TREATMENT OF PALM OIL MILL SECONDARY EFFLUENT (POMSE) USING FENTON OXIDATION SYSTEM

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ABSTRACT

The feasibility of Fenton oxidation system to treat palm oil mill secondary effluent (POMSE) was investigated in this study. This study also evaluated the effect of UV lamp and solar light on the efficiency of Fenton oxidation in term of COD, colour and organic content removal within the experimental design. The Fenton oxidation processes were optimized by applying Central Composite Rotatable Design (CCRD). While the results depend on the concentration of reagents used in the study, in general, COD (82.4%) and UV absorbance (86.1%) were best removed using Solar-Fenton reagent. Colour (95.5%) was best removed using Photo-Fenton reagent. The best overall removal in term of COD (82.4%), colour (92.1%) and UV absorbance (83.3%) was achieved using Solar-Fenton reagent with 348.7 mg/L Fe^{2+} and 1397.5 mg/L H_2O_2. Using factorial analysis, *p*-value in Fenton reagent indicated the significance of iron dosage and significance of interaction effect between two variables (Fe^{2+} and H_2O_2) on COD and colour removal. It was found that only iron dosage gave significant effect to the COD, colour and UV removal in Photo-Fenton study. In Solar-Fenton study, iron dosage, H_2O_2 dosage and interaction effect between the two variables (Fe^{2+} and H_2O_2) were significant on COD removal. However, only iron dosage gave significant effect on colour and UV removal in Solar-Fenton study. Statistical relationship between COD and UV absorbance removal with Fe^{2+}, H_2O_2 dosage was also developed in this study.

ABSTRAK

Kajian keberkesanan pengoksidaan sistem Fenton dalam rawatan air sisa sekunder kelapa sawit telah dijalankan. Kajian ini juga mengkaji kesan penggunaan lampu UV dan cahaya matahari terhadap pengoksidaan Fenton. Keberkesanan pengoksidaan Fenton ditinjau dari segi COD, warna dan kandungan organik. Pengoksidaan Fenton dioptimumkan dengan aplikasi *Central Composite Rotatable Design* (CCRD). Walaupun kebanyakan keputusan ini bergantung kepada penggunaan kepekatan reagen, secara umumnya, pengurangan COD (82.4%) dan penyerapan UV (86.1%) yang terbanyak dicapai dengan menggunakan Fenton-suria. Pengurangan warna (95.5%) yang terbanyak dicapai dengan menggunakan Fenton-foto. Secara menyeruluh, pengurangan COD (82.4%), warna (92.1%) dan penyerapan UV (83.3%) yang terbaik dicapai dengan menggunakan Fenton-suria dengan dos Fe^{2+} dan H_2O_2 sebanyak 348.7 mg/L dan 1397.5 mg/L masing-masing. Dengan menggunakan analisis faktorial, nilai-*p* dalam Fenton reagen menunjukkan kuantiti dos Fe^{2+} dan interaksi kedua-dua dos Fe^{2+} dan H_2O_2 merupakan faktor-faktor yang penting dalam pengurangan COD dan warna. Dalam Fenton-foto, hanya dos Fe^{2+} memberikan kesan penting kepada pengurangan COD, warna dan penyerapan UV. Dalam Fenton-suria, dos Fe^{2+}, H_2O_2 dan interaksi kedua-dua dos Fe^{2+} dan H_2O_2 memainkan peranan penting dalam pengurangan COD. Hanya dos Fe^{2+} sahaja memberi kesan yang ketara terhadap pengurangan warna dan penyerapan UV dalam Fenton-suria. Hubungan statistik antara pengurangan COD dan penyerapan UV dengan dos Fe^{2+} dan H_2O_2 telah dibentuk dalam kajian ini.

CONTENT

LIST OF ABBREVIATIONS/ SYMBOLS/ TERMS

% R	-	Percentage of removal
A_0	-	Initial UV absorbance
ALK	-	Alkalinity
AOP	-	Advanced oxidation process
A_t	-	UV absorbance at t time
BOD	-	Biological oxygen demand
BOD_0	-	Initial BOD
BOD_F	-	Final BOD
CCRD	-	Central composite rotatable design
COD	-	Chemical oxygen demand
COD_0	-	Initial COD
COD_F	-	Final COD
COD_t	-	COD at t time
$Colour_0$	-	Initial colour
$Colour_t$	-	Colour at t time
CTC	-	Charge transfer conduction bands
EFB	-	Empty fruit brunch
Fe(II)	-	Ion ferum(II)
Fe(III)	-	Ion ferum(III)
FR	-	Fenton reagent
H_2O_2	-	Hydrogen peroxide
H_2SO_4	-	Sulphuric acid
$HO^{\bullet}$	-	Hydroxyl radical
HRT	-	Hydraulic retention time
MF	-	Microfiltration
NaOH	-	Sodium hydroxide

