TREATMENT OF TRACES OF OIL FROM ELECTROPLATING INDUSTRY WASTEWATER BY USING MEMBRANE BIOREACTOR

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Specially dedicated to
my beloved father, Khalifa Ghenghesh , my beloved mother, Pauline Ghenghesh
and
those who have guided and inspired me throughout my journey of education

Thanks for your love

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ABSTRACT

Membrane bioreactor (MBR) is a modification of an activated sludge process and is considered as a novel technology for treating wastewater. MBR process combines the activated sludge process with membrane filtration, which allows for a high effluent quality in terms of removal efficiency of oil and grease (O&G) and chemical oxygen demand (COD). In this study, performance of a laboratory-scale submerged hollow fibre membrane to treat oily wastewater from an electroplating plant in Johor was investigated. The degradation of raw oily wastewater at a hydraulic retention time (HRT) of 12.7 hours was studied. The experimental work was divided into three runs; the sludge retention time was one week prior to each run. Results of the three runs showed that O&G was biodegraded in the MBR treatment system with high extent, with removal efficiency between 91.1 to 98.7%. Results also showed a high removal efficiency of COD and BOD. The removal efficiency was 97.8% to 99.1% for COD and 77.8% to 86.1% for BOD. During the three runs membrane separation played an important role in providing a stable and excellent final effluent quality. The higher mixed liquor suspended solids (MLSS) concentration in Run 3 lead to higher biodegradability of O&G and COD in the biological tank, as a result the removal efficiency for this run was higher then for Runs 1 and 2, with a removal efficiency of 98.7% and 99.1% for O&G and COD respectively.

ABSTRAK

Bioreaktor membran (MBR) adalah modifikasi proses lumpur teraktif yang dipertimbangkan sebagai teknologi unggul untuk merawat sisa air buangan. Proses MBR menggabungkan proses lumpur teraktif dengan penurasan bermembran, menjamin sisa air buangan yang berkualiti tinggi selepas rawatan, dari segi kecekapan pengurangan minyak dan gris dan juga pengurangan kepade keperluan oksigan terkimia (COD). Dalam kajian ini, kecekapan membran jenis fiber berongga dalam yang ditenggelamkan dengan skala makmal, telah digunakan untuk merawat air buangan daripada industri pengelektrosaduran di Johor telah dikaji. Pengurangan minyak dalam air buangan pada masa penahanan hidraulik 12.7 jam telah dikaji. Eksperimen ini telah dibahagikan kepada 3 tahap ujikaji; dan masa penahanan lumpur adalah seminggu sebelum setiap ujikaji. Keputusan daripada 3 ujikaji menunjukkan pengurangan kepekatan minyak dan gris dalam rawatan system MBR dengan sempurna, dengan kecekapan perpindahan dari 91.1 kepada 98.7%. Keputusan juga menunjukkan kecekapan yang tinggi dalam pengurangan COD dan BOD. Kecekapan perpindahan adalah dari 97.8% kepada 99.1% untuk COD dan, dari 77.8% kepada 86.1% untuk BOD. Pemisahan membran pada ketiga-tiga ujikaji memainkan peranan yang penting dalam pemberian kualiti air buangan yang stabil dan berkualiti tinggi. Kekotoran membran telah didapati tidak ketara dalam eksperimen MBR. Kepekatan MLSS yang tinggi dalam ujikaji ketiga memberi tahap biodegradasi minyak dan gris dan juga COD yang lebih tinggi dalam tangki biologi, disebabkan kecekapan perpindahan yang lebih tinggi bagi ujikaji ketiga berbanding dengan ujikaji pertama dan kedua, kecekapan pengurangan bagi ujikaji ketiga adalah 98.7% untuk minyak dan gris, dan 99.1% untuk COD.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLE

LIST OF ABBERVIATION

AC	-	Activated Carbon
API	-	American Petroleum Institute
AS	-	Activated Sludge
ASP	-	Activated Sludge Process
BOD	-	Biochemical Oxygen Demand (mg/L)
COD	-	Chemical Oxygen Demand (mg/L)
DAF	-	Dissolved Air Floatation
DO	-	Dissolved Oxygen
DOC	-	Dissolved Organic Carbon
EPS	-	Extracellular Polymeric Substance
FMNS	-	Free Metals Non Solids
FS	-	Flat Sheet
HF	-	Hollow Fibre
HRT	-	Hydraulic Retention Time (hr)
J	-	Permeate Flux
MBR	-	Membrane Bioreactor
MF	-	Microfiltration
MLSS	-	Mixed Liquor Suspended Solids (mg/L)
MT	-	Multi Tube
NF	-	Nano-filtration
O&G	-	Oil and Grease concentration (mg/L)
ONS	-	Organics Non Solids

PAC	-	Powdered Activated Carbon
PES	-	Polyethersulfone
RO	-	Reverse Osmosis
SRT	-	Solid Retention Time (day)
T	-	Temperature (^{o}C)
TDS	-	Total Dissolved Solids
TMP	-	Transmembrane Pressure (kpa)
TN	-	Total Nitrogen
TOC	-	Total Organic Carbon
UF	-	Ultra-filtration

CHAPTER 1

INTRODUCTION

1.1 Research Background

Oily wastewater is known as one of the highly concerned pollution sources. Oil and grease (O&G) are common pollutants in many industries such as steel, aluminum, food processing, textile, leather, petrochemical and electroplating. These industries report a high level of oil and grease in their effluent wastewater (Cheryana and Rajagopalanb, 1998). There are several forms of oil and grease present in oily wastewater: free, dispersed or emulsified (Rhee *et al*., 1987), in an oil-water mixture, oil is classified based on its droplet size, free oil is characterized with droplets sizes > 150 µm. While dispersed oil has a droplet size between 20-150 µm and emulsified oil has a droplet size < 20 µm. Oily wastewater is considered as a hazardous wastewater, due to containing toxic substances, which include: petroleum hydrocarbons, polyaromatic hydrocarbons and phenols.

