

Filtration of Palm Oil Milling Effluent (POME) using Kenaf

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Abstract - Palm Oil Mill Effluent (POME) is a waste water generated that contains huge amount of toxicity because of its high content of heavy metals, discharged from sterilization process, crude oil clarification and cracked mixture separation process. Due to its chemical content, POME is not suitable to be released to nature as it will inhibit natural life. On the other hand, Kenaf is a southern Asia-native plant that are now world-widely used as pulp and paper manufacturing. Some studies have stated the potential ability of kenaf to be used as a filter material, with cost effective factor is in play. This paper will demonstrate the ability of kenaf as filter, in pretreating POME.

I. Introduction

Kenaf is a plant that is probably native in southern Asia, though its exact natural origin is relatively unknown ("Hibiscus Cannabinus - Zipcodezoo"). The plant is known to be used as an allied fiber in jute worldwide. The name of the plant also applies to the fiber obtained from this plant. In United States, the research to use the kenaf bast (outer bark) fibers for rope began in the 1940's when jute imports from Asia were briefly interrupted by World War II. In the 1950's, the Agricultural Research Service (ARS) of the U.S. Department of Agriculture screened more than 500 plant species as potential fiber sources for pulp and paper manufacturing. As a result, kenaf was selected as the most promising non-wood fiber plant for this use.

Kenaf are also cost effective if it is used in filtration system, as kenaf does not need to undergo pretreatment processes before shaped and used directly in the filter as soon as it has been shaped. Filtration is by definition, any of various mechanical, physical or biological operations that separate solids from solids by applying a medium through where only fluid are to pass.

The fluids that have flowed through the system are called filtrate. In physical filters oversize solids in the fluid are detained and in biological filters are trapped and removed. Filtration occurs in both naturally and engineered system, in form of biologic, geologic and industrial. For instance, renal filtration in humans (and animals) removes wastes from blood. Comparatively, in water treatment and sewage treatment, unwanted components are separated by adsorption into a biological film grown on or in a filter medium.

There are different methods in attain the separation of substances. The substance that is move through the filter must a liquid or gas. The waste water that is included in this research is POME which is palm oil milling effluent. The waste water is discharged from sterilization process, crude oil clarification and cracked mixture separation process. POME is dangerous if untreated, as anaerobic process will release methane gas and has 21 times Global Warming Potential (GWP) when compared to any other gasses.

Biogas is promising, but the utilization in Malaysia is still in a very early stage, if it can be utilized as fuel for power generation and co-generation. Kenaf fibre should be able to filtrate organic materials contained in the POME and with further simple downstream processes, clean water or drinkable water should be able to be retrieve from POME.

II. Material and Methods

A. Filtration

The materials that involved are POME, kenaf filter and a weak acid which dilute Hydrochloric Acid (37 % concentration). POME used was obtained from Felda Sungai Tenggi Palm Oil Mill, Kuala Kubu Baru, Selangor and with pH 7. The kenaf in used has been reshaped into a proper form of filter to be able to perform filtration and adsorption process.



Figure 1: Kenaf filter

The method used for this research is filtration process. Filtration process is a process where a liquid flow to a system where a filter is attached to the system. The filter functions to allow components which have smaller sizes flow through it, and resist any of those components with a size that are bigger or larger than the pore size of the filter.

The usage of the filter is dependent on the size of the components that are to be filtrate, and therefore the

type of the filter is also need to be determined as the biggest pore size of a filter cannot filter out smaller molecules (if they need to be removed) and the use of a smallest pore size of a filter can definitely remove a very small molecule, but it will be unnecessary if a bigger pore size of a filter is sufficient to remove the unwanted substance in the liquid. Depending on the material of the filter, the filter will also have an adsorption effect on the liquid flown through it.

