SUBMERGED MEMBRANE BIOREACTOR FOR TENUN DYE WASTEWATER TREATMENT

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Thesis submitted in fulfilment of the requirements
for the award of the degree of
B.Eng (Hons.) Civil Engineering

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JUNE 2014

ABSTRACT

The textile processing industry, from among the larger industrial consumers of water is a prime candidate for the development of intensive water recycling strategies and the recovery of valuable chemical products. Most studies have been directed towards the treatment of final effluent (end-of-pipe approach) in order to deal with the problems associated with textile waste water. New technologies, such as MBR, enable water re-use in combination with additional membrane filtrations, as a post treatment step. An important feature of MBR is the possibility of employing high sludge concentrations, facilitating the growth of specialised microorganisms, and promoting improved organic degradation. In this review, the characterisation of coloured wastewaters and the treatment methods are discussed, not only to enable water discharge but also its re-use. Parameters that need to be considered are COD, BOD, TSS, Colourization (ADMI) and MLSS. The results showed that the COD is decreased in the last 72 hours and increased in 96 hours. BOD results show that when the 24-hour period the value is decreased steadily until 96 hours in line with the increasing in time. TSS values decreased as the particles cannot pass through the filter as particles blocked during the refining process. Then MLSS increased due to the growth of microorganisms. Percentage of color removal was 26%, indicating that the MBR has the potential to emit particles in weaving dye wastewater. The data collected is used to improve the effectiveness of research looms dye using MBR.

ABSTRAK

Industri pemprosesan tekstil dari kalangan pengguna industri yang menggunakan jumlah air yang lebih besar adalah calon utama untuk pembangunan strategi kitar semula air intensif dan pemulihan produk kimia bernilai. Kebanyakan kajian telah diarahkan ke arah rawatan efluen akhir untuk menangani masalah-masalah berkaitan dengan air sisa tekstil. Teknologi baru, seperti MBR, membolehkan penggunaan air kitar semula iaitu melalui satu kombinasi dengan penapisan membran tambahan, sebagai salah satu langkah rawatan. Satu ciri penting MBR adalah kemungkinan dalam menggunakan kepekatan enapcemar yang tinggi bagi memudahkan pertumbuhan mikroorganisma yang khusus, dan menggalakkan degradasi organik lebih baik. Dalam kajian ini, pencirian air sisa berwarna dan kaedah rawatan akan dibincangkan, bukan sahaja untuk membolehkan pelepasan air tetapi juga penggunaan semula air sisa tersebut. Parameter yang akan diambil kira adalah COD, BOD, TSS, perubahan warna dan MLSS. Keputusan menunjukkan bahawa nilai COD adalah menurun dalam tempoh 72 jam dan meningkat dalam tempoh 96 jam. Keputusan BOD menunjukkan bahawa ketika tempoh 24 jam ia mengalami penurunan dan semakin menurun sehingga tempoh 96 jam seiring dengan peningkatan masa. Nilai TSS menurun memandangkan zarah tidak boleh melalui penapis seperti zarah disekat ketika dalam proses penapisan. Kemudian MLSS meningkat disebabkan oleh pertumbuhan mikroorganisma. Peratusan penyingkiran warna adalah 26% dan ini menunjukkan bahawa MBR mempunyai potensi untuk mengeluarkan zarah yang terdapat dalam tenun pewarna air sisa. Data yang dikumpul digunakan untuk meningkatkan keberkesanan penyelidikan tenun pewarna menggunakan MBR.

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LIST OF ABBREVIATIONS

ADMI	American Dye Manufactures' Institute
BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand
CWA	Clean Water Act
EPA	Environmental Protection Agency
HRT	Hydraulic Retention Time
IWK	Indah Water Konsortium
MBR	Membrane Bioreactor
MLSS	Mixed Liquor Suspended Solid
RAS	Return Activated Sludge
TSS	Total Suspended Solid
WWTP	Wastewater Treatment Plant

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

The textile industry is one of the largest water consumers and sources of pollution globally. Environmental problems within the textile industry are mainly caused by wastewater discharges. In general, the finishing processes (e.g. dyeing, printing…) are the most harmful textile production stages because of their water resource consumption and amount of contaminated wastewater with a synthetic origin of complex structure compounds and heavy metals. Textile processing employs a variety of chemicals, depending on the nature of the raw material, and the product. The effluents generated contain a wide-variety of contaminants, such as salts, surfactants, soaps, enzymes, and oxidizing and reducing agents.

