TENUN WASTEWATER TREATMENT USING MEMBRANE BIOREACTOR (MBR) WITH EXTERNAL CERAMIC MICROFILTRATION

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ABSTRACT

Tenun industry in Malaysia is one of the small traditional businesses but it has contributed in increase economic resources of Malaysia. Tenun was popular at the East Coast of Malaysia and it is an inherited skill from generation to generation. In Pahang, tenun has been established as Tenun Pahang Royal and it is an exclusive handicraft where it difficult to obtain in other countries. The productions of tenun handicraft product require high of skill in managing and operate the tenun machine. The color consume in making the colorful tenun textile is one of the most important part in producing the attractive to fill the demands. Besides, the color utilize high chemical contain where it can contribute to pollution. Most of the tenun industries do not provide any pre-treatment before discharge the tenun wastewater from industries. Due to this action, it has cause pollution to the environment surrounding the industrial area. The preliminary study shows that the wastewater from tenun textile used to color the yarn contains suspended solids and high concertration of dyes whether organic or inorganic. This study explores the use of aerobic membrane bioreactor process in removing the suspended solid due to coloring process from the tenun wastewater. In the other hand, the effect of COD, BOD and color concentration were studied based on due to hydraulic retention time. The data collected shows the effectiveness of membrane in dye removal that contains in the wastewater by using the membrane bioreactor technology.

ABSTRAK

Industri pembuatan tenun di Malaysia telah menjadi sebagai salah sebuah peniagaan kecil- kecilan tetapi membantu kepada peningkatan sumber ekonomi Malaysia. Tenun dikenali oleh masyarakat Pantai timur sebagai indusrti tenun dan diwarisi secara turun temurun. DiPahang telah diwujudkan Tenun Diraja Pahang yang menjadi sebagai sebuah pusat kraftangan yang ekslusif dan sukar didapati di negara-negara lain. Didalam menghasilkan sebuah hasil daripada tenunan memerlukan daya ketelitian dan kemahiran yang tinggi untuk mengendalikan mesin tenun. Penggunaan warna merupakan factor penting untuk menghasilkan hasil tenunan mengikut kreativiti dan permintaan pelanggan. Kebanyakkan industri mengalirkan sisa warna yang telah digunakan ke sungai-sungai berdekatan tanpa melakukan rawatan awal sebelum melepaskan sisa warna daripada kawasan industri. Hal ini boleh menyebabkan pencemaran terhadap kawasan sekitar industri tersebut. Kajian awal mendapati bahawa warna yang digunakan untuk mewarna benang tenun mengandungi pepejal terampai dan kepekatan warna organik dan bukan organik yang tinggi. Masalah ini telah mendorong penyelidik mengkaji penggunaan membran penurasan mikro untuk menyingkirkan pepejal terampai hasil daripada proses pewarnaan benang daripada sisa industri tenun. Penyelidikan ini akan membantu merungkai penggunaan aerobic bioreactor membran untuk menyingkirkan bahan terampai dan pewarna. Disamping itu, kesan COD, BOD, kepekatan pewarna dikaji berdasarkan waktu retensi hydrolik. Keputusan kajian menunjukkan bahawa kepekatan warna dan parameter yang dikaji mempunyai kesan terhadap proses penapisan. Data yang diperoleh boleh digunakan bagi meningkatkan keberkesanan penapisan dengan menggunakan bioreactor membrane untuk menyingkirkan pewarna yang terkandung didalam air sisa tenun.

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LIST OF ABBREVIATIONS

$Al_2(SO_4)_3$	Alum
APHA	American Public Health Association
BOD	Biological Oxygen Demand
Cd	Cadmium
COD	Chemical Oxygen Demand
CO_2	Carbon Dioxide
$Cr_2O_7^{2-}$	Dichromate
DOE	Department of Environmental
EQA	Environment Quality Act
$FeCl_3$	Ferum Chloride
Hg	Mercury
H_2O	Water
HRT	Hydraulic Retention Time
ISIC	Industrial Standard Industries Classification
ISO	International Organization for Standardization
MBR	Membrane Bioreactor
MLSS	Mixed Liquor Suspended Solid
NTU	Nephelometric Turbidity Unit
Pb	Plumbum
SMEWW	Standard Method for Examination of Water and Wastewater
SS	Suspended Solid
THM	Trihalomethane
UF	Ultrafiltration
MC	Microfiltration
UMP	University Malaysia Pahang

