Green Technology in Treatment of Wastewater

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ABSTRACT: As severe water problems have been observed around the globe, rising questions around water sources are becoming a hot subject. Despite, membrane bioreactor (MBR) created substantial strides and developed as a practical alternative for wastewater treatment, conventional MBRs do have a number of drawbacks, As a result, integrated MBR technology for wastewater treatment has arisen. The aim of this paper is to provide a thorough overview of the existing state of knowledge for the integrated MBR and various other wastewater treatment methods, as well as the treatment process's long-term viability. This paper investigates the various applications of MBR. Its aim is to pave the way for advanced MBR to be implemented as a viable wastewater treatment technological advancement. In an advanced MBR, wastewater improvement can reduce pollution while providing a new form of energy as well as nutrients at the same time. Furthermore, the optimized MBR allows for both environmental as well as economical energy and nutrient restoration..

KEYWORDS: Bioreactors, Membrane Bioreactor, Membrane, Wastewater Treatment, Water.

INTRODUCTION

The implementation of the membrane bioreactor (MBR) method to wastewater treatment and reclamation has made tremendous strides. Rapid population increase in developed countries has overburdened existing traditional wastewater treatment facilities, also there will be no room for the current treatment plant to be expanded. In light of this, MBR has grown in popularity due to its distinct advantages over conventional activated sludge treatment, including a smaller footprint, less sludge performance, enhanced separation quality, and significantly improved effluent consistency. Some viruses may also be retained by MBR with ultrafiltration membrane.

Legislation, the levels of water tension, and the trust in the efficiency of MBR are main market factors that lead to the industry's expansion. Asia-Pacific, followed by Europe, accounts for 38 percent of global MBR revenue, according to the Market Research Report. By 2015, the global MBR industry is expected to be worth $627 million, with a compound annual growth rate of 13.2 percent. The MBR industry is increasingly expanding, leading to the overall demand for wastewater treatment devices, which involves physical, chemical, biological, as well as membrane filtration. In the meantime, other membrane processes used to treat wastewater, like microfiltration, ultrafiltration, Nano-filtration, as well as reverse osmosis, depend heavily on MBR. Even if such wastewater treatment plants can handle commercial wastewater to meet existing sanitation standards and provide water for basic industrial uses, for applications requiring high quality water, the treated effluent will ought to be refined further using an optimized MBR.

The position of MBR knowledge as a biotechnology drift was investigated by Fletcher et al. [1]. Researchers concentrated on the MBR mechanism's basic components, such as the membrane and the configuration process. Rather than wastewater treatment. In addition, the upsides and downsides of MBR in the handling of strong industrial wastewater have indeed been investigated. Goh et al. analyzed membrane distillation bioreactors (MDBR) applications and configurations. In a surface distillation bioreactor, fouling and its regulation were investigated by M. Yang et al. [2]. Membrane processing advancements, pretreatment, MBR architecture, membrane fouling, stationary film including anaerobic MBR (AnMBR) and modelling were all studied by P. Krzeminski et al. for urban and industrial applications [3]. The majority of integrated MBR journal articles are regarding MBR technology, that seems to have benefit of using anaerobic methods to reduce organic matter and produce steam. Phattaranawik et al. conducted yet another AnMBR study, this time focusing on performance in relations to industrial scale deployment [4]. Despite this, there have been few certain researches that includes a description of the different types of integrated MBRs for wastewater treatment and valorization. The aim of this study was to provide a review of current studies for the MBR wastewater remediation project that has been applied.It's the first research to combine MBR to advanced oxidation processes (AOPs), granulation and forward as well as reverse osmosis as a wastewater treatment method. The majority of the paper concentrated on the long growth of MBR towards biofuel production and electricity generation, whereas the rest of it concentrated on the short-term growth of MBR for bioenergy, including nutrient regeneration in order to gain more profit while also helping the ecosystem.

