American Journal of Biology and Natural Sciences
https://biojournals.us/index.php/AJBNS
ISSN: 2997-7185

A Review of Membrane Bioreactor Technology for Industrial Wastewater

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Received: 2025, 15, Nov
Accepted: 2025, 21, Dec
Published: 2026, 05, Jan

Annotation: In this study, the operation, activation, process and use of membranes in bioreactors in wastewater treatment are explained. The membrane bioreactor (MBR) method is a simple, one-step method that combines a membrane-bound bioreactor with visualization and description of the activated sludge process. The activated sludge plant can be operated in a single step and when used as MBR, high quality wastewater that can be recycled can be produced. The robustness of MBR technology also attracts attention in wastewater treatment. Theoretically, maintaining longer SRTs in MBRs promotes the growth and survival of certain microorganisms, which can improve the removal of refractory materials and enhance energy production for destruction and exchange. Published studies show that the theoretical expectation of improving the biodegradation of compounds with low biodegradability in MBRs is not always met. This review first introduces the basic concepts of MBR tools and then describes the latest developments in all MBR tools. The characteristics of the bioreactor purification process are discussed in depth, and then the membrane separation process is examined. The consequences of scaling, which is a major issue in the adoption of MBR facilities, and recent scaling reduction methods are discussed in detail. Many efforts regarding the new MBR process have been documented. Current issues and future research to resolve the current limitations of MBR and make it more applicable on a larger scale are presented.

Keywords: Wastewater Treatment, MBR, Activated Sludge.

Introduction

In a global sense, the development of a country can be considered a good development depending on its economic growth. The image received by the business sector can be very different depending on the products they produce. Rapid economic growth and its concentration in urban areas or adjacent areas have put pressure on the carrying capacity of certain areas. Water in these areas is often damaged by pollutants released into rivers, lakes and coastal waters. Waste generated as a result of human activities related to the production and processing of raw materials is called wastewater. This wastewater causes the end of the life of the product, starting from processes such as cleaning, cooking, cooling, heating, removal, chemical reactions from the products, separation and quality control. Past treatment technologies were developed from the perspective of increasing demand, ultimately leading to increased wastewater production. As new technologies emerge, the problems created by old technologies disappear. Wastewater treatment plants are designed to improve water quality to meet safety requirements for wastewater treatment. Different treatment processes can reduce the amount of bacteria in water in addition to removing suspended solids that can contaminate the waterway and affect the movement of water through the water and plumbing after installation. It also reduces the amount of organic waste in terms of Biological Oxygen Demand (BOD) [1, 2].

Wastewater treatment must be removed sufficiently to provide drinking water. To improve the performance of the treatment plant, some aspects of water use need to be controlled; therefore these parameters need to be taken into account throughout the design phase. Due to the uncontrolled release of waste water into the environment and the transfer of toxins to the humanoid system, protecting the environment requires the removal of pollutants and the use of treatment/purification methods. Effective wastewater treatment reduces unnecessary water consumption and saves water resources. The main objective of this study is to provide an overview of effective technologies for the treatment of wastewater produced by various industries, including the characteristics of the wastewater and the location of the affected enterprises [3, 4].

Industrial growth

An important part of the country's economic growth is the promotion of trade. The Industrial Revolution is necessary for the renaissance of agriculture because fertilizers, pesticides, insecticides, and other industrial products are important for increasing productivity and production science and technology. The main problem affecting the Indian economy is the financial crisis.

Implicit and positive wealth will increase business profits, which can be used to stimulate growth and development. The economy continues to grow due to modernization. It is necessary to encourage exports and production changes in the context of international trade to prevent the balance of payments deficit from widening the economy. When deciding how to strengthen energy and energy policy, it is important to consider the environmental impacts of energy production and use, each way of producing energy, and each link in the fuel chain that creates positive and negative impacts. The country's real energy needs and social needs should be taken into account in the decision-making process [5, 6].

Critical environmental impacts

Uncontrolled wastewater appears to cause hazardous substances to leak into the environment. **Wang et al. (2011)** [7] stated that wastewater from many industries is linked to diseases such as cancer, immune problems, lung diseases and respiratory diseases. According to the National Environmental Protection Inspectorate (PIOS), more than 60% of wastewater is harmful to the environment and public health. To ensure a safer and more efficient wastewater management, risk assessment, including situation analysis, risk assessment and risk assessment behavior, should be taken into account [8, 9]. Wastewater often contains bacteria that cause cholera, typhoid, and other allergic diseases [10]. E. coli and salmonella are two of these bacteria. There has been an increase in the deadly disease called byssinosis, which textile workers contract after being exposed to cotton dust for a long time, in recent years. This disease, called myeloid leukemia, mainly affects workers in the chemical industry and is caused by long-term exposure to formaldehyde without adopting the necessary safety procedures [11]. Asthma-like syndrome is a breathing disorder that is not associated with hypersensitivity or persistent airway inflammation despite the presence of asthma symptoms. Lung deterioration is sometimes only seen with cross-operative testing and is therefore difficult to document in a formal clinical setting [12, 13]. The decline in FEV1 varies between 10% and 15%, but is usually less than 10%. It usually affects 10% of pig workers but can also attack people working in agriculture.

Wastewater treatment becomes more complex because companies often produce many products and the products are very diverse. Biological and chemical processes are frequently used to purify wastewater [14, 15].

Biological treatment is now widely used to treat wastewater because it is the cheapest and most environmentally friendly of these processes. Today, research and practice focus on all methods. Currently, it is important to mainly use oxidation ditch, SBR (sequential batch reactor) method, CASS (circulating activated sludge system) method and (intermittent circulation extended aeration) method as oxidation methods in domestic and foreign wastewater. Medical procedures. However, the purification efficiency of these systems is excellent due to the presence of antibacterial and refractory organic compounds in wastewater [16, 17].

The world economy produces large amounts of wastewater that, if properly treated, could become an important source of energy [17, 18]. Wastewater contains a lot of solid waste, and a good separator can remove waste and wastewater almost simultaneously. Additionally, impurities in wastewater can cause sludge accumulation during membrane separation, which can affect water quality if not treated [19, 20].

Membrane bioreactor technology, or MBR technology, has many advantages over traditional sludge treatment systems and is a major breakthrough in wastewater treatment [21, 22]. Membrane bioreactor technology is a new wastewater treatment method that combines bioorganic systems and membrane separation. It uses a membrane separation - reaction tank containing activated sludge (ASP) and biological products. Keeping the organic molecules in place in the second sedimentation tank greatly improves the performance of the bioreactor. This makes the water clean and increases the concentration of activated sludge [23, 24]. Membrane bioreactor (MBR) technology is an integrated process that combines biological and biological treatment. By applying MBR, conventional wastewater treatment plants can be converted to single-step processes to produce better wastewater [25, 26] By keeping a large portion of the (ASP) within the membrane reactor instead of transferring it to the secondary settling tank, the sludge concentration in the MBR can be effectively increased to 1800-1900 mg/L [27, 28].