In this case, kenaf fiber (in filter form) is tested on its adsorption abilities, where the adsorption process will minimise the chemical oxygen demand (COD) as well as turbidity and heavy metal content. The kenaf fiber has been shaped as a filter in a system. The method used is where the raw POME sample is being placed in an empty tank. The experiment begins when raw POME pumped into the filtration tank before flow through a sedimentation and finally move into the recycle stream into the input tank for 25 minutes. The sample has been collected for every 5 minutes for each pH (pH 6 and pH 7). The samples are then to be examined in terms of particle size, color, turbidity, COD, heavy metal concentration and Total Suspended Solid (TSS).

Turbidity, according to American Public Health Association in APHA method 2120A, is the amount of suspended matter that affects the clearness of the water. This means that the higher the amount of suspended matter, the higher the turbidity of the liquid respectively. Turbidity is measured by using a turbidity meter. Total suspended solid is the total of all undissolved solids in a liquid be it a mixture or pure solution. Color testing is used to detect the amount of organic materials that have been dissolved in the liquid. The color of the sample is measured by the using the PtCo measurement for both sample in pH 6 and 7. The equipment used to measure the color, COD and TSS are Spectrophotometer. COD is the amount of oxygen that it takes to oxidize the organic matter in the respective liquid.

This means that the lower the amount of the COD, the lower the content of organic matter contained in the liquid. The concentration of heavy metals like Pb, Ba and Ca are measured by using an equipment named ICP-OES or Inductively Coupled Optical Emission Spectrometry. The particle size analyzer is used in this research to obtain the particle size in the filtrated POME for both pH 6 and 7 samples.

III. Result

a. TSS

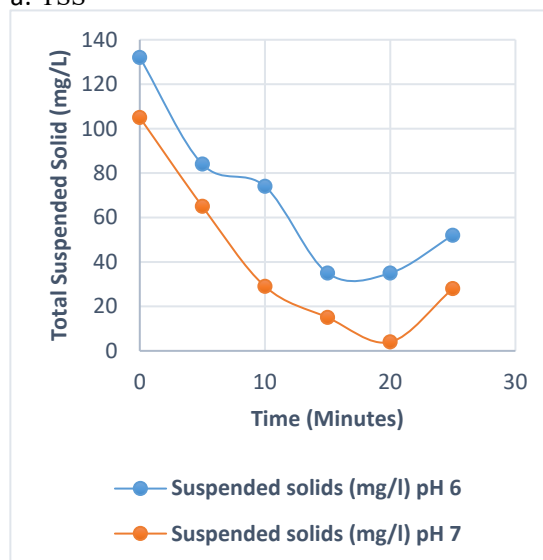


Figure 2: TSS (mg/L) vs Time (minutes)

As seen above, the total suspended solid in pH 6 is higher than pH 7 through the whole 25 minutes. The initial value of TSS with pH 6 is 105 mg/l while it is 132 mg/l. At the final 25th minute, the value for sample in pH 6 and pH 7 is 28 mg/l and 52 mg/l respectively.

b. Color

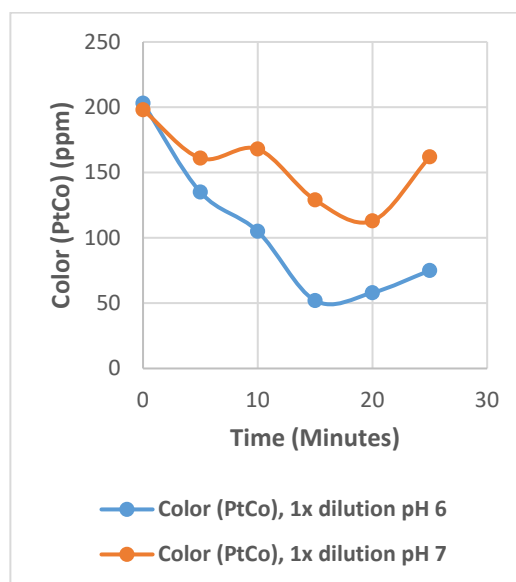


Figure 3: Color (PtCo) (ppm) vs Time (Minutes)

From the graph above, it is acquired that the color measured in PtCo in pH 6 is significantly lower than in pH 7. The value at zero minute of the sample in pH 6 is 203 ppm which is slightly higher than the sample in pH 7 (198 ppm). In the final 25th minute, the value of the sample (pH 6) is 75 ppm. This value shows a major

difference in comparison to the sample in pH 7 which is 162 ppm.