Furthermore, 90% of reactive dyeing wastewater discharged into municipal treatment plants through the applied treatment systems and, thus reach surface waters. Most of the coloured, high molecular-weight compounds are resistant to biological degradation especially those reactive dyes that remain in the environment under natural conditions for 40 years and longer. Therefore, special attention is directed towards the appropriate selection of the physico-chemical and biological treatments of coloured wastewaters, as well as their combination.

MBR systems can be categorized according to the location of the membrane component. Until recently, the immersed or internal membrane MBR was typically more cost-effective than the external membrane MBR particularly in the treatment of larger wastewater flows. The technical advantages of the external membrane configuration, and recent significant membrane and system design advances resulting in reductions in operating power costs, have translated to broader application of this configuration. External membrane MBRs have recently been designed to treat wastewater flows as high as 3785 m3/day.

Therefore, the wastewater discharged has high COD/BOD values, high totally dissolved solids, high pH value, and often contains residual color. The residual dye remains in the wastewater due to incomplete dye fixation on the textiles, many different incomplete reactions of the dyes to fibers, numerous variations during the dyeing process and in color shading.

In order to remove pollutants from wastewater before discharging it into the receiving water bodies, different treatment methods could be applied, such as:

- Biological treatment by fungi, activated sludge, anaerobic/aerobic, fixed biomass
- Conventional treatment as filtration, on activated carbon (and other adsorbents), ion exchange, complex formation and chemical precipitation, flocculation and coagulation, chemical oxidation and reduction
- Advanced treatment – membrane filtration and photo decolourisation

Biological methods, especially the traditionally activated sludge process have been widely used for the treatment of textile wastewaters, due to their low operational costs. Biological treatment is reported to be a preferable alternative to other physico-chemical treatments because it can remove dyes from large volumes of wastewater at a low cost. These systems offer high efficiency in COD removal, but cannot provide complete colour removal, since most textile dyes have complex aromatic molecular structures that resist degradation.

Biodegradation processes may be anaerobic, aerobic or involve a combination of the two. Under aerobic conditions, for example, in activated sludge systems for wastewater treatment, low azo dye decolourisation is achieved because oxygen is a more effective electron acceptor than the azo dyes. Nevertheless, the bioconversion of these aromatic compounds under aerobic conditions is relatively quick. The reduction in azo dyes is generally regarded as a rate limiting step in the overall reaction.

1.2 PROBLEM STATEMENT

Dyes in wastewater can be eliminated by various methods. The wastewater from the dye house is generally multi-coloured. The dye effluent disposed into the land and river water reduces the depth of penetration of sunlight into the water environment, which in turn decreases photosynthetic activity and dissolved oxygen (DO). The adverse effects can spell disaster for aquatic life and the soil. Many dyes contain organic compounds with functional groups, such as carboxylic (–COOH), amine (–NH2), and azo (–N=N–) groups, so treatment methods must be tailored to the chemistry of the dyes. Wastewaters resulting from dyeing textile with reactive dyes are highly polluted and have high BOD/COD, coloration, and salt load.

1.3 OBJECTIVE OF STUDY

a) To characterize the Tenun Pahang Dye Wastewater.
b) To determine the effectiveness of submerged membrane bioreactor for wastewater treatment; before and after of wastewater quality based on its BOD, COD, TSS, MLSS and Colourization (ADMI).
c) To determine the effects of submerged membrane bioreactor on Tenun Pahang Dye Wastewater based on the retention time of the test.

1.4 SCOPE OF STUDY

This research will be conducted in University Malaysia Pahang because we are using the environment laboratory to test the wastewater from the tenun dye wastewater.

To succeed this research, we have to collect several sample of wastewater from tenun factory in Pekan, Pahang and from this sample, we have to do some experiment regarding the suitability and effectiveness in treating the wastewater so that it could prevent the pollution from happen.

