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Wastewater Treatment Using Environment Friendly Technology

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ABSTRACT
The increasing water supply challenges have become a significant problem; as severe water shortages have been seen worldwide. While the MBR has made great development and has shown to be a viable option for waste water treatment, conventional MBRs still have numerous weaknesses, which is why the MBRs for waste water processing technologies have been incorporated. This article aims to combine the current state of the art for the integrated MBR process with other wastewater treatment systems and offer a consolidated analysis of the sustainability of the treatment process. This article looks at the potential applications of various types of MBR. It aims to prepare the path for the future deployment of improved MBR as a potential wastewater treatment technology. The improvement in wastewater in integrated MBR will reduce emissions and provide a new energy and nutrient source. The improved MBR also enables the recovery of energy and nutrients ecologically and economically feasible.

Keywords
AnMBR, Green Technology, MBR, Membrane Bioreactor, Wastewater Treatment.

1. INTRODUCTION
In the field of wastewater treatment and reclamation, the use of the membrane bioreactor (MBR) technique has made significant advances. Rapid population growth in industrialized nations has overloaded existing conventional wastewater treatment facilities, and there will be no room for expansion of the current treatment facility in the foreseeable future. Consequently, as compared to conventional activated sludge treatment, membrane bioreactors (MBR) have gained in popularity due to their unique benefits such as smaller footprints, lower sludge production, greater separation efficiency, and significantly improved effluent uniformity. Comparing MBR to the conventional activated sludge technique, the latter is also more effective at keeping organic micro contaminants with low molecular weights. Additionally, MBRs equipped with ultrafiltration membranes may be effective in retaining viruses[1].

Main market drivers contributing to the growth of the sector include legislative changes, water tension levels, and public confidence in the efficacy of MBR. In accordance with the Market Research Report, Asia-Pacific accounts for 38 percent of the worldwide MBR sales market, with Europe claiming the top position. MBR sales are expected to reach $627 million by 2015, increasing at a compound annual growth rate of 13.2 percent over the next five years. With the fast growth of the MBR sector, it is making significant contributions to the larger market for wastewater treatment equipment, which includes physical treatments, chemical treatments, biological treatments, and membrane filtering systems. Meanwhile, the MBR market is the most significant market for various membrane systems used to treat wastewater, such as microfiltration, ultrafiltration, Nano-filtration, and reverse osmosis systems. When it comes to applications requiring high grade water, even if certain wastewater treatment systems are capable of handling commercial wastewater to meet current drainage requirements and providing water for simple industrial needs, the treated effluent will need to be more polished by incorporating integrated MBRs[2].

In the field of wastewater treatment technology, there are many research papers accessible for MBR. Fletcher et al. investigated the current state of MBR technology as a biotechnology trend in the United Kingdom. It was the authors' intention to focus on the fundamental elements of the MBR process, including the membrane and configuration procedure. MBR was investigated for its potential to be used in fermentation technology rather than wastewater treatment to produce ethanol and biogas. A further investigation has been conducted on the benefits and drawbacks of using MBR in the treatment of high-strength industrial wastewater. A comprehensive examination of physical, chemical, and biological cleaning in MBR was carried out by Wang et al., who also proposed techniques for assessing suitable cleaning procedures in MBR. A number of researchers looked at membrane distillation bioreactors (MDBR) and their possible uses and configurations, whereas Wang and Chung looked into MDBR growth, configuration design, and application. A membrane distillation bioreactor was the subject of M. Researchers' investigation on fouling and its regulation. In this study, researchers looked at membrane processes for urban and industrial applications. They looked into pretreatment, MBR design, membrane fouling, fixed film and anaerobic MBR, membrane technological advances, and modelling. It is anaerobic MBR (AnMBR) that accounts for the majority of integrated MBR research publications. Anaerobic MBR (AnMBR) has the benefit of decreasing organic matter while also generating energy via anaerobic processes. The integration, limitations, and needs of AnMBR for urban wastewater treatment were examined by the researchers. A second study of AnMBR was carried out by the researchers, this time focusing on the efficiency and constraints associated with industrial-scale deployment.

Using other wastewater treatment systems as a comparison, the researchers looked at the efficiency of AnMBR. They also looked at energy recovery and fouling issues with the membranes. In spite of this, only a few additional studies have been conducted to give an overview of the various types of integrated MBR and their effects on wastewater treatment and valorizability. Providing an overview of current research for the integrated MBR technique of wastewater reclamation is the goal of this article, which aims to do so by providing an overview of current research in the field of integrated MBR. As far as we know, this is the first study to integrate MBR with other wastewater treatment technologies, including advanced oxidation processes (AOPs), granulation technology, reverse and forward osmosis (FO), MDBR, and hybrid moving bed biofilm reactor-membrane bioreactor (Hybrid MBBR-MBR). As for the other relevant sections of the paper, they focused on the long-term growth of MBR for the purpose of processing biomass for biofuel, energy generation, and nutrient recovery, all while making money and making a positive contribution to environmental conservation[3].