DISCUSSION

1. *Wastewater Treatment using Membrane Bioreactors:*

Membrane bioreactors are a combination of an attached growth biomedical biological treatment, normally activated sludge, including membrane filtration systems, generally low-pressure microfiltration (MF) and ultrafiltration (UF) membranes, for primarily wastewater treatment. The membranes are in charge of carrying out the crucial solid-liquid separation role. Historically, primary and tertiary separators, and also tertiary filtration, have been utilized in activated sludge plants to accomplish this. There are two kinds of MBR systems: vacuum systems as well as pressure-driven systems. Hollow fiber or flat sheet membranes are used in either the bioreactors or even a subsequent membrane container in submerged vacuum or gravity systems. In-pipe cartridge structures that are installed outside of the bioreactor are known as pressure-controlled systems.

An MBR System is a fully integrated membrane device with all of the vital elements for the process to run smoothly. Fine scanning, the Membrane Zone, and, for most cases, some kind of post-disinfection activity are among the ten or eleven sub - systems that make up an MBR unit. Microbes degrade pollutants in an MBR, or Membrane Zone, that are then filtered by a sequence of immersed membranes. Mods, cassettes, and shelves are used to hold specific membranes, and a working membrane unit is a series of these modules. Air is added into the filtration process through integral diffusers to continuously scour membrane surfaces, promote mixing, and, in some cases, add oxygen to a biological process.

MBR takes up less space than a conventional active sludge system with secondary clarifiers including media tertiary filtration, which is usually 30-50 percent narrower. The process also produces excellent effluent purity that meets the tightest water quality specifications, a modular schematic that leads to faster expansion and adjustment flexibility, a reliable and effective system, and lower downstream decontamination requirements. Membrane Bioreactors for Wastewater Treatment. Wastewater treatment using membrane bioreactors is shown in Figure 1.

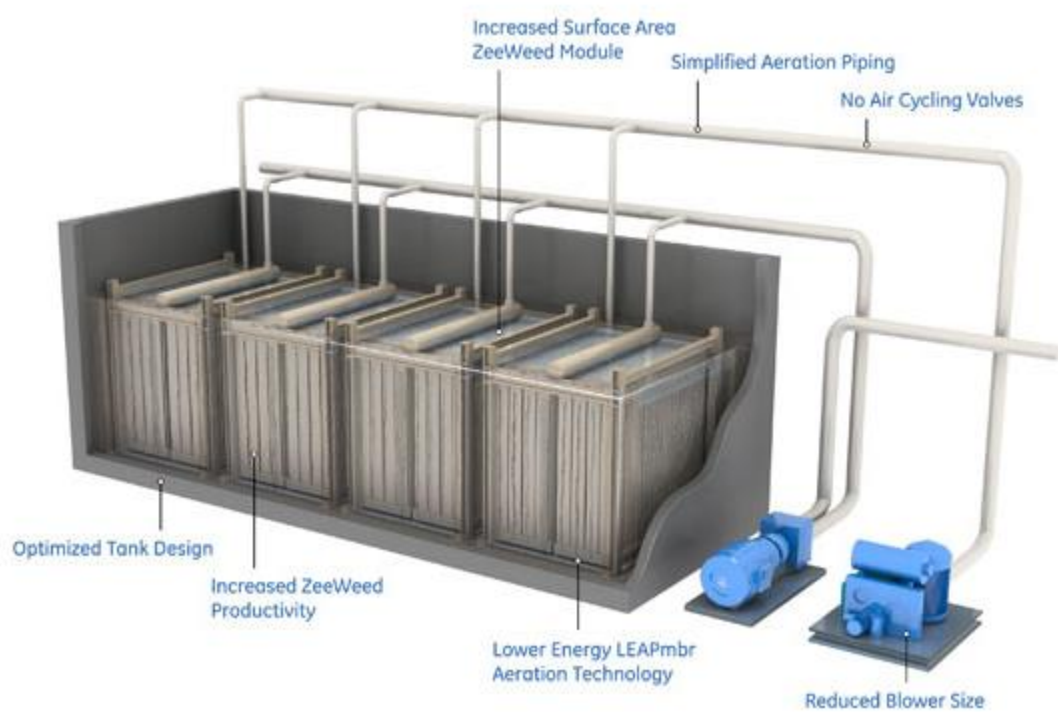
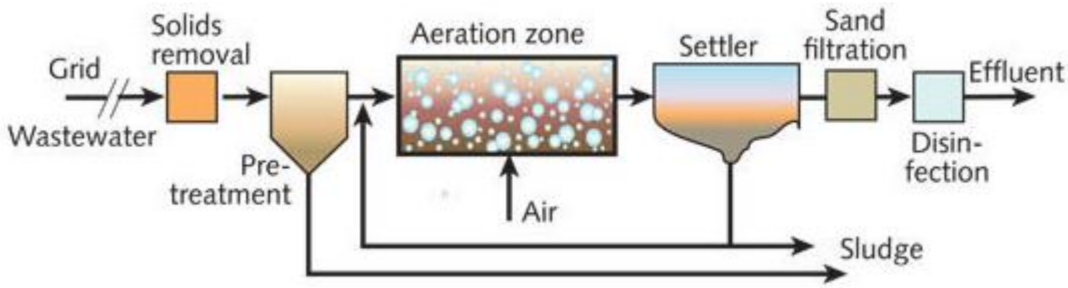


