Enviroquip Membrane Bioreactor Systems – Novel Wastewater Treatment Process for Enhanced Nutrient Removal

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ABSTRACT

Nutrients (nitrogen and phosphorus) discharged into water bodies result in eutrophication and poor water quality. Eutrophication can change the aquatic ecosystem and impact human societies. Nutrient removal processes in wastewater treatment facilities is one of the keys for successful nutrient control and water resources protection. This paper introduces the Enviroquip membrane bioreactors (MBRs) for enhanced nutrient removal. Combining membrane filtration, biological nutrient removal, and optimized energy consumption, Enviroquip MBRs is a great alternative for advanced wastewater treatment.

Keywords: energy consumption, enhanced nutrient removal, eutrophication, membrane bioreactor, wastewater treatment.

1 INTRODUCTION

Nutrients such as nitrogen and phosphorus are essential for life. However, too much nutrients result in "dead zones" that can not sustain life by eutrophication and harmful algae blooms. A lot of the estuaries in the USA are suffering from decline of fisheries due to severe entrophication. These include the Chesapeake Bay, Tampa Bay (Florida), Long Island Sound (New York), and Mobile Bay (Alabama). Eutrophication not only causes water quality deterioration, but also leads to destruction of habitats and change of food web that will results in species changes that is detrimental to the established fisheries. The changes of the aquatic environments will eventually impact human societies with the loss of employment, the migration of workers and their families, and the loss of sustainable water resources [1].

Wastewater treatment plant effluent is one of the resources for nutrients discharged into aquatic environments. Biological nutrient removal (BNR) processes (Fig. 1) have been used in many wastewater treatment plants. However, traditional treatment technologies are not sufficient in protecting sensitive receiving waters. Agencies are required to meet Enhanced Nutrient Removal (ENR) limits that are increasingly difficult to achieve (e.g. 3.0mgN/l and 0.1mgP/l). Various techniques are being explored for ENR. Enviroquip, a division of EIMCO Water Technologies, offers a novel membrane bioreactor (MBR) system that has been proven to successfully achieve ENR by combining BNR and membrane filtration processes in over 2,500 wastewater treatment plants worldwide.

Another advantage of Enviroquip's MBR systems is that they minimize the operational energy consumption by using the Energy Pro™ System. The Energy Pro System enables Enviroquip MBRs with exceptional turndown capability and improves their energy efficiency.

2 OPTIMIZED BNR PROCESS

Enviroquip MBRs for ENR (Fig. 2) use the patented SymBio® process for simultaneous nitrification and denitrification (SNdN) in the pre-aeration basin. The SymBio® process offers the advantages as follows:

1. SymBio® reduces aeration energy of the treatment plant by maintaining low dissolved oxygen (DO<1.0mg/l) in the pre-aeration basin. This is achieved by using a nicotinamide adenine dinucleotide (NADH) probe (Fig. 3) to monitor the redox state of the sludge mixed liquor and automatic aeration blower control;
2. SymBio® minimizes negative impact of DO and nitrate in the internal recycle stream to the anaerobic basin, ensuring stable and efficient biological phosphorus removal;
3. SymBio® allows a unique recycle strategy (Fig. 2) that reduces pumping energy and operational complexity compared to other ENR processes.

2.1 MBR Basin

In addition to filtration, the aerated MBR basin (Fig. 4) is also an important biological treatment unit for ENR:

1. The MBR basin further removes ammonia from the effluent and prevents the release of captured phosphorus from the biomass back into the liquid phase;
2. The MBR basin produces high biomass concentration to reduce the ENR process footprint;
3. Biofilms on membranes remove slowly biodegradable organics and nutrients remained in the wastewater, further improving effluent quality;
4. Biofilms on membranes reduce the actual pore size for filtration, enhancing the particle removal capability of the membranes. The membranes provide additional removal of phosphorus precipitate from the effluent;
5. Membranes provide nearly 100% removal of total suspended solids (TSS). Pathogenic organisms, including *Giardia*, *Crytosporidium*, bacteria, and

some viruses are also removed by the membranes, significantly reducing downstream disinfection requirements.