MBR is an biochemical technology that uses two different products: 1) scale-up growth bioreactors for biochemical processes such as nitrification, fermentation, biooxidation and denitrification, 2) membrane bioreactors in which the separated liquid is stored for further processing [29, 30]. Using anaerobic reactors with microfiltration and ultrafiltration membranes could be another method of purification. A combination of anaerobic sludge bed and membrane bioreactor was used to remove total solids (TSS) from municipal wastewater and achieve COD removal; this resulted in 98% to 100% efficiency based on TSS [31, 32]. MBR technology replaces water and sludge separation with membranes that are more effective and less depend on oxygen in the water. The operation of this method is almost the same as ASP [33, 34].

Submerged membrane bioreactors (MBRs) have been used for many years due to their many advantages, such as good water flow, low sludge formation, small footprint, and easy expansion for growth [35, 36]. The potency, large size, and unique biological refractory, inhibited, and difficult-to-sterilize category of the waste make alternative treatment such as MBR attractive. Due to these features, the application of MBR technology in wastewater treatment is also very popular. The characteristics of the reactor have a strong influence on the selection of biomass and separation products.

However, refractory chemicals in wastewater can have a significant impact on the microbial selection process of MBR [37, 38]. The type of industrial process used and the amount of non-biodegradable material are designed to determine the success of organic removal. This article provides a comprehensive review of the literature on MBR treatment of refractory wastewater and offers new perspectives to the field to address this issue.

Biochemistry, principally including fermentation engineering, wastewater production, effluent, domestic sewage and process water. While high-pressure water systems directly increase COD due to the highest amount of water used per service, washing water becomes the main source of wastewater due to the high amount of waste discharged. In addition, there are problems such as high and low nitrogen content and nitrogen ratio, high color, and inhibitory microbial degradation chemicals in fermentation biochemical wastewater [37, 38]. Figure 1 shows the differences between treatment methods and provides an overview of the development of membrane systems in wastewater treatment. It is important to evaluate the effectiveness for MBR in EDC removal. As shown in Figure 2 compares the results of treating two micropollutants using conventional and MBR technology according to specific tests [39, 40].

Activated sludge (CAS) generally consists of two steps. First, the wastewater is treated in an aeration basin using (ASP), which is treated with active bacteria. In the settling tank (also known as the second settling tank), purified activated sludge and water are separated. Wastewater treatment is generally less as activated sludge cannot be completely separated in the tank. However, when MBR is used, a large part of the activated sludge can be separated because the membranes have different pore sizes [3, 4].

The performance of bioreactors is generally affected by the size of bacteria, content of filamentous bacteria, growth, etc. has a significant impact on. However, microbial activity can affect MBR performance in two different ways: membrane fouling properties and membrane fouling properties. Water quality and wastewater treatment capacity of MBR. Therefore, a comprehensive understanding of the fundamentals of wastewater treatment, including microbiology, microbial metabolism, microbial stoichiometry, and bioreactor kinetics, is required to determine optimal bioreactor performance and MBR facility characteristics [7, 8].

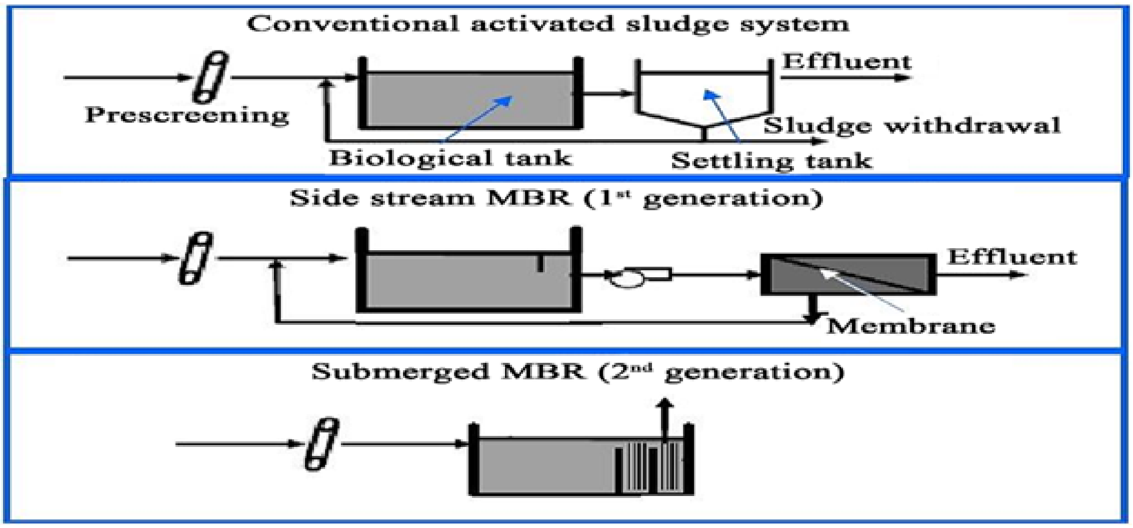

Figure (1): Development of combined use of membranes and bioreactors.

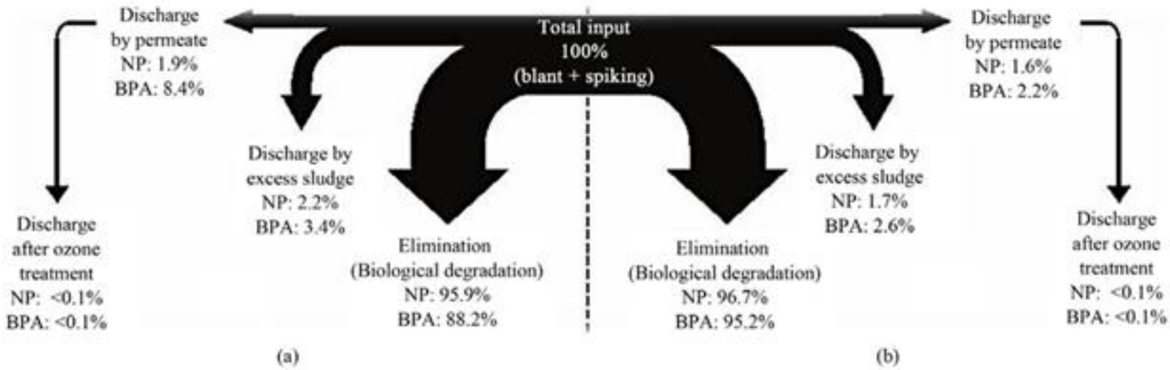

Figure (2): a schematic figure illustrating the treatment of two micropollutants in three different methods: conventional, MBR, and O3.

