

EVALUATION OF THE EFFICIENCY OF MEMBRANE BIOREACTOR TECHNOLOGY IN INDUSTRIAL WASTEWATER TREATMENT

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Abstract. Membrane Bioreactor (MBR) technology is an emerging wastewater treatment method that utilizes the advantages of membrane filtration. At the Uzbekistan GTL plant, the project reuses wastewater for technological purposes by using MBR instead of traditional treatment, i.e., secondary clarifier, which provides a high level of wastewater treatment. This analytical article presents a comprehensive literature review on the use of MBR technology for various industrial wastewaters. Particular attention is paid to information on membrane selection, its configuration, and practical application of the technology. The literature review shows that MBR technology is recognized as an effective and economically viable technology that allows wastewater to be recycled and reused without harmful effects to the environment.

Keywords: industrial wastewater, bioreactor, ultrafiltration, wastewater treatment, permeate.

Introduction. Water is a natural resource that is important for public health and should be protected by reducing the discharge of pollutants into water systems. Domestic and industrial activities contribute to the discharge of total solids, organic matter, and dissolved solids into water. Therefore, strict standards must be met to reduce the content of pollutants in wastewater and to discharge them without harming water resources. Over the past century, as a result of population growth and industrial expansion, ecosystems essential for human life have been seriously polluted. Pollution of groundwater and surface water is caused by the discharge of industrial and domestic wastewater without complete and high-quality treatment. Although these wastewaters are usually easily biodegradable, their components such as total suspended solids (TSS), biochemical oxygen demand (BOD), and chemical oxygen demand (COD) load the ecosystem in the amount of thousands of mg/L [1-5].

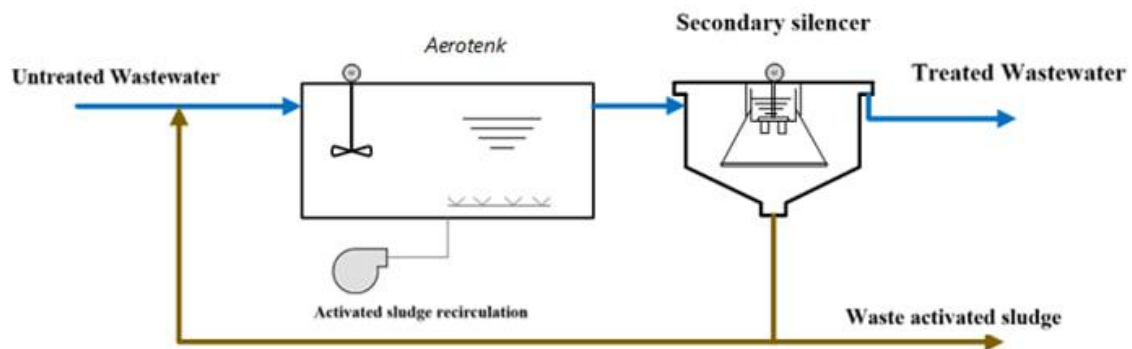


Figure 1. Traditional method

(Figure 1) where the activated sludge is then returned to the bioreactor for biological treatment, instead of the traditional method (Figure 2), where the activated sludge is separated by secondary sedimentation and then returned to the bioreactor for biological treatment. This

allows for the effective separation of total suspended solids, including activated sludge, high organic matter, and nutrients, in a small-sized bioreactor that requires little space. Therefore, MBR technology is becoming the most effective treatment technology due to its advantages. However, its main disadvantage is that the membranes often become clogged with sludge, which causes problems in the application of this process [6-8].