1.1 Membrane Bioreactors

Membrane bioreactors are a combination of a suspended growth biomedical treatment system, typically activated sludge, and membrane filtration devices, typically low-pressure microfiltration (MF) or ultrafiltration (UF) membranes, used primarily for wastewater treatment. Cellulose membranes are in charge of carrying out the critical solid-liquid separation process. Traditional methods for accomplishing this have included primary and tertiary clarifiers, as well as tertiary filtration in activated sludge plants. Generally speaking, MBR systems may be split into two types: vacuum (or gravity-driven) MBR systems and pressure-driven MBR systems. Immersed vacuum or gravity systems make use of hollow fiber or flat sheet membranes, which are housed in either the bioreactors or a subsequent membrane tank after the bioreactors. Systems that are pressure controlled are in-pipe cartridge systems that are placed externally to the bioreactor (Figure 1).

"MBR System" is defined as a fully integrated membrane unit (sub-systems) with all of the associated components required for the process to operate properly. Typically, an MBR device is composed of ten or eleven subsystems, which include fine screening (headwork), the Membrane Zone (which contains the bacteria), and, in most cases, some type of post-disinfection procedure. An MBR, also known as a Membrane Zone, is the first step in a biological process in which microbes degrade contaminants that are then purified by a series of immersed membranes. An MBR is also known as a Membrane Zone (or membrane elements). Modular units such as modules, cassettes, or shelves are used to store specific membranes, and an entire functional membrane unit is comprised of a collection of modules. Air is introduced into the filtration process through integral diffusers in order to continuously scour membrane surfaces, promote mixing, and, in some cases, to provide oxygen to a biological process in the process of separation[4].

MBR has a smaller footprint than a comparable traditional active sludge facility with secondary clarifiers and media tertiary filtration, which is typically 30 to 50 percent smaller on average. Aside from that, the method produces excellent effluent consistency that is capable of meeting the most stringent water quality specifications, a flexible schematic that allows for rapid extension and modification versatility, a stable and efficient system, and reduced downstream disinfection requirements.

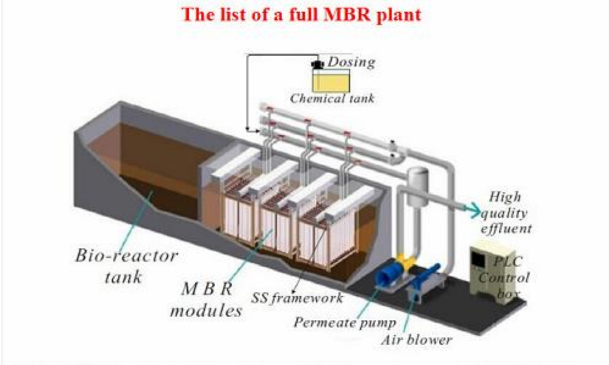

Figure 1: Treatment of Wastewater using Membrane Bioreactors [YX-FILTER]

1.2 Membrane Bioreactor Design

Because membrane bioreactors (MBRs) are activated sludge processes, the same generally accepted design rules that apply to conventional activated sludge processes apply to the design of MBRs. The food-to-microorganism (F/M) ratio is the most important design parameter, and when high levels of mixed liquid suspended solids (MLSS) are achieved, tank capacities are reduced to reduce the risk of contamination. It is necessary to modify the aeration equipment in order to accommodate the high actual volumetric oxygen concentrations that occur. Because the membranes must permeate the greatest amount of flow, the hydraulic load and feasible flux are the most important factors to consider while designing the membrane surface[5].Defining the shape of the membrane and membrane modules as early in the design process as feasible is essential for the successful implementation of setup, repair, and membrane cleaning facilities. Because of the back flushing and washing processes used in MBRs, the overall degree of automation is higher than that seen in conventional wastewater treatment facilities.

1.3 Fundamental Design Principles and Treatment Procedures

Membrane Bioreactors combine traditional biological treatment techniques with membrane filtration to provide a new level of organic and suspended solids removal that is unmatched in the industry. These systems may also offer sophisticated nutrient removal capabilities if they are constructed properly. The membranes of an MBR system are submerged in an aerated biological reactor to provide proper filtration of the water. The porosities of the membranes vary between 0.035 microns and 0.4 microns, which is in the middle of the microfiltration and ultrafiltration spectrum[6].