Figure 1: Membrane Bioreactors for the Treatment of Wastewater [AMTA/Membrane Bioreactors for Wastewater Treatment].

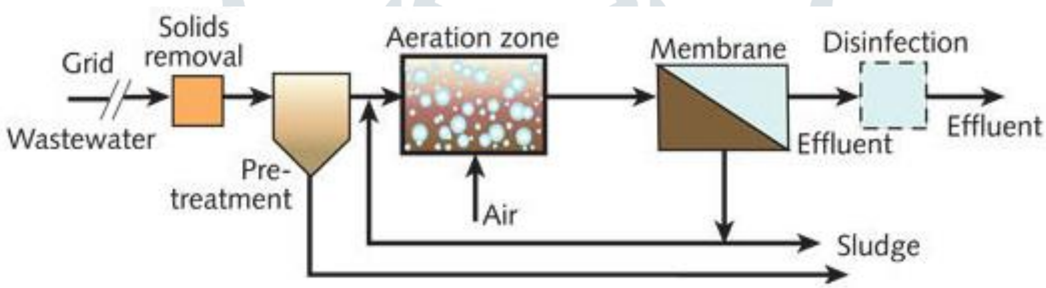
2. Design of Membrane Bioreactor:

Since MBR is an activated sludge process, the same widely agreed design regulations that apply to traditional activated sludge processes apply to MBR design. The food-to-microorganism (F/M) ratio is the most critical design parameter, and when high mixed liquor suspended solids (MLSS) levels are reached, tank volumes are decreased. The aeration equipment must be adjusted to handle the high real volumetric oxygen concentrations that occur. The hydraulic load and feasible flux are the main parameters for the membrane surface design, as the membranes must permeate the maximum flow [5].

It is critical to define the form of membrane and membrane modules as early as possible in the design of the setup, repair, and membrane cleaning facilities. Overall, the level of automation in MBRs is greater than in traditional wastewater treatment plants due to back flushing and washing procedures. Figure 2 illustrates (a) The block diagram of activated sludge process and (b) Membrane bioreactor (MBR) process.



(a)



(b)

Figure 2: (a) The block diagram of activated sludge process and (b) Membrane bioreactor (MBR) process [6]**.**

3. Basic Design Principles and Treatment Process:

Membrane Bioreactors combine traditional biological treatment approaches with membrane filtration to provide a breakthrough in organic as well as suspended solids reduction. These systems may also provide advanced nutrient reduction if installed correctly. The membranes of an MBR framework are immersed in an oxidized biological treatment. Membrane porosities range from 0.035 micrometers to 0.4 micrometers, ranging from micro to ultrafiltration.