1.5 RESEARCH SIGNIFICANCE

This research study could provide some information about how to treat wastewater since it become some of the dangerous chemical that can easily harmed human being. Since water is the most important needs in whole wide world, and it cover almost 3 out of 4 lands on earth, so it is the easiest option when handling waste. Further, this study would be beneficial to those who are involved in textile industry since it is about how to treat water treatment when involving with the dye method.

The characteristic of textile wastewater is categorized by its method of treatments and its application for the wastewater treatment and water reuse. This research covers about the characteristic of textile wastewater and methods of treatment also the use of membrane bioreactor for treatment of textile wastewater.

CHAPTER 2

LITERATURE REVIEW

2.1 CHARACTERISTIC OF TENUN DYE WASTEWATER

2.1.1 Textile Wastewater Characteristics

Al-Kdasi et al., (2005) said that composite textile wastewater is characterized mainly by measurements of biochemical oxygen demand (BOD), chemical oxygen demand (COD), suspended solids (SS) and dissolved solids (DS). Typical characteristics of textile industry wastewater are presented in table below:

Table 2.1 : Composite textile industry wastewater characteristics

Parameters	Values
pH	7.0 9.0
Biochemical Oxygen Demand (mg/L)	80 6,000
Chemical Oxygen Demand (mg/L)	150 12,000
Total Suspended Solids (mg/L)	15 8,000
Total Dissolved Solids (mg/L)	2,900 -3,100
Chloride (mg/L)	1000 1600
Total Kjeldahl Nitrogen (mg/L)	70 80

B. Deepti and J. Shahnaz on Dyes and Chemical stated that Dyes and dyestuffs find use in a wide range of industries but are of primary importance to textile manufacturing. Increasingly, the environmental and subsequent health effects of dyes released in textile industry wastewater are becoming subject to scientific scrutiny. Wastewater from the textile industry is a complex mixture of many polluting substances ranging from organ chlorine-based pesticides to heavy metals associated with dyes and the dyeing process. Inefficiencies in dyeing result in large amounts of the dyestuff being directly lost to the wastewater, during textile processing, which ultimately finds its way into the environment.

2.2 EFFECTIVENESS OF THE TREATMENT PROCESS

2.2.1 Treatment of Textile Wastewater by Membrane Bioreactor and Water Reuse

Z. Badani et al (2005) studied about the Treatment of Textile Wastewater by Membrane Bioreactor and Reuse, it is as well on of reasons that the membrane separation is very used in the industries. This reuse of wasted effluents allows the reducing of the manufacturing cost. The objective of our study is to determine the operating conditions to the operation of internal membrane bioreactor for the treatment of waste of textile industry. The pilot-plant includes a reactor of 500 L in which develops an adapted biomass. The mixed liqueur pumped from bioreactor to the membrane owing a centrifugal pump. For the three considered feed outputs. Number of conclusions can be obtained from this study, the experimental have shown that the average dejection of the COD is to 97%, the rate of elimination of the ammoniac nitrogen is 70%, whatever is the age of sludge. A decrease observed of 70% of the colour of the treated effluent.

2.2.2 Substrate and Solids Removal

Scott and Smith, 1996 said that one of the main advantages of MBR systems is 100% removal of suspended solids from the effluent. MBR systems are also well suited for treating high strength wastewater with COD and BOD loads up to 13,000 mg/L and 6,500 mg/L, respectively. Pankhania et al,. 1999; Scott and Smith, 1996; Rosenburger et al., 2002; Xing et al., 2001 studies show that COD removals ranging from 89% to 97% have been reported. Xing et al., 2000; Xing et al., 2001 further investigation revealed that the majority of COD removal occurred in the bioreactor with the membrane separation contributing 8 to 12% of the total removal.

2.2.3 Decolourisation by Using Biodegradation Process

Irena Petrinic, Prof. Mirjana Curlin, MSc Justina Racyte and Prof. Marjana Simonic (2009) research state that total colour removal is achieved, but the process cost is quite high and the formation of toxic by-products is highly probable. Physico-chemical processes enable very efficient Pre/Main and Post – treatment, especially for the countries with high water costs. However, they are not widely applied due to the production of by-product and toxic sludge. Each treatment method has its own advantages and disadvantages, and the method of selecting mainly depends on the treatment target. All the above mentioned treatment methods are basically applied as end of- pipe processes to comply with those discharge limits imposed by legislation.