High-quality effluent is pulled through the membranes at this degree of filtration, eliminating the need for sedimentation and filtering techniques that are often employed in wastewater treatment. Because sedimentation is no longer required, the biological process will be able to operate at considerably greater mixed liquor concentrations than previously possible. As a result, the quantity of process tankage available is reduced considerably, enabling many existing facilities to be updated without the need for additional tanks. Normally, the blended liquor is kept in the range of 1.0-1.2 percent solids in order to give the best aeration and scour over the membranes, which is four times the amount provided by a conventional plant[7].

1.3.1 Aeration Membrane Bioreactors

Specifically, this is the membrane aeration bioreactor method, which uses membranes that are permeable to gas supply with highly concentrated oxygen straight to a biofilm without the formation of bubbles (this is a film of decomposing microorganisms that are usually contained on substrate materials in aquatic systems, such as stones, sticks, and leaves to which they are attached). The coating is remains slimy or slippery in its natural state). The aeration process is carried out in this scenario without the need of a bubble because an artificial polymer barrier is placed between the liquid and gas phases. Large quantities of oxygen and air are transferred into the drainage environment via the membrane, which aids in the breakdown of organic waste by microorganisms. The gas diffuses into the wastewater as a result of the membrane's operation. Frame and plate or hollow fiber unit configurations are often used to assemble these membranes.

1.3.2 MBR Separation Bioreactors

This membrane-based waste water treatment system is a novel technique that integrates membrane filtration with a growth reactor for biological waste decomposition to produce a highly efficient system. It is proposed that liquid-solid separation membrane bioreactors be used as filtration barriers in this method. For biosolids separation, this procedure is employed in conjunction with the conventional activated sludge technique. In the presence of high-quality pollutants and suspended particles, the membrane functions as a full buffer. When activated sludge combined with ultrafiltration was first commercially available at the end of 1960, its application gained momentum only recently, with major implementations and production of membrane processes in combination with biological treatment methods taking place over the last decade, according to the American Water Works Association[8].

1.3.3 Membrane Bioreactors with A Recycled Membrane

Bioreactors are constructed of two parts: a reaction vessel and an external membrane. The vessel is used as a fuel tank for a reactor with a stirring core. This technology is utilized in industry in two fundamental configurations: the beaker shape and the tubular form. Tubular designs are often chosen for industrial applications on a big scale. In this scenario, the biocatalysts may be fixed or loaded on the shell or tube side of the reaction vessel, respectively. As a result of enzyme diffusion resistances and substrate orientation, this method has a loss of activity ranging from 10 percent to 90 percent, which is considered to be a disadvantage.

Bioreactors Using Extractive Membrane Technology

These bioreactors are often used in waste water treatment facilities to increase the effectiveness of membrane bioreactors by a factor of two or three. It takes advantage of the membrane's capacity to create a normal separation while yet enabling components to be transported from one stage to the next, a property known as membrane permeability. It is possible to maintain optimum conditions within the bioreactor with the help of this separation technique, which allows microorganisms to breakdown wastewater pollutants more effectively. The use of membrane bioreactors for waste water treatment has shown that this method has established a place in the wastewater treatment industry, and this is the last point[9].

1.4 Advantages of Membrane Bioreactors

Hydraulic Retention Time (HRT) and Solids Retention Time (SRT) are controlled independently of one another: It is possible to control the SRT independently of the HRT due to the fact that the biological solids (mixed liquid or sludge) are solely contained inside the bioreactor. During the Conventional Activated Sludge (CAS) process, the flocculants solids (also known as "flocs"), which are essentially biomass, must be allowed to grow in size to the point where they may be sorted out in the secondary clarifier. The HRT and SRT are thus connected in CAS; when the HRT increases, the flocs must expand in order to increase their settle ability, and vice versa.

Excellent Effluent Quality: Because the membrane pores of the MBR are relatively small (0.5), the handled effluent has very good visibility and a little reduced pathogen burden as compared to the conventional filtration technique. As long as the effluent is of good quality, it may be released into bodies of water or utilized for a variety of applications such as municipal drainage and utilities, or for toilet flushing. It may also be put straight into a reverse osmosis system, resulting in a permeate with an even higher water content than before.

Small Environmental Footprint: Because CAS has a high HRT, a bigger plant capacity is anticipated to be required. A smaller footprint is achieved by storing the same total mass of solids in a smaller space, which is made possible by the greater quantities of solids generated in MBRs.Improvements in Bio-Treatment: Because MBRs have a high SRT, they are able to support the development of slower-growing microorganisms, such as nitrifiers, resulting in an overall improvement in bio-treatment. As a result, MBRs are very effective in biologically extracting ammonia (also known as 'nitrification').