CHAPTER 1

INTRODUCTION

1.1 Background Study

Tenun Pahang also called as Tenun Pahang Diraja was one of the famous woven silk in Pahang, Malaysia. The silk weaving in Pahang was originated from Malay people from Bugis descent. This famous Pahang woven silk cloth was conferred royal status by Duli Yang Teramat Mulia Tengku Mahkota Pahang, Tengku Abdullah Sultan Ahmad Shah on the 8th of May 2006. Tenun industries have been an economic growth to country besides give an opportunity to remain the traditional ethics and culture for generation in future There are some Tenun industries operated in Malaysia. Various color are used to produce beautiful and attractive colored of tenun fabric. The tenun themes incorporated of many patterns where the themes can be according to the life event and lifestyle within the community. The result of the colorful tenun fabrics comes from the dyeing process. Dyeing is a process of imparting colors to a textile material through a dye. Dyes can be obtained from natural such as flowers, nuts, berries and the other forms of vegetables. The other class of dyes known as synthetic dyes based on particular type of chemical composition as an example vat dyes, reactive dyes, neutral-premetalized dyes and etc.

Tenun industries were one of the big contribution to the Malaysia growth economy since it have been demands from abroad and local itself. Unfortunately, the tenun industries have become as one of the environment effect especially to water pollution where this industries utilize a lot of chemical content from dying activities.

Based on the preliminary study, it shows that the wastewater from this industries contain grease, wax, heavy metal, surfactant, suspended solid, and dyes (organic and inorganic) (Ahmad, A.L et al., 2002:Harris, W.A. et al.,2002: Syafiie et al., 2002: Ooi.B.S. et al., 2002). At the end of making the tenun product, the wastewater usually will be released to the activated sludge. Activated sludge is not suitable to be one of the treatment of dye wastewater since it is increasing the BOD value if the incoming effluent was introduced at the end of the tank. Furthermore, the kinetic of this microorganism at the end will be more active than those at the other end. All those defect will rectified in the complete mixing activated sludge. Meanwhile, the membrane bioreactor was known as a more efficient agent to treat wastewater as the system which does not required flocs to be form and remove the solids by settlement reaction. MBR, which combines membrane separation technology and bioreactor has led to a new focus on wastewater treatment. It was introduced to treat municipal wastewater by Dorr–Oliver in 1960s. The wastewater treatment is important in preserving the environment from pollution., it also does not required primary, secondary stages or ultraviolet stages to achieve very high disinfection quality. In addition, even high doses of ozone do not completely mineralize the organic dye to carbon dioxide and water due to the decolourisation rate which is decreasing with increasing initial dye color. Therefore, the study on Tenun wastewater dye treatment by using Membrane Bioreactor with addition of sludge to the effluent sample will be one of the solution as the environmental treated wastewater before discharged.

1.2 Statement of Treatment

Treatment of tenun wastewater using Membrane Bioreactor (MBR) is complicated since the wastewater itself contains toxicity and visibility even at very low concentration of dyes (Pierce et al., 2003; Robinson et al., 2001; Banat et al., 1990). Hence, the arrangement of optimal operating condition and process using Membrane Bioreactor should be in consideration in order to obtained the result in a more compliant tenun effluent which can be reused in the next cycle of dying and waxing process. There will be no doubt in the future, if all of the tenun industries will reused the purified recycled water as their main resources for dyeing their textile.

Regarding to the environmental effects, Malaysia government pay more concerned with the preservation and conservation of the environment in which the government has called on all industries to work together to control environmental problems by practices the ISO14001. The government has introduced the requirement to carry out the Environment Quality Act (EQA) 1974 (Amendment 1996). In order to protect and reduce the environmental impact, the effluent limits from textile mills have become more stringent. The strict regulation forced the plant manager to upgrade existing waste treatment system or to install new system where none were needed in the past (Rott U, Minke R., 1999). Hence, the industries are necessary to provide with the proper treatment by using the Membrane Bioreactor (MBR) in order to protect the environment from contaminated from those chemical reaction that might occurs.

1.3 Objectives of the Study

The objectives of this study are:

1. To determine the characteristic of tenun dye wastewater
2. To determine the effects of hydraulics retention time (HRT) to the tenun wastewater quality
3. To determine the characteristic of the treated tenun wastewater.

1.4 Scope of Study

1. This study is about to treat the tenun wastewater from tenun industries.
2. The area choosen is the east coast Peninsular Malaysia where Kampung Sungai Soi located.
3. The aeration system is 3 litres/minutes.
4. The hydraulic retention time was 48 hour 96 hour and 144 hour.
5. The parameter of this study are biological oxygen demand (BOD), chemical oxygen demand (COD), suspended solid (SS, total suspended solid (TSS) and color (ADMI).

