PERFORMANCE STUDY OF POTASH ALUM ON WASTEWATER TREATMENT SYSTEM FROM BIOMASS GASIFIER WATER SCRUBBER

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by

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TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AAS	Atomic absorption spectroscopy
COD	Chemical oxygen demand
DOE	Department of Environment
EFBs	Empty fruit bunches
EJ	Exajoule
MWth	Megawatt thermal
NAPL	Non-aqueous phase liquid
NTU	Nephelometric turbidity unit
PAC	Powdered activated carbon
PAHs	Polynuclear aromatic hydrocarbons
POMEs	Palm oil mill effluents
rpm	Revolutions per minute
SS	Suspended solids
TDS	Total dissolved solids
TSS	Total suspended solids

KAJIAN PRESTASI KALIUM ALUM TERHADAP SISTEM RAWATAN AIR SISA DARIPADA PENGGAHAR AIR GASIFIER BIOMAS

ABSTRAK

Prestasi kalium alum ($KAl(SO_4)_2$) sebagai agen penggumpal dalam merawat air sisa daripada penggahar air gasifier biomass telah dikaji dalam rawatan secara kimia. Kalium alum telah terbukti mampu menyingkirkan jumlah pepejal terampai (TSS), jumlah pepejal terlarut (TDS), dan mengurangkan kekeruhan air pada kepekatan optimum. Rawatan telah dilakukan dengan menggunakan radar jar. Setelah kalium alum dicampur di dalam bikar, percampuran pantas telah dilakukan dengan menggunakan radar jar sebelum sisa gumpalan dibiarkan untuk mendap selama 30 minit. Sebelum rawatan dimulakan, sifat awal sisa air seperti pH, suhu, kekeruhan, TSS, TDS dan logam berat di dalam air sisa telah dikaji. Kehadiran logam berat di dalam air sisa telah dikaji dengan menggunakan spektroskopi penyerapan atom (AAS). AAS ialah satu prosedur spektro-analisis untuk mengkaji jumlah elemen kimia dengan menggunakan penyerapan sinaran optik (cahaya) oleh atom bebas yang berada dalam keadaan gas. Pada kepekatan optimum, kecekapan penyingkiran untuk TSS dan TDS, untuk masing-masing telah ditemui mencapai 62.5 dan 52.8%.

PERFORMANCE STUDY OF POTASH ALUM ON WASTEWATER TREATMENT SYSTEM FROM BIOMASS GASIFIER WATER SCRUBBER

ABSTRACT

The performance of potassium alum or also known as potash alum ($KAl(SO_4)_2$) as coagulant on treating wastewater from biomass gasifier water scrubber were investigated in a chemical treatment. Potash alum is proven to be capable of removing total suspended solids (TSS), total dissolved solid (TDS), and decrease the turbidity at optimum concentrations. The treatments were performed in a jar apparatus. The rapid mixing was performed in jar test after the potash alum were added in the beaker before the floc were allowed to settle down for 30 min. Before the treatments were started, the initial conditions of wastewater such as pH, temperature, turbidity, TSS, TDS and heavy metals contain in wastewater were being investigated. The presence of heavy metals in the wastewater were being checked by using atomic absorption spectroscopy (AAS). AAS is a spectro-analytical procedure for the quantitative determination of chemical elements using the absorption of optical radiation (light) by free atoms in the gaseous state. At optimum concentrations, the removal efficiency were found to achieve 62.5 and 52.8% for TSS and TDS, respectively.

CHAPTER ONE

INTRODUCTION

1.1 Research background

Due to rapid industrialization and improvement of living standards of the society, the global energy demand has been increasing steadily for last several decades. However, the production of fossil fuel is experiencing a depletion of source. Thus, the development of renewable energy and alternative sources has potential to fulfil world energy demands. One of the sources of renewable and alternative energy is biomass. Biomass is expected to provide half of the main energy consumption sources of the world in the future (Ismail and El-Salam, 2017). Biomass is available in different forms such as, by products of biological materials, agricultural and forestry residues and wood. By using photosynthesis process, it stores chemical energy in the form of carbohydrates by combining solar energy and carbon dioxide. For woody biomass, the most common application for the production of heat energy is thermochemical conversion route which is through combustion. However, gasification is more efficient since both heat and power generation requirements can also be met more effectively, efficiently and environment-friendly. End product of gasification can be used for heating, transportation fuels, electricity etc (Sansaniwal et al., 2017).