The structure and composition of the bioreactor microbial community for a given MBR unit varies between different MBR facilities and changes over time. The main reason for this change is that microorganisms play an important role in environmental engineering systems, including MBR facilities. Different diseases have occurred in many societies due to the mixture of wastewater and chemicals in the air. However, by adjusting the operation and reactor design, certain organisms can be effectively produced in bioreactors [3, 4].

CAS and MBR devices share the same system type and functionality. However, due to the long SRT and high biomass concentration in MBR bioreactors, their characteristics are different:

1. Compared with the short SRT of the CAS aeration tank, slow-growing bacteria are retained, which is effective in removing stubborn skin. corruption. However, it can also produce harmful bacteria, such as foaming bacteria.

2. Increase the amount of waste to reduce the proportion of biomass in the bioreactor to the total waste.

Bacteria (such as Proteobacteria), protozoa (such as amoebae, flagellates, ciliates), metazoans (such as rotifers, nematodes, tardigrades), filamentous bacteria, algae and fungi are the main components of bioreactors. However, most (more than 90%) of the organisms in activated sludge are bacteria. Bacteria often come together to form pairs, chains, or colonies, but they can also live singly. They can use various electronic products, electronic products, electronic products and carbon products. Their adaptability not only allows them to overcome many types of organic and inorganic pollution, but also provides conditions for the purification of certain products in wastewater [5, 8].

Endocrine disrupting chemicals (EDCs) are substances that can cause harm when used in wastewater. An example of EDC is BPA. It is used in the production of flame retardants, polycarbonates, epoxy resins and other specialty products. Additionally, BPA is part of dental care, a developer in thermally coated materials, an antioxidant in plastic production, and a step in the production of polyvinyl chloride. Researchers work on BPA removal in submerged membrane bioreactors (MBRs) [42, 43]. According to these findings, the primary mechanism for removing BPA is biodegradation. Many studies have examined the suitability of MBR for the removal of estrogenic compounds from solid waste and municipal wastewater. The distribution of pollution was analyzed. The concentration of the supernatant is higher than that of the filtrate. They concluded that some DOC macromolecules in wastewater were removed by ultrafiltration membranes, although micropollutants tend to interact with and bind to the removed macromolecules. Other researchers use wastewater treatment plants (BWWTP) and MBR to treat urban wastewater. Ozone (O_3) is also used to clean wastewater. Chemical demand (COD) decreased by 95% ± 2%. The removal efficiency of 4-NP and BPA was >98% or 97.8% in the MBR treatment and >98% and 91.6% in the non-ozone treatment. The balance showed that biodegradation was the main factor in the removal of 4-NP and BPA in both treatments. According to early studies, pilot-scale MBRs treated wastewater more effectively than conventional MBRs to reduce cholesterol, coprostanols, stigmastanols, estrogenic substances (E1, EE2), and BPA ng/L. The traditional activated sludge plant is successful. The authors suggest that the reason why MBR can achieve lower flow rates may be related to thinner films or higher SRT. Active substances and potential endocrine disruptors were examined in two laboratory-scale and three-scale bioreactor (MBR) systems using liquid chromatography-mass spectrometry (LC-MS-MS) analysis and potassium estrogen analysis bioanalysis [44, 45].

The amount of adsorbed estrogen per kilogram of dry matter is low because the hydraulic retention time of MBR is short and the percentage of suspended solids in the mixed liquid is higher than that of STP. Studies have been conducted to evaluate the effectiveness of various membranes in removing chemicals, endocrine disruptors, and hygiene products. Artiga et al., 2005 studied eight chemicals, two polycyclic musk odorants, and nine endocrine disruptors in various wastewater treatment plants (WWTPs) [46]. Operating wastewater treatment plants with SRT (SRT 4 - 10 days, 10 °C) suitable for nitrogen removal also makes it possible to remove some micropollutants. There was no significant difference in treatment between the two methods. The removal capacity of the MBR is determined by the SRT, as in wastewater treatment plants[47, 48].

Ultrafiltration membranes prohibit the chemicals under research from being retained any longer due to size exclusion. On the other present, MBRs produce a high SRT within a small reactor. Variations in redox conditions, which are critical for the breakdown of nonylphenol polyethoxylates, led to a better elimination of those compounds in extremely low-loaded classical WWTPs. conducted a pilot-scale study to treat pharmaceutical effluent from chemical synthesis utilising a membrane bioreactor (MBR) and anaerobic digestion in two phases (TPAD) system [49, 50].

It has been determined that the pH of the effluent from an MBR system typically falls within a narrow range of 6.8 to 7.6, meaning that it is suitable for direct discharge into natural water. Visvanathan et al., 2007 (51) examined the use of a laboratory-scale membrane bioreactor (MBR) as an adjunct to the activated sludge (CAS) process for 22 months to treat capital municipal wastewater composed of polar contaminants by family and industrial chemicals to change. For half of the chemicals such as benzotriazole, benzothiazole-2-sulfonate, 1,6-naphthalenedisulfonate (1,6-NDSA), the removal effect of MBR is better than CAS. The other half of the compounds, including 4-TTri, 1,5-NDSA, 1,3-NDSA, and 1-naphthalenesulfonate, did not show any improvement. When examining the impact of poor performance of MBR on contaminant removal, there was no significant interaction with changes in hydraulic time (7 vs. 14 h) or sludge residence time (26 vs. 102 days). This means that the minimum value chosen is high enough to allow effective removal. However, for most compounds that can be removed by neutralization in CAS