OLR	-	Organic loading rate
PF	-	Photo-Fenton
POME	-	Palm oil mill effluent
POMSE	-	Palm oil mill secondary effluent
RBC	-	Rotating biological contractor
SBR	-	Sequence batch reactor
SF	-	Solar-Fenton
t	-	Time
TDS	-	Total dissolved solid
TSS	-	Total suspended solid
$Turbidity_0$	-	Initial turbidity
$Turbidity_F$	-	Final turbidity
UASFF	-	Up-flow anaerobic sludge fixed film
UF	-	Ultrafiltration
UV	-	Ultraviolet
UV-Vis	-	Ultraviolet visible
VFA	-	Volatile fatty acids

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CHAPTER I

INTRODUCTION

1.1 Introduction

Malaysia is currently one of the largest producer and exporter of palm oil in the world. In 2003, Malaysia contributed to 13.4 million tons or 49% of world production and 12.2 million tons or 58% of total world exports. However, this important economic activity generates an enormous amount of effluent which could pollute the environment if not properly treated. It is estimated that for every ton of crude palm oil produced, about 2.5-3.5 ton of palm oil mill effluent (POME) is generated (Ahmad *et.al.*, 2005). In palm oil mills, liquid effluent is mainly generated from sterilization and clarification processes in which large amounts of steam and/or hot water are used. The mixed effluent is commonly known as POME. Fresh POME is thick brownish slurry. It is hot around 80 to 90^{o}C, acidic with pH 3.8 to 4.5 and contains very high concentration of organic matter (COD = 40, 000 to 50, 000 mg/L, BOD = 20, 000 to 30, 000 mg/L). The effluent is non-toxic as no chemical was added in the oil extraction process (Zinatizadeh *et.al.*, 2005). A typical characteristic of POME and palm oil mill secondary effluent (POMSE) (i.e. after biological process) are given in Table 1.1.

In Malaysia, the Department of Environment enforced the regulation for the discharge of effluent from the crude palm oil industry under the Environmental Quality (Prescribed Premises) (Crude Palm Oil) Order and Regulations 1977. While biological treatment processes are widely applied to treat POME, their applications are normally incapable in complying with the standard requirements set by the regulator. In addition, the effluent is also coloured and contained high concentration of non-biodegradable organics (based on high COD/BOD ratio) and thus requires further treatment. These biological treatments of anaerobic and aerobic systems need proper maintenance, close monitoring, long retention time, skilled personnel and commitment from management (Ahmad *et.al.*, 2005). Thus, an efficient treatment system is highly desirable in all palm oil mills in order to control the discharge of effluents to any bodies of water.

Table 1.1: Characteristics of POME, POMSE and its respective standard discharge limit by the Department of the Environment in Malaysia (Ahmad *et.al.*, 2005)

Parameter	POME	POMSE	Standard Limit
pH	4.5	8.1	5.0 – 9.0
Biochemical oxygen demand (BOD_5)	30000 mg/L	160 mg/L	100 mg/L
Chemical oxygen demand (COD)	50000 mg/L	1854 mg/L	-
Suspended solids	59350 mg/L	1138 mg/L	400

1.2 Objectives of Study

The objectives of the study were:

1. To evaluate the feasibility of three types of Fenton oxidation system, i.e. Fenton reagent, Photo-Fenton and Solar-Fenton in treating POMSE in term of COD, colour and organic content.
2. To identify the optimum dosage used in these Fenton reagent systems.
3. To explore the effect of UV lamp and solar light on the efficiency of Fenton oxidation.

1.3 Scope of Study

This study comprised of experimental work at laboratory scale. Actual POMSE from a palm oil mill was used throughout the study. Three types of Fenton oxidation system, i.e. Fenton reagent, Photo-Fenton and solar-Fenton were evaluated. Batch reactor system was used and the experiments were designed using Response Surface Method. Parameters to assess the performance of Fenton oxidation system include colour, COD and UV absorbance at 286.5nm.

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