Biomass gasification can be performed in a special reactor known as a gasifier. The quality of the generated gas is influenced by the gasifier design and fuel performance significantly. In this research, the feedstock that will be used in the process of gasification is Empty Fruit Bunch (EFBs) pellet as it is source of renewable energy. EFBs from the palm plantation sector are abundant agricultural waste products in Malaysia. Palm EFBs has high heating value and low greenhouse gas emissions during combustion (Sivasangar et al., 2015). In addition to process gases (product of biomass gasification), wastewater (generate from water scrubber) and the water–organic condensate (condensed water with simple organic compounds produced during the thermal decomposition of biomass) are also obtained thus need to be treated (Muzyka et al., 2015).

The treatment of water obtained by the gasification of biomass can be performed either by using physical, chemical or biological methods. In this research, chemical treatment by coagulation and flocculation using potash alum has been studied to treat water from biomass gasifier. Potash alum is a salt that act as coagulant to promote formation of flocs and also reduce the concentration of colloidal and particulate matter in the wastewater.

1.2 Problem statement

Wastewater generated during water scrubbing of producer gas formed in biomass gasifiers consist mainly of phenolics, heterocyclics, mono and polynuclear aromatic hydrocarbons (PAHs) (Jeswani and Mukherji, 2015). Depending on gasifier operating conditions and water recycling practices, the concentration of organics in wastewater is vary over a wide range. The performance of biological treatment processes may be impact due to the toxic nature of constituents.

Thus, treatment of wastewater from the water scrubber is necessary for the successful operation of biomass gasification plants. One of the method of the treatment is by chemical treatment which is coagulation. In this study, potash alum ($KAl(SO_4)_2$) is used as coagulant for chemical treatment. Therefore, the performance of potash alum as coagulant and also the optimum doses of alum needed to treat wastewater is being studied.

1.3 Research objectives

The main objectives of this study are:

i. To identify the initial composition of raw wastewater from biomass gasifier water scrubber.

ii. To identify the optimum doses of alum (coagulant) required to achieve the best treatment efficiency.

iii. To identify the final composition of treated wastewater and compare the result with the standard of Department of Environment (DOE).

1.4 Scope of study

In this work, the raw wastewater was obtained from the biomass gasification plant at Universiti Tenaga Nasional (UNITEN) in Selangor. The initial composition contain in wastewater was being determined. The results then were compared with the Department of Environment (DOE) Standard in Malaysia to check whether it is in the range of standard or it has been exceeded. The focus of the result was to make sure all the parameters that have been studied manage to be in the range of DOE Standard.

Potash alum has a great solubility in water. At optimum concentrations of potash alum, it is proven to be capable of removing colour, total suspended solids (TSS) and total dissolved solids (TDS). The experiments of coagulation-flocculation was utilized by using jar apparatus with various concentration. The results after treat once again being compared with DOE standard and also with initial result to see how much treatment efficiency of potash alum. This method may prove to be one of the fastest and most techno-economically feasible method for biomass gasification wastewater (Mehta and Chavan, 2009).

1.5 Organization of thesis

The following are the contents for each chapter in this study:

Chapter 1 introduces the biomass gasification as new sources of renewable energy process, discusses on wastewater generated from the biomass gasifier water scrubber, problem statement, research objectives, scope of study, and organization of thesis.

Chapter 2 discusses the literature review of this study which includes the introduction of biomass, Empty Fruit Bunches (EFBs), biomass gasification, water scrubber of biomass gasifier, wastewater generated from the process, introduction of potash alum as coagulant, and the process of coagulation and flocculation.

Chapter 3 covers the materials and details of methodology. It discusses on the description of equipment and materials used, jar test experiment, and experimental procedure.

Chapter 4 refers to the experimental results and discussions of the data obtained. Further elaboration on the effect of optimum dosage of potash alum are also provided in this chapter.

Chapter 5 concludes all the findings obtained in this study. Recommendations are also included as well.

CHAPTER TWO

LITERATURE REVIEW

2.1 Biomass

The essential factor for the stable and sustainable global development of society, science and industry is energy. The annual global energy consumption level in 2013 is 533.0 EJ, or 12730 million tonnes oil equivalent (2.3% more than the level in 2012), in which continues to increase (Muzyka et al., 2015). Figure 2.1 presents the global primary energy consumption of fuel in 2013.

