Changes In The Quality of Palm Oil Mill Effluent (POME) Under Aerobic Treatment

Gilbert Kalaween Anak Mangga (23539)

Bachelor of Science with Honours
(Resource Chemistry)
2012
Changes In The Quality of Palm Oil Mill Effluent (POME) Under Aerobic Condition

Gilbert Kalaween Anak Mangga (23539)

A project report submitted in partial fulfillment of the
Final Year Project 2 (STF 3015) Course Resource Chemistry

Faculty of Resource Science and Technology
Universiti Malaysia Sarawak
2012


Declaration

No portion of the work referred to in this dissertation has been submitted in support of an application for another degree of qualification of this or any other university or institution of higher learning. I hereby declare that this project is the work of my own excluded for the references document and summaries that have been acknowledge.

………………………………………….

(GILBERT KALAWEEN ANAK MANGGA)

Date:

Resource Chemistry Programme

Department of Chemistry Faculty of Resource Science and Technology

Universiti Malaysia Sarawak
Acknowledgement

This dissertation would not have been possible without the guidance and the help of several individuals who in one way or another contributed and extended their valuable assistance in the preparation and completion of my research. First and foremost, my utmost gratitude to Prof. Lau Seng, whose generous guidance and encouragement I will never forget. A lot of advices, ideas and information had been given. I would also like to thanks both of my parent that always support me along the way in this research. I would like to thanks Mr.Ismadi who offers his help in the laboratory and also during samplings. Big thanks to Bau Palm Oil Mill (BAPOM) management and all the staff giving the opportunities for me to use their palm oil mill effluent (POME) sample for my research. Credits also given to my laboratory partner, Azimah Binti Mat, Norhidayah Brawi, Lai Mei Kin, friends and family members that help me along the way in doing this research. Last but not least, thanks to everybody that involve directly and indirectly in this research.
# Table of Content

Acknowledgement ........................................................................................................... I
Table of Contents ............................................................................................................ II
List of Abbreviations .......................................................................................................... III
List of Table and Figure ..................................................................................................... IV
Abstract ............................................................................................................................. 1

1.0 Introduction .................................................................................................................. 2
  1.1 Objective ..................................................................................................................... 5

2.0 Literature Review ......................................................................................................... 6
  2.1 Palm Oil Mill Effluent ................................................................................................. 6
  2.2 Principle of Aerobic Digestion ..................................................................................... 8
  2.3 Previous Study ............................................................................................................. 9
  2.4 Limitations ................................................................................................................. 10

3.0 Methodology ............................................................................................................... 11
  3.1 Sample collection ....................................................................................................... 11
  3.2 Experimental Design ................................................................................................. 11
  3.3 Quality Control ......................................................................................................... 12
  3.4 Materials ................................................................................................................... 12
  3.5 Analytical Method ..................................................................................................... 13
    3.5.1 Biochemical Oxygen Demand ............................................................................. 13
    3.5.2 Chemical Oxygen Demand ................................................................................ 14
    3.5.3 Oil and Grease ..................................................................................................... 15
    3.5.4 Total Suspended Solids ....................................................................................... 16
    3.5.5 Volatile Suspended Solid ..................................................................................... 17

4.0 Result and Discussion ................................................................................................ 18

5.0 Conclusion .................................................................................................................... 37

6.0 References ................................................................................................................... 38

7.0 Appendixes .................................................................................................................. 40
## List Of Abbreviation