c. Turbidity

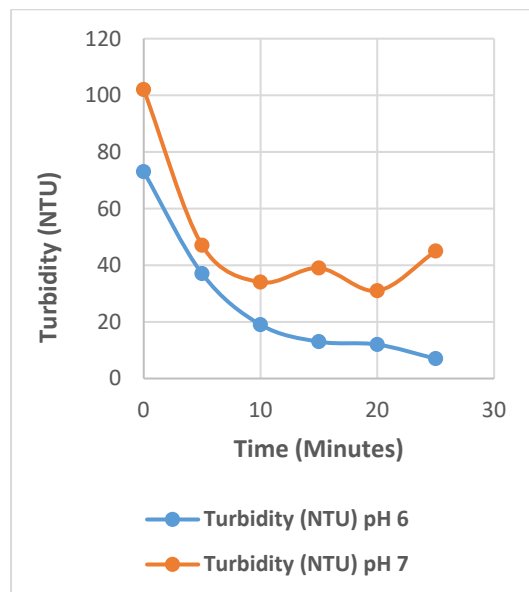


Figure 4: Turbidity (NTU) vs Time (minutes)

Figure 4 shows that the turbidity of both sample of pH 6 and pH 7 follows the same trend which is decreasing along time. Another noticeable point that can be seen in the figure above is that, the value of turbidity on pH 6 is lower at all times. The initial value for pH 6 is 73 NTU, that is far lower than the initial value for pH 7 which is 102 NTU. The end-value for pH 6 at 25th minute is 7 NTU and 45 NTU for pH 7.

d. Chemical Oxygen Demand

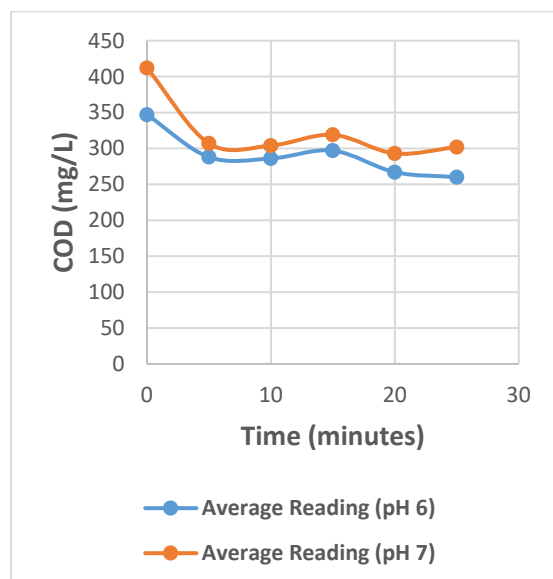
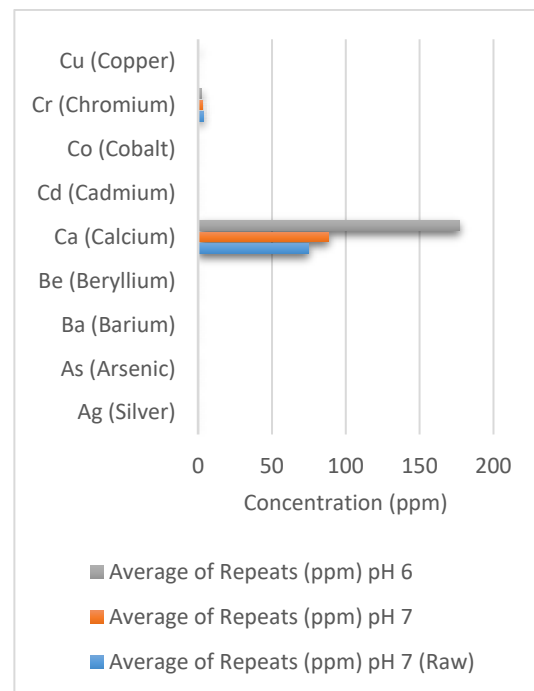