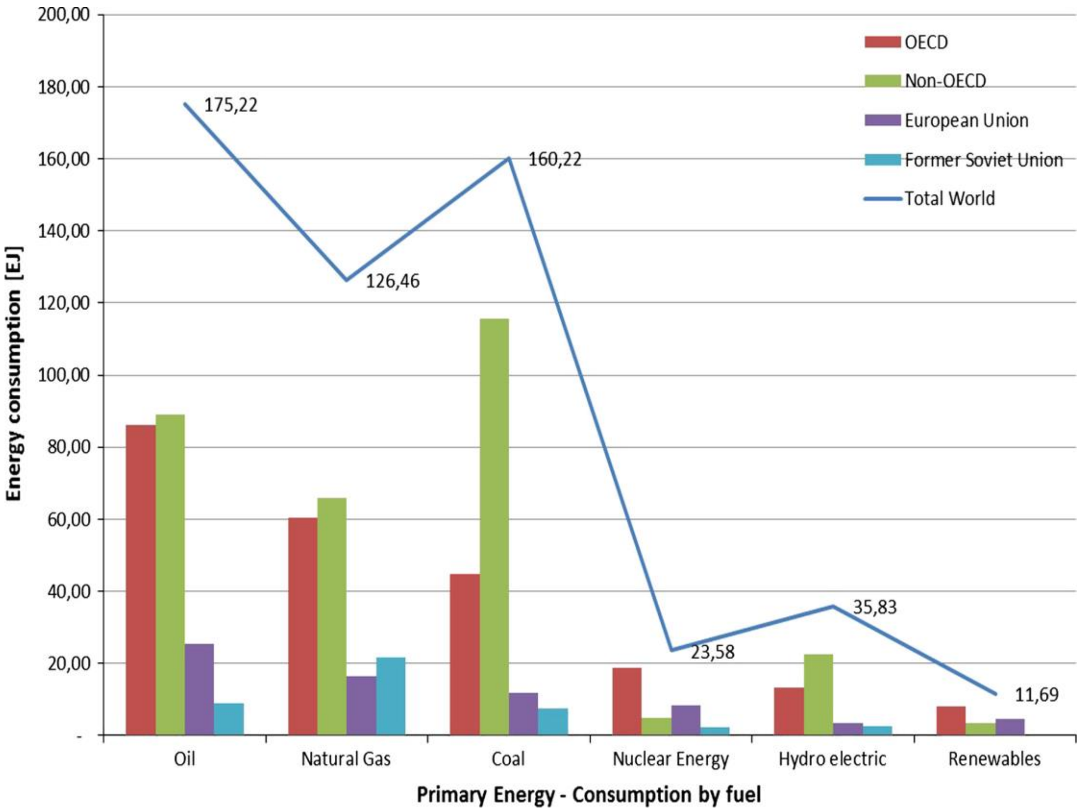


Figure 2.1: Global primary energy consumption of fuel in 2013(Muzyka et al., 2015).

The major energy demand is compensated from conventional energy sources such as coal, oil, natural gas, etc. Two major problems that world is facing with these conventional fuels are as follows:

(i) World's oil reserves are estimated to get depleted by 2050. These energy sources are at the approach of getting extinct.

(ii) The conventional fuels extraction causes pollution. The SO_2 emission produced by burning fossil fuels is the major cause of acid rain. Globally, increase in emissions rates of greenhouse gases, for example, CO_2 present a threat to the world climate. As an estimate in the year 2000, over 20 million metric tons of CO_2 were expected to be released in the atmosphere every year (Pütün et al., 2001). If this trend continues, some extreme natural disasters are expected such as excessive rainfall and consequent floods, droughts and local imbalances.

According to market analysts, the global energy demand is expected to increase up to 41% by 2035. Since of the increasing cost of fossil fuels, renewable energy sources are expected to become the world’s second largest source of electricity generation by 2035. Based on data from 2012, almost 50% of energy from all renewable sources, is derived from biomass, which represents 5.54 EJ. Renewable biomass is being considered as an important energy resource, internationally. The most common for biomass utilization as a fuel for power and heat generation are direct combustion and co-firing with conventional fossil fuels (Hoffmann et al., 2012).

Biomass is providing about 14% of the world's primary energy consumption. It is the fourth largest source of energy in the world after coal, petroleum and natural gas (Saxena et al., 2009). Among all the renewable sources of energy, biomass is unique as it effectively stores solar energy. It is the only renewable source of carbon that can be converted into convenient solid, liquid and gaseous fuels through different conversion processes (Özbay et al., 2001).

Three main type of products of biomass is shown in Table 2.1:

Table 2.1: Main type of biomass products (Saxena et al., 2009)

Main type of products	
i.	Electrical/heat energy
ii.	Fuel for transport sector
iii.	Feedstock for chemicals

Biomass had been utilized through direct combustion traditionally and produces pollutants including dust and the acid rain gases such as sulfur dioxide (SO_2) and nitrogen oxides (NOx). Nevertheless, the SO_2 produced is 90% less than that is produced by burning coal. The quantities of atmospheric pollution produced are insignificant compared to other pollution sources.