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>POME</td>
<td>Palm Oil Mill Effluent</td>
</tr>
<tr>
<td>BOD</td>
<td>Biochemical Oxygen Demand</td>
</tr>
<tr>
<td>COD</td>
<td>Chemical Oxygen Demand</td>
</tr>
<tr>
<td>TSS</td>
<td>Total Suspended Solid</td>
</tr>
<tr>
<td>VSS</td>
<td>Volatile Suspended Solid</td>
</tr>
<tr>
<td>FFB</td>
<td>Fresh Fruit Bunch</td>
</tr>
<tr>
<td>CPO</td>
<td>Crude Palm Oil</td>
</tr>
<tr>
<td>O &amp; G</td>
<td>Oil And Grease</td>
</tr>
<tr>
<td>DO</td>
<td>Dissolve Oxygen</td>
</tr>
<tr>
<td>H₂</td>
<td>Hydrogen Gas</td>
</tr>
<tr>
<td>CO₂</td>
<td>Carbon Dioxide</td>
</tr>
<tr>
<td>CH₄</td>
<td>Methane</td>
</tr>
<tr>
<td>NH₃</td>
<td>Ammonia</td>
</tr>
<tr>
<td>FAS</td>
<td>Ferrous Ammonium Sulphate</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>PAGE</td>
</tr>
<tr>
<td>-----------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>Figure 1: Design of the POME sample container</td>
<td>12</td>
</tr>
<tr>
<td>Figure 2: Graph for average BOD value against time</td>
<td>19</td>
</tr>
<tr>
<td>Figure 3: Graph for average COD value against time</td>
<td>23</td>
</tr>
<tr>
<td>Figure 4: Graph of average concentration value of oil and grease against time.</td>
<td>27</td>
</tr>
<tr>
<td>Figure 5: Graph of Total Suspended Solids (mg/L) against time.</td>
<td>31</td>
</tr>
<tr>
<td>Figure 6: Graph of VSS value against time</td>
<td>37</td>
</tr>
</tbody>
</table>
LIST OF TABLES

Table 1: Standard Discharges of palm oil mill effluent (POME) 4
Table 2: Characteristics of palm oil mill effluent (POME) 7
Table 3: Sample and Reagent quantities for various digestion vessels 15
Table 4: Average BOD value for batch 1, 2, and 3 sampling for four weeks. 18
Table 5: BOD percentage reduction for three batch of sampling. 18
Table 6: Average COD value for batch 1, 2, and 3 sampling for four weeks. 22
Table 7: COD percentage reduction for three batch of sampling 22
Table 8: Average Oil and Grease value for batch 1, 2, and 3 sampling for four weeks. 26
Table 9: Oil and grease percentage reduction for three batch of sampling. 26
Table 10: Average TSS value for batch 1, 2, and 3 sampling for four weeks. 30
Table 11: TSS percentage reduction for three batch of samplings. 30
Table 12: Average VSS value for batch 1, 2, and 3 sampling. 34
Table 13: VSS percentage reduction for three batch of sampling. 34
Changes in the Quality of Palm Oil Mill Effluent (POME) Under Aerobic Condition

Gilbert Kalaween Anak Mangga

Resource Chemistry Programme
Faculty of Resource Science and Technology
Universiti Malaysia Sarawak

ABSTRACT

Malaysia is a rapid growing country. The economy of Malaysia is mostly depends on production of palm oil. However, the production of crude palm oil will also give side effect which is the Palm oil mill effluent (POME). This type of product can pollute our environment. Therefore, the palm oil mill waste management must know how to treat the POME before it is being discharged. POME has high BOD, COD, Oil and Grease, TSS and VSS value. In this project, the raw POME was subjected into 55°C temperature and the sample was aerated by using air pump. The POME that had been subjected into that condition is monitored in its quality changes for four consecutive weeks. Parameters such as BOD, COD, Oil and Grease, TSS and VSS have been conducted. The pattern for the changes of BOD, COD and Oil and Grease is decreasing with time. As the time increased, the value of BOD, COD and Oil and Grease decreased. However, for TSS and VSS, both of it show increase in value as the time increased.

Keyword: Palm oil mill effluent, environmental impact, temperature, and aerated condition.

ABSTRAK


Kata kunci: Efluent kilang minyak kelapa sawit, kesan terhadap persekitaran, suhu dan keadaan beroksigen.
1.0 Introduction

Malaysia is a rapid growing country and also being identified as the biggest producer and exporter of palm oil around the world. Palm oil is an important agriculture based industry for Malaysia. Apart from being a major foreign exchange earner for Malaysia, it is one of the largest single sources of water pollution. Oil palm was first introduced to Malaysia in 1875 as an ornamental plant. Only from year 1917 the oil palm sector began to develop (Thani et al., 1999).

Wet process of palm oil milling usually consumes large amount of water. About 5 – 7.5 tonnes of water are required to produce 1 tonne of Crude Palm Oil (CPO). Approximately more than 50% of the water will become palm oil mill effluent (POME) at the end of the process (Latif Ahmad et al., 2003b). About 53 million m$^3$ of POME is produced yearly in 2005 on palm oil production in Malaysia (14.8 million tonnes) (Rupani et al., 2010). This massive amount of effluent from each palm oil mill can cause environmental problems.