This degree of filtration requires maximum effluent to pass through the membranes, eliminating the need for membrane filtration, which are common in wastewater treatment. The biological process can function at much higher mixed liquor concentrations so sedimentation is no longer needed [7]. This reduces the amount of available process tankage, allowing some existing plants to really be modified without the need for innovative containers. The filtered liquor is traditionally placed mostly in 1.0-1.2 percent crystals range to provide optimum oxygenation and scour using the membranes, that are four times that of a conventional plant (Figure 3).

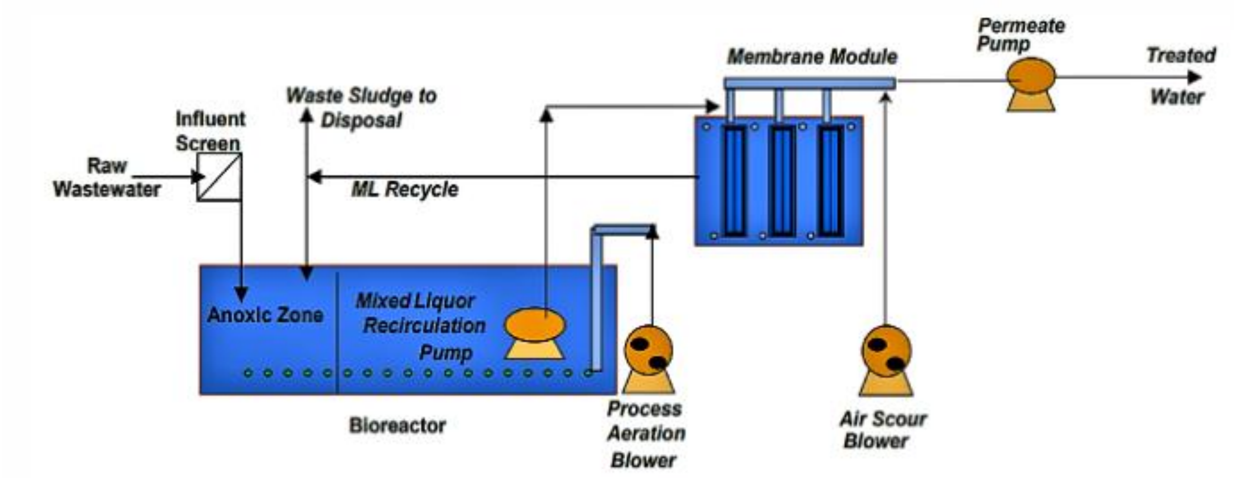


Figure 3: Representative schematic designed for membrane bioreactor system [SSWM/ membrane bioreactor].

4. *Bubble-less Aeration:*

This membrane aeration bioreactor technique uses permeable membranes to directly supply highly concentrated oxygen to a biofilm without the formation of bubbles. The film is still gelatinous or oily in nature. The aeration procedure is carried out in this case without the need of a bubble by creating a polymer membrane in between liquid ands well as gas phases. The membrane aids in the degradation of organic materials by microorganisms by transferring large amounts of oxygen through into drainage environment. Via the filter, the gas diffuses further into wastewater. Typically, these membranes are configured in a frame as well as plate or hollow fibre unit configuration (Figure 4).