Biological methods, especially the traditionally activated sludge process have been widely used for the treatment of textile wastewaters because it can remove dyes from large volumes of wastewater at a low cost. Biotechnological approaches for decolourising azo-containing wastewaters are very broad, and micro-organisms other than bacteria also show this capacity in them. Biodegradation processes may be anaerobic, aerobic or involve a combination of the two. Under aerobic conditions, e.g. in activated sludge systems for wastewater treatment, low azo dye decolourisation is achieved because oxygen is a more effective electron acceptor than the azo dyes.

2.3 EFFECTS OF SUBMERGED MEMBRANE BIOREACTOR ON RETENTION TIME

2.3.1 Treatment Efficiency

Jadhao R. K., Dawande S. D. (2013) on Effect of Hydraulic Retention Time and Sludge Retention Time on Membrane Bioreactor said that many researchers have used MBR systems with longer SRT since they understood that a higher biomass concentration, which was resultant of longer SRT, gave rise to higher treatment efficiency. In order to keep large amounts of biomass, some MBR plants were run with an infinite SRT. SRT is a vital characteristic in the elimination of pollutants and in the minimization of the amount of wasted sludge. Long SRT has a commercial advantage and avoid nitrifying bacteria from being washed out of the bioreactor, which improves the nitrification capability of the activated sludge. This study was to examine the effect of HRT and SRT on parameters such as Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD) , Nitrogen and Phosphorus contents (Ammonia NH4,Nitrate NO3 and Phosphate PO4), Solid Contents(Total Suspended Solids TSS, Volatile Suspended Solids VSS), Soluble Microbial Products Contents (SMP, Proteins, Carbohydrates and Acetate) and alkalinity (ALK) for wastewater originating from a tenun dye wastewater.

Trouve et al. stated the sludge production in the membrane bioreactor to be lower than in a conventional activated sludge process. Chaize and Huyard explored the treatment performance change at different SRT. However, most of these studies have concentrated on the conventional type, i.e. re-circulated type, of membrane bioreactor, in which membrane modules are allocated outside a bioreactor; there are very few reports on submerged membrane bioreactors.

2.3.2 Advantages of Higher Retention Time to Membrane Bioreactor System

R. Van den Broecka, J. Van Dierdoncka, P. Nijskensb, C. Dotremontb, P. Krzeminskic, J.H.J.M van der Graafc, J.B. van Lierc, J.F.M. Van Impea and I.Y. Smetsa, stated that higher SRTs do offer an MBR some additional advantages, including the following aspects:

- Slow growing microorganisms responsible for the biodegradation of specific organic pollutants, can be maintained in the bioreactor.
- The MBR can be operated at higher MLSS concentration which reduces the plant's footprint.
- In general, lower membrane fouling rates are observed at higher SRTs. Indeed, a recent review on membrane fouling in MBRs pinpoints the solids retention time (SRT) as an important factor influencing membrane fouling.

2.4 SLUDGE

Sludge is a generic term for a solids separated from suspension in a liquid. Commonly sludge refers to the residual, semi-solid material left from industrial wastewater, or sewage treatment process. It can also refer to the settled suspension obtained from conventional drinking water treatment, and numerous other industrial process. sludge also can define as the bulk of residual generated from wastewater by physical primary and biological (secondary) treatment process and must be treated before properly disposed off.

2.4.1 Activated Sludge

Activated sludge is a process for treating sewage and industrial wastewaters using air and a biological floc composed of bacteria and protozoa. The combination of wastewater and biological mass is commonly known as mixed liquor. In all activated sludge plants, once the wastewater has received sufficient treatment, excess mixed liquor is discharged into settling tanks and the treated supernatant is run off to undergo further treatment before discharge. Part of the settled material, the sludge, is returned to the head of the aeration system to re-seed the new wastewater entering the tank. This fraction of the floc is called return activated sludge (RAS)

CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

A membrane is defined as a material that forms a thin wall capable of selectively resisting the transfer of different constituents of the fluid and thus effecting a separation of the constituent. Thus, membranes should be produced with a material of reasonable mechanical strength that can maintain a high through out of a desired permeate with a high degree of selectivity. The optimal physical structure of the membrane material is based on a thin layer of material with a narrow range of pore size and a high surface porosity. This concept is extended to include the separation of dissolved solutes in liquid streams and the separation of gas mixtures for membrane filtration.