POME had brought about heavy stress on the environment in the 1970s. In that time, the mean BOD is 25,000 parts per million (ppm) and it has exceeded the limit which is allowed in the Environmental Quality Act (EQA), Malaysia (Er et al., 2011). Some of the palm oil mill irresponsibly discharged untreated POME into the river which leads to water pollution. Apart from that, improper land application for solid waste can contribute to environmental issues. Generally explain, excessive quantity of untreated POME will deplete the water-body of its oxygen and thus will put the aquatic life in danger (Thani et al., 1999).
Most of the palm oil by-product is not easily converted to other things such as energy and fertiliser. The by-product usually forms environmental problems producing methane and polluting waterways. There are many ways that have been carried out to manage this problem. In Malaysia itself, about 225,000 tons of methane emission from the POME ponds which is equivalent to 5.17 million tons of carbon dioxide or 3.6% of the estimated total emission (Yeoh, 2004). Apart from that, the aquatic environment of Malaysia is exerted by 30% of the total biochemical oxygen demand (BOD) which is contributed from POME (Yeoh, 2004, Yeoh et al., 1988).

Aerobic digestion is a method whereby it is using the anabolic and catabolic activity of aerobic organisms to stabilize the waste biological sludge. Aerobic digestion will produce product which is stable when compared to anaerobic digestion. Apart from that, this method also produced supernatant liquors which have a lower $BOD_5$ concentration of less than 100mg/l (Matsch and Drnevich, 1977). The digestion usually conducted independently or can be combined with anaerobic digestion in order to get the advantages of both processes. Aerobic digestion can function normally with sufficient oxygen supply (Zupancic and Ros, 2008).

Oxygen supply is important in the aerobic digestion especially in high temperature. When the temperature is high, the oxygen absorption is low and the rate of sludge digestion is higher at thermophilic temperatures (Zupancic and Ros, 2008). In aerobic digestion, the food for microorganism is limited. Therefore endogenous respiration occurs in order to maintain their cell reactions. Due to this, the biomass concentration is decreasing until it is safe to be disposed to the environment. The pH value of the sludge also decreased due to nitrification (Bernard and Gray, 2000).
Other objective of aerobic digestion is to reduce the fraction of biodegradable organic material into a level which is 10 to 20% of volatile solids. The stable standard discharges for POME can be referred to Table 1.

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>LIMITS FOR CRUDE PALM OIL MILLS (SECOND SCHEDULE)</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biochemical Oxygen Demand (BOD; 3-Day, 30°C)</td>
<td>mg/L 100</td>
<td></td>
</tr>
<tr>
<td>Chemical Oxygen Demand (COD)</td>
<td>mg/L *</td>
<td></td>
</tr>
<tr>
<td>Total Solids</td>
<td>mg/L *</td>
<td></td>
</tr>
<tr>
<td>Suspended Solids</td>
<td>mg/L 400</td>
<td></td>
</tr>
<tr>
<td>Oil and Grease</td>
<td>mg/L 50</td>
<td></td>
</tr>
<tr>
<td>Ammoniacal Nitrogen</td>
<td>mg/L 150</td>
<td>Value of filtered sample</td>
</tr>
<tr>
<td>Total Nitrogen</td>
<td>mg/L 200</td>
<td>Value of filtered sample</td>
</tr>
<tr>
<td>pH</td>
<td>-</td>
<td>5 - 9</td>
</tr>
<tr>
<td>Temperature</td>
<td>°C 45</td>
<td></td>
</tr>
</tbody>
</table>

*Note: *No discharge standard after 1984.(Thani et al., 1999)
1.1 Problem statement

Residue oil is one of the key ingredients of POME which influences the high Chemical Oxygen Demand (COD) and Biochemical Oxygen Demand (BOD) values. COD and BOD parameters were identified as the major problem in POME. The maximum allowable limit set by the Malaysian Department of Environment (DOE) for residue oil is 50mg/l (Thani et al., 1999). Hence, the challenge of converting POME into an environmental friendly waste requires efficient treatment and effective disposal. Therefore, in my research, I am going to determine the changes in the quality of POME under aerated condition.