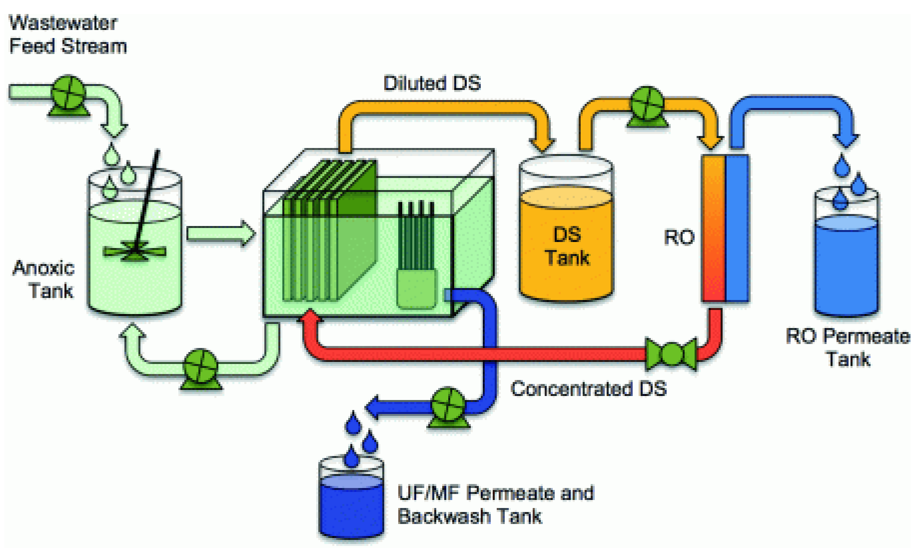


Figure 4: The Layout of Bubble-less Aeration Membrane Bioreactors [Era Hydro-Biotech/ Membrane Bioreactors.]

5. *MBR Separation Bioreactors:*

This MBR waste water treatment method is a novel approach that combines membrane filtration along with such a biological waste degradation growth reactor. Filtration barriers are liquid-solid distributed approach bioreactors in this process. The conventional activated sludge system for biosolid separation uses this technique. The membrane protects against high-quality toxins and suspended solids. Although the concept of activated sludge coupled with ultrafiltration was commercially viable by the end of 1960, significant applications and development of membrane processes in conjunction with biological treatment options have only started to gain traction. [8]. The image of MBR Separation Bioreactors plant (Figure 5).

Figure 5: The image of MBR Separation Bioreactors plant [9]**.**

6. *Reprocess Membrane Bioreactors:*

A reaction vessel as well as an outer membrane make up these bioreactors. A stirred reactor uses the reservoir as a fuel tank. In industry, this device is used in two basic setups: beaker shape and tubular form. Tubular configurations are often used in large-scale industrial applications. The biocatalysts can be trapped or mounted on the pipe or tube side of this situation. Because of enzyme diffusion resistance values and substrate orientation, this treatment results in a loss of operation varying from 10% to 90%.

7. *Extractive Membrane Bioreactors:*

These particular types of bioreactors are commonly used in waste water treatment plants to increase the performance of membrane bioreactors. It takes advantage of the membrane's capacity to attain natural separation while enabling components to move from one phase to the next. This separation process aids in maintaining optimum conditions within the bioreactor, allowing microbes to more effectively degrade wastewater pollutants. Finally, the use of membrane technologies for treating wastewater has demonstrated that this method has reached a commercial opportunity in the treating wastewater sector.

8. *Advantages of Membrane Bioreactors:*

8.1.Independent Control of Hydraulic Retention Time (HRT) and Solids Retention Time (*SRT):*

Since the biological solids (mixed liquor or sludge) are exclusively enclosed inside the bioreactor, the SRT can be regulated independently of the HRT. The flocculant solids (‘flocs') that are basically the biomass must be allowed to expand in size to the point where they can be settled out in the secondary clarifier during the Conventional Activated Sludge (CAS) process. So, in CAS, the HRT and SRT are linked; as the HRT rises, the flocs must expand, increasing their settleability.

8.2.High Quality Effluent:

Since the membrane pores of the MBR are very narrow (0.5), the handled effluent has a very high visibility and a slightly lower pathogen content as compared to the CAS method. The effluent is of sufficient high quality to be discharged into bodies of water or used for purposes such as municipal drainage, utilities, or toilet flushing. It can also be directly fed into a reverse osmosis device to create a permeate of still greater water content [10].

8.3.Small Footprint:

Since CAS has a high HRT, a larger plant size is expected. Because of the higher amounts produced in MBRs, the same total mass of solids is stored in a lower volume, resulting in a smaller footprint.

8.4.Better Bio-Treatment:

MBRs have a high SRT, which facilitates the growth of slower-growing microorganisms, especially nitrifiers, and hence offers a better overall bio-treatment. Because of this, MBRs are very efficient at biologically extracting ammonia (‘nitrification').