1.5 Signification of Study

Membrane bioreactor was one of the technologies develop in treating the dye wastewater using the biology reaction to treat the chemical content that results from waxing and coloring process. This innovative design and fabrication by locally-made bio-membrane was the advantages provide by this invention instead of beneficial in terms of cost and environment itself.

The tenun textile have become a demand nowadays since the batik industries have experience its popularity where this demand will require a lot of environmental impact to the river condition since the river present for this decade have been polluted. This problem arise regarding to the parties from the industries do not take any part or lack in monitoring the effluent waste product from their industrial.

The effluent by waste product contain high in BOD, COD, inorganic material and others where this invention helps in reduce the material in the waste product and reduce the level of hazardous material to the acceptable level as mentioned in regulation stipulated by Department of Environment (DOE).

Besides, this membrane bio-reactor will be one of the solution to the industries textile as a pre-treatment that used dye as the main sources in coloring the material. The membrane bio-reactor will treat the dye wastewater until meet the standard A or B where this treated dye wastewater can be used again. It is also can reduce the cost in operation and maintenance of the product itself.

In the other hand, the invention of membrane bio-reactor used the bioreactor where it is an organic compound that will react to the chemical content in the dye wastewater instead of apply the chemical compound such as Alum $Al_2(SO_4)_3$, and Ferric chloride ($FeCl_3$) as a coagulant to trigger a reaction to the dye compound.

1.6 Expected Outcome

The expected results from this study are the characteristic of the tenun wastewater itself. The parameters of the tenun wastewater sample which are biological oxygen demand (BOD), chemical oxygen demand (COD), suspended solid (SS) and color (AMDI) before and after the treatment are expected to be differ and better than the result before the treatment process. The membrane bioreactor has highly effective system for treating the tenun dye wastewater effluent when the different hydraulic retention time give the different effect on the tenun effluent quality. The previous study shows that the flux will increase if the membrane pressure were increase.

CHAPTER 2

LITERATURE REVIEW

2.1 Wastewater

Wastewater is the liquid waste that discharges from commercial properties, agriculture and domestic residences which contain contaminant that cause by wastewater from different sources. Wastewater need to be treated as a matter of caring to environment and for human health besides keeps a clean ambiance to the aquatic life.

The industries and commercials consume large amount of water to generate and produce the goods or products. Increasing water demand for both industrial and public uses as well as more restrictive laws referred to water consumption and its final disposal into the main sewage network makes industrial wastewater reuse necessary, especially in those industries characterized by both high water consumptions and extremely polluted effluents. This is the particular case of textile industries, which are characterized by their high water consumption and pollution (Tang et al.,2002; Marcucci et al., 2002).

2.1.1 Type of Wastewater

The wastewater can be classified into industrial, agriculture, sanitary or domestic and storm water. Sewage is different compare to wastewater because it contains feces or urine.

2.1.1.1 Industrial Wastewater

In general, the industrial wastewater comes from the industrial activities that discharge a liquid of water that contain high pollution where colloidal and dissolved (mineral and organic), suspended solids also available in the industrial wastewater. The industries wastewater classify in many ways such as from extraction to consumption, The Industrial Standard Industries Classification (ISIC) system subdivides these uses into the following major categories (UN Static Division, 2003):

i. Manufacturing
   - Manufacture of tobacco products
   - Manufacture of food product and beverages
   - Manufacture of textile
   - Manufacture of wood and products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
   - Manufacture of wearing apparel; dressing and dyeing of fur
   - Tanning and dressing of leather; manufacture of luggage, handbags, saddler, harness and footwear
   - Manufacture of paper and paper products
   - Manufacture of coke, refined petroleum product and nuclear fuel
   - Publishing, printing and reproduction of recorded media
   - Manufacture of basic metal

- Manufacture of fabricated metal products, except machinery and equipment
- Manufacture of office, accounting and computing machinery
- Manufacture of electrical machinery and apparatus
- Manufacture of medical, precision and optical instrument, watches and clocks
- Manufacture of motor vehicles, trailers and semi –trailer
- Manufacture of other transport equipment
- Manufacture of furniture
- Recycling (James L. W, Jr. and Gilbert F.W, 2003)
- Manufacture of radio, television and communication equipment and apparatus
- Manufacture of chemical and chemical products

The term of 'industry effluent' used was defined as the any waste in form of liquid or wastewater generated from manufacturing process including the treatment of water for water supply or any activity occurring at industrial premises [Environmental Quality (Industrial Effluent) Regulation 2009].