1.5 Disadvantages of Membrane Bioreactors

The most significant disadvantages of an MBR are the complexity of the operational phase and the cost, which is translated into CAPEX and OPEX throughout the course of the business. Both of the latter are extremely sensitive to the cost of the membrane. Furthermore, the OPEX is influenced by the following factors:

On the other hand, an analysis of real membrane life revealed that it can last for at least 8 years when used in a large number of installations, with more recent membrane products having a longer life. Membrane Replacement: Ceramic membranes, on the other hand, are expected to last significantly longer[10].

Membrane Permeation Flux: The membrane permeation flux is defined as the amount of volume that passes through the membrane per unit area per unit time in a given period of time. It is important to note that pressure and temperature have a significant impact on the volume of gases and vapors transported.

2. DISCUSSION

There are two methods that may be used to decrease MBR's energy consumption. Aeration systems, for example, account for the bulk of the energy used by MBRs. The first is the production of power throughout the treatment process and its delivery to the device, such as the aeration system. This can only be accomplished via the use of a Microbial Fuel Cell (MFC), which generates energy by oxidizing organic molecules produced by bacteria. However, the poor uniformity of the material is one of the most significant disadvantages of MFC. If you want to polish the effluent even further or improve the treatment process, another polishing approach, such as bio-augmentation of existing bacteria, may be required in MFC-MBR. Research and development on powering up the MFC to produce electricity while emitting no hazardous pollutants may become more important in the future, according to certain predictions.

The integrated anaerobic MBR is the second kind of integrated MBR that has the capability of generating energy, after the integrated aerobic MBR. However, due to membrane fouling and sensitivity to toxicity, the commercialization of AnMBR on an industrial scale is still a long way down the road. It is most successful when treating low/no sulphate wastewater in warm/hot climes, with potential maximum energy outputs of 0.11 kW hm3 and prospective maximum energy outputs of 0.11 kW hm3. In summary, the power and energy generated by the integrated MBR are expected to be sufficient to meet the energy requirements for wastewater treatment, with any excess energy being utilized for other reasons.

Use of a device with low or non-hydraulic pressure and/or a lower membrane fouling propensity is the second suggestion for lowering MBR energy consumption, and both are effective. Reverse osmosis and forward osmosis are less energy-intensive and have a lower fouling proclivity than other methods. Although this technology resulted in salt buildup inside the reactor, it did not have an adverse effect on the biological output of the system. The long-term dependability of RO-MBR and FO-MBR is dependent on the effectiveness of membrane improvements and the monitoring of microbiological activity. Some bacteria that are able to survive the salty environment and oxidase organic compounds in the reactor may be added to the system as a bio-augmentation strategy to maintain the system's biological efficiency.

Membrane fouling and energy consumption (aeration) are closely related and are often considered as significant disadvantages in the use of membrane bioreactors. Air scouring for the membrane and aeration of activated sludge account for 60-80% of the total energy used by MBR systems. The improvement of HRT and SRT, for example, are two methods for decreasing MBR membrane fouling that have been explored in a number of research papers. It should be noted that the emphasis of this study is on an integrated device with MBR that is capable of preventing membrane fouling. While there is agreement on the need to minimize membrane fouling in Biofilm Membrane Bioreactor (BF-MBR) and granular MBR, there is disagreement on how to do so. Furthermore, increasing the SRT resulted in reduced fouling of the MBR membranes when the temperature was raised. Raised fouling of the Reverse osmosis membranes was observed when the SRT of the MBR was increased. It is shown by these findings that the components of foul MBR membranes differ from those of foul reverse osmosis membranes. As a consequence, future research should focus on SRT and/or HRT of the combined MBR in order to remove membrane fouling completely.

3. CONCLUSION

With the many advantages connected with MBR technology, it has emerged as a reliable and practical option that surpasses alternative waste management methods. This research has taken into consideration and addressed the integration of MBR with other care programmes. Future MBR research will most likely focus on lowering the energy consumption of the system and decreasing membrane fouling while in operation. In recent years, a growing number of contemporary MBR designs have been suggested for use in actual environmental engineering applications. When it comes to high organic reduction, the MBR demonstrated acceptable efficiency, and it will be a viable option for water reuse and recycling in the near future. The second component of the integrated MBR implementation is the solution of design issues for simultaneous wastewater treatment and re-use of treated wastewater. When it comes to selecting the most appropriate MBR technology for a particular application, there are many options available. With its tempting advantages and intriguing technological characteristics, integrated MBR has the potential to play a significant role in wastewater treatment for long-term sustainable development. Continued work in academia and business will result in the development of integrated MBR systems for wastewater treatment and valorization, according to the authors.

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