Figure 5: COD (mg/l) vs Time (minutes)

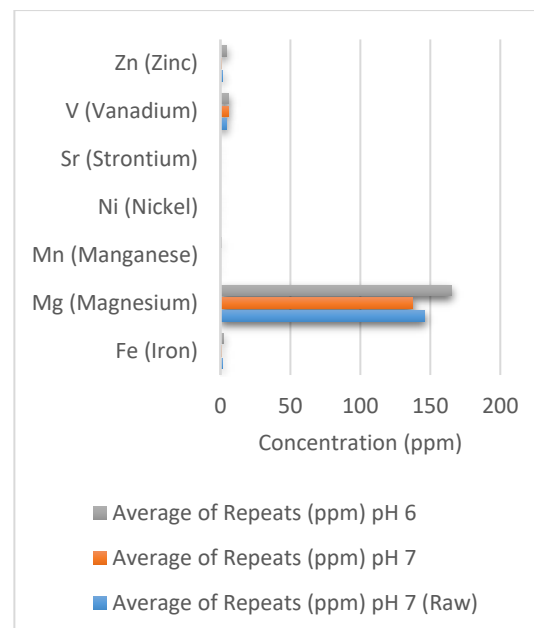
The trend of for both pH 6 and pH 7 are appeared to be similar, although their values are only marginally differ from each other. The average COD value at zero

minute for pH 6 are 347 mg/l and pH 7 with the value 412 mg/l. At last 25th minute, both COD value have diminished to 260 mg/l and 302mg/l respectively.

e. Heavy Metal



Bar Chart 1: Concentration of Heavy Metal (ppm)



Bar Chart 2: Concentration of Heavy Metal (ppm)

As seen on the two figure above (figure 6 and 7), the POME that have been filtered by the kenaf filter shows very little or no concentration of heavy metal with the exception of Magnesium and Calcium on both sample. However, the concentration of heavy metal in the sample of pH 6 is seemed to be higher. For the raw, neutral POME, the concentration of heavy metals are as follows:

Element	Average of Repeats (ppm)
Ag (Silver)	0.21
As (Arsenic)	0
Ba (Barium)	0
Be (Beryllium)	0
Ca (Calcium)	74.9114
Cd (Cadmium)	0
Co (Cobalt)	0
Cr (Chromium)	3.34607
Cu (Copper)	0
Fe (Iron)	1.34617
Mg (Magnesium)	146.134
Mn (Manganese)	0.106756
Ni (Nickel)	0
Sr (Strontium)	0.0209368
V (Vanadium)	4.11333
Zn (Zinc)	1.17549

Table 1: Concentration of Heavy Metal of sample pH 7 before experimentation.

At the 25th minute mark, the concentration of heavy metals in the pH 7-sample are as the following:

Element	Average of Repeats (ppm)
Ag (Silver)	0
As (Arsenic)	0
Ba (Barium)	0
Be (Beryllium)	0
Ca (Calcium)	88.0331
Cd (Cadmium)	0
Co (Cobalt)	0
Cr (Chromium)	2.65621
Cu (Copper)	0
Fe (Iron)	1.01902
Mg (Magnesium)	137.572
Mn (Manganese)	0
Ni (Nickel)	0
Sr (Strontium)	0
V (Vanadium)	5.48235
Zn (Zinc)	0.483966

Table 2: Concentrations of Heavy Metal of sample (pH 7) on 25th minute.

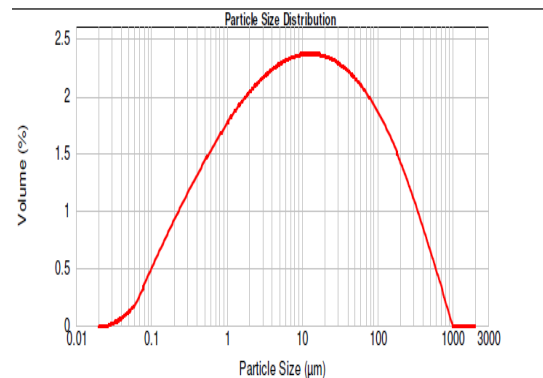
And the next data below shows the concentration of heavy metal on filtrated POME sample with pH of 6 at the 25th minute.