Textile effluents contain many chemical substances coming from desizing, dyeing, printing and finishing processes. Moreover textile wastewater quality is variable with time and may include many types of dyes, detergents, sulphide compounds, solvents, heavy metals and inorganic salts, their amounts depending on the kind of process that generates the effluent (Marcucci et al., 2002). According to the studies, the dye wastewaters that cause form textile industries contribute to the pollution as well as to marine and groundwater. Textile processing industry which comprises different operations such as pretreatment, dyeing, printing and finishing, is one of the major environmental polluters. In order to process a ton of textile, one might have to use as much as 230-270 tons of water (Nouha Tahri,2012). The effluent generated by this much water would pollute the environment as it may contain a heavy load of chemicals used during textile processing. There are two main ways to limit the environmental impact of textile processing. One is to construct sufficiently large and highly effective effluent treatment plants, and the other way is

to make use of dyes and chemicals that are environment friendly (Mohammad et al., 2011).

The governments have established the Environmental Quality Act 1974 for the industries in Malaysia which the effluent discharge from industries must not exceed:

THIRD SCHEDULE

ENVIRONMENTAL QUALITY ACT 1974

ENVIRONMENTAL QUALITY (SEWAGE AND INDUSTRIAL EFFLUENTS)

REGULATIONS 1979

(REGULATIONS 8(1), 8(2), 8(3)

PARAMETER LIMITS OF EFFLUENTS OF STANDARDS A AND B

Parameter	Unit	Standard A	Standard B
a) Temperature	°C	40	40
b) pH value	-	6.0-9.0	5.5-9.0
c) BOD_5 or 20°C	mg/ l	20	50
d) COD	mg/ l	50	100
e) Suspended solid	mg/ l	50	100
f) Mercury	mg/ l	0.005	0.05
g) Cadmium	mg/ l	0.01	0.02
h) Chromium, Hexavalen	mg/ l	0.05	0.05
i) Arsenic	mg/ l	0.05	0.1
j) Cyanide	mg/ l	0.05	0.1
k) Lead	mg/ l	0.1	0.5

l) Chromium Trivalent	**mg/ l**	**0.2**	**1.0**
m) Copper	**mg/ l**	**0.2**	**1.0**
n) Manganese	**mg/ l**	**0.2**	**1.0**
o) Nickel	**mg/ l**	**0.2**	**1.0**
p) Tin	**mg/ l**	**0.2**	**1.0**
q) Zinc	**mg/ l**	**2.0**	**2.0**
r) Boron	**mg/ l**	**1.0**	**4.0**
s) Iron (Fe)	**mg/ l**	**1.0**	**5.0**
t) Phenol	**mg/ l**	**0.001**	**1.0**
u) Free Chlorine	**mg/ l**	**1.0**	**2.0**
v) Sulphide	**mg/ l**	**0.5**	**0.5**
w) Oil and Grease	**mg/ l**	**Not Detectable**	**10.0**

Table 2.1: Parameter limits of effluent for Standard A and Standard B

* the standard stated above only can be applied for industrial and development projects which catchment area (area upstream of surface or above sub-surface water supply intakes, for the purpose of human consumption including drinking)

ii. Mining and quarrying

- Extraction of crude petroleum and natural gas; service activities incidental to oil gas extraction, excluding surveying
- Mining of coal and lignite
- Mining of metal ores
- Mining of uranium and thorium ores
- Other mining and quarrying

2.1.1.2 Domestic or Sanitary Wastewater

Domestic wastewater comprises of the effluent discharge from residences, commercials or industrial premises into the public sewer that come from all aspect of human sanitary water usage. The domestic wastewater flow from the combination of constituent of flows from floor traps, bathroom, toilets, kitchen sinks, washing machine and dishwasher where this can be divided into black water and gray water.

The parameters of biological of domestic wastewater for every country was differ greatly in terms of the seasons, food consumed, water use and personal hygiene practices. The improperly treated wastewater might cause hazardous to human health especially due to the contaminant known as germ and waterborne pathogen lives in the wastewater. The waterborne pathogens include the species of bacteria, viruses, protozoa and helminths (parasites worm). These organisms are not live in aquatic natively but they require an animal host to growth and reproduction. They are also can survive in water and maintain their infectious ability for a significant period of time. In addition, the pathogens can contaminate water supplies when the wastewater allowed reaching the water table before adequate treatment occurs.

2.1.1.3 Agriculture Wastewater

Agriculture wastewater is generated from a variety of farm activities including the animal feeding operation and also the processing of agriculture products that may polluted from groundwater and until to surface if it does not properly managed. The agriculture wastewater was not only to manure, milking center wash water, barnyard and feedlot runoff, egg washing and processing, slaughterhouse wastewater and horse washing waters. In addition, the runoff from farmland and cropland will contribute to sediment, fertilizer and pesticides flow to the surface water.