The usage of biomass has benefits such as shown in Table 2.2:

Table 2.2: Benefits of biomass usage (Saxena et al., 2009)

Benefits of Biomass usage	
i.	Biomass provides a clean, renewable energy source that could improve our environment, economy and energy securities.
ii.	Increased use of biomass would extend the lifetime of diminishing crude oil supplies.
iii.	The combustion of biomass produces less ash than coal combustion and the ash produced can be used as a soil additive on farms, etc.
iv.	Biomass is a domestic resource which is not subject to world price fluctuations or the supply uncertainties as of imported fuels.

2.2 Empty Fruit Bunches (EFBs)

Empty fruit bunches (EFBs) from the palm plantation sector are abundant agricultural waste products in Malaysia. Agricultural residues are potential biomass wastes that can be used for energy conversion. The biomass wastes have advantages such as they are cheap, sustainable, and could solve waste disposal problems. Palms are among the most successful commercial crops in the Southeast Asian region (Malaysia, Indonesia, and Thailand). Malaysia is the second largest palm oil producer in the world with an overall production capacity of 18.8 million tonnes of crude palm oil from its 5.08 million hectares of cultivation (Sivasangar et al., 2015). The tropical climate and fertile land support vast plantation areas for palm cultivation and high oil production.

Demand for palm oil utilization is constantly growing, mainly as edible oil, and other oil-related industries such as oleochemical and biodiesel production. The growing palm oil industry produces a large amount of by-products from the extraction mills including empty palm fruit bunches (EFBs), fibers, shells, and palm oil mill effluents (POMEs). Normally, solid wastes are used as a boiler fuel to produce electricity and the required steam for the oil extraction process (Konsomboon et al., 2011).

Reactivity of EFBs increase as it have high content of volatiles (>82%), and more than 90% decomposed at 700°C; however, a high content of moisture (>50%) and oxygen (>45%) resulted in a low calorific value (Mohammed et al., 2012). Large quantities of EFBs still have no specific use, thus need to be practically utilized (Lahijani and Zainal, 2011). Thus, pyrolysis and gasification can be considered as feasible technologies for handling EFBs and simultaneously producing valuable liquid and gaseous biofuels.

2.3 Biomass gasification

Gasification technologies offer the potential of clean and efficient energy. Gasification process use heat, pressure, and steam to convert materials directly into a gas composed primarily of carbon monoxide and hydrogen. In general, gasification involves the reaction of carbon with air, oxygen, steam, carbon dioxide, or a mixture of these gases at 1,300 °F or higher to produce a gaseous product that can be used to provide electric power and heat (Rezaiyan and Cheremisinoff, 2005).Gasification can be performed by using a biomass gasifier.

Gasification convert various kinds of whole biomass to gaseous or liquid fuel with high conversion rates and, thus, have the potential to become practically processes. The technology in gasification process has been developed well. According to the World Gasification Database (2007), existing world gasification capacity was 56,238 MWth of syngas output from 144 operating plants and about 400 total gasifiers (Ogi et al., 2013). Coal was dominant (30,835 MWth, 54.8%), then was petroleum 18,454 MWth, 32.8%. For biomass, it had very low share of 2.0%. Liquids and chemicals (49%, 32% respectively) is the product of coal gasification, meanwhile, products of biomass were gaseous fuels and power. It is necessary to develop biomass gasification from now, raising and modifying on coal gasification.

Biomass gasification has gained lots of interests due to its high conversion efficiency compared to other various thermo-chemical and biochemical platforms. There are four major categories of gasifiers including fixed bed, moving bed, fluidized bed and entrained flow are applied in gasification process. Due to the excellent mixing and gas–solid contact, fluidized bed gasifiers have offered some advantages over fixed beds which improves the reaction rate as well as conversion efficiency (Warnecke, 2000). The fluidized beds originates from the implemented bed materials act as heat transfer medium and tar cracking catalysis which can reduce tar content and improved quality producer gas (Alauddin et al., 2010).

Fluidized biomass gasification use various gasifying agents including air, steam, oxygen-steam, air–steam, O_2-enriched air and oxygen–air–steam (Campoy et al., 2009). Even though use of oxygen or steam as the gasifying agent improves the quality of producer gas in terms of heating value or H_2 content, however the high cost and energy consumption of O_2 or steam generation makes the process unfavorable for industrial applications (Alauddin et al., 2010). Thus, the suitable choice which improves the feasibility of the gasification process for industrial plants is to use of air-blown bubbling fluidized bed gasifier to generate producer gas.

For liquid fuel synthesis and chemical product, fluidized-bed and entrained-flow gasifiers are usually used. The entrained flow gasifier has many advantages; for example, it has a simple structure, no catalyst is required, the tar yield is low, control of the gaseous components is easy, and various kinds of biomass are available as feedstock (Ogi et al., 2013).

