fluence

How To Save Energy And Produce Top-Quality Effluent With MABR Technology

Wastewater professionals are always under pressure to save costs while improving treatment. So, new technology that helps to accomplish these goals is always welcome. Wastewater equipment and treatment methodologies are becoming more effective and efficient, providing valuable solutions for utilities and industries.

Fluence is a global leader providing innovative and cost-effective water, wastewater, and reuse solutions to meet today's challenges. Water Online spoke with Fluence's Udi Tirosh, Director of Product Management, to learn how membrane aerated biofilm reactors (MABR) can help lower costs, save energy, and meet stringent regulations.

What is a Membrane Aerated Biofilm Reactor?

The MABR is a wastewater treatment solution for low-energy, high-quality resource recovery from wastewater. The membrane in an MABR is made of materials that prevent water passage but allow for oxygen molecule passage. Unlike ultrafiltration (UF), microfiltration (MF), and membrane bioreactors (MBR), in MABR water does not get filtrated by the membrane but gets aerated by the membrane.

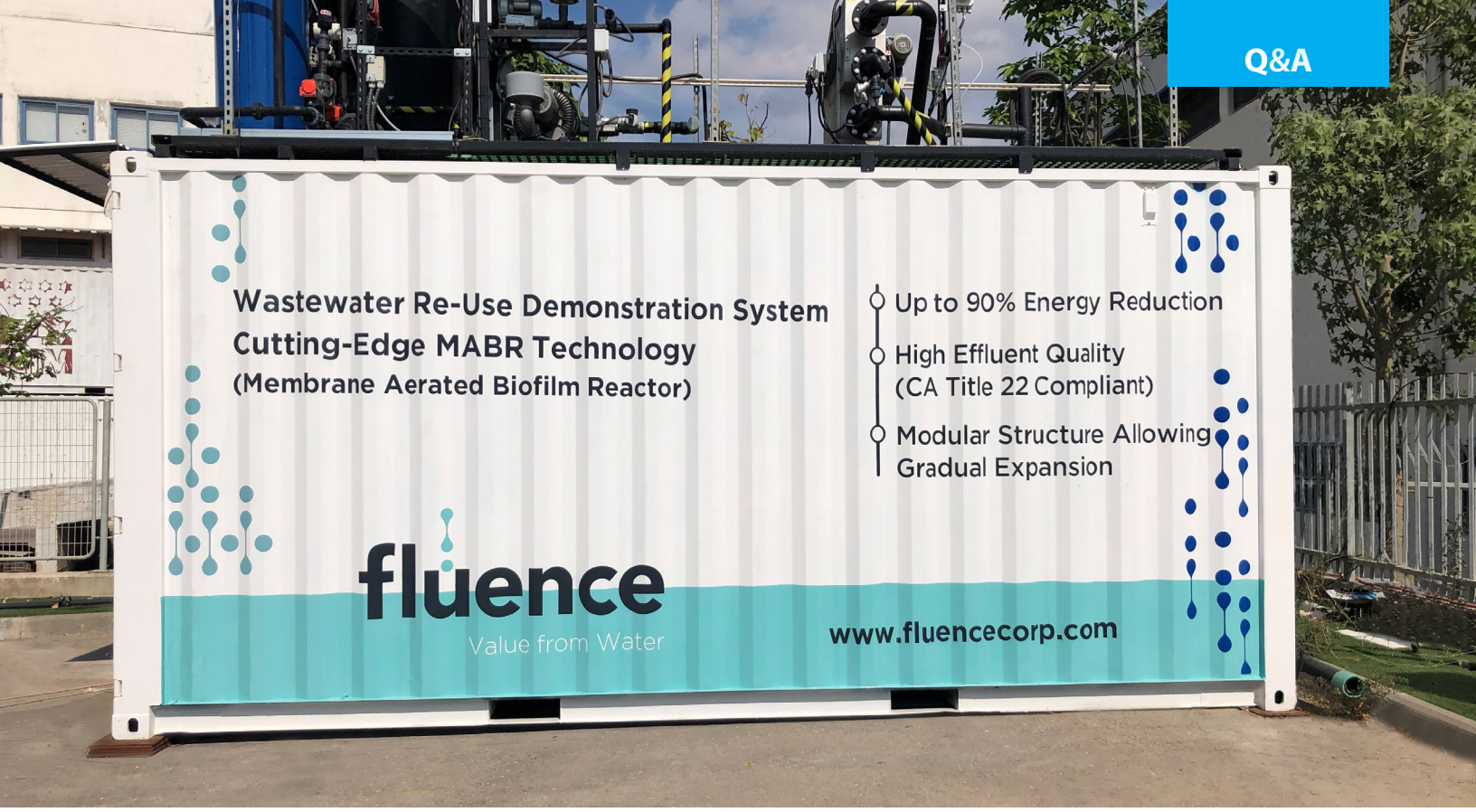
The MABR reactor consists of a basin full of wastewater which a very compact membrane module is inserted. This module is made of membrane sleeves which are constantly aerated by a low-energy blower. The membrane sleeve remains open for air passage even under water pressure using an internal air spacer. This long, spirally-wound sleeve is immersed in the wastewater basin. A special water spacer and regular mixing ensures wastewater is evenly dispersed throughout the length of the sleeve.