1.2 Objectives

1. To determine the changes in the quality of Palm Oil Mill Effluent (POME) under aerated condition.

2. Determine the percentage reduction of COD, BOD, TSS, VS, and Oil and Grease in POME under aerated condition
2.0 Literature Review

2.1 Palm oil mill effluent (POME)

Palm oil is an edible oil which derived from the fleshy mesocarp of the fruit of oil palm (*Elaeis guineensis*). The palm oil production consists of several stages which are sterilization, stripping or threshing, digestion and palm oil extraction. Palm oil mill industry contribute huge amount of waste. Generation of palm oil mill effluent (POME) usually comes from the process of oil extraction, washing and cleaning process in the mill. The characteristics of POME depend on the process of making palm oil and the quality of the raw material used. Huge amount of water needed to extract crude palm oil (CPO) from the fresh fruit brunch (FFB) (Rupani *et al.*, 2010).

It is estimated that about more than 5 – 7.5 tonnes of water is required to produce 1 tonne of crude palm oil. About 50% of the water ends up as palm oil mill effluent. (Rupani *et al.*, 2010). POME is a combination of wastewater generated from three principal sources which is sterilizer condensate (36%), clarification wastewater (60%) and hydro-cyclone wastewater (4%). Average about 0.9 – 1.5 m$^3$ of POME is generated for each ton of crude palm oil produced (Wu and Mohammad, 2007). Raw POME is a thick brownish liquid which will be discharged at a temperature between 80°C and 90°C. The pH value for POME is between 4 and 5. The typical characteristics of POME can be referred to Table 2.
Table 2: Characteristics of palm oil mill effluent (POME)

<table>
<thead>
<tr>
<th>PARAMETER*</th>
<th>GENERAL PARAMETERS</th>
<th>METAL &amp; OTHER CONSTITUENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MEAN</td>
<td>RANGE</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| pH         | 4.2    | 3.4 – 5.2              |
| Oil & Grease (O&G) | 6,000  | 150 – 18,000          |
| Biochemical Oxygen Demand (BOD, 3-day, 30°C) | 25,000  | 10,000 – 44,000 |
| Chemical Oxygen Demand (COD) | 50,000  | 16,000 – 100,000 |
| Total Solids (TS) | 40,500  | 11,500 – 79,000 |
| Suspended Solids (SS) | 18,000  | 5,000 – 54,000 |
| Total Volatile Solids (TVS) | 34,000  | 9,000 – 72,000 |
| Ammoniacal Nitrogen (AN) | 35  | 4 – 80 |
| Total Nitrogen (TN) | 750  | 80 – 1,400 |

Note: *All parameters units in mg/l except pH. (Thani et al., 1999)
### 2.2 Principle of aerobic digestion

Aerobic digestion of wastewater sludge is defined as the stabilization process in which the aerobic microorganisms consume the biological degradable organic component of the sludge. The main objectives of aerobic digestion are to produce biological stable product and to reduce both sludge mass and volume (Bernard and Gray, 2000). Aerobic digestion for the sludge from the municipal wastewater treatment plant (WWTP) is the continuation of sludge process. The condition of the process is endogenous condition. When the aerobic heterotrophic microorganism is presence and there is a source of organic material, it will degrade and remove the material.

About one quarter of the organic material is being removed. The removal organic material function is to utilize the synthesis of new microorganism. This will lead to increase in biomass. The other material left will be oxidized to carbon dioxide, water and soluble inert material. Their function is mainly to provide energy for the microorganism’s vital function. Once there is no more source of organic material, endogenous respiration will occur where the cellular material is being oxidized to get the energy required. The total quantity of biomass will be reduced and the remaining material will exist at a low energy state if the condition is maintained over a period of time. The product is considered as biologically stable and suitable to be dispose to the environment (Zupancic and Ros, 2008).
2.3 Previous study

There are various treatment schemes that are currently used by the Malaysian palm oil industry which is anaerobic facultative ponds, tank digestion and mechanical aeration, tank digestion and facultative ponds, decanter and facultative ponds and the physico-chemical and biological treatment. Aerobic digester is used to treat activated sludge. The start-up reactor consists of seeding phase, acclimatization phase and biomass build-up phase.