9. Disadvantages of Membrane Bioreactors:

The major drawbacks of an MBR are the difficulty of the operating phase and the expense, which is converted into Capital expenditure (CAPEX) and operational expenditure (OPEX). Both of the latter are highly responsive to membrane expense. Furthermore, the OPEX is affected by:

9.1.*The Membrane Life:*

However, based on the change out of membranes over a large number of installations, an analysis of real membrane life indicated a life of at least 8 years, with more recent membrane products offering longer life. Ceramic membranes, on the other hand, are supposed to last much longer.

9.2.Permeate Flux:

The quantity of volume flowing through the membrane per unit area per unit time is known as the membrane permeation flux. The volume of gases and vapors transported is highly influenced by pressure and temperature.

10. MBR Technology's Future Tendencies:

10.1. Energy Demand Minimization:

MBR's energy consumption can be reduced in two ways. The first one is the generation of electricity mostly during primary treatment as well as its delivery to devices like the aeration machine, which contributes for the bulk of MBR energy consumption. This can only be done with a Microbial Fuel Cell (MFC), which uses microorganisms to produce energy through oxidizing organic compounds. However, one of the main weaknesses of MFC is the low consistency of the permeates. To further refine the effluent or optimize the treatment process, another polishing technique, like bio augmentation of existing bacteria, may indeed be required in MFC-MBR. In the future, fundamental research on upgrading the MFC to produce electricity without any harmful emissions will become more relevant [11].

The embedded anaerobic MBR appears to have been the second type of integrated MBR that can generate electricity. However, owing to membrane fouling and the possibility of toxicity, advanced manufacturing commercial production of AnMBR has still been pending. With potential optimal power outputs of 0.11 kW hm^3, In hotter weather, AnMBR is quite useful for handling reduced sulphate wastewater. Finally, the combined MBR should provide enough power and equipment to balance the energy needed for wastewater treatment, with any surplus energy being used for other purposes.

The second choice for reducing MBR energy consumption is by using a system with minimal or quasi-pressure as well as a lower membrane fouling propensity. Forward osmosis as well as reverse osmosis consume less electricity and are less likely to foul. This unit, however, caused salt to accumulate within the reactor, which has an impact on the system's biological output. Membrane enhancements and microbiological activity monitoring are critical to the long-term reliability of reverse osmosis membrane bioreactor (RO-MBR). One option for preserving the system's biological efficiency may be the bio augmentation of some bacteria that can tolerate salty atmosphere as well as oxidize biological composites inside container.

10.2. Membrane Fouling Decrement:

Energy consumption and membrane fouling are linked and regarded as major drawbacks to MBR usage. Air looking for the membrane, as well as oxygen levels of activated sludge, use 60-80% of its strength in an MBR. There are a variety of techniques for minimizing MBR membrane fouling, like enhancing HRT and SRT, that have been discussed in a number of research papers. The emphasis of this study, nevertheless, would be on an integrated system with MBR that can prevent membrane fouling. Furthermore, inside biofilm membrane bioreactor as well as granular MBR, there seems to be some controversy over how to eliminate membrane fouling. Furthermore, the MBR membranes fouled less when the SRT was increased. Increased MBR SRT, resulted in increased reverse osmosis membrane deposition. These findings suggest that foul MBR membrane constituents differ from foul Reverse osmosis constituents. As a result, future research should focus on the combined MBR's SRT and HRT to remove membrane fouling.

CONCLUSION

The numerous benefits of MBR technology make it a dependable choice, yet practical option that outperforms many waste management methods. This research has incorporated MBR integration with other treatment programs. Future MBR studies will most likely focus on lowering energy consumption and preventing membrane fouling during use. The number of new MBR architectures are being proposed to be used in ecologically advanced manufacturing. MBR demonstrated promising results in terms of nitrogen elimination, and it could soon be a feasible alternative for water reuse and recycling. The solution of architecture issues for concurrent wastewater treatment as well as valorization is another part of the integrated MBR deployment. When it comes to determining the best MBR technology for a particular region, there are several options. Integrated MBRs have the ability to play a significant role in wastewater management for long-term development due to their alluring advantages and interesting technological features. Continuous collaboration between academia and industry will result in the development of an integrated MBR for treating wastewater as well as valorization.

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