Many models have been developed to establish the required kinetic parameters of biomass gasification such as the distributed activation energy model (Sonobe and Worasuwannarak, 2008), least-squares estimation method for a first-order reaction model (Orfão et al., 1999), and Kissinger’s model-free kinetics equation (Harris and Zhong, 2008).The least-squares estimation method for a first-order reaction model seems more applicable among all the methods to investigate the behavior patterns of various biomass samples, particularly for three independent parallel reactions involving the cellulose, hemicellulose and lignin contents of biomass (Li et al., 2008).

The high potential of palm solid biomass residues to generate fuel and energy boosts the importance of gasification plants establishment in Malaysia. In the present study, the chemical, physical, fuel-oriented and thermal characteristics of EFBs are presented. The thermal decomposition behaviors of different EFB particle sizes were thermogravimetrically analyzed. Additionally, the kinetic behavior of EFB is reported using the least-squares estimation model (Mohammed et al., 2012).

2.4 Scrubber in biomass gasification

Gasification which is the most promising biomass utilization method produces not only useful fuel gases, char and chemicals, but also some unwanted byproducts like fly ash, NO_x, SO_2 and tar. Generally, by-products will cause the clogging of pipes and engines. It also cause erosion and corrosion on metals. Meanwhile, biomass gasification contain tar which consists of several hundreds of hydrocarbons, which include single-ring to five-ring aromatic compounds. When the temperature falls below its dew point, tar condenses resulting in the clogging of fuel lines, filters, and engines. The tar concentration in the producer gas varies greatly with the reaction conditions and the type of gasifier (Nakamura et al., 2016)

Various technologies for tar removal have been developed until now. According to the location where the tar is removed, these technologies can be classified into primary and secondary methods. In general, primary methods such as catalytic cracking, thermal cracking, and plasma gasification exhibit a high tar removal rate. In some studies using catalysts, it showed high tar removal performance. By using Ni catalysts, it was reported that 98–99% of the tar in the producer gas was decomposed, which also increased the gas heating value (Baidya and Cattolica, 2015). Furthermore, various catalysts, such as dolomite and olivine, were investigated for improvement, providing remarkable results (Sarıoğlan, 2012). Nevertheless, the primary methods acquire higher initial and running costs due to the high temperature, short lifetime and complicated gasifier constructions of the catalysts (Anis and Zainal, 2011)

In contrast, secondary methods such as using a scrubber, filter, and centrifuge are easier to commercialize because of their low cost and simple procedures. For the wet system, water scrubbing is often used in gasification plants, which has a low cost and is easy to perform. However, most tar has less or zero solubility in water, so the rate of tar removal by water scrubbing is low. Generally, primary measures can reduce the tar content considerably, but complete removal is not feasible without applying secondary measures (see Figure 2.2)**:**

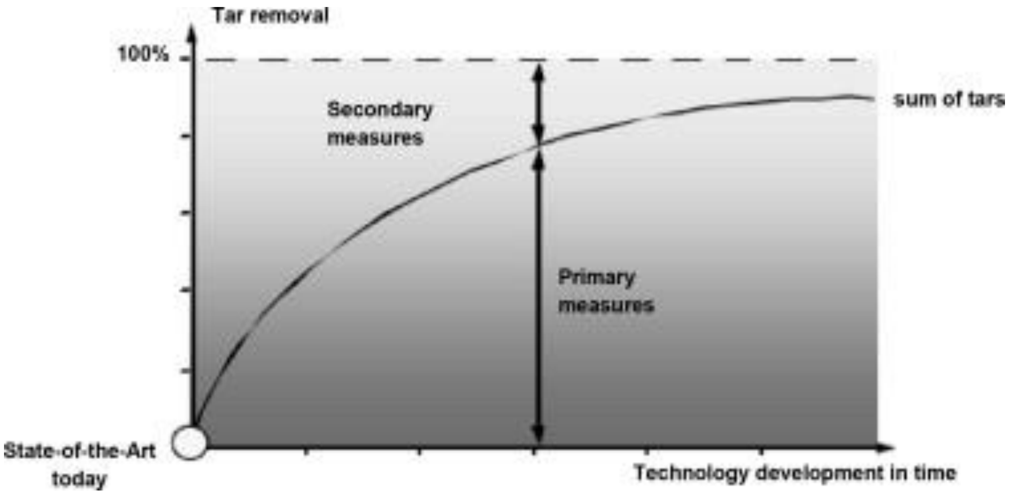


Figure 2.2: Illustration of the need of primary and secondary measures versus technology development in time

2.5 Wastewater generated from biomass gasification

Biomass gasification wastewater is a by-product of the wet scrubbing method. It is employed to clean producer gas generated from biomass gasifiers, contains numerous impurities, organic and inorganic compounds. Many factors affect the amount of contaminants, including the type of reactor and the process parameters (e.g., the temperature, pressure, residence time, and the flow rates of the reactants) (Muzyka et al., 2015).

