EFFECT OF TEMPERATURE ON SUBMERGED MEMBRANE ACTIVATED SLUDGE REACTOR

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"TO MY LOVES FAMILY….."

AYAH, MAMA, SHAHRIL, SYAFIQ, SAIFUDIN AIMAN

THANKS FOR YOUR SUPPORT,

TO MY LOVES ONE, THANKS FOR YOUR LOVE, CARE AND ENCOURAGEMENT….

ALL FRIENDS…..

THANK YOU FOR EVERYTHING…..

OUR LOVES NEVER ENDS

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ABSTRACT

This study investigates the performance of Submerged Membrane Activated Sludge Reactor on treating synthetic wastewater and also the effects of varying temperature of a laboratory scale Submerged Membrane Activated Sludge reactor. Laboratory bench-scale continuous reactors, fed with synthetic wastewater were used. The operational volume of the reactor was 20 litres and included a membrane. The membrane was made from a polymer material (HDPE) with a thickness of 3.5 mm. The membrane, whose pore size ranged between 0.1 – 1mm, played the role of a secondary clarifier. Effects of temperatures of 27, 32, 37, 42, and 47°C were studied. Studies on the effects of temperatures were carried out as the pH was maintained in the range of 6.5 to 8.00 by adjustment of the feed pH with NaOH. Nutrients levels were maintained in the ratio of COD: N: P at 100:5:1. The biomass was considered to be acclimatized when MLSS concentration maintained constant levels (3000 ± 2000 mg/L). The reactor was aerated continuously with an aquarium air stone with compressed air supplied at approximately 3 L/min to maintain dissolved oxygen (DO) concentration of 1.5 to 3.0 mg/L. Results indicated that as the operating temperatures of the reactors were increased, the percent removal of the soluble chemical oxygen demand (COD) also increased. The highest percent removal of soluble COD was obtained at 47 ºC (90.45%) while the lowest percent removal of soluble COD was obtained at 32 ºC (24.27%). The higher concentration of MLSS was obtained at 42 ºC (80 mg/L) while the lowest concentration was obtained at 10 mg/L at the same temperature (42 ºC). The patterns of the MLSS concentration for the temperature of 27 ºC, 32 ºC, 37 ºC, 42 ºC, and 47 ºC was increased and decreased gradually. The greatest concentration of MLVSS was achieved at 47 ºC and 32 ºC (80 mg/L) while the lowest was attain at 42 ºC which is 10 mg/L. On the other hand, increases the temperature affected the DO concentrations. The highest and lowest DO concentration was obtained at 27 ºC which is 5.1 mg/L and 1.7 mg/L.

ABSTRAK

Kajian ini dijalankan bagi mengkaji keupayaan Reaktor Penenggelaman Membran Enapcemar Teraktif di dalam merawat air sisa sintetik dan juga mengkaji kesan ke atas pelbagai suhu terhadap reaktor tersebut. Reaktor berskala makmal yang beroperasi secara berterusan ini telah menggunakan air sisa sintetik sebagai larutan penyuapan. Isipadu opearasi bekerja bagi reaktor tersebut termasuk membran adalah 20 liter. Membran yang digunakan diperbuat daripada bahan polimer (HDPE) dengan ketebalan 3.5mm. Membran tersebut mempunyai saiz liang berjulat 0.1 – 1mm, bertindak sebagai klarifier sekunder. Kesan ke atas suhu 27 ºC, 32 ºC, 37 ºC, 42 ºC dan 47 ºC telah dikaji. Kajian terhadap kesan suhu dijalankan dengan pH ditetapkan di dalam julat 6.5 – 8.0 dengan menukarkan pH larutan penyuapan dengan penambahan NaOH. Kadar nutrisi ditetapkan di dalam nisbah COD : N : P (100: 5: 1). Kandungan berat biologi dianggap sesuai dengan iklim sekitaran apabila kandungan MLSS berada pada (3000 ± 2000 mg/L). Reaktor tersebut telah diudarakan secara berterusan dengan menggunakan batu udara akuarium yang membekalkan udara pada anggaran 3 L/min bagi mengekalkan kandungan oksigen terlarut (DO) pada 1.5 – 3.0 mg/L. Berdasarkan keputusan yang diperoleh, apabila suhu operasi reaktor dinaikkan, peratus penyingkiran permintaan oksigen kimia (COD) hancur tertinggi dicatatkan pada suhu 47 ºC (90.45%) manakala yang terendah dicatatkan pada 32 ºC (24.27%). Kandungan MLSS yang tertinggi dicatatkan pada suhu 32 ºC (80mg/L) manakala yang terendah pada suhu yang sama iaitu 10 mg/L. Corak kandungan MLSS bagi kajian terhadap suhu 27 ºC – 47 ºC adalah menaik dan menurun dengan perlahan. Kandungan MLVSS yang paling tinggi dicapai pada 47 ºC dan 32 ºC (80 mg/L) manakala yang terendah pada 42 ºC (10mg/L). Selain itu, peningkatan suhu turut mempengaruhi kandungan oksigen terlarut (DO). DO yang tertinggi dan terendah dicapai pada suhu 27 ºC iaitu 5.1 mg/L dan 1.7 mg/L.