(15% to 80%), such as drugs, medical devices, and pharmaceuticals, MBR is better. reduce the flow rate from 20% to 50%. The behavior of two distinct radioactive variants of 17-ethynylestradiol (EE2) has been examined in laboratory-scale MBRs [52,53]. The resemblance observed in the metabolite structure within the radio chromatograms of the two different labeling methods implies that the elimination process may not necessarily eliminate the ethinyl group from the EE2 molecule. Researchers examined the effectiveness of wastewater (WW) biodegradation treatment for some nonadsorbed persistent pollutants (P3) by comparing activated sludge treatment (AST) with laboratory-scale membrane bioreactors (MBR). If sludge remains when MBR is used, the P3 concentration in the water will decrease [54, 55]. The ability of soaked MBR to extract active chemical compounds (PhAC) was studied by Bienati et al. 2008 [56]. Rahman et al. (2006) examined the degradation of 11 chemicals, two endocrine disruptors, and three estrogens in an experiment using a membrane separation bioreactor. At the same time, the membrane can remove more and more chemicals; but for hydrophilic substances the difference is not wider. Researchers conducted extensive studies and experiments to eliminate 14 drugs, 6 hormones, 2 antibiotics, 3 PCPs (personal cleaning products) and 1 fire extinguisher in drinking water and wastewater. Yes. Vanini (2008) [58]. The researcher discusses the effectiveness of membrane bioreactor (MBR) and fully activated sludge (CAS) treatment in the removal of various chemicals, chemicals (PhACs), which have different physical properties and fall into various groups treatment. However, the findings evidenced that the treatment of membrane bioreactors (MBR) did not exert any influence on the content of erythromycin, carbamazepine, naproxen, trimethoprim, diclofenac and TCEP. The water levels and presence in the products of 31 chemicals included in the analysis were checked. Finally, the treated sludge is sent to agricultural land and the remaining twenty chemicals are mixed into the treated sewage. Barrios-Martinez investigated the activity of 12 micropollutants in membrane bioreactors (MBRs) used to treat wastewater [59]. Drugs of choice include antibiotics, antibiotics, sulfamethoxazole, trimethoprim, naproxen, diclofenac, carbamazepine, diazepam, and tricyclic musk (galmus, tonality, tilinolactone). Synthetic wastewater entering the reactor contains environmentally harmful micropollutants in the range of 10-20 μg/L. The sludge retention time (SRT) of MBR runs between 44 and 72 days due to the higher price. This measure is important in eliminating micropollutants. In these cases, different results were observed depending on the drug and human characteristics (PPCP). Musk-based fragrances and other hydrophobic compounds will partially absorb dirt. This explains the overall efficiency of the half extraction reactor of approximately 50%. The biodegradation of some of the most commonly used pesticides, such as spindle, 2,4-D, 2,4-DP, and MCPP, as well as diclofenac acid, using membrane bioreactors (MBR) and fixed bed bioreactor (FBBR) has been investigated in several studies reactors [60, 61].

Liu et al. (2008) investigated the removal of trimethoprim, macrolides, and sulfonamides from wastewater from some urban water treatment plants. An article from Taiwan describes a (MBR) process for experimental wastewater treatment [62]. Wastewater does not contain solid waste. The results show that the MBR system can treat and efficiently convert high-pressure wastewater. Sutton et al. (1994) collected biomass from membrane bioreactors (MBR) and sequenced batch reactors and performed adsorption studies at different concentrations. Activated sludge spontaneously absorbs 17-ethynyl estradiol (EE2). The G value varies between -16 and -11 KJ/mol, the H value is enthalpy driven (37 and 48 KJ/mol for MBR and SBR, respectively), and the S value is entropically retarded (74 and 119 J/mol). /K stands for MBR and SBR respectively). Although EE2 is nonpolar, hydrophobic interactions are not the dominant force. Chang et al., 2006 [64] measured biomass energy in experiments with different parameters in membrane bioreactors (MBR) and conventional bioreactors (CBR) and examined the distribution of 17-ethynyl estradiol (EE2) effects and adsorption hysteresis effects. The average biomass particle size has a significant impact on the partition coefficient (Kd) and adsorption hysteresis index (HI) observed when biomass is produced without nitrogen limitation. The membrane bioreactors Kd (0.33 - 0.57 g/l) value is greater than or equal to the CBR (0.25 - 0.33 g/l). Analysis of factors affecting the removal of organic micropollutants in wastewater shows that the two main removal methods for

FRP and MBR are adsorption and biodegradation. Criteria include biomass concentration, sludge retention time (SRT), pH, temperature, micropollutant group, etc. takes place. It is relevant to research, for example, hydrophobic substances (NP, EE2, etc.) can be absorbed into the sludge, and it is removed from the body and incoming water. In addition to the main bacteria in MBR sludge, Paenibacillus azoreducens and Bacillus sp. Also there. Research shows that they are involved in the color changing process of textiles.

Reverse osmosis system was used to evaluate the recycling of secondary wastewater (20% municipal wastewater, 80% wastewater) to produce wastewater that can be used in the textile industry. MBR filtrate, on the other hand, tends to ensure the stability and continuous operation of the RO module, and due to its stability, the specific flux decreases over time. While large water treatment plants use sludge to treat wastewater, some researchers are experimenting with membrane bioreactors. In addition to improving the removal of solids and contaminants, Pilot MBR also provides better COD removal and color removal compared to existing conventional water treatment plants. Episode

In 2006, Paulville et al. (65) In addition to the existing wastewater treatment plant (sludge treatment + clarification flocculation + ozonation), a new MBR model will be built to treat wastewater (Figure 3). Additionally, Bacillus spp. It was also determined that the main bacterium in MBR sludge was Paenibacillus azoreducens.

Shun et al., 2011 (66) evaluated a pilot plant membrane bioreactor combined with a large waste treatment plant using activated sludge to treat textile mill effluents. In addition to improving the removal of suspended solids and pollutants, Pilot MBR provides greater COD removal and color removal compared to existing continuously aerated wastewater treatment plants. On average, pilot plants achieved higher removal results than wastewater treatment plants, with COD removal of up to 93% and total solids removal of over 99%. Color is removed as in a wastewater treatment plant. Although the pilot plant removed more bicarbonate (98.2 vs. 97.1), it removed less anionic surfactant from the wastewater (90.5% vs. 93.2%, respectively). Çiçek N, 2003 (67) conducted a second experiment to evaluate the feasibility of converting activated sludge wastewater treatment plants (WWTPs) to membrane bioreactors (MBR) to treat textile and municipal wastewater. Since biomass is stored in the MBR reactor and heterotrophic organisms can proliferate without the need for additional nutrients. Others examines whether MBRs can produce water that meets reuse requirements. Because most dye biodegradation occurs at very low oxygen levels, MBR cannot treat wastewater in an aerobic environment like conventional MBR. Instead it should be used in anoxic or anaerobic conditions. Based on this, the anoxic-aerobic MBR wastewater treatment process was examined.

The effects of COD and dye treatment were examined on aerobic and anoxic MBRs. A gravity flow membrane bioreactor (MBR) designed to treat wastewater from wool mills used for dyeing and printing has been tested in the laboratory. The results show that better water flow can meet China's water recovery needs. Another's (69) examines the development and implementation of a new, state-of-the-art integrated process for large-scale reuse of wastewater at the Klingelmeyer Laundry in Germany using membrane technology. MBR filtrate meets all the needs of cleaning and also provides the quality water required for cleaning water. Water recycling and efficient chemical technology are designed for the textile industry. The oxidation process is carried out by specific bacteria, so selection of the microbial population is important to achieve high results.