This chapter explains about the flow chart of the treatment process, the experimental study, the experimental model design, used equipment, sample preparation and procedure of the treatment process

3.2 FLOW CHART

The flow chart of the methodology process for the wastewater treatment is shown in Figure 3.1. Selection of material, used equipment, experimental design, sample preparation and testing method are all include in the flow chart.

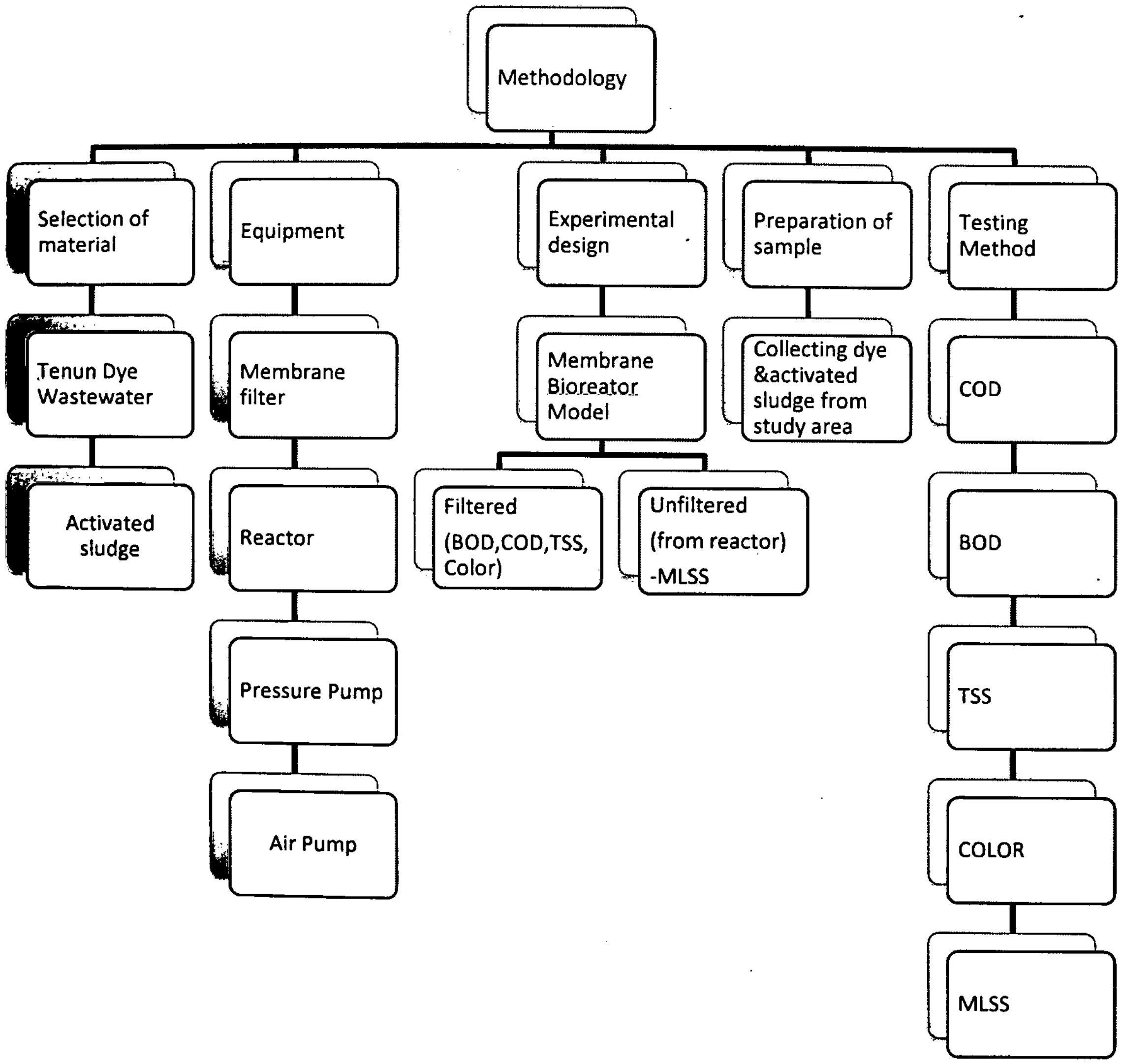

Figure 3.1 : Methodology Process Flow Chart

3.3 MATERIAL SELECTION

Materials using in Submerged Membrane Bioreactor treatment process are tenun dye wastewater and activated sludge.

