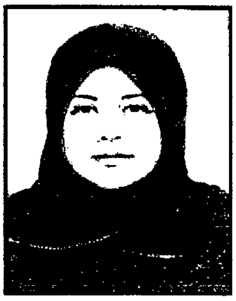
MEMBR GE TREATMENT



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ABSTRACT

Sewage is the highest contributor to the world's water pollution which contributes 60% of the pollution which is kindly straightly comes from the municipal and domestic/residential. Sewage water treatment is a must, when environmental issues are an increasing concern. Submerged membrane bioreactor (MBR) is a technology which is able to fulfill those specific purposes. The Membrane Bioreactor (MBR) process is an emerging advanced wastewater treatment technology that has been successfully applied. The combination of membrane separation with a suspended growth bioreactor is now widely used for waste treatment. The raw sample has shown that it fulfilled the characteristic of sewage where the value of Chemical Oxygen Demand, Suspended Solids and Biochemical Oxygen Demand are higher than what have being comply in Environmental Quality Act 1979 Maximum Effluent Parameter Limits Standard A and B. Pink and blue colours developed since nitrate and phosphorus are present in the sewage. In this project, Chemical Oxygen Demand and Suspended Solids have been chose to be the monitor parameter where HRT and microfiltration affects the performance of the sewage quality. Even the result do not comply the standard, somehow the sewage quality improved all along the experimental run. At 4 hours HRT, COD resulted 135mg/l at 1 bar while SS resulted 10mg/l at also 1 bar pressure. It shows that at lowest HRT and pressure, the treatment is getting better. The treatment is through microfiltration which is typically required low pressures (0.2 to 0.5 bar) to obtain the selective separation and HRT for MBR's are typically 4 to 20 hours since on most domestic wastes, this is enough time to allow for the oxidation of organic material which explain why HRT 24 hours resulted COD and SS values at 279mg/l and 31mg/l at 3 bar pressures. This shows that membrane bioreactor process is capable in treating sewage wastewater at low HRT and pressure.

ABSTRAK

Air kumbahan merupakan penyumbang tertinggi kepada pencemaran air di dunia yang menyumbang 60% pencemaran yang mana datang dari kawasan perbandaran dan kediaman. Rawatan air kumbahan adalah perlu memandangkan isu-isu alam sekitar menjadi kebimbangan yang semakin meningkat. Bioreaktor membran (MBR) adalah teknologi yang mampu memenuhi tujuan tersebut. MBR merupakan proses rawatan air baru yang berteknologi maju yang telah berjaya digunakan. Kombinasi antara pengasingan membran dengan bioreaktor terampai membiak kini digunakan dengan meluas dalam rawatan sisa kumbahan. Sampel mentah menunjukkan bahawa ia memenuhi cirri-ciri air kumbahan di mana nilai COD, SS dan BOD adalah melebihi daripada apa yang mematuhi Akta Kualiti Alam Sekitar 1979 Had Maksimum Parameter Efluen Standard A dan B. Warna merah jambu dan biru terbentuk menunjukkan bahawa nitrat dan fosforus ada di dalam air kumbahan. Dalam projek ini, COD dan SS telah dipilih untuk dijadikan parameter kawalan di mana HRT dan penapisan mikro memberi kesan kepada kualiti air kumbahan. Walaupun keputusan tidak memenuhi standard, namun begitu kualiti air kumbahan bertambah baik sepanjang eksperimen berlangsung. Pada 4 jam HRT, keputusan COD adalah 135mg/l pada tekanan 1 bar. Manakala keputusan SS adalah 10mg/l juga pada tekanan 1 bar. Ini menunjukkan bahawa pada HRT dan tekanan yang paling rendah, rawatan ini bertambah baik. Rawatan menggunakan penapisan mikro ini biasanya memerlukan tekanan yang rendah (0.2 sehingga 0.5 bar) untuk mendapatkan pengasingan terpilih dan HRT untuk MBR biasanya 4 hingga 20 jam memandangkan ia merupakan masa yang mencukupi untuk membenarkan pengoksidaan kepada bahan organic pada kebanyakan sisa domestik yang membuktikan kenapa 24jam HRT menunjukkan keputusan COD dan SS adalah279mg/l dan 31mg/l pada tekanan 3 bar. Ini menunjukkan bahawa proses bioreaktor membran berkemampuan dalam merawat air sisa kumbahan pada HRT dan tekanan yang rendah.