Wichitsathian et al. (2004) (70) treated two different wastewaters with different components using MBR for 120 days. Operating biomass greater than 8 g VSS/L results in a reduction in oxygen exchange. An experiment using MBR and CASP to assess the tannins efficiency in wastewater treatment containing vegetal tannins. There is a slight difference between the removal of the two phenols depending on the presence of tannins. Orshansky et al., 1997 (71) studied a chamber laboratory scale membrane bioreactor to determine the best operating conditions for wastewater with high nitrogen and organic content and to evaluate the treatment results. Leaks occur when moisture enters the waste area, dissolves bacteria in the liquid phase, and creates pressure to mobilize the liquid. Leachate fluctuates over time due to changes in temperature, hydrogeology, and waste content and varies with each landfill. Therefore, advances in landfill design have focused on minimizing production, collection, and treatment prior to disposal[72, 73].

These elective procedures often combine physical, chemical, and/or biological treatments; The main functions are organic cargo and affect storage time. Due to the high energy content of solid waste, aerobic high-temperature membrane bioreactors (MBR) have been used to treat solid waste at two landfills in Thailand. During the 24-hour hydraulic retention time (HRT), As the BOD level increased, COD removal increased from 62% to 79% on average. Significant BOD removal was also observed (between 97% and 99%) [74, 75]. Some researchers (2006) [75], temperature above 43 °C inhibits nitrification. Temperature, mixing, and pH affect ammonia removal in hot and cold conditions. Although ammonia removal decreases with increasing BOD/COD ratio, this system seems risky because COD removal is important. In the agricultural sector of municipal landfills in Finland, treated waste is transported in batches to submerged membrane bioreactors (MBR) and sequenced batch reactors (SBR). We use special long HRT (SBR = 5 days, MBR = 10 days) and appropriate retention period (SBR = 10 - 41 days, MBR = 35 - 61 days). The study found that suspended solids in SBR wastewater were 89% lower than influent. However, sometimes swelling can reduce effectiveness.

However, when the process was interrupted, it was observed that the suspended solids, phosphorus and BOD_7 contents were high as sludge that released from the SBR unit. MBR water output is less oscillatory and better. A description of biological treatment and acid quality in landfills is given by Zou et al. 2007 [76]. They noted that ex-situ operations often require a multi-stage process combining chemical precipitation and/or oxidation with aerobic and anaerobic techniques. For biological feedstocks (BOD/COD = 0.03 to 0.16), MBR-based treatment solutions appear to provide very good COD removal results with an average COD removal of approximately 80% across all units compared to the feedwater COD of the conventional system. The value is approximately 63% and the BOD/COD ratio of water is 0.21 - 0.3 (Figure 3).

Refineries produce a lot of wastewater due to complex processes. The main processes that produce wastewater include desalination, storage, reforming, fractionation, thermal and catalytic cracking, alkylation, polymerization, solvent refining and isomerization. Chang et al., 2019 [77] investigated the treatment of animal feed waste prepared by sheep air flotation (DAF) with aerobic MBR at room temperature (20 °C) and in the lower thermophilic range (45 °C). The oil and gas (O&G) value in the wastewater sample was determined as 6 g/L, volatile fatty acid (VFA) value was 8.3 g/L, BOD was 16 g/L and COD was 51 g/L. works on submerged membrane bioreactors for crude oil purification using microfiltration hollow fiber membranes [78].

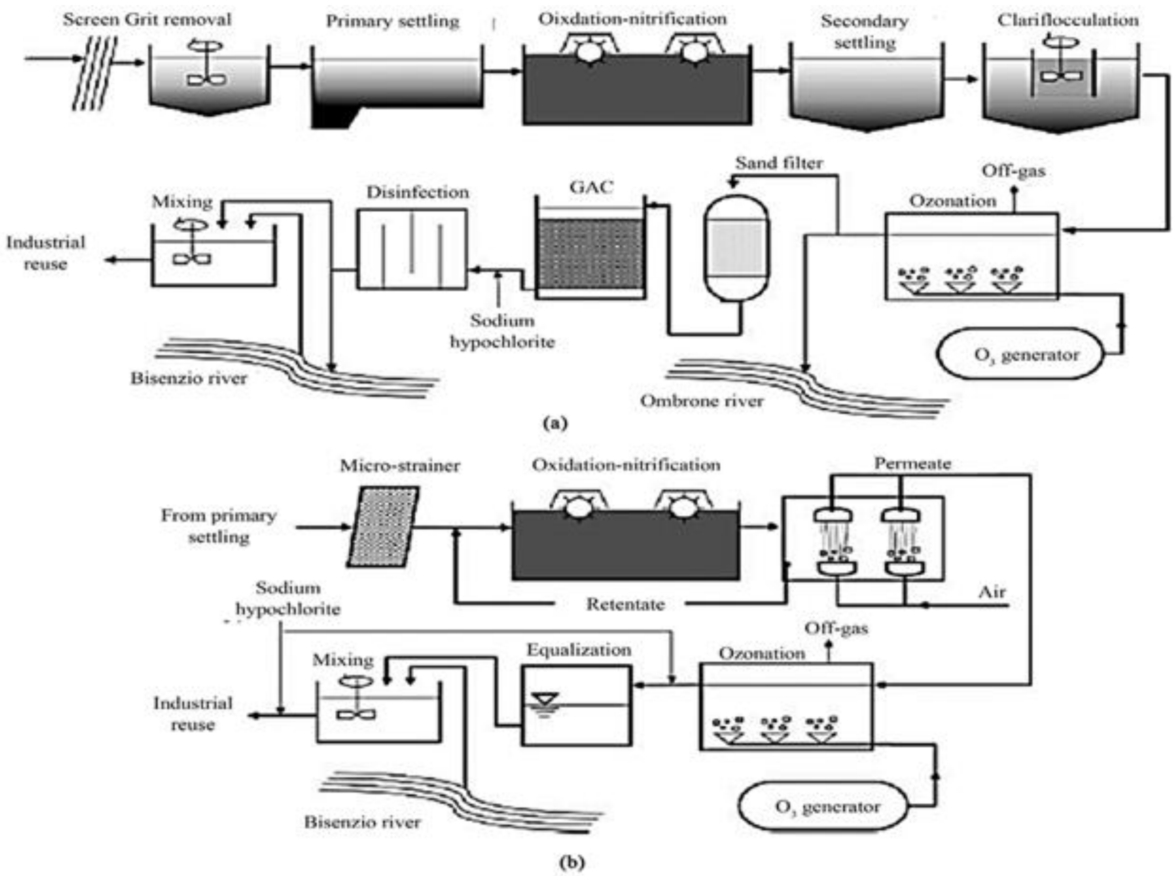

Figure (3): Schematic diagram of two wastewater treatment methods (a) Quality control by traditional methods; (b) Further treatment under MBR.