2.2 The Energy Pro™ System

Energy Pro System can be best described as "MBR on Demand." The control strategy used to calculate and match plant demand generally employs two levels of optimization. The first level of automatic optimization determines how many MBRs (membrane zones) are actually required for a certain flow. In an Enviroquip MBR system, each MBR is equipped with independent blower and permeate control. Therefore, a different number of reactors can be activated to match the incoming flow based on adjustable operator setpoints. This design concept enables the treatment plant to have "MBR basin turn-down capability." When the status of an MBR basin is set to standby, its sludge mixed liquor will be aerated intermittently to maintain an aerobic environment. The return activated sludge (RAS) system will continue to operate and maintain homogeneous mixed liquor in the treatment plant.

The second level of Energy Pro optimization involves the fine-tuning for scouring air using by controlling blowers via variable frequency drives (VFDs) or flow control valves (FCVs). In Energy Pro System, the scouring air supply to the MBR basins is proportional to the flows. There are three operation modes for online MBR basins defined based upon the incoming flows, namely Low Mode (<0.5Q, where Q is the design flow), Medium Mode (0.5Q-1.5Q), and High Mode (1.5Q-2Q). One or multiple online MBR basins may change their status to a certain operation mode according to the actual flow measured by the control system. This allows the ancillary equipment and scouring air supply to either be reduced or turned off while in this mode. The remaining basins in service will process the flow in the mode that as defined above.

The basic components of an Energy Pro System are:

1. Simultaneous nitrification and denitrification (SNdN) in one or more process zones
2. Automation to incrementally match process capacity, air scouring and filtration rates to plant (pollutant) loading
3. Air delivery systems, permeate control and recycle components with sufficient turndown to meet system turndown requirements
4. Turbo fan technology (optional)

The operation of Enviroquip's MBRs with Energy Pro System is illustrated in Table 1. Savings of greater than 20% of net energy has been achieved with Energy Pro System in Enviroquip's MBRs [2].

3 CONCLUSION

The Enviroquip MBR system is an excellent treatment process that combines SymBio®, MBR, and Energy Pro System to offer:

1. Reliable treatment for ENR (TN<3mg/l and TP<0.1mg/l);
2. Supreme removal of TSS including pathogenic organisms to protect public health; and
3. Better process control and fine-tuning capabilities for plant operators with direct, real-time monitoring biological activities;
4. Cost-effective operation with lower pumping and aeration energy consumption.

REFERENCE

[1] Randall, C.W., "Potential societal and economic impacts of wastewater nutrient removal and cycling" *Water Science and Technology*, Vol. 48, No.1, p11-17, 2003.

[2] Livingston, D., "MBR Turndown". *Membrane Technology* (Fall 2008), p18-19.

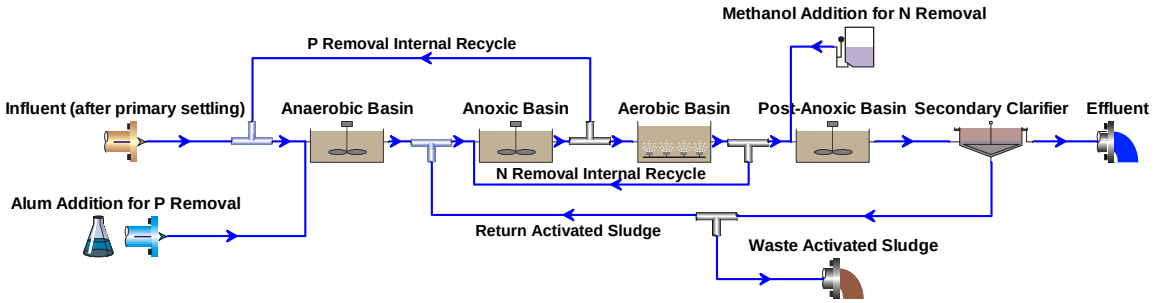


Fig. 1 Process Flow Diagram of A Traditional Biological Nutrient Removal Process. Two internal recycle streams and one RAS stream for nitrogen and phosphorus removal.)

