**MABR Demonstration Testing at the Ejby Mølle WWTP**

**Synopsis and Partners**

The Membrane Aerated Biofilm Reactor (MABR) is a disruptive technology that brings together two important aspects of resource recovery-focused wastewater treatment: process intensification and low-energy consumption. This technology employs gas-transfer membranes to deliver oxygen to a biofilm that is attached to the membrane surface. The direct supply of oxygen to the biomass growing in the biofilm increases dramatically the oxygen transfer efficiency (OTE), a key parameter for efficient and low-energy aeration. At the same time, the biofilm increases the inventory of biomass in the system and enables more process intensive nutrient removal, among other benefits.

VanCenter Syd and its project partners AarhusVand, Jacobs, Oxymem and SUEZ Water Technologies and Solutions will demonstrate at the Ejby Mølle Wastewater Treatment Plant (WWTP) the potential of MABR technology to play a key role in the future of our wastewater resource recovery facilities.

**Background on MABR Technology**

The membrane aerated biofilm reactor (MABR) is an emerging and potentially market disrupting technology for wastewater treatment that combines the ideas of highly efficient oxygen transfer and process intensification through biofilm-based treatment. The technology has been demonstrated to be substantially more energy efficient than conventional aeration technologies while providing the increased process capacity benefits of integrated fixed film activated sludge (IFAS). MABR is based on passing air or pure oxygen through bundles of gas permeable hollow fibre membranes. Aerobic biomass, typically nitrifying bacteria, grow directly on the outside of the membranes, allowing for extremely efficient use of oxygen, with heterotrophic denitrification typically taking place in the outer layer of the biofilm.

While MABR could theoretically be designed to be the only aeration and treatment device in the biological treatment system in a similar manner to straight biofilm-based technologies such as Moving Bed Bioreactor (MBBR), it is more typically applied in concert with suspended growth activated sludge systems. There are a number of reasons why MABR is thought to be best applied in such a “hybrid technology” manner, including the ease of retrofit into existing activated sludge tanks as well capital and lifecycle cost reasons. On this latter point, MABR can an economically attractive solution for upgrading activated sludge plants to expand capacity and/or improve nutrient removal performance. Applying MABR in the first anoxic or anaerobic zone of the activated sludge process allows for higher ammonia concentrations, thereby improving process rates, with the overall design potentially targeting 30-50% of the ammonia removal taking place at the membrane surface, with the balance managed by the activated sludge system.
Rationale for Demonstration Testing Program

Prior to embarking on the demonstration testing, a desktop, model-based evaluation was carried out to determine the potential benefits of installing MABR at full-scale at the Ejby Mølle WWTP. The results suggest that aeration savings of approximately 40% could be achieved, compared to the existing highly efficient aeration system by oxidizing 50% of the ammonia on the MABR cassettes. Additional benefits suggested by this exercise include a 45% increase in peak wet weather flow capacity through secondary treatment (through operation at lower suspended growth solids retention times (SRTs)), 20% reduction in effluent total nitrogen, and a 5% increase in biogas production.

The above potential benefits are substantial, especially when considering that the Ejby Mølle WWTP has been in a net positive energy condition since 2014, while achieving benchmark effluent performance in terms of total nitrogen and phosphorus.

Demonstration Testing Program

The overall goal of the MABR demonstration is to determine the practical design parameters of the MABR while identifying unique aspects related to the counter-diffusional biofilm nature of the technology. To accomplish these goals, it was decided to test one full size cassette each manufacturer directly in one of the anoxic zones, as well as one each in individual test tanks. The following six major areas of investigation have been developed as part of the demonstration program:

- **Biofilm management, material accumulation, and flow distribution** – Testing of the MABR units in an active bioreactor in the presence of dispersible materials (rags, hair, plastics, etc.) and varying MLSS concentrations is a critical aspect of the demonstration testing. In addition, biofilm thickness management through adequate mixing and air scour will be evaluated.

- **Stress condition response** – Through the 2-year program, the MABR will be subjected to stress conditions such as cold water temperatures, high loading conditions, and diurnal changes in flow and bulk liquid ammonia concentrations. Some of this stress testing will occur naturally from the seasonal variability, while other tests will be planned.

- **OTR optimization and long-term performance** – The oxygen transfer rate of the MABR can be used to assess the nitrification rate using stoichiometric rates for nitrification as well as the overall oxygen transfer efficiency of the MABR. The ability to control nitrite accumulation and nitrous oxide production can also be determined by varying the OTR of the MABR.

- **Nitrous oxide production and control** – Research has shown that the MABR produces a unique ecology that produces a low level of nitrous oxide in the liquid phase. This could be a major benefit to the overall carbon footprint for the Ejby Mølle facility.

- **Specific nitrification and denitrification rate** – Measuring the specific nitrification and denitrification rate throughout demonstration testing provides a large data set of rates that can be correlated with operating conditions to better understand key performance drivers for the MABR and allow for optimized treatment.

- **Microbial Ecology** – The microbial ecology can provide insight into the added benefits of the MABR biofilm. The testing program will provide an understanding of the competition of ammonia oxidizing bacteria (AOBs), nitrite oxidizing bacteria (NOBs), and the potential for short-cut nitrogen removal with the MABR.