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CHAPTER 1

INTRODUCTION

1.1 Background of study

Malaysia surprisingly had been reported producing about 5 million m^3 of sewage sludge per year. This is one of the best reason other than being exposed to the syllabus in module of Waste Management and Environmental Management for individually take some part in contributing some useful and benefits to our human being and our nature by spreading out the simplest initiative of how important it is to keep our world's clean for the next generation.

Nowadays, increasingly stringent environmental legislation relating to freshwater conservation and pollution abatement requires the application and development of reliable technologies for wastewater treatment. Submerged membrane bioreactor (MBR) is a technology which is able to fulfill those specific purposes. The use of membrane bioreactors for both domestic and industrial wastewater treatment has expanded significantly in the last few years.

Urban wastewater is usually treated by conventional activated sludge processes (CASP's), which involve the natural biodegradation of pollutants by heterotrophic bacteria (i.e. activated sludge) in aerated bioreactors. Activated sludge could be separated by gravitational setting. The treatment efficiency is usually limited by the difficulties in separating suspended solids (SS's). The optimal sludge concentration is generally up to 5 g.l−1, which imposes large size of aerated bioreactor.

Membrane bioreactor (MBR) is an improvement of the 100-year old CASP, where the traditional secondary clarifier is replaced by a membrane unit for the separation of treated water from the mixed solution in the bioreactor. Originated from the use of membrane separation, MBR technology has various advantages.

The absolute retention of all micro-organisms insures an increase in sludge concentration and complete disinfection of treated water. It allows a complete separation of the hydraulic retention time (HRT) and sludge retention time (SRT). As a result, a high sludge concentration can be maintained in the bioreactor and high-strength wastewater can be treated effectively.

Due to the absence of secondary clarifier and the presence of a high sludge concentration, the overall size of the treatment plant can be reduced significantly. Furthermore, the contact time between activated sludge and organic pollutants can be enhanced, which facilitates an effective removal of low biodegradable pollutants.

Highly treated water (by the MBR) is free from bacteria and has a potential in municipal and industrial reuse. About 200 MBR's are currently in operation for various wastewaters, and 90% of them are employed in municipal treatment. In the application of MBR that is based on polymeric materials, most MBR systems are used for water recycling in buildings. As these organic membranes are normally sensitive to caustic cleaning reagents, the difficulty met with in cleaning is often encountered especially when the membrane module is seriously fouled during industrial operation.

In order to overcome this difficulty, an MBR system equipped with ceramic membranes was first developed in France. It makes the cleaning of membrane easy and convenient in situ because these inorganic membranes possess a high degree of resistance to chemical abrasion and biological degradation. The membrane has a great chemical stability in a wide range of pH and temperature.

The Membrane Bioreactor (MBR) process is an emerging advanced wastewater treatment technology that has been successfully applied at an ever increasing number of locations around the world. In addition to their steady increase in number, MBR installations are also increasing in terms of scale.

Recent technical innovation and significant membrane cost reduction have pushed membrane bioreactors (MBRs) to become an established process option to treat wastewaters. The combination of membrane separation with a suspended growth bioreactor is now widely used for municipal and industrial waste treatment (Judd, 2006). When used with domestic wastewater, MBR processes could produce effluent of high quality enough to be discharged to coastal, surface or brackish waterways or to be reclaimed for urban irrigation.

Whilst sewage water pollution is one of the major problems in cities. The sewage water is drained off into rivers without treatment. The careless disposal of sewage water leads to a chain of problems, such as spreading of diseases, eutrophication, increase in Biological Oxygen Demand (BOD). The waste water that flows after being used for domestic, industrial and other purposes is termed as sewage water. In ideal situations, the sewage water is channeled or piped out of cities for treatment. Bulk of the sewage contains water as the main component, while other constituents include organic wastes and chemicals.

Improper handling of waste water is the main reason behind the pollution of water. The sewage is drained off in large quantities into rivers. It slows down the process of dilution of the constituents present in the water; which in turn, stagnates the river. Draining off the water without treatment is also a reason behind sewage water pollution. These effluents contain innumerable pathogens and harmful chemicals. The detergents that release phosphates in water help the growth of algae and water hyacinths.

The pathogens contained in the sewage water spread many diseases. Stagnant water fosters the growth of mosquitoes, which cause malaria. Another disease that spreads through contaminated water is typhoid. Excessive deposition of chemical nutrients in water bodies is called eutrophication. It is one of the numerous problems created by sewage water pollution.

If the sewage water is treated before being released into rivers, most of the problems pertaining to pollution would be solved. Removing contaminants is the main objective behind treating sewage water. Before the actual treatment, the effluent is pretreated. Pretreatment helps in separating materials like oils, greases, gravel and sand from the polluted water. It can be done, by filtering the sewage water.