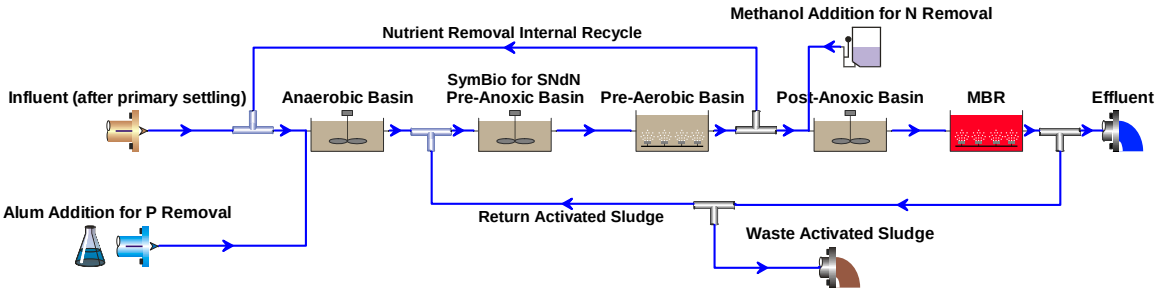


Fig. 2 Process Flow Diagram for Enviroquip MBR for Enhanced Nutrient Removal. The SymBio process requires only one internal recycle stream is required for nitrogen and phosphorus removal.

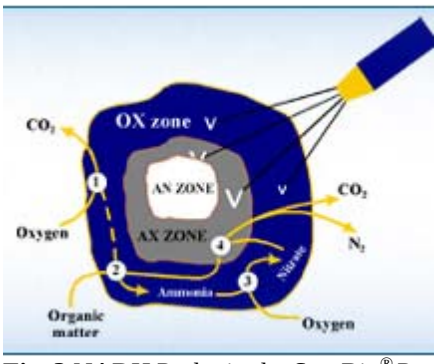


Fig. 3 NADH Probe in the SymBio® Process for Simultaneous Nitrification and Denitrification When the dissolved oxygen is blow 1.0mg/l in the bulk mixed liquor, oxygen gradients are created in the biological flocs, forming anaerobic zone (AN), anoxic zone (AX), and aerobic zone (OX) inside to accomplish simultaneous nitrification and denitrification.