Element	Average of Repeats (ppm)
Ag (Silver)	0
As (Arsenic)	0
Ba (Barium)	0.0142644
Be (Beryllium)	0
Ca (Calcium)	177.007
Cd (Cadmium)	0
Co (Cobalt)	0
Cr (Chromium)	2.50686
Cu (Copper)	0.576885
Fe (Iron)	1.92787
Mg (Magnesium)	165.014
Mn (Manganese)	0.828135
Ni (Nickel)	0
Sr (Strontium)	0.262986
V (Vanadium)	5.90681
Zn (Zinc)	4.10655

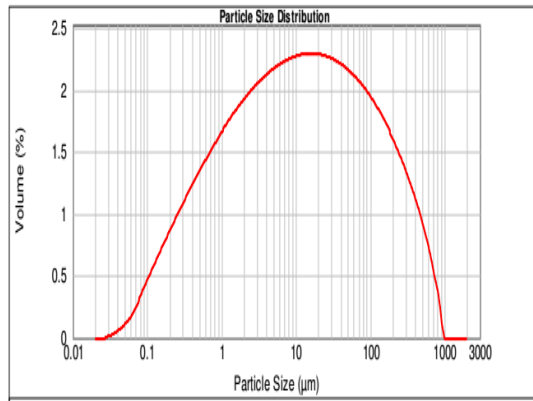
Table 3: Concentration of Heavy Metal of sample (pH 6) on 25th min ute

In unison, the concentration of heavy metal in pH 7 (raw), pH 6 and pH 7 (25th minute) sample are completely differ from each other. In pH 7 sample, there are zero concentration for 10 types heavy metal, where in pH 6 sample, there are zero concentration for 6 types of heavy metal. In addition to that, in the pure POME, pH 7 before experimentation, there are 7 types of heavy metal that with zero concentration.

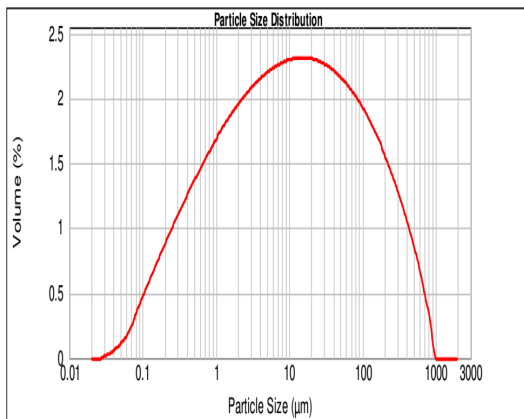
f. Particle Size



Graph 1: Volume (%) vs Particle Size (μm) for pH 6 sample on 25th minute



Graph 8: Volume (%) vs Particle Size (μm) for pH 7 sample on 25th minute



Graph 9: Volume (%) vs Particle Size (μm) for pH 7 sample on 25th minute

In comparison, the three graphs above are identical to each other with the highest peak of the curve is 15 μm in size with the percentage of 2.5 % in volume. The tables below (4 to 9) demonstrates the difference of particle sizes in detail at specific micrometer.

Size	Volume In % (pH 7 raw)	Volume In % (pH 7)	Volume In % (pH 6)
0.01			
0.12	2.05	2.02	2.14
0.23	3.27	3.22	3.41
0.34	2.71	2.67	2.83
0.45	2.46	2.43	2.57
0.58	2.09	2.06	2.18
0.67	1.39	1.37	1.45
0.78	1.53	1.51	1.60
0.89	1.39	1.37	1.44
0.95	0.70	0.69	0.73
1.00	0.56	0.55	0.59
1.132	1.39	1.37	1.45