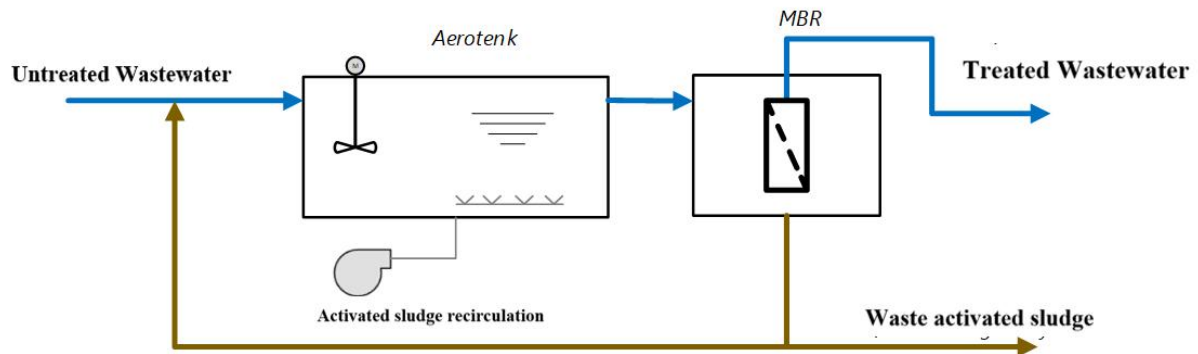


Figure 2. MBR (membrane bioreactor) method

MBR technology is a form of the traditional activated sludge process combined with micro- or ultrafiltration systems. The main advantage of this technology is that it breaks down pollutants in wastewater and separates the treated water from the mixed sludge by suctioning water through the small pores of the membranes using suction pumps. Typically, the membrane pores are between 0.01 and 0.1 micrometers. The bioreactor and membrane module perform the following main functions: a) in the bioreactor, organic pollutants are decomposed by microorganisms; b) using the membrane module, microorganisms are separated from the treated water. Membranes serve as a physical barrier to all suspended solids, bacteria and viruses, and at the same time ensure the return of activated sludge to the bioreactor. The separation of organic substances using a membrane is the main difference between MBR technology and traditional treatment methods, where the efficiency of the final treatment stage does not depend on the sedimentation properties of the sludge. For information, if filamentous bacteria appear in the activated sludge in the traditional treatment method, then the activated sludge does not settle in secondary clarifiers, that is, activated sludge particles pass into the treated water [9-10].

Methodology. Membrane Selection There are two main types of membrane materials: 1) polymeric; 2) ceramic.

Metal membrane filters are also available, but their application in MBR technology is limited. Therefore, the membrane module must be designed in such a way that wastewater can easily pass through it. Theoretically, any polymer can be used to make a membrane, but only certain polymers are suitable for use as membranes. These include:

- a) Polyethylsulfone (PES)
- b) Polyvinylidene fluoride (PVDF)
- c) Polypropylene (PP)
- d) Polyethylene (PE)

commonly used membranes in MBR systems are microfiltration (MF) and ultrafiltration (UF). When choosing a membrane, the following are considered: surface area, pore size, mechanical strength, hydrophobicity, morphology, chemical stability, density, and cost.

Membrane fouling depends on the material and pore size. If the pore size is too large, the pores will be blocked, and if it is too small, the membrane permeability will decrease. If the pores are evenly distributed, fouling will decrease. In general, negatively charged membranes

are less susceptible to fouling because colloidal particles in the wastewater have a negative charge and repel each other. In addition, hydrophilic membranes are less susceptible to fouling than hydrophobic membranes.

Result. Membrane filtration consists of two main parts: an organic component (a bioreactor that breaks down pollutants) and an MBR device (a module that physically separates the treated water). MBR systems are mainly divided into two types:

Submerged MBR (submerged MBR) - membranes are installed directly in the bioreactor. This system usually uses hollow fiber (tubular) membranes, this type of MBR is used at the Uzbekistan GTL plant.

External MBR — membranes are located outside the bioreactor. In a submerged system, low pressure is used to force water through the membrane or a negative pressure (vacuum) is created on the permeate (purified water) side. Membrane washing is performed by backwash or regular cleaning with chemicals. Air diffusers are placed under the membranes to help keep their surface clean. In addition, mixing and aeration are also carried out through this system. At the same time, anaerobic and anoxic sections are added, ensuring simultaneous separation of organics and nutrients.

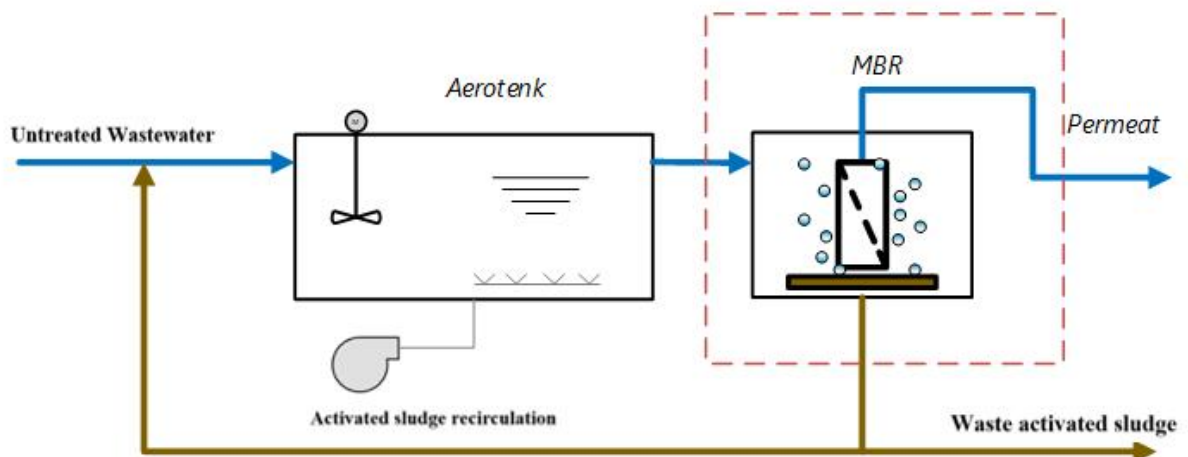


Figure 3. Submerged submersible MBR system

Table 1. Types of membranes used in submerged MBR systems and their characteristics