The agriculture of crop required fertilizer to nourish the crops where it will be organic fertilizer or inorganic fertilizer. When the fertilizers were used, it will absorb to the root of crops and some of it will absorb into the ground where this fertilizer

will mixed with the ground water or the water flow passing the cropland went into the river or water body. Without any appropriate treatment to the wastewater, it will cause bad effects to the environment instead of human health.

2.1.1.4 Storm water

Storm water originally developed during precipitation event. It is happened when rain and snow melt that runs as rooftops, paved streets, highways and parking lots. As the water flow through this surfaces, it may pick up or bring along the the pollution as an example oil, fertilizer, pesticides, soil, trash and animal waste. After that, the water might flow directly to the into the local stream, lake or it will went into storm drain and continue through storm pipes until it is released untreated into the a local water surface.

The untreated storm water give effects in term of human health where it contain toxic metals, organic compounds, bacteria and viruses instead of not recommended for swimming. Besides, the untreated storm water discharging to the ground could contaminate and does not suitable for drinking water. In other hand, the urban storm water pollutes and harm streams that provide fish and wildlife habitat.

2.1.2 Characteristic of wastewater

The wastewater quality parameter can be categorized as:

2.1.2.1 Physical Characteristic

a. Turbidity: turbidity has describe as a major water quality characteristic affecting freshwater fish communities (Judy et al, 1984) ,it occurs in surface due to erosion of the colloidal material such as clay, silt, rock, vegetable fibres, microorganism and metal oxides from the soil. It is measure in terms of where light can absorbed or scattered by suspended material in water. The unit of measure is a nephelometric turbidity unit (NTU).

b. Color: The color of wastewater depends on the reaction of constituent to the chemical or dissolved material. The industrial waste from dyeing and textile operations may add substantial coloration to water in receiving streams.

c. Odour: in wastewater can be caused by foreign matter such as organic compounds, inorganic salt or dissolved gases. The substances that produce an odor in water will almost invariably impart a taste as well. The odors measure by successive dilution of the sample with odor free water until the odor is no longer detectable. Odor-free water water is prepared by passing distilled, deionized water through an activated charcoal filter (Ruth, F.W., Robin, M., 2003). The odor not significant if aerobic but if anaerobic wastewater, it will release hydrogen sulphide where it smells like rotten egg.

d. Temperature: the temperature is not used to evaluate potable water or wastewater only but it has one important parameter in natural surface-water system. The use of water in dissipation of waste heat by industries and the subsequent discharge of the heated water may result localized in temperature changes in receiving streams. The wastewater temperature is higher than water temperature due to the microbiological activities.

2.1.2.2 Chemical Characteristic

The characteristic of chemical parameter are organic compound and inorganic compound. The organic compound contains carbon in combination with one or more elements while the inorganic compound dissociate into electrically charged atoms referred to as ions that most likely linked in ionic bond.

2.1.2.2.1 Organic compound

a. Classification of organic matter

The organic matter differs in ability in degradable where it is consider into two parts biodegradable and non-degradable. The biodegradable organics is easily to oxidized by organisms and as a food for micro-organism. The example of biodegradable is starch, fat protein, alcohol and human waste.

The non-biodegradable organics is more complicated than degradable organics where it is difficult and take longer time to biodegrade and toxic to microorganisms such as polyvinylchloride, industrial waste, cellulose and phenol.

b. Properties of organic compound

Organic compound usually easily to be combustible. Besides, it has lower melting point and boiling point where the treatment does not require high intensity of energy.

c. Sources

The organic compound originally comes from the sources of nature, synthesis and fermentation. Fibers, vegetable oils, animal oil and fats, cellulose, starch and sugar are comes from nature. The synthesis contain wide variety of compound and material prepared by manufacturing process such as polyvinyl chloride and dichlorodiphenyltrichloroethane while the alcohol, acetone, glycerol, antibiotic and acid was in group of fermentation.

d. Effects

There are many example can be taken to show the effects of organic compound such as depletion of the dissolved oxygen in the water where it could destroying the aquatic life and ultimately destroying the ecosystem as well. Besides, some of organic contain in the wastewater might cause cancer such as trihalomethane (THM-carcinogenic compound) are produced in water and wastewater treatment plant when natural organic compound combine with chlorine added for disinfection purposes.

e. Wastewater measurement

There are high organic compound in wastewater which has been adversely affected in quality by anthropogenic influence. Anthropogenic means the impacts on biophysical environment, biodiversity and other resources. It can be measure by 'Biochemical Oxygen Demand' (BOD)