Table 4: Particle Size comparison from 0.01 μm until 1.132 μm

Size	Volume In % (pH 7 raw)	Volume In % (pH 7)	Volume In % (pH 6)
1.132			
1.282	1.43	1.41	1.49
1.452	1.47	1.45	1.53
1.644	1.51	1.49	1.57
1.862	1.55	1.53	1.61
2.108	1.58	1.56	1.65
2.387	1.62	1.60	1.68
2.703	1.65	1.63	1.71
3.061	1.68	1.66	1.74
3.466	1.71	1.68	1.77
3.924	1.73	1.71	1.79
4.444	1.76	1.73	1.82

Table 5: Particle Size comparison from 1.132 μm until 4.444 μm

Size	Volume In % (pH 7 raw)	Volume In % (pH 7)	Volume In % (pH 6)
4.444			
5.032	1.78	1.76	1.84
5.698	1.80	1.78	1.86
6.452	1.82	1.80	1.88
7.306	1.83	1.81	1.89
8.273	1.85	1.83	1.90
9.368	1.86	1.84	1.91
10.607	1.87	1.85	1.92
12.011	1.87	1.86	1.92
13.601	1.88	1.86	1.92
15.401	1.88	1.87	1.92
17.439	1.88	1.87	1.92

Table 6: Particle Size comparison from 4.444 μm until 17.439 μm

Size	Volume In % (pH 7 raw)	Volume In % (pH 7)	Volume In % (pH 6)
17.439			
19.474	1.88	1.86	1.91
22.361	1.87	1.86	1.90
25.320	1.86	1.85	1.89
28.671	1.85	1.84	1.88
32.466	1.84	1.83	1.86
36.762	1.82	1.82	1.84
41.628	1.80	1.80	1.81
47.137	1.78	1.78	1.78
53.375	1.76	1.76	1.75
60.439	1.73	1.73	1.72
68.438	1.70	1.71	1.68

Table 7: Particle Size comparison from 17.439 μm until 68.438 μm

Size	Volume In % (pH 7 raw)	Volume In % (pH 7)	Volume In % (pH 6)
68.438			
77.496	1.67	1.68	1.64
87.752	1.63	1.64	1.59
99.366	1.59	1.61	1.55
112.517	1.55	1.57	1.49
127.408	1.50	1.52	1.44
144.270	1.45	1.48	1.38
163.364	1.40	1.43	1.32
184.964	1.34	1.38	1.25
209.466	1.28	1.32	1.18
237.188	1.22	1.25	1.11
268.580	1.15	1.20	1.03

Table 8: Particle Size comparison from 68.438 μm until 268.580 μm

Size	Volume In % (pH 7 raw)	Volume In % (pH 7)	Volume In % (pH 6)
268.580			
302.125	1.08	1.13	0.95
344.375	1.01	1.06	0.86
389.952	0.93	0.96	0.77
441.561	0.85	0.90	0.68
500.00	0.76	0.81	0.59

Table 9: Particle Size comparison from 268.580 μm until 500.00 μm

From table 4 until 6, it is seen that a range from 0.01 μm until 17.349 μm , the percentage in volume for sample with both raw pH 7 and pH 7 at 25th minute is slightly lower than those in pH 6. From 17.349 μm onwards, the percentage of volume in pH 6 lower than pH 7 (raw and 25th minute).

IV. Discussion

The results obtained are conclusive, that even a slight change in pH, will affect the performance of kenaf filter on POME pretreatment via filtration and/or adsorption. The change in pH is caused by the high contents of cation and anion in the fluid content. With the difference of ions, it affected the kenaf filter ability to adsorb and filter undesired materials in the POME.

V. Conclusion

In conclusion, although that the kenaf filter was able to perform rather the kenaf filter was able to perform better in lower pH of 6 rather than neutral pH 7. As a suggestion, the POME should be filtered first on neutral pH of 7 to immensely decreases the concentration of heavy metal as the result shows that a pH 6 sample contains higher concentration of heavy metal than those in pH 7 sample. After the neutral pH 7 sample being filtered, the filtered neutral POME should entered an acidification tank, before moving on to filtration process again, using kenaf filter again, in order to achieve a very low concentration of heavy metals, turbidity, color, COD, TSS, and particle size.

VI. References

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