The membrane bioreactor operates in a subcritical flow regime with a hydrocarbon concentration of 600-1500 mg/L. Sludge concentrations range from 14 to 28 g/L. Wastewater treated with MBR has high biomass and short hydraulic time (about 10 hours) and clarity (about 98%). Chen et al, cited that; the use of cross-flow membrane bioreactor (CF-MBR) in refinery wastewater treatment was investigated. The year is 2020 (79) and the effectiveness of the CF-MBR system is evaluated with 3500 mg/L MLSS. Process efficiency is measured by hydraulic efficiency and COD removal efficiency.

This study concluded that COD removal was greater than 93% for two MLSS stages. The analysis also showed that hydraulic retention time had no significant impact on system performance. Treatment of olive mill wastes (OMW) has been studied by conducting experiments in external reactors (MBRs) in China and other countries (80). OMW is part of the most common wastewaters. Table 1 show compares COD removal rates in wastewater treated by different olive oil processing methods. Petroleum and petrochemical refineries mostly use phenol and its derivatives as raw materials..

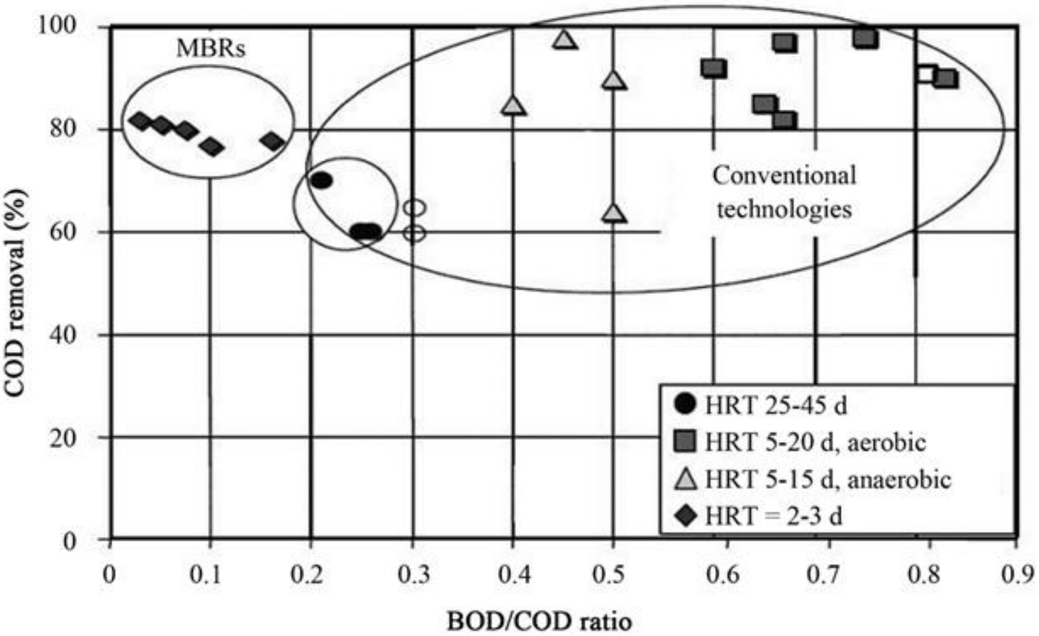

Figure (4): COD removal as compared to the plants overall leachate BOD/COD ratio at various HRT; Open data points represent the two-level process, while shaded areas represent data comparison.

Table (1): Removal of COD from olive mill waste processed by different methods

Process	Phenol inlet (mg/l)	Phenol removal (g)	COD Inlet (mg/l)	COD (g) removal
Electrochemical	1521	>91	1476-6546	36-16
Electro-coagulation	ND	ND	4851	53
UASB reactors	ND	ND	5001	71
CAC reactors	721-1421	71-75	10257-26212	33-65
Fungal Laccase	3700	65	43000	5.3
Pleurotus	3400	96-76	140000	ND
MBR	5410	>92	1500-5300	81-37

In municipal wastewater treatment plants, phenolic compounds can prevent or destroy all bacterial growth due to their high toxicity. Christina and colleagues (2020) [(81)] provide an example of how MBR can effectively treat wastewater with high phenol content. Biodegradation and membrane performance of the bioreactor membrane process were evaluated. In just a few hours, the phenol degradation experiment reached a steady state, demonstrating the effectiveness of the activated sludge conditioning step. The filtrate does not contain phenol and a large amount (50 g-day-1) of phenol is decomposed. The high removal of phenol, the absence of solid waste and the good performance of MBR in removing organic matter indicate its good potential. Chapter

Chu BT, et al. (2018) [(82)] investigated other ways to improve wastewater treatment plants for MBR technology. Due to the high water quality, wastewater can be reused in food and paper production. This study demonstrates the advantages of MBR over simple water filtration (Table 2). Experiments carried out in MBR with activated sludge concentrations up to 48 g/1 showed good biodegradation of both surfactant and oily wastewater. The metals industry has developed technologies to enhance the quality and durability of degreasing solvents for surface treatment processes based on membrane bioreactors (MBRs) equipped with submerged multi-channel flat ceramic membranes. Higher biomass concentration results in a fivefold increase in volumetric biodegradation compared to conventional (“open”) bio regeneration. An experimental study lasting several months was conducted by Correia and colleagues. (2015) [(83)] documenting the process and creating knowledge.

Table (2): Comparison of operating parameters for the industrial-scale application of ultrafiltration system for purification of oily wastewater with mechanical processing and membrane bioreactor system

	Membrane bioreactor	Membrane application
COD (mg·l−1)	129-131	373
Oil (ppm)	0.036-0.35	1
COD removal efficiency (%)	97	85.6
Oil removal efficiency (%)	99.9	99.2

These tests treat wastewater in the automotive industry, gather design data, and assess performance. Experimental studies served as foundation for designing an integrated MBR demonstration system for treating oily wastewater. Researchers investigated the feasibility and effectiveness of treating wastewater containing butadiene, acrylonitrile and styrene (ABS) in aerated submersible membrane bioreactors (ASMBR) (84, 85). De La Luz-Pedro A et al., 2019 (86) studied the efficacy of two wastewater laboratories that treated hospital wastewater simultaneously. In general, the CAS method reduces the disease population by approximately 1 log, while the MBR method reduces the disease by approximately 3 hours (87, 88).

In an industrial area in Shanghai, its wastewater treatment industry uses the coagulation sedimentation process – MBR, and knowledge of the quality and volume of wastewater produced, where labile, high-chromium particles are removed along with refractory materials (88). Since December 2006, water production is 120 m3·D-1 and COD content is 3000 - 6000 mg/L. The results of the continuous production process are wastewater with a COD level of 100 mg/L, a 98% removal rate and all other parameters to meet emission limits. Afterwards, the stabilization period was gradually maintained at 1.76 yuan-m-3 (88, 89).