The biological wastes dissolved in the water are treated with microbes. This helps in converting them into a solid mass, which can be separated easily thereafter. After the biological treatment, the partially pure effluent is treated with chemical disinfectants. The water treated in the treatment plants can be used in golf courses for watering the lawns and in agriculture for irrigation. Some sewage treatment plants are very efficient and produce clear and clean water at the end of the process.

Sewage water treatment is a must, when environmental issues are an increasing concern. Efforts need to be taken to purify the effluents. It will not only benefit human beings but also the varied flora and fauna on our planet. Let's pledge to keep our environment beautiful and free from any kind of pollution.

1.2 Problems Statement

- The usage of membrane bioreactor contributes tremendously benefits in the research which are economical and easy to be controlled individually at lab/home (minimal operating labour required).
- As sewage contributes 60% of the pollution which is kindly not from the industrial wastes, but the sewage which straightly come from the municipal and domestic/residential.

1.3 Objectives

- To categorize the sewage properties.
- To determine the effects of HRT to the sewage quality.
- To determine the effects of microfiltration to the sewage quality.

1.4 Scope of Study

- Indah Water Konsortium's sewage.
- Membrane bioreactor's pressure less than and equal to 3 bar.
- HRT (4 hours, 20 hours and 24 hours).

1.5 Expected Outcomes

- Each of sewage properties are able to be categorized.
- The differences of HRT are able to give differs effects to the sewage quality.
- Microfiltration affects the quality of the sewage.

1.6 Significant of Study

The significant of this study is that to ensure that the world manages to provide good and clean water's resource by going through any kind of treatment so that pollution can be reduced and at the same time, the human being and the nature itself can be live in a good matter of constituent.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The membrane bioreactor technology has great potential in wide ranging applications including municipal and industrial wastewater treatment, groundwater and drinking water abatement, solid waste digestion, and odor control. The technical feasibility of this process has been demonstrated through a number of pilot and bench scale research studies. Full scale systems are operational in various parts of the world and substantial growth in the number and size of installations is anticipated for the near future.

The MBR process is already considered as a viable alternative for many waste treatment challenges and with water quality issues firmly placed into the forefront of public debate, ever tightening discharge standards and increasing water shortages will further accelerate the development of this technology.

Sewage or sewage waste is just dirty water. It is the water which leaves our home, factories, shops or farms and runs down the plug hole or toilet or bath or shower and into underground pipes called sewers. It is mostly 99.5% water with only 0.05% of the wastewater dissolved into suspended solid material. Sewage treatment is a multi-stage process to renovate wastewater before it re-enters a body of water, is applied to the land or is reused.

The sewage treatment plant is a huge biological factory using enhanced natural processes to break down and remove substances that might harm the natural environment. The majority of substances in dirty water are biodegradable (that is they can break down). This means that the sewage can be broken down into environmentally safe components such as fertilizer. Pathogens or disease-causing organisms are present in sewage. These need to be got rid of before the sewage can be released back into the environment. The goal is to reduce or remove organic matter, solids, nutrients, disease-causing organisms and other pollutants from the wastewater.

2.2 Paper Review

2.2.1 Membrane Bioreactor

Membrane bioreactor is the combination of a membrane process like microfiltration or ultra filtration with a suspended growth bioreactor, and is now widely used for municipal and industrial wastewater treatment with plant sizes up to 80,000 population equivalent. It has being used on wastes ranging from domestic effluent with Biological Oxygen Demand (BOD) ranges of 200-600 mg/l to industrial waste with influent BODs of 18,000 mg/l. Hydraulic retention times (HRT) for MBRs are typically 4-20 hours. On most domestic wastes this is enough time to allow for the oxidation of organic material and ammonia (nitrification).

The MBR process was introduced by the late 1960s, as soon as commercial scale ultrafiltration (UF) and microfiltration (MF) membranes were available. The original process was introduced by Dorr-Olivier Inc. and combined the use of an activated sludge bioreactor with a crossflow membrane filtration loop. The flat sheet membranes used in this process were polymeric and featured pore sizes ranging from 0.003 to 0.01 μm

Although the idea of replacing the settling tank of the conventional activated sludge process was attractive, it was difficult to justify the use of such a process because of the high cost of membranes, low economic value of the product (tertiary effluent) and the potential rapid loss of performance due to membrane fouling. The breakthrough for the MBR came in 1989 with the idea of Yamamoto and co-workers to submerge the membranes in the bioreactor.

