane operation. Flow equalization can be used to reduce the number of membranes necessary in the treatment system. All of the plant effluent passes through the membranes. Reducing the flow rate by equalization reduces the membrane surface area required to process the effluent. Disinfection is not needed, unless the water is required for non-potable reuse. Changes to the biological process of the MBR can be made to allow for nitrogen and phosphorus removal. Coagulant can be added directly to the MBR for chemical removal of phosphorus.

BOD removal, nitrogen removal, phosphorus removal and non-potable reuse are four applications where MBRs may compare favorably to conventional wastewater treatment.



Zenon membrane cartridge
Courtesy of ZENON Environmental Inc.

Advantages of MBRs

Membrane bioreactors have a number of advantages over conventional wastewater treatment. Secondary clarifiers and sand filtration, where necessary, can be replaced by microfiltration or ultrafiltration membranes. MBRs therefore reduce process difficulties and problems associated with settling, which can be the most troublesome part of wastewater treatment.

Replacing the clarifier with membranes allows the biomass concentration to be increased within the bioreactor. This allows for a reduction in the size of the footprint of the biological system because the same biomass is retained in a smaller volume.

Another advantage of the MBR process is the production of a very high quality effluent. Ultrafiltration has been employed successfully to treat municipal wastewater. These membranes reject bacteria and viruses, potentially eliminating the need for extensive disinfection.

Disadvantages of MBRs

There are also a number of disadvantages associated with MBR systems. Fouling problems can lead to frequent cleaning of the membranes. This stops operation of a portion of the system periodically. The MBR mixed liquor typically exhibits poor settleability and filterability, making waste activated sludge disposal problematic. When operated at high solids retention times (SRTs), inorganic compounds accumulating in the bioreactor may reach harmful concentration levels, which can affect the microbiological population or membrane surface.

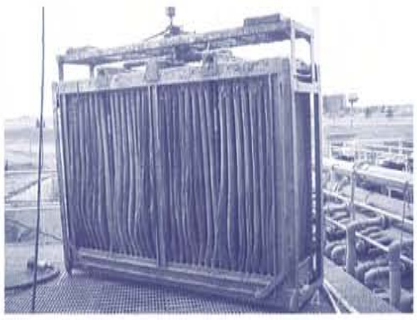
Cost-effectiveness

For BOD removal, conventional wastewater treatment is more cost-effective than MBRs. The difference is due to the equipment associated with the MBR itself, which includes the membranes, blowers to clean the membranes, and permeate pumps. Flow equalization reduces the total cost of the membrane equipment by reducing peak hour to the peak day flow. However, the cost of a flow equalization tank may be offset by the savings achieved by not needing UV disinfection or secondary clarifiers in the MBR system.

For nitrogen removal, conventional wastewater treatment is generally the most cost-effective solution. There is not a significant difference between the process configuration for BOD removal and nitrogen removal. The reasons for the increased cost of the MBR system for BOD removal are the same for the nitrogen removal.

For phosphorus removal, the MBR system can be cost competitive with a conventional wastewater treatment system. The need for filtration following biological treatment significantly increases the cost of the conventional system, while the cost of the MBR system is relatively constant.

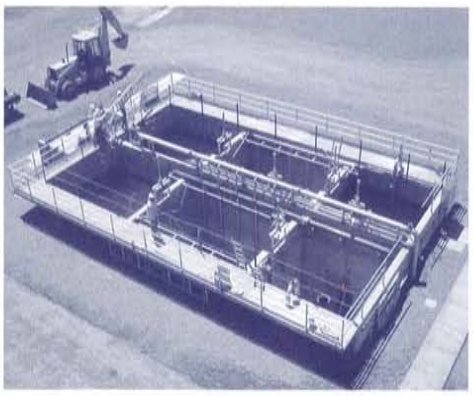
For non-potable reuse, the MBR system may be cost competitive with the conventional wastewater treatment system. The MBR system can be more cost-effective if it decreases disinfection requirements. Even with stringent E coli limits and the requirement for disinfection of the effluent, it may be possible to meet the limits with a low dose of chlorine. This may not be true for the conventional system.