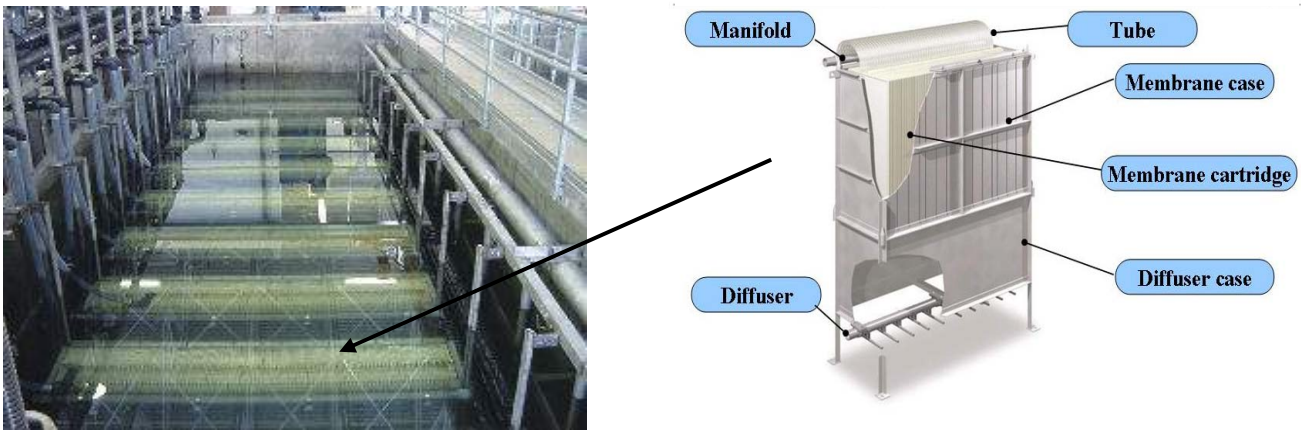
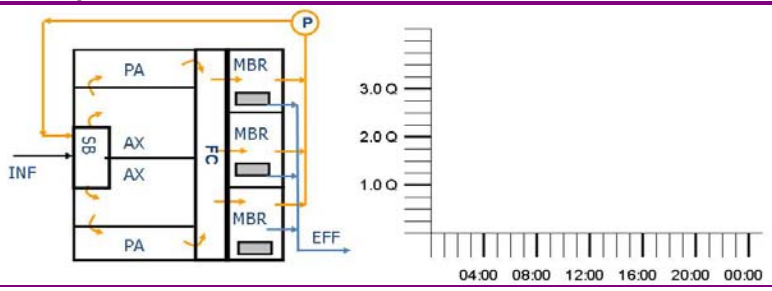
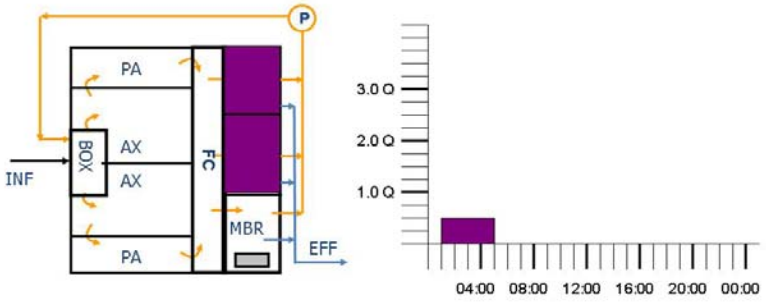
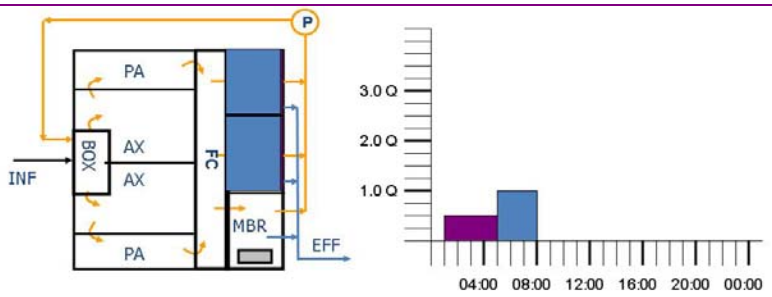
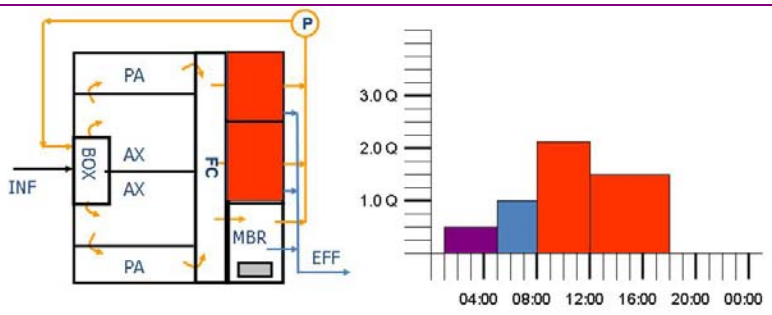
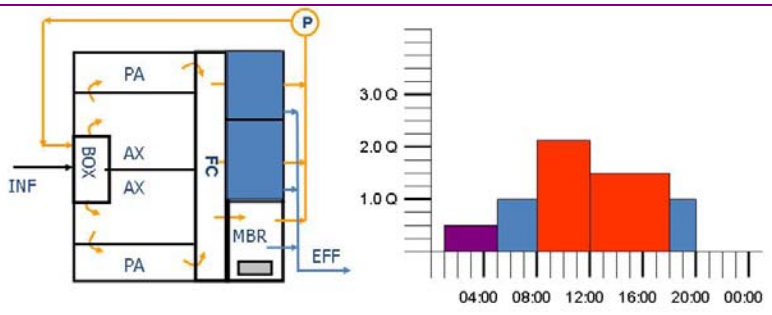


Fig. 4 MBR Basin with Installed Submerged Membrane Units (Left), and Schematic Diagram of A Submerged Membrane Unit (Right).

Table 1. Illustration of Energy Pro System Operation in Enviroquip MBRs

MBR Operation under Different Flow Conditions	Description
	No flow enters the plant; All MBR basins are placed in standby status; Intermittent aeration is provided to the MBR basins to maintain an aerobic sludge mixed liquor.
	**Low Mode**: Up to 0.5Q enters the plant; Two MBR basins are brought online in this example; Low scouring air intensity is provided in the online MBR basins.
	**Medium Mode**: 0.5Q to 1.5Q enters the plant; Two MBR basins remain online operating at average hydraulic loading; Scouring air is increased to medium intensity, cleaning the membranes faster.
	**High Mode**: 1.5Q to 2.0Q enters the plant; In this example, the control system determines that the two online MBR basins are sufficient, just need to maximize the scouring air intensity.
	Depending on the entering flow for the treatment plant, more MBR basins may be brought online, or the number of the online MBR basins remains the same with different scouring air intensity.

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