Until then, MBRs were designed with the separation device located external to the reactor (side stream MBR) and relied on high transmembrane pressure (TMP) to maintain filtration. With the membrane directly immersed into the bioreactor, submerged MBR systems are usually preferred to side stream configuration, especially for domestic wastewater treatment.

The submerged configuration relies on coarse bubble aeration to produce mixing and limit fouling. The energy demand of the submerged system can be up to

2 orders of magnitude lower than that of the side stream systems and submerged systems operate at a lower flux, demanding more membrane area. In submerged configurations, aeration is considered as one of the major parameter on process performances both hydraulic and biological. Aeration maintains solids in suspension, scours the membrane surface and provides oxygen to the biomass, leading to a better biodegradability and cell synthesis.

Recent technical innovation and significant membrane cost reduction have pushed membrane bioreactors (MBRs) to become an established process option to treat wastewaters. The combination of membrane separation with a suspended growth bioreactor is now widely used for municipal and industrial waste treatment (Judd, 2006). When used with domestic wastewater, MBR processes could produce effluent of high quality enough to be discharged to coastal, surface or brackish waterways or to be reclaimed for urban irrigation. Other advantages of MBRs over conventional processes include small footprint, easy retrofit and upgrade of old wastewater treatment plants into MBRs.

The membrane bioreactor (MBR) is a system which combines traditional activated sludge treatment process with microfiltration (MF) or ultrafiltration (UF) membrane for solid- liquor separation. Two basic MBR configurations exist: the external (side stream) and the internal (submerged). However, due to the high cost of pumping of activated sludge from separate unit process back to bioreactor makes side stream configuration unpractical for full-scale municipal wastewater treatment plants (Gander et al. 2000).

In contrast, submerged system, where the membranes are immersed in biological reactor, is a more economic solution and is increasingly becoming an important innovation technology in wastewater treatment since its introduction in 1990's. Ever since unit costs for application of commercially available submerged

MBR systems reduced by up to 30-fold and the further reductions are expected (DiGiano et al, 2004).

Such significant reduction in the costs of both membranes and processes over the past 10–15 year was possible due to improvements in process design, improved operation and maintains schedules and greater membrane life (Kennedy and Churchouse, 2005).

MBR is a highly effective treatment process and especially is recommended for wastewater treatment in areas requiring a high quality effluent (such as discharge to bathing waters or water reuse) or specialization in the microbial community (e.g. high strength liquors, effective nitrification) (Gander et al. 2000). One of the main drawbacks of MBR technology is related to managing membrane fouling (Le-Clech, et al. 2006).

2.2.2 Membrane Bioreactor Technology

The membrane bioreactor technology has great potential in wide ranging applications including municipal and industrial wastewater treatment, groundwater and drinking water abatement, solid waste digestion, and odor control. The technical feasibility of this process has been demonstrated through a number of pilot and bench scale research studies. Full scale systems are operational in various parts of the world and substantial growth in the number and size of installations is anticipated for the near future.

The MBR process is already considered as a viable alternative for many waste treatment challenges and with water quality issues firmly placed into the forefront of public debate, ever tightening discharge standards and increasing water shortages will further accelerate the development of this technology (Cicek, N. 2003).

Membrane bioreactor technology provides a good alternative to the conventional treatment of municipal wastewater (Huber Technology, 2004). Most of the current regulatory requirements will be met by the membrane separation step. Membrane bioreactor technology is a space saving technique. Its module based design allows the capacity to be easily increased when needed.

Membranes will continue to decrease in price in the coming years. With improved effluent quality, re-use of the formerly wasted effluent is possible, which makes it a sustainable technology. It also combines the biological treatment with a membrane separation step.

Membrane bioreactor technology combines the use of biological processes and membrane technology to treat wastewater and provide organic and suspended solids removal. A high standard of wastewater treatment can be achieved, without the conventional arrangement of aeration tank, settling tank and filtration to produce a tertiary standard effluent of 5: 5: 5 BOD: Suspended Solids: Ammonia.

Flow passes through the membranes, while solids remain in the biological treatment system. The membrane bioreactor system combines the benefits of a suspended growth reactor with the solids separation capability of an ultrafilter or microfilter membrane unit. The membrane provides a long solids retention time, usually 30 - 60 days, which can greatly enhance the biological degradation of influent organics (Choppen. J, 2004)

A membrane bioreactor system can be operated in either an aerobic or anaerobic mode, increasing the spectrum of chemicals suitable for biological treatment. MBR applications have included batch chemical plant effluents, groundwater filtration, landfill leachate, chlorinated solvents in manufacturing plant wastewaters, oily wastes, phosphorous control, and pharmaceutical intermediates.