The aeration process of transferring oxygen to the water happens by diffusion due to the high (20%) oxygen content in air and very low oxygen content in water. This aeration provides the basis of wastewater treatment. It provides oxygen to autotrophic nitrifying biofilm and eventually to heterotrophic bacteria in the suspended biomass.

How do MABRs transfer oxygen to the mixed liquor suspended solids?

In MABR, oxygen does not get transferred directly to the mixed liquor suspended solids. Instead, the oxygen is first used by a nitrifying biofilm spread over the membrane sleeve to nitrify ammonia. The nitrates that result diffuse to the suspended biomass under anoxic conditions, and heterotrophic bacteria strip nitrate from the oxygen to oxidize carbon molecules — biochemical oxygen demand and chemical oxygen demand (BOD and COD). Nitrogen is released from the system as nitrogen gas (N_2).

There are two known biological mechanisms which are the basis for



this process: Biosorption and anoxic denitrification. The following description is helpful to clarify and explain how it works.

- There are two biomasses in the MABR reactor: One is the biofilm attached to the membrane, and the other is the suspended solids obtained from the bottom of the secondary clarifier.

- The suspended biomass mixes with the wastewater at the inlet to the biological reactor (CMABR tank or basin), and within a few minutes it **adsorbs** almost all of the BOD. This effect is known as biosorption, originally discovered as a means to prevent filamentous bacteria that cause bulking and foaming.

- The result is that BOD concentration in the water, after a short distance in the bioreactor, is very low, too low to support the significant development of a heterotrophic biofilm on the membranes.

- The nutrient that remains in the water is ammonia nitrogen, and this supports the development of an aerobic autotrophic biofilm on the membranes (nitrifying biofilm). This nitrifying biofilm uses up most or all of the oxygen that permeates by diffusion through the membrane to oxidize ammonia into nitrate. The nitrate diffuses from the biofilm to the water.

- The suspended solids in the water, with the adsorbed BOD, use this nitrate for anoxic denitrification: a process where BOD is oxidized using nitrate (instead of oxygen). These are practically the same bacteria that can oxidize BOD when oxygen is present, but they use the nitrate because there is insufficient or no oxygen in the water.

How does the MABR process save energy?

In most conventional wastewater treatment reactors, oxygen is induced into the wastewater by pressurized diffusers that spread fine bubbles to the bottom of the reactor. This method is inefficient. Only a small fraction of the oxygen is dissolved into the water, and the pressure required is high proportionally to the depth of the basin. In MABR, the membrane provides aeration, and the driving force for oxygen mass transfer is diffusion. The MABR membrane is an extremely efficient and effective way to transfer oxygen to wastewater. It has the potential to save up to 90 percent of wastewater treatment aeration energy.