Electroplating process involves the deposition of a thin layer onto a surface of metal, by using electrochemical processes. Electroplating involves several steps such as:

pretreatment, plating, rinsing, and drying. The overall wastewater stream generated from electroplating process is extremely variable (1-500 liters per square meter) of surface plated (World Bank Document, 1996). This produced wastewater is usually high in heavy metals, oil and grease contents, these substances can be found in wastewater via rinsing the finished parts or due to spillage and dumping of the process bath.

Conventional processes of treating oily wastewater include gravity separation, skimming process, dissolved air floatation, coagulation and flocculation (Beisinger *et al*., 1974). The physical treatment of oily wastewater such as gravity separator and dissolved air flotation does not remove the pollutants completely but just transfers them to a more concentrated waste (Scholz & Fuchs., 2000). Gravity separation is considered the most common primary treatment of oily wastewater. This treatment is primarily used to separate floatable oils from water. If the permeate from this process does not meet the target limits, secondary treatment steps are required to reduce the levels of dissolved emulsified and dispersed breaking of emulsions with chemicals followed by sedimentation to reduce additional oil and grease. Some of the shortcomings of conventional approaches are:

(i) The system is highly susceptible to changes in influent quality.
(ii) Skilled operators are required to achieve normal operation.
(iii) The equipment has a large footprint.
(iv) It produces a large volume of sludge.
(v) Mechanical problems due to clogging of chemical feeding line.

Therefore, there is a need to develop a more efficient treatment process based on biological treatment to treat the oily wastewater.

Membrane bioreactor (MBR) treatment system is one of the novel processes for wastewater treatment in recent years. The first MBR system was commercially developed in 1969 (Smith, 1969), for wastewater treatment and since then, the MBR technology has evolved, and research on MBR system has increased, especially in the past 5 years (Aileen *et al*., 2006). MBR treatment system combines both the activated sludge process with a membrane filtration process. The bioreactor is operated similarly to the conventional activated sludge system without the need for secondary clarification steps like sand filtration.

Low pressure membrane filtration, either microfiltration (MF) or ultra-filtration is used to separate effluent from activated sludge. The two MBR process configurations are: submerged membrane (internal) and external circulation (side stream configuration). The submerged MBR configuration is more widely used for wastewater treatment.

MBR treatment systems have many advantages over conventional processes with their highly improved effluent quality which allows for water reuse. MBR process can typically operate at higher mixed liquor suspended solid concentration (MLSS), which results in less sludge production and stability against shock loading. Another advantage for MBR system is that it eliminates the requirement for clarifying basins to settle the biomass, allowing the system to be more compact.

Membrane fouling remains the most serious problem affecting the MBR system performance. Fouling leads to a decline in effluent flux and higher energy consumption, requiring more frequent membrane cleaning. A number of studies have been conducted to find out the causes of membrane fouling phenomenon. Recent efforts have been done to modify the MBR treatment system to make it more efficient in wastewater treatments. Various techniques have been developed to minimize membrane fouling, such as periodic back washing and membrane aeration. Ueda *et al*., 1997, studied the effect of aeration on membrane fouling. It was concluded that air bubbles prevent the deposition on the membrane surface, therefore reducing fouling and providing better filterability (Ueda *et al*., 1997).

1.2 Problem Statement

Basically there are 14 wastewater streams generated by the electroplating plant in Skudai, Johor. The method of treatment depends on the type of wastewater generated. The electroplating plant has reported a higher level of oil and grease in the effluent wastewater of the FMNS (Free Metal Non Solids) and ONS (Organics Non Solids) streams.

One of the latest worldwide interests for treating water and wastewater is by membrane technology (MBR), MBR is a good option to treat industrial wastewater because of the high effluent quality. This study will cover the removal of oil traces from the FMNS and ONS wastewater streams in the electroplating plant using an MBR treatment system, in order to meet the Malaysian standards for effluent wastewater (Standard A, Environmental Quality Act, 1974).

1.3 Objectives of the Study

This study aims to develop an MBR treatment system to treat the oily wastewater from the FMNS and ONS streams in the operation of an electroplating plant in Skudai, Johor, effectively to meet the effluent standards for electroplating industry in Malaysia. Aerobic submerged membrane bioreactor (MBR) will be used for this study. This will significantly increase the final water discharge quality of wastewater streams.

Specific objectives of this study for achieving the above purpose are:

(i) To determine the critical flux and operation flux for the MBR treatment system to treat the oily wastewater.

(ii) To evaluate the performance of the MBR treatment system to treat the oily wastewater in terms of removal efficiency of O&G, COD and BOD, for both biological tank and final effluent.

(iii) To investigate the effects of MLSS concentration on MBR system performance and fouling phenomena.

1.4 Scopes of the Study

The scopes of this study are as follows:

(i) Determination of the critical flux was performed by using short-term flux-step method. The operation flux was determined by considering the critical flux value.

(ii) The effluent quality and removal efficiency were mainly determined in terms of O&G, COD and BOD concentrations.

(iii) MLSS concentration was varied to investigate its effect on MBR system performance to treat oily wastewater from ONS stream.