As the temperature drops below the tar condensation temperature, the organics generated during gasification at high temperature start to condense to form tar. The gas contain tar cannot be directly used in internal combustion engines. Thus, utilization of wet scrubbing to achieve gas cleaning through tar removal is being used. The more soluble components dissolve in water, while the less soluble components are retained in the residual tar phase that exists as a non-aqueous phase liquid (NAPL) (Jeswani and Mukherji, 2015). Wide variation of chemical oxygen demand (COD) ranging from 920 to 1,60,000 mg/L shows that various organic strength of gasifier wastewater (Lata et al., 2006).

Gas composition and impurities concentration depends on the gasifier design, feedstock type, gasifying agent and other process parameters. In addition, temperature and pH conditions existing in the scrubber and also concentration of the constituent in the tar phase would affect the concentration of an organic constituent in biomass gasification wastewater. The water organic condensate from the biomass gasification process consists primarily of water (82–93%), whereas the remainder of the condensate (7–18%) consists of carboxylic acids, aldehydes, ketones, and linear and aromatic alcohols. The lack of management or treatment of these components can significantly negatively affect the environment.

Water obtained from the biomass gasification process can be utilized in several ways such as by a qualifying deposit, by a purification plant and by the combustion of biomass. Unfortunately, the combustion of biomass requires a large amount of additional fuel. The purification of water obtained by the gasification of biomass can be performed using physical, chemical or biological methods. Physical methods include sedimentation, centrifugation and filtration (including membrane methods). Physical treatment can be applied for the pre-treatment of undiluted water. Operational problems in water purification mode is usually cause by tar compounds contained in sub cleaned water; result in clogging of the filter surface.

Thermal method is other processes of treating water from biomass gasification. Examples of thermal method are such as evaporation (concentration of low-volatility components), distillation (evaporation and fractional separation of volatile compounds) and stripping methods (release of volatile substances using bubbling air or steam). In other hand, chemical methods of purifying water from the biomass gasification process include neutralization; oxidation; reduction; ion exchange, which is not comprehensive; coagulation and flocculation. Adsorption onto active carbon can also remove hydrocarbons from water; however, this method of water treatment is not common because of its high costs. Lastly, biological methods (anaerobic and aerobic) can also treating wastewater from biomass gasification. However, they usually involve long processes and are associated with unsatisfactory efficiency because of the toxicity of the compounds in these waters (Lettner et al., 2007).

2.6 Potash alum

Potassium alum (potash alum) is well known to have a role in water treatments (coagulation and clarification). Recently, it has been reported as a reusable, cheap and excellent catalyst for the syntheses of some rare organic chemicals (Aderemi and Hameed, 2009). Alums produce from kaolin, bauxite or alunite now is well developed. It is relatively cheap, environmentally friendly and readily available.

Alum results the following equation in water decreasing the alkalinity:

$$Al_2(SO_4)_3 + 6HCO_3^- \leftrightarrow 2Al(OH)_3 + 6CO_2 \qquad (2.1)$$

At optimum concentrations, potash alum proved to be capable of removing color, total suspended solids (TSS) and total dissolved solids (TDS) (Mehta and Chavan, 2009). The removal efficiency achieved at optimum concentrations were 78.6, 62.0, 62.5 and 52.8% for color, alkalinity, TSS and TDS, respectively. If coagulation-precipitation by using potash alum and followed by adsorption on PAC, it resulted in 92.3% chemical oxygen demand (COD) removal and 100% phenol removal at equilibrium. Ammonia removal efficiency was found to be 11.7% during coagulation-flocculation and 36.2% during adsorption on PAC (Mehta and Chavan, 2009).

The efficiency of the treatment system was measured in terms of maintenance of neutral pH, and removal of total suspended solids (TSS), total dissolved solids (TDS), color, alkalinity, ammonia, chemical oxygen demand (COD) and phenol.

2.7 Coagulation and flocculation for wastewater treatment

In wastewater treatment, coagulation/flocculation processes are mainly used for the removal of colloidal material, which cause color and turbidity. The important feature of wastewater flocculation is the elimination of suspended solids (SS) and as much organic material as possible (Amuda and Alade, 2006). Suspended particles vary in source, charge, particle size, shape, and density, which affect the correct application of coagulation and flocculation. Suspended solids in water have negative charge and repel each other when they are close together since they have the same type of surface charge. Hence, suspended solids will remain in suspension and will not clump together and settle out of the water, unless proper coagulation and flocculation is used.