Munz li others, 2007 found the applications of MBR system in Agricultural wastewater kho mob. (74). Therefore, before the MBR system can be widely used, a better understanding of the microbe population, activation and survival for new bacteria is required. Sphingomonas sp. A laboratory-scale membrane bioreactor (MBR) supported by QYY was used with bromoacid (removal activity of (BAA)) to study microbial population change in (1) and (2); It is most commonly used to produce anthraquinone dyes. However, as the concentration of BAA in the active substance increases, clearance decreases. In addition, the structure and dynamic balance of organisms are also affected. However, higher MBR shows a higher clearance rate (50% over and 90% for COD and colour, respectively) (as shown in Figure 5). The stable working capacity of MBR development can enable the imported QYY bacteria to survive and live in harmony with the local population. Çiçek et al., 2003 reported that membrane bioreactors (MBR) biofortified with genetically modified microorganisms (GEM) could effectively and stably remove atrazine after the initial phase. These products can be easily transferred from the BN210 variety to conventional types of MBR biomass. Additionally, bacteria that degrade native 3CBA may take advantage of certain conditions in the MBR. Researchers analyzed the chemical composition of acid in middle-aged landfills using mixed cultures in a bioreactor process called a yeast membrane bioreactor (YMBR) (81 , 85). The effectiveness of YMBR may be due to large yeast cell size and low levels of soluble extracellular polymers (EPS), which are an important component of membrane biofouling. Article

Submerged membrane bioreactor was developed by Bienati et al. (2008) (56) Treatment of wastewater containing dyes. The microbial population is heterogeneous and dominated by Kosella, a fungus that causes white rot. During long-term evaluation, the reactor was able to remove approximately 97% of total organic carbon (TOC) and 99% of dyes from applied 4.5 ± HRT waste products. Soaked at 0.2 modified pH for 15 hours and processed at 29°C ± 1°C. Adsorbents can be added to biological treatment to reduce the problem of many organic compounds from bacteria and remove them from wastewater or non-biodegradable ones. (56). Poorly or slowly biodegradable species are adsorbed in the reactor for a long time, allowing the necessary biodegradation time [71, 76].

Daim duab 6, Chanthapon et al., 2017 [78] demonstrates the hybrid PAC-membrane-biodegradation concept.

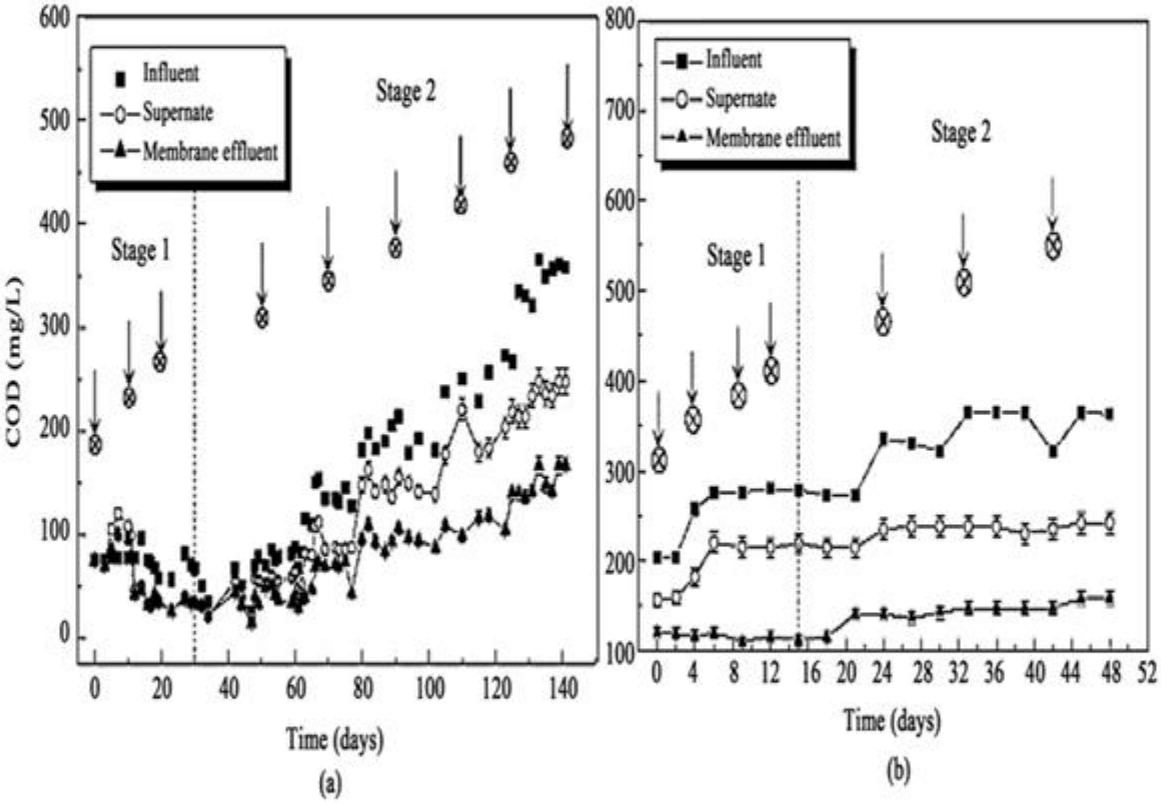

Figure (5): Removal of COD from wastewater containing the refractory compound bromoamic acid (BAA) in non- augmented (a) and bio - augmented (b) MBR systems.