No.	Type	Membrane	Pore size (µm)	Purified wastewater	Source
1	Flat	MF-Polyethylene	0.4	Household	16
2	Hollow fiber	Polyethylene	0.1	Utility	17
3	Hollow fiber	Zeno	0.1	Synthetic raw milk	17
4	Hollow fiber	Zeno	0.1	Utility	16
5	Hollow fiber	Polypropylene	0.1	Synthetic, Utility	18
6	Hollow fiber	Hydrophilic polyethylene	0.1	Utility	18
7	Hollow fiber	Polyethylene	0.1	Household	19
8	Hollow fiber	MF-polyethylene	0.1	Synthetic	20

9	Hollow fiber	MF	0.1	Utility	10
10	Flat- cell fiber	MF-polyolefin	0.4	Utility	21
11	Hollow fiber	MF-Polyethylene	0.1	Utility	22
12	Plate	MF-polyolefin	0.4	Utility	22
13	Plate and frame / Hollow fiber	Polysulfone	0.4	Household	23
14	–	Polypropylene, non- woven	0.5–5	Household	23



Figure 4. Hollow fiber membrane module in a submerged MBR system

Conclusion. Based on a comprehensive literature review of membrane bioreactor (MBR) systems for various types of wastewater, the following conclusions were reached: MBR systems are widely used in industrial wastewater treatment in developed countries and are capable of effectively removing 95% to 98% of the total pollutant load. The international demand for membrane filtration technology is growing at an average annual rate of 13.2% (CAGR). The growth rate of this technology is higher than that of other wastewater treatment technologies. Compared to the current growth rate, the global market is projected to double in the next five years.

REFERENCES:

1. Damir, A. (2022). Wastewater treatment using energy-efficient AnMBR technology: an analytical review. *Journal of Cleaner Production* , 356, 131784. <https://doi.org/10.1016/j.jclepro.2022.131784>
2. Judd, S. (2010). *The MBR Book: Principles and Applications of Membrane Bioreactors in Wastewater Treatment*. Second Edition. Elsevier Publishing. ISBN: 9780080966823.
3. Meng, F., Zhang, H., Yang, F. (2006). Fouling in membrane bioreactors: characteristics, causes and solutions. *Journal of Membrane Science* , 284(1–2), 87–94. <https://doi.org/10.1016/j.memsci.2006.07.010>
4. Le-Clech, P., Chen, W., Fane, AG (2006). Fouling in membrane bioreactors for wastewater treatment. *Journal of Membrane Science* , 284, 17–53. <https://doi.org/10.1016/j.memsci.2006.08.019>



5. Yang, W., Cicek, N., Ilg, J. (2006). Membrane bioreactors: Worldwide research and commercial applications in North America. *Journal of Membrane Science* , 270, 201–211. <https://doi.org/10.1016/j.memsci.2005.07.010>
6. Smith, AL, Stadler, LB, Love, NG (2012). Improving BXO through membrane biofilm development in anaerobic membrane bioreactors. *Environmental Science & Technology* , 46(21), 11273–11281. <https://doi.org/10.1021/es303002c>
7. Drews, A. (2011). Fouling in membrane bioreactors: description, causes and countermeasures. *Bioresource Technology* , 102, 3717–3730. <https://doi.org/10.1016/j.biortech.2010.11.115>
8. Skouteris, G., Hermosilla, D., Lopez, P., Negro, C., Blanco, A. (2012). Anaerobic membrane bioreactors: efficiency and challenges. *Chemical Engineering Journal* , 198–199, 138–148. <https://doi.org/10.1016/j.cej.2012.05.070>
9. Hai, FI, Yamamoto, K., Fukushi, K. (2007). Hybrid MBR systems for wastewater treatment and reuse: a review. *Critical Reviews in Environmental Science and Technology* , 37(4), 439–477. <https://doi.org/10.1080/10643380600986855>
10. Van der Roest, HF, Lawrence, DP, van Bentem, AGN (2002). Membrane bioreactors for wastewater treatment . IWA Publishing. ISBN: 1900222910.