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^{o}C	Degree celcius
DO	Dissolved Oxygen
COD	Chemical Oxygen Demand
BOD	Biological Oxygen Demand
MLSS	Mixed Liquor Suspended Solids
MLVS	Mixed Liquor Volatile Suspended Solids
SS	Suspended Solids
VSS	Volatile Suspended Solids
HDPE	High Density Polyvinyl Ethylene
mg/L	Milligram per litre
g/L	Gram per litre
UTM	Universiti Teknologi Malaysia
m	metre
cm	centimetre
mm	milimetre

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The expand number of industrial sector in Malaysia have increased the production of products such as plastics, metals and chemicals in order to fulfil the living needs of human and increased national economics. Through the increases of industrial sector in Malaysia, the manufacturing produce millions tans of industrial waste which will arise the environmental quality issues, safety and health concerns in the wastewater management, which will develop seriously and should be aware. Effective and quick measurements should be done in order to minimize serious problems that may arise such as the increase treatment costs of drinking and clean water supply, public health and safety and also declining on health and environment standards.

The production of industrial solid waste increase tremendously every year. Approximately around 10, 000 of new organic material concentrations were added in the industrial waste each year (Metcalf and Eddy, 2004). The new organic materials concentrations were mainly consists complex materials which require high treatment cost that will be treated in conventional systems.

According to Environmental Quality Report 2004, in Malaysia approximately an average of 431,000 tan metric a year of industrial waste mainly from textile and chemical industries, pharmaceutical wastes, agricultural and domestic waste are produced. The effluent from industrial waste was highly in toxic, danger to public health and seriously affects the environment conditions. Normally, the industrial factory did not apply the suitable and standardize treatment required by the authority and ignore the standard or law that being permitted.

Aerobic treatment systems include the activated sludge process, extended aeration activated sludge process, activated sludge with granular activated carbon, or natural or genetically engineered microorganisms and aerobic fixed growth system such as trickling filters and rotating biological contactors. Among the aerobic processes, the trickling filter and the activated sludge processes have been used to treat industrial and domestic wastewater. In the past few years the treatment of wastewater by a modified activated sludge process, the sequencing batch reactor (SBR) has gained recognition. The SBR system do receive worldwide attention and several thousands SBR facilities have been designed, built and put into operation (Wilderer *et al*., 2000, Hastings *et al*., 2007). Most sewage treatment facilities are still based on continuously operated activated sludge processes. Aerobic systems have many advantages such as relatively easy operation, lower equipment cost, produce a better quality supernatant lower nitrates and phosphorus concentrations, thereby protecting the liquid side upstream and can achieve comparable volatile solids reduction with shorter retention periods, less hazardous cleaning and repairing tasks (Metcalf and Eddy, 2004).

In this study, the efficiency of a submerged membrane activated sludge reactor in treating synthetic wastewater which was similar to industrial wastewater was being studied in order to determine the efficiency of the reactor as an effective alternative technique in treating industrial wastewater. Furthermore, this study also analyzes the effect of varying temperature of a laboratory scale aerobic digester on process performance.

1.2 Problem Statement

Industry is a huge source of water pollution, it produces pollutants that are extremely harmful to people and the environment. Many industrial facilities use freshwater to carry away waste from the plant and into rivers, lakes and oceans. Pollutants from industrial sources include asbestos, lead, mercury, nitrates, phosphates, sulphur, oils and petrochemicals.

Increasing population, rapid urbanization and rapid intensifying human activities have exerted immense pressures on water quality. Whenever human and industrial wastes are not properly managed, surface waters and ground waters become the sink for receiving such waste. When effluents from industries are discharged into river channels, the river water will be polluted due to the increase concentration of dissolved solids, toxic chemicals, BOD loadings, heavy metals and other pollutants. Other than that, pesticides and herbicides from agricultural areas add to the increasingly polluted water sources.

According to the Environmental Quality Report (EQR) 2006, 16 rivers in Malaysia are polluted and 33 rivers are slightly polluted. Sources of the pollutions are from domestic waste and industrial waste which was mainly from agriculture and also factory sector. On the other hand, effective and suitable wastewater treatment systems that are economically and reducing cost were complicated and difficult to select which required fundamental knowledge about the critical role and operation of the wastewater treatment system.