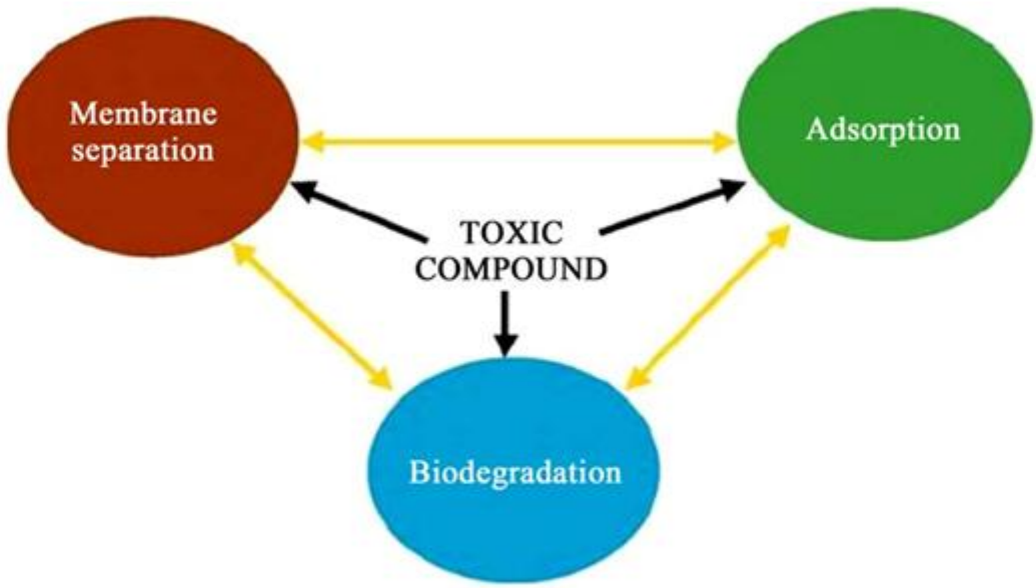

Figure (6): Diagram illustrating the integrated process combining adsorption, membrane separation, and biodegradation for the degradation of toxic compounds.

A 2017 study by Chanthapon et al. [78] investigated the use of membrane-bound fungal reactors with PAC addition in wastewater treatment. Synchronized PAC adsorption with fungal MBR has many advantages, including improvement of dye degradation through enzyme leaching and inhibition of dye adsorption. To study the water filtration process and water quality improvement, Chanthapon et al. 2017 [78] (1) and (2) A pilot-scale membrane bioreactor (MBR) was operated with the incorporation of powdered activated carbon (PAC). The following parameters were used to evaluate the observed process: scaling rate, sludge filterability and scaling reversibility. The use of membrane bioreactors (MBRs) to eliminate chemical issues has been compared to hybrid membrane bioreactors (HMBRs), which include membrane separation, bioactivity, and adsorption of powdered activated carbon (PAC). Unlike HMBR, the biological activity of MBR is inhibited by bioinjection, while the biological activity of HMBR is maintained by biodegradation of the negative material during the cooling season. The mechanism of phenolic compounds was studied by Chanthapon et al. 2017 [77] Two membrane bioreactor systems were utilized: one combining activated sludge with MBR (AS-MBR) and the other integrating biogranular activated carbon with MBR (BAC-MBR). When EPS composition and sludge properties were evaluated, the results showed that precipitation was related to the protein/carbohydrate ratio rather than EPS. Adding iron hydroxide or salt to the sludge mixture of the same activated sludge process (metal process) aeration tank will increase the physical capacity and filterability of the sludge. Considering this, Chanthapon et al., 2017 [78] added $Fe(OH)_3$ to the submerged membrane bioreactor (SMBR) to increase the removal rate and reduce membrane fouling.

Theta angle is often used to characterize the hydrophilicity/hydrophobicity of the film. The larger the value, the more hydrophobic the membrane surface. This angle is related to the morphology of the membrane and the size of the membrane pores. The hydrophilicity/hydrophobicity of film materials is related to their antifouling properties [65, 66].

Compared with the hydrophobic film, the hydrophilic film is less affected by adsorption, has more film, and has the best antifouling properties. However, some researchers have concluded that more hydrophilic PES membranes are more susceptible to membrane fouling; this may be related to the large pore size of the PES membrane. It is worth noting that the hydrophilicity/hydrophobicity of the membrane usually has a significant impact on the fouling of the membrane only during the first stage of filtration. After the initial fouling, the chemical composition of the scale becomes important and the chemical composition of the membrane changes [17, 23].

As the operation continues, the level of membrane fouling intensifies, resulting in an increase in pressure difference across the membrane and a decrease in flow rate. Additionally, membranes with smaller pore sizes exhibit slower exchange rates and longer cycle times. Conversely, membranes with larger pore sizes experience more fouling and shorter lifespan. However, the membrane possesses certain advantageous characteristics including high porosity, a mesh structure woven with fibers, and the ability to be effectively cleaned. It can also be renewed through repeated use, and it remains permeable to water. Overall, not much has changed [77, 78].

Membrane porosity and roughness also affect fouling behavior. The greater the porosity, the lower the transmembrane pressure (TMP). However, as the porosity of the film changes, surface properties such as roughness also change. This changes the chance of bacteria adsorbing to the membrane. Organic membranes generally have higher porosity than inorganic membranes but the flux is generally lower. Membranes are more susceptible to fouling when their roughness is high [71, 75 Membrane separation systems are built around membrane modules. In the separation membrane of large systems, membrane materials and equipment with compact structure, stable performance and good separation properties should be used [77, 78].

During the evaluation of PVC membrane materials, it was observed that membrane bioreactors employing vertical membranes exhibit favorable flow conditions compared to horizontal ones under identical operating conditions. The shear force, which is influenced by aeration and aeration-induced gas-liquid two-phase flow, is notably stronger in vertical configurations. Furthermore, horizontal equipment typically features a ventilation hole at the bottom, causing the PVC membrane to accumulate thick sludge on the ventilation side, resulting in rapid fouling and shorter startup cycles. [61, 69].

Conclusion:

- This study clearly demonstrates the advantages of MBR systems. Application of MBR requires prolonged retention, retention, and subsequent hydrolysis of biosolids to enable bacterial biodegradation. The physical and chemical properties of foreign objects affect removal, and different objects have different effects. High MLSS and long SRT sometimes further affect biomass adsorption, membrane retention and biodegradation, in addition to promoting the growth of specific microorganisms that ultimately lead to biodegradation. Better removal is required when PAC or bioenrichment is used.
- MBR has an advantage over wastewater due to its ability to adapt to additional parameters. The observed effect of MBR biolevel and high biomass concentration enhances membrane quality by eliminating bacteria. This raises the actual concentration of pollutants in the bioreactor, and while biodegradation lowers the concentration of pollutants in the filter feed stream, bioavailability boosts biodegradation efficiency. The primary advantage of membrane bioreactors is that the majority of bacteria are mineralized there. Further advances in this field are expected to result in more effective treatment methods for complex wastewater.
- It is clear that industrial wastewater is an environmental pollutant because it contains heavy metals, organic compounds, dyes and other substances that cannot be disposed of properly. When wastewater is not disposed of properly, ecosystems are destroyed and water becomes unfit for human consumption. It is thought that wastewater from various industries such as textile, paper, pulp and petroleum, brewing, food and beverage will provide a better understanding of wastewater and its problems.
- In this study, the problems in the treatment process and their purification as well as the water treatment process suitable for recycling and reuse are discussed. While many conventional treatments and technologies have emerged for the treatment of wastewater, the export of recycled water promotes the use of wastewater; the waste is recycled, thus ensuring sufficient work to provide clean water.

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