Coagulation and flocculation occurs in consecutive steps, thus allowing particle collision and growth of floc. Then, it is followed by sedimentation. If coagulation is incomplete, flocculation step will be unsuccessful, and if flocculation is incomplete, sedimentation will be unsuccessful. The coagulation/flocculation process has been found to be cost effective, easy to operate and is an energy-saving treatment alternative. Coagulant dosages vary in a wide range to maximize removal efficiency of pollutants using minimum doses at optimum pH; 4-6.

A jar test procedure comprising six beakers was set up at room temperature for each trial. Each beaker is equipped with a thermostatic magnetic stirrer. Each of the beakers contained 1 L of mixed liquor or settled wastewater. The coagulants were added into the beakers, and the pH values were immediately adjusted to the preset values (8.5–9.0) using NaOH or HCl as appropriate. The jar tests investigated different aspects to the removal of COD, TSS and TDS were not replicated (Mehta and Chavan, 2009).

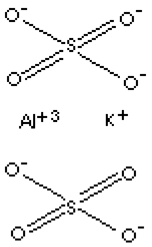
CHAPTER THREE

MATERIALS AND METHODS

3.1 Materials

In this study, the wastewater was obtained from the biomass gasifier water scrubber plant at Universiti Tenaga Nasional (UNITEN), Selangor. The gasification process from biomass gasifier used Empty Fruit Bunch (EFBs) pellet as feedstock. Potash alum $AlK(SO_4)_2 \cdot 12H_2O$ used as chemical coagulant. Potash alum properties were summarized in Tables 3.1.

Table 3.1 Properties of Potash Alum (Helmenstine, 2016)

Properties	
Common name	Potassium alum (Potash alum)
IUPAC name	Aluminum potassium sulfate dodecahydrate
Other name	Kalinite $KAl(SO_4)_2 \cdot 11H_2O$
Molecular formula	$AlK(SO_4)_2 \cdot 12H_2O$
Molecular weight	474.37 g/mol
CAS number	7784-24-9 (Decahydrate) 10043-67-1 (Anhydrous)
Physical state	White crystals or powder
Melting point	92-93 °C
Boiling point	200 °C (Decomposes)
Specific gravity	1.757
Solubility in water	Very soluble
Chemical structure	

3.2 Equipment and instrumentations

3.2.1 Determination of pH and temperature

The identification of pH of wastewater was done by using pH meter (Model Eutech Instruments pH 1500). The pH meter consists of meter reading and also pH electrode. Figure 3.1 shows the pH meter used to determine the pH of wastewater before and after treated.

Figure 3.1: pH meter

Besides this, temperature was taken by using simple thermometer as shown in Figure 3.2.

Figure 3.2: Thermometer

3.2.2 Turbidity

Turbidity of wastewater could be measured by using turbidity meter (Model Hach 2100P Turbiditimeter). In physical terms, turbidity is due to particles of varying sizes scattering or absorbing light, giving the medium in question a cloudy appearance. This turbidity is caused by suspended particles such as sludge, limestone, yeast or microorganisms.

The principle of turbidity is as shown in schematic diagram in Figure 3.3:

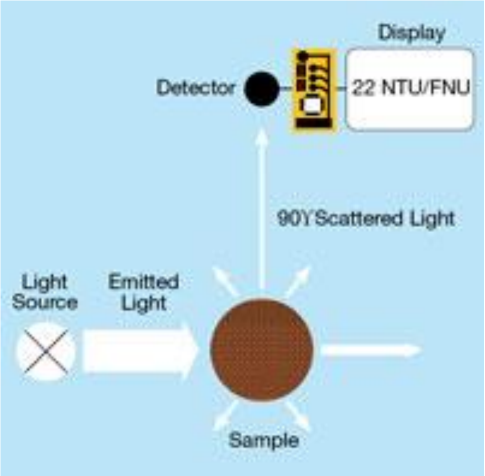


Figure 3.3: Schematic diagram of turbidity meter

The scattered light is generally measured at an angle of 90°. This measurement principle is known as nephelometry. A nephelometer is therefore a turbidity meter that measures scattered light at an angle of 90°. The results are shown in NTU (Nephelometric Turbidity Unit).

3.2.3 Total Suspended Solids (TSS) and Total Dissolved Solids (TDS)

Total suspended solids (TSS) and total dissolved solids (TDS) were performed by using simple apparatus such as conical flask, filter funnel, filter paper and evaporating dish. Analytical balance (Model Shimadzu AC220) was used to weight filter paper and evaporating dish before and after the experiments were done to calculate TSS and TDS value. Oven was also used for drying. Figure 3.4 below shows the type of analytical balance used for measuring potash alum.