The activated sludge process is the most commonly used treatment system for industrial and municipal wastewater. The activated sludge process consists at least one aeration tank (aeration period) and one sedimentation tank (settling period) (Gerardi, 2002).

The activated sludge process is capable of performing four critical wastewater treatment functions which are: the degradation or oxidation of carbonaceous waste, the degradation or oxidation of nitrogenous wastes, the removal of fine materials and the removal of heavy metals. The objective of the activated sludge process in treating industrial wastewater is to remove soluble and insoluble organics and to convert this material into a flocculent microbial suspension that settles well in conventional gravity clarifiers (Arthur, 2002). Several modifications of activated sludge process have been developed to accommodate specific wastewater characteristics and operational needs.

The activity and the physical properties of the microbial community within a system will determine the efficiency of treatment in terms of substrate utilisation, floc formation and efficient separation of the solids (specifically in gravity separators) from the treated supernatant. In order to achieve these objectives, the environmental and operational parameters that need to be controlled are dissolved oxygen, F/M ratio, solids retention time (SRT), organic loading, pH, temperature and nutrients. Therefore, operational condition in the aerobic reactor must be periodically monitored and maintained within optimum ranges.

Temperature affects all biological reactions. The magnitude of the effect is related to the characteristics of the wastewater organics and their physical state. Previous study from Henze *et. al.,* (2001). shows that the activity of the biomass increases with the increasing in temperatures which results in low the solubility of the oxygen. Experimental work has also demonstrated that widely varying mixed liquor temperatures (25 °C to 5 - 8 °C) during treatment can yield an increase in suspended solids in the treated effluent (Eckenfelder and Musterman, 2001). There have been some efforts to operate the activated sludge process in the thermophilic range (45 to 55 ºC) when the influent wastewater temperature is already in this range and the BOD is high (2500 to 3000mg/L). Under these operating conditions, the sludge generated was frequently difficult to separate, the mixed liquor was dispersed, and effluent solids concentrations were high (Grau and Eckenfelder, 2001). The activated sludge process can adapt to a wide range of temperatures but will become unstable with a sudden temperature change resulting in floc dispersion and increase in effluent suspended solids (Eckenfelder, 2001).

Therefore in this study, the effectiveness of the Submerged Membrane Activated Sludge Reactor in treating synthetic wastewater which is similar to industrial wastewater will be investigate as one of other effective alternative treatment in order to produce treated wastewater that are safe and clean to be disposed and used.

1.3 Aim and Objectives

The aim of this research is to evaluate the effect of temperature in aerobic reactor by using Submerged Membrane Activated Sludge Reactor. To achieve this aim, the following objectives are as follows:

a) To investigate the performance of Submerged Membrane Activated Sludge Reactor on treating synthetic wastewater,

b) To investigate the effect of varying temperature of laboratory scale aerobic reactor on treating synthetic wastewater

This study does not aim to develop or optimise a system and does not provide detailed design criteria. However more importantly, it explores the potential of aerobic treatment under strictly controlled extreme operating conditions.

1.4 Scope and Limitation

Scope of this research is based on the treatment of synthetic wastewater by using Submerged Membrane Activated Sludge Reactor in order to investigate the performance of this reactor. This research will be focused on the treatment of synthetic wastewater that has been prepared with glucose as the main component.

Sludge that is used for microb growth was collected from Glaxo Smith Kline (GSK) company, near Ulu Klang, Selangor.

In this research, the sludge sample and the synthetic wastewater will be examined by performing lab work analyse at Environmetal Engineering Lab, Universiti Teknologi Malaysia (UTM) International Campus. The parameter that are being tested in order to identify the synthetic wastewater characteristics effluent are Chemical Oxygen Demand (COD), Mixed Liquor Suspended Solids (MLSS), Mixed Liquor Volatile Suspended Solids (MLVSS), pH and Dissolved Oxygen (DO).

This study determined the effect of temperature on the performance of the Submerged Membrane Activated Sludge Reactor on treating synthetic wastewater. In this study, different range of temperature will be used in order to determine the effectiveness of this aerobic reactor. Temperature factors are important in affecting the process performance of the aerobic reactor and have to be considered. This is important to ensure that the effluent that will produce from treatment are followed the allowable standard required.

1.5 Importance of the Study

The research is important to ascertain the effectiveness of Submerged Membrane Activated Sludge Reactor in treating wastewater. In order to investigate the effect of temperature on the performance of Submerged Membrane Activated Sludge Reactor, the optimization and the appropriate temperature that will affect the aerobic reactor on process performance and for the most efficient in the aerobic reactor will be recognized. Other than that, the efficiency of this aerobic reactor will be determined. The exact water parameter of the effluent is important to make sure such as the COD values, which are important in order to characterize the organic strength of wastewater.