Used Zenon membrane cartridge ~ Centennial, CO

Arber
Water, Wastewater & Reuse Engineers
Richard P. Arber Associates • www.arber.com
198 Union Boulevard, Suite 200 Lakewood, CO 80228 • Phone: 303.831.4700 • Fax: 303.831.0290
65 Sandrock Road, Sedona, Arizona 86351 • Phone: 928.284.9091 • 800.884.5922

Membrane Bioreactors (MBRs), continued



0.5 mgd MBR plant in Chino Valley, AZ
Courtesy of Enviroquip

Operation and maintenance (O&M) costs also differ between conventional wastewater treatment and MBRs. Electricity, labor, chemical use, and membrane replacement all effect the O&M costs of the two systems. MBRs use more electricity than conventional systems. High biomass concentrations require more air because oxygen transfer is less efficient, additional blowers are required for membrane cleaning, and permeate pumps are required. All of these things increase electricity demand. Labor is roughly the same for the two systems, although limited data is available for MBR systems. Cleaning of the membranes and maintaining additional equipment is required for MBR systems. The chemical requirements for MBR cleaning is not substantial. When coagulant is required, doses are similar for phosphorus removal in both systems. Membrane replacement cost is a substantial long-term investment. Most membranes are warranted for eight years. However, the majority of systems have not been in operation for that long, and the actual life of the membranes is unknown.

The waste activated sludge from conventional systems and MBR systems will likely have different characteristics and volumes, which need to be considered in the evaluation. However, the requirements for stabilizing the sludge will depend on local conditions for disposal. The volume of solids generated by MBR systems may be less than conventional systems due to a decreased wastage rate, but, as noted earlier, MBR solids have been found to be more difficult to handle than conventional solids.

The cost of land may be important in comparing MBR and conventional systems. Key advantages of MBR systems are the reduced footprint of the system and the elimination of secondary clarification. If the cost of land is high, or if adequate land is not available, the cost comparison may favor the MBR system.

Conclusion

MBR systems may be cost-effective compared with conventional wastewater treatment systems under certain conditions. When conventional systems require filtration for phosphorus removal or non-potable reuse, MBR systems should be considered. MBR systems are a viable treatment technology as discharge standards become increasingly strict and land is limited or costly.

FIRM NEWS

Arber Relocates Company Headquarters to Lakewood

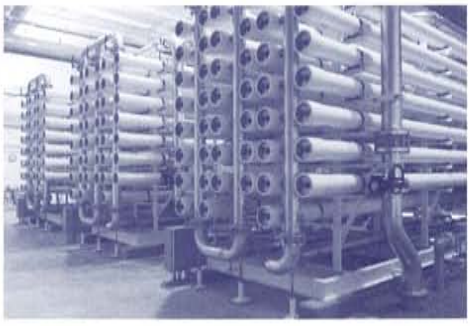
Richard P. Arber Associates moved their company headquarters to Lakewood, Colorado on March 14, 2005. Arber Associates started their 25th year of service in March. Rick Arber, Company President stated, "We are excited to be starting this new chapter of the company's history. We enjoyed our offices in the Historic Mansion on Grant Street for 10 years, but in order to continue to meet our client's needs, we need more space to add more engineers."

Arber Named Top 50 Civil Engineering Firm to Work For In the U.S.

Richard P. Arber Associates was recently ranked as one of the Top 50 Best Civil Engineering Firms to Work For in the U.S. This is the second year in a row that Arber Associates has attained the Top 50 ranking. CE News Magazine organized the competition which placed Richard P. Arber Associates 42nd. Richard P. Arber Associates was the only Colorado headquartered firm to be honored among the Top 50 and the only firm that specializes exclusively in water and wastewater engineering.

Arber Projects Receive Engineering Excellence Awards

The City of La Junta's New Water Treatment Plant and Denver Water's New Water Reuse Facility were both honored by the American Council of Engineering Companies (ACEC) at the 2005 Engineering Excellence Awards Competition. Richard P. Arber Associates provided design services for both of these projects. La Junta's new water treatment facility (pictured below)produces 6.6 million gallons per day of water, making it the second largest Reverse Osmosis System in Colorado.