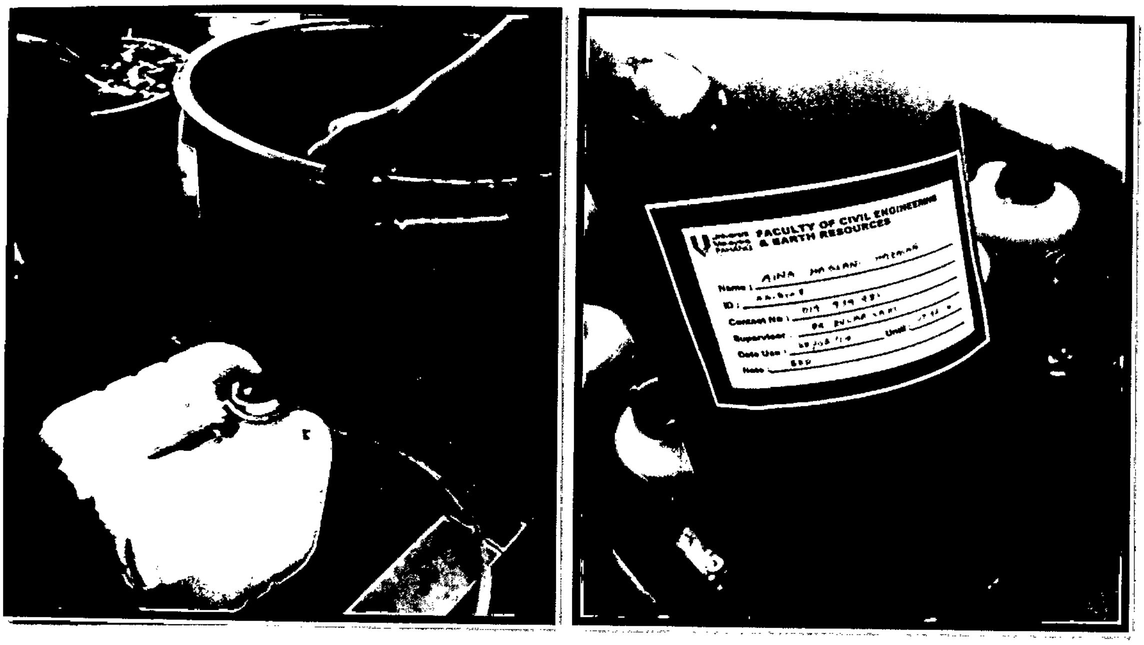

Figure 3.2 : Sample of Tenun Dye Wastewater

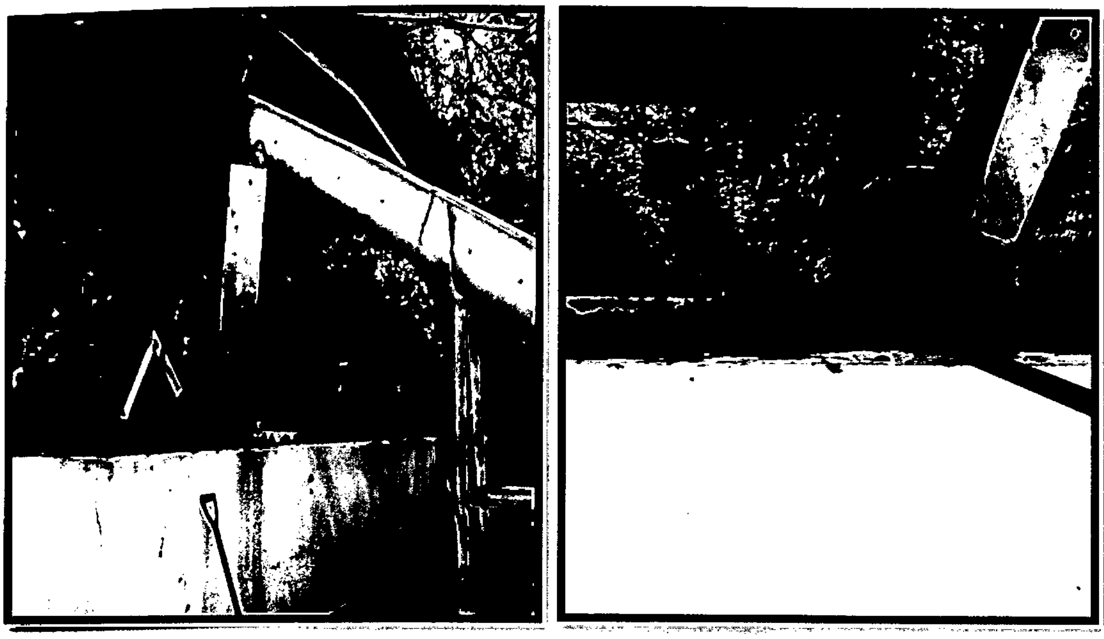

Figure 3.3 : Sample of Activated Sludge

3.4 SAMPLE COLLECTION

In this study, the tenun dye wastewater from the textile industry is taken from Pahang Weaving Centre in Kampung Sungai Soi, Pekan, Pahang. The sample is taken after the coloring process is done and then it will be put into a 10 litre container. For the activated sludge, it