In this previous study, microflora was added to the activated sludge during the seeding phase. The reactor also fed with nutrients such as Ni, Co, K, Fe and Ca. The process then proceeds to the acclimatization phase. Ten litre of wastewater consists of POME and cow dung was added into the seed microflora for a hydraulic retention time of 1 week. The addition was repeated until the operating level liquid is about 91L. At the end of the process the biomass concentration (MLSS) was found to be 2370 mg/l. In order to have the desired concentration, the biomass build-up phase was carried out.

The biomass build-up phase was carried out in order to maintain the MLSS concentration of about 3900 ± 200 mg/l. At the end of this study, the data of each parameter have been recorded. In the case of the aerobic oxidation of diluted raw POME at the end of the 60 hours of hydraulic retention time (HRT), the COD and $BOD_5$ removals were found to be 89% and 82% with residual oil and grease and TKN values of 112 and 3 mg/l respectively. The DO concentration, pH and Si ranges between 1.8 and 2.2 mg/l, 7% and 8.5% and 1.1% and 1.9% respectively during the operation of the activated sludge reactor (Vijayaraghavan et al., 2007).
2.4 Limitations

Aerobic digestion had been used widely to treat POME around the world. However, there are limitations for this type of treatment. The main limitation of aerobic treatment is the energy cost of aeration at an adequate rate to maintain the oxygen levels needed. This will increase the operating costs. Apart from that, the process is dependent on the temperature. During the cold weather, the efficiency of the process is reduced. Moreover, methane gas, which is a useful by-product, is not produced during this type of treatment. The concentration of solids, type of sludge, location and type of mixing aeration system can affect the performance of the aerobic digestion (Turovskiy and Mathai, 2006).
3.0 Methodology

3.1 Sample Collection

The sample of palm oil mill effluent (POME) was collected from the Bau Palm Oil Mill. Total sample collected was 10 Litre. The analysis was carried out in the same day to avoid the degradation of POME. The first sampling was on 24\textsuperscript{th} November 2011. The second sampling was on 20\textsuperscript{th} February 2012 and the third sampling was on 19\textsuperscript{th} March 2012.

3.2 Experimental Design

Overall, the experimental design was to monitor the changes of the quality of POME weekly. Each parameter BOD, COD, TSS, VSS and Oil and Grease were analyzed weekly for the next four weeks. We want to see the changes of the profile of BOD, COD, TSS, VSS, and Oil and Grease when the sample were being provided with oxygen by using air pump and applying temperature of 55\textdegree C using water bath. Thermometer is used to check the temperature. Condenser is used to prevent the water in the POME samples from evaporate.
3.3 Quality Control

In order to ensure the reliability of this study, we make six replicates for each parameter. Apart from that, we will also set a controlled experiment. Condenser was used to prevent the evaporation of water from the sample. The sample was aerated with air pump to maintain oxygen in the sample and the sample was subjected into 55°C temperature using water bath and it was measured using thermometer.

3.4 Material

Vacuum filtration, Electronic balance, Thermometer, Beaker, Separatory funnel, Measuring cylinder, Oven, Furnace, Water Bath, Filter paper, Ferrous ammonium sulphate, N-hexane, Sulfuric acid, Deionized water, Ferroin indicator, Magnesium Sulphate, Calcium Chloride, Ferric Chloride, Sodium Sulphate, Potassium Dichromate, Hydrochloric acid, Mercury sulphate
3.5 Analytical Method (Apha, 1992)

3.5.1 Biochemical Oxygen Demand (BOD₅)

BOD₅ was measured according to BOD₅ Test of Standard Method (5210B) (APHA, 2005. The POME sample will be diluted in this analysis. 1 ml of POME sample is diluted in 100 ml volumetric flask. Then, 10 ml of the diluted POME is further diluted in 1000 ml volumetric flask. In this flask, add 500 ml of seed that have been prepared and dilute until the mark reached for 1000 ml volumetric flask. The initial DO was determined shortly after the dilution. The bottle was wrapped with aluminium foil to avoid the light and incubated at 20 ± 1 °C for 5 days. The final DO was taken with DO meter after 5 days.