Membrane bioreactors offer an excellent solution for in-process, at-source treatment applications, and full-scale suspended growth membrane bioreactors have been operating in wastewater treatment systems for more than 20 years (USFilter, 2002).

Biological treatment technologies have been utilized in wastewater reclamation for over a century. Out of the many different processes employed, the activated sludge system has proven to be the most popular (Tchobanoglous et al. 2003).

The implementation of membranes within the treatment sequence of a water pollution control facility was initially limited to tertiary treatment and polishing. Ultrafiltration, micro-filtration, or reverse osmosis units were utilized in areas where discharge requirement were very stringent or direct reuse of the effluent was desired (Tchobanoglous et al. 2003).

High capital and operational costs as well as inadequate knowledge on membrane application in waste treatment were predominant factors in limiting the domain of this technology. However, with the emergence of less expensive and more effective membrane modules and the implementation of ever-tightening water discharge standards, membrane systems regained interest.

2.2.3 Membrane Uses

Membranes and membrane separation techniques have grown from a simple laboratory tool to an industrial process with considerable technical and commercial impact. Membranes are used on a large scale to:

* Produce potable water from the sea by reverse osmosis.
* Clean industrial effluents.
* Recover valuable constituents by electro dialysis.
* Fractionate macromolecular solutions in the food and drug industries by ultrafiltration.
* Remove urea and other toxins from the bloodstream by dialysis in an artificial kidney.
* Release drugs such as scopolamine and nitroglycerin, at a predetermined rate in medical treatment.

Although membrane processes may be very different in their mode of operation, in the structures used as separating barriers, and in the driving forces used for the transport of the different chemical components, they have several features in common, which make them attractive as a separation tool. In many cases membrane processes are faster, more efficient, and more economical than conventional separation techniques.

With membranes, the separation is usually performed at ambient temperatures, thus allowing temperature sensitive solvents to be treated without the constituents being damaged or chemically altered. Membranes can also be tailor made so that their properties can be adjusted to a specific separation task (Porter, 1990).

2.2.4 Membrane Technologies

These processes differ depending on the type of substance to be removed; there is still plenty of scope for technological improvement, and increasing the field of application. The membrane processes, which Caetano (1995) cites as being of practical interest for water purification, are micro filtering, ultra filtering, reverse osmosis and electro dialysis. Membrane types can be broadly placed into four categories, with classification being dependent on the pore size of the membrane. These categories, from largest to smallest pore size, are listed below. Nanofiltration has been included to demonstrate the relativity of the categories.

2.2.4.1 Microfiltration

This is a dynamic mechanical filtering process performed by means of membranes, which allow selective separation, purification and concentration of organic substances of high molecular weight. Small particles (of the order of a micron), such as those produced by metal surface working, can therefore be separated. The advantages are the low pressures required to obtain the selective separation (0.2 - 0.5 bar) and therefore the low quantities of energy needed for the process.

2.2.5 Separation Principles

The basic principle of any separation process is that the minimum amount of energy is required to accomplish the separation. Two substances will mix spontaneously when the free enthalpy of the mixture is smaller than the sum of the free enthalpies of the individual substances.

The minimum amount of energy necessary to complete separation is at least equal to or larger than the free enthalpy of mixing. In practice the energy requirement for separation will be many times greater than the minimum value. Many different types of separation processes exist and each requires a different amount of energy.

2.2.6 Membrane Materials and Properties

Membranes can be made from a large number of different materials. A first classification can be made into two groups, biological and synthetic membranes. Synthetic membranes can be divided into organic and inorganic membranes. The organic membrane materials (polymers or macromolecules) are the most important. The choice of a given polymer as a membrane material is based on very specific properties, originating from structural factors. Basically all polymers can be used as a barrier or membrane material but the chemical and physical properties differ so much that only a limited number are used in practice.

A further classification can be made between the open, porous membranes, which are used in microfiltration and ultrafiltration, and the dense nonporous membranes, used in gas separation and pervaporation. For porous membranes, it is not the choice of material that determines the separation characteristics, but the pore size and the pore size distribution relative to particle or molecular size. The material is considered for its adsorbtion, cleansing abilities and chemical stability under the actual application conditions.

The main problem in microfiltration and ultrafiltration is flux decline because of concentration polarisation and fouling (Mulder, 1991). Therefore the choice of material is primarily concerned with the prevention of fouling and cleaning the