Is the MABR process capable of removing nutrients?

Nutrient removal is an integral part of the MABR operation. Simultaneous nitrification and de-nitrification happens in one passage by the nitrifying biofilm and the denitrifying biomass. Additionally, it has been discovered recently that phosphorus removal occurs in the reactor at levels of 80 to 90 percent. This might be explained by sufficiently low ORP in the first stage MABR of the process followed by sufficiently anoxic and aerobic conditions downstream.

For which type and size of treatment facilities is the MABR process most suitable?

For decentralized, fast installation for wastewater treatment, containerized MABRs can treat 25,000 to 50,000 gallons per day (GPD) for a 40-foot container size, depending on design temperature. Sets of multiple containers can treat higher capacities. Concrete basins can also be designed for capacities of 50,000 GPD up to 0.5 MGD.

For larger sizes central facilities we have the SUBRE installation in Concrete basins for either green-field installation or for upgrades to existing Activated Sludge Basins.

Biological nutrient removal (BNR – removal of nitrogen and phosphorus compounds) is a regulatory requirement in China, several U.S. states, Europe, and most reuse applications. If BNR is desired, the added capital cost of the MABR membrane is offset by several factors (besides aeration energy savings):

1. The size of system (construction costs)

   a. In greenfield applications, a basin equipped with an MABR will require up to 50 percent less volume, thus reducing the costs of civil and construction works.

   b. In brownfield (retrofit) applications, adding MABR modules to an existing basin can extend the effective treatment capacity of that basin by up to 30 percent, thus saving on new basin construction.

3. Simplicity of operation (lower operator cost) and,

4. Nitrates circulation pump energy savings.

Can existing wastewater facilities be converted or retrofitted to use the MABR process?

For centralized wastewater resource recovery facilities, MABR is used to enhance nutrient (total nitrogen and total phosphorus) removal in an existing facility, as well as to increase treatment capacity of an existing facility by approximately 30 percent.

MABRs are inserted into the existing basin and provide enhanced functioning — nutrient removal and capacity increase — while reducing the specific aeration energy consumption.

How difficult are MABR processes to operate, and are there special operational considerations?

It is important to realize that MABRs are improved Activated Sludge plants so essentially there is no complexity added to the operation.

MABRs are very robust treatment reactors. The biofilm biomass ensures resilience to chemical and hydraulic shocks and the quick recovery from such shocks. The operation process does not require continual presence of a professional operator, as the process was demonstrated to work unattended for long periods of time. Fluence does provide remote control of all its units for normal operation and for alerts, if any.

What are the most important maintenance issues related to MABRs?

Generally MABRs require little maintenance. Maintenance is similar to maintenance of any regular Activated Sludge system. If anything, MABRs require less maintenance than fine bubble diffusers reactors as diffusers require replacement every few years and the MABR membrane does not need replacement.

What type of configurations are available for an MABR system?

Greenfield applications:
Fluence MABRs reactors are supplied with a process air blower and mixing air blower.

The containerized reactors come today in 2 sizes – 20 feet for capacities up to 10,000 GPD, 40 feet for capacities up to 50,000 GPD. The first one arrives with a built-in clarifier. In larger configurations, a separate clarifier is supplied or constructed on-site. Additional models of containerized units are in design and will be released.

For concrete basin configuration, there are many variations up to 0.5 MGD.

Upgrades:
For existing basins upgrades, Fluence provides a full design of the reactor rearrangement and aeration rearrangement. The membrane modules arrive encapsulated in steel frames and are inserted and fastened to the basin floor.

Do MABRs require additional noise or odor control equipment to be neighborhood-friendly?

MABR systems produce very little noise or odor, so no special requirements for odor control or noise control are required. ■