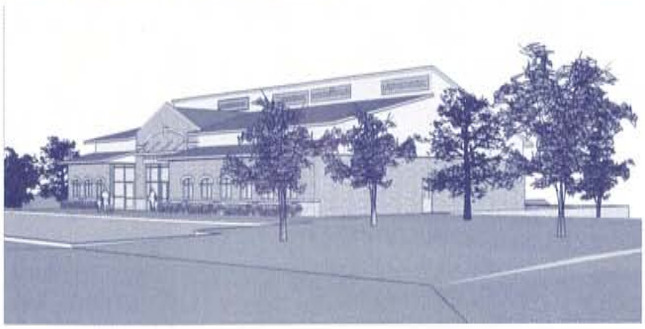


City of La Junta Reverse Osmosis System

Richard P. Arber Associates · www.arber.com
198 Union Boulevard, Suite 200 Lakewood, CO 80228 · Phone: 303.831.4700 · Fax: 303.831.0290
65 Sandrock Road, Sedona, Arizona 86351 · Phone: 928.284.9091 · 800.884.5922
Arber
Water, Wastewater & Reuse Engineers

ARBER PROJECTS

City of Troy, Missouri ~ Membrane Bioreactor Design



Richard P. Arber Associates served as a Membrane Bioreactor (MBR) Process Consultant to THH of Columbia, MO. The City of Troy is located in eastern Missouri, 60 miles northwest of St. Louis. The new facilities being designed include a new headworks building consisting of coarse screening, grit removal, and fine screens. An equalization basin will be used to equalize flow to the MBRs. UV disinfection will be used prior to discharge or possible reuse of the treated wastewater.

City of Alamosa, Colorado ~ Membrane Water Treatment Plant Design (Arsenic Removal)

Richard P. Arber Associates is preparing to start final design of the City of Alamosa's new Water Treatment Plant. The facility will be approximately 4.5 mgd which will make it the largest arsenic removal project in the State of Colorado. Treatment processes will include coagulation followed by microfiltration membranes.

Arapahoe County and Cottonwood W&S District, Colorado ~ Indirect Potable Reuse

Richard P. Arber Associates is working with Arapahoe County Water and Wastewater Authority and Cottonwood Water and Sanitation to complete final design for Colorado's first indirect potable water reuse system. Recharge of the alluvium with effluent from the wastewater plant will increase water supply for the agencies. The joint system will use the Cherry Creek alluvium to supply potable drinking water. The treatment system includes reverse osmosis and advanced oxidation processes.

FIRM NEWS

CONTINUED

Arber Supports 2nd Annual RMWEA/RMSAWWA Student Conference

Kevin Bergschneider of Richard P. Arber Associates represented the firm at the RMWEA/RMSAWWA Student Conference at the University of Wyoming in Laramie in May. He was part of a judging team that named three top oral presentations winners as well as three poster presentations winners. Students from the University of Wyoming, CU-Boulder, CSU, and the Colorado School of Mines participated. Next year's conference is scheduled for May in Fort Collins.

Student winners from the RMWEA/RMSAWWA Conference

PEOPLE

Arber Heads AWWA Membrane Standards Committee

Rick Arber has been heading up the AWWA Membrane Standards Committee. Mark Beebe of the firm is also on the committee that recently met at the June AWWA National Convention in San Francisco.

Johnson and Noteboom Honored As Young Engineers

Ben Johnson, P.E. and Matthew Noteboom, P.E. of Richard P. Arber Associates were both presented with ACEC awards recently. The ACEC New Faces of Engineering program highlights the interesting and unique work of young engineers and the resulting impact on society. Young engineers with two to five years of experience are the focus of this recognition program. The New Faces of Engineering program (www.eweek.org), sponsored by the National Engineers Week Foundation, recognized 65 nominees out of 1.8 million engineers in the U.S. Congratulations also to Ben and Matthew who both recently received their Professional Engineers Licenses.

Ben Johnson, P.E. and Matthew Noteboom, P.E.

New Hires at Arber

Sarah

Jamie

Sarah Ladenburger and Jamie Eichenberger, both recent graduates of the Masters of Environmental Engineering program at the Colorado School of Mines, have recently joined Richard P. Arber Associates. Sarah will be giving a presentation on Endocrine Disruptors at the WateReuse Symposium to be held in Denver on September 18-21.

Arber
Water, Wastewater & Reuse Engineers
Richard P. Arber Associates · www.arber.com
198 Union Boulevard, Suite 200 Lakewood, CO 80228 · Phone: 303.831.4700 · Fax: 303.831.0290
65 Sandrock Road, Sedona, Arizona 86351 · Phone: 928.284.9091 · 800.884.5922