Figure 3.4: Analytical balance

3.2.4 Determination of heavy metal

As in the wastewater contain heavy metal elements, the determination was done by using atomic absorption spectroscopy (AAS) (Model Shimadzu AA-6650). The heavy metal that found to exceed the limit of Department of Environment (DOE) Standard was zinc (Zn). Figure 3.5 below shows the model of AAS used for determine heavy metal.

Figure 3.5: Atomic absorption spectroscopy (AAS)

3.2.5 Jar apparatus

Wastewater was treated by chemical coagulant; potash alum in jar apparatus. The speed of the mixer and the time could be set at desired conditions. Figure 3.6 shows the setup of jar test experiment:

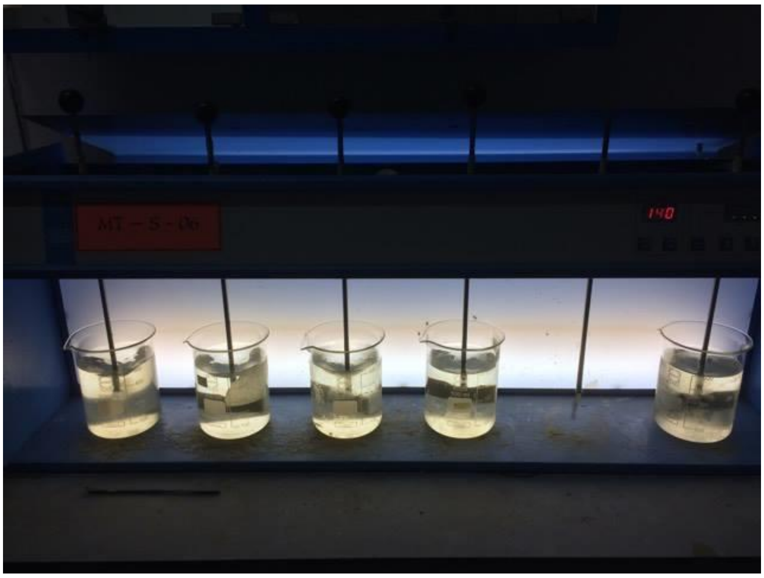


Figure 3.6: Jar apparatus

3.3 Experimental procedures

3.3.1 Determination of pH and temperature

The procedure for pH determination was by dipping the pH electrode in the wastewater sample and the reading would appeared on the meter. Before that, calibration was done by dipping pH meter into buffers (test solutions of known pH) and the meter adjusted accordingly. The temperature was taken by using thermometer by dipping it into the beaker containing wastewater.

3.3.2 Turbidity

Turbidity was measured by filling the small bottle with the sample before put it into the detector. The turbidity meter would show the reading in NTU.

3.3.3 Total Suspended Solids (TSS) and Total Dissolved Solids (TDS)

For TSS, weigh of initial filter paper was measured. Then, filtration apparatus was set up. Filter paper was wetted by distilled water. 100 ml of sample was titrated into filter while stirring. After 3 times washed, the filter paper was dried in the oven before weighted it again. The calculation for TSS is shown as below:

$$Suspended\ solids\ \frac{mg}{L} = \frac{(A-B) \times 1000}{ml\ of\ sample} \tag{3.1}$$

A= weight of filter paper + dried residue, mg

B= weight of filter paper, mg

Procedure for TDS, the evaporating dish was weighed first. Next, 50 ml was taken from filtered sample in TSS and transferred into evaporating dish. The sample was put into the oven for drying. The evaporating dish was weigh again to get final result. The calculation for TDS is shown as below:

$$Dissolved\ solids\,\frac{mg}{L} = \frac{(A - B) \times 1000}{ml\ of\ sample} \tag{3.2}$$

A= weight of evaporating dish + dried residue, mg

B= weight of evaporating dish, mg

3.3.4 Determination of heavy metal

Atomic absorption spectroscopy (AAS) was used to determine heavy metal. Before the determination could be done, a calibration curve must be done by using standards solution. Then, a graph of absorbance versus concentration could be plotted. Thus, the quantity of heavy metal was being measured.

3.3.5 (a) Preparation of potash alum as coagulant

Before jar test experiment could be conducted, the concentration of potash alum must be prepared. The concentrations were 0.1, 0.2, 0.4, 0.6, 0.8, 1.0, 2.0, 3.0, 4.0, 5.0 g/L.

3.3.5 (b) Jar test

The experiments were conducted at initial pH of 6.7-7.0 and at ambient temperature. The sample was drawn into a beaker before placed on a jar apparatus.

The mixer of jar apparatus was set at speed 140 rpm for 5 minutes for rapid mixing before it was switched to 35 rpm for 30 minutes.

3.3.6 Sample analysis of treated wastewater

For analysis of treated wastewater, the procedures from 3.3.1 to 3.3.3 were repeated to get final result to compare with initial result.