is taken from the Wastewater Treatment Plant in Indera Mahkota under the supervision of Indah Water Konsortium (IWK).

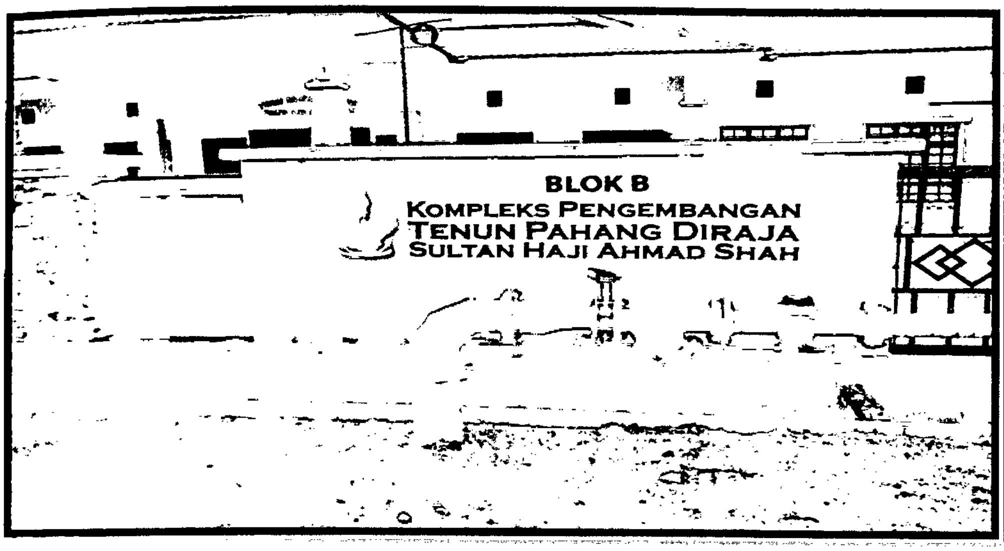

Figure 3.4 : Pahang Weaving Centre, Kampung Sungai Soi, Pekan

3.5 APPARATUS PREPARATION

Apparatus is one of the most important things to be taken care of in order to prepare the membrane bioreactor model. The apparatus that are been used are pressure pump, air pump, reactor and membrane filter.