Preparation of seed:

To prepare a seed with volume of 2 Litre, we must dilute all the material until it reached 2 Litre. The constituents of the seed are phosphate buffer solution, magnesium sulphate solution, ferric chloride solution, and calcium chloride solution. For phosphate buffer, dissolves 8.5g of KH₂PO₄, 21.75g of K₂HPO₄, 33.4g of Na₂HPO₄.7H₂O, and 1.7G of NH₄Cl in distilled water. For magnesium sulphate solution, dissolve 22.5g of MgSO₄.7H₂O into distilled water. For ferric chloride solution, dissolve 0.25g of CaCl₂ into distilled water. Mix all the solution in a 2 Litre volumetric flask. The seed was aerated for one day before it can be used. For this analysis, we made six replicates to ensure accuracy.
Calculation for BOD₅ Days analysis:

\[
\text{Seed} = \frac{\text{Initial DO} - \text{Final DO}}{2}
\]

\[
\text{BOD}_5 \text{ (mg/L)} = (\text{Initial DO} - \text{Final DO} - \text{Seed}) \times 10000
\]

### 3.5.2 Chemical Oxygen Demand (COD)

Culture and caps was washed with 20% H₂SO₄. 2.5 ml of sample and 2.5 ml of deionized water was poured into two culture tube. 1.5 ml of digestion solution was added and 3.5 ml of sulfuric acid reagent was run down inside the vessels. The tube was capped and inverted several times to mix the mixture. The tube was placed in block digester preheatd to 150°C and refluxed for 2 hours. The tubes were cooled to room temperature. The sample was measured spectrophotometrically at 600nm.

Preparation of digestion solution:

4.913g Potassium dichromate was dried at 103°C for 2 hours. Dried potassium dichromate was mix with 500 mL distilled water. Then the mixture was dissolved with 167 mL concentration sulphuric acid and 33.3g Mercury sulphate. The mixture was cooled and dissolved to 1000 ml.
Table 3: Sample and Reagent quantities for various digestion vessels

<table>
<thead>
<tr>
<th>Digestion vessel</th>
<th>Sample mL</th>
<th>Digestion Solution mL</th>
<th>Sulfuric Acid Reagent mL</th>
<th>Total Final Volume mL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Culture tubes:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 × 100 mm</td>
<td>2.5</td>
<td>1.5</td>
<td>3.5</td>
<td>7.5</td>
</tr>
<tr>
<td>20 × 150 mm</td>
<td>5.0</td>
<td>3.0</td>
<td>7.0</td>
<td>15.0</td>
</tr>
<tr>
<td>25× 50 mm</td>
<td>10.0</td>
<td>6.0</td>
<td>14.0</td>
<td>30.0</td>
</tr>
<tr>
<td>Standard 10mL ampules</td>
<td>2.5</td>
<td>1.5</td>
<td>3.5</td>
<td>7.5</td>
</tr>
</tbody>
</table>

3.5.3 Oil & Grease

Liquid – liquid partition method will be used to determine the value of oil and grease in the POME sample. Hexane was use to extract the sample. Oil and grease content of sample can determine after removal of hexane. For this analysis, we made six replicates. The volume of sample used is 250ml. The equation that was used to calculate the value of oil and grease is shown below:

\[
\text{Oil and Grease Mg/L} = \frac{W_r (mg)}{Vs (L)} \times 1000
\]

- \(W_r\) (mg) = \(W_f - W_i\)
- \(W_f\) (mg) = Weight empty flask + weight extraction
- \(W_i\) (mg) = Weight empty flask
- \(Vs\) (L) = Initial sample volume
3.5.4 Total suspended solid

The filtering apparatus was set up. The membrane filter was weighed using an electronic balance. The membrane filter is placed onto the filter support and the clamp the funnel over the membrane filter. 5ml of the sample POME is poured into a beaker. The POME sample was shaken before pouring it into the measuring cylinder. 5ml of POME sample was pour into the filter funnel slowly and switch on the vacuum pump. The pump was stopped once all the water is drained out.

The membrane filter is removed with a forceps. The membrane filter is dried in an oven at 103°C for 2 hours. For this analysis, six replicates were made. The dried membrane filter is weighed using the electronic balance. The value of TSS (Total suspended solid) is calculated using the formula as below:

\[
TSS \text{ (mg/L)} = \frac{(\text{Final weight (mg)} - \text{Initial weight (mg)}) \times 1000}{\text{volume of sample (L)}}
\]

- Initial Weight (mg) = Clean filter paper
- Final Weight (mg) = Filter paper + Solids