Leafy Vegetables Waste Leachate Treatment by Using Newly Developed Flat Sheet Membrane

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DOI: 10.29322/IJSRP.8.3.2018.p7513
http://dx.doi.org/10.29322/IJSRP.8.3.2018.p7513

Abstract— Vegetable waste is one of the types of food waste that can contribute to leachate production. Different characteristics of leachate produce from a different type of waste. Leafy vegetables waste (LVW) has a high tendency to accumulate heavy metal, for example, Cadmium (Cd). Leachate produced from leafy vegetable waste should be treated specifically alone instead of mix with another type of food waste. Treatment of leachate by using conventional method is no longer suitable to comply with the more stringent discharge standards. This study determines and quantifies the amount of leachate produced from different amount leafy vegetables waste. Experimental was conducted to determine the quality of leachate generated by the effect of leafy vegetables waste age from 8 parameters of water quality which are pH, turbidity, colour, suspended solids, COD, BOD, Cd and Nitrate. In this study, a newly fabricated flat sheet membrane had been using to treat leafy vegetable leachate to determine suitability and effectiveness of the membrane in treating leachate. The material used in this study was Polysulfone (PSF), Polyvinylpyrolidone (PVP) and N, N-dimethylacetamide (DMAC). Formulation of dope used in this study based on the past literature review. Based on weight percentage (wt %) for PSF: DMAC: PVP composition, the formulation was 18:69:13. The suitability and effectiveness of membrane filtration method in the treatment of leafy vegetable leachate were measured by computing the percent removal of the contaminants. From the results obtained, it shows that membrane that had been fabricated was Ultrafiltration (UF) membrane. This membrane is suitable for pre-treatment process, and further treatment is needed to improve the quality of discharged to comply with the standard based on the result of this study.

Index Terms— *Leafy vegetable waste, Leachate, PSF, PVP, DMAC*

INTRODUCTION

Rapid development keeps increasing the amount of Municipal Solid Waste (MSW). 60% of the MSW is food waste, and it makes up the highest contribution [1]. Food wastes in Malaysia contain high moisture which can lead problem in disposal for example in a landfill site. Leachate is the contaminated liquids that build up in the landfill site, produced during the decomposition or biodegradation process when water seeps through the ground cover and flows out the landfill [2,3,4].

Vegetable waste is one of the types of food waste. Vegetable wastes have a characteristic of a high percentage of water content especially leafy vegetable because it poses a large number of cell saps [5]. Therefore, it will lead to severe adverse impacts on landfill such as nuisance smell and abundant leachate production. Since leafy vegetable has high moisture content and shorter shelf life, it would be the primary production of leachate. Leachate produced from leafy vegetable waste should be treated alone since it contributes high generation in the production of food waste. The production of leachate from leafy vegetable waste will be treated by using membrane technology since it is has been successful in treating leachate produced from MSW. The composition of membrane used in this study is based on the past research. The treatment is known as leafy vegetable waste leachate by using newly developed flat sheet membrane.

EXPERIMENTAL PROCEDURE

A. Production of LVW leachate

The production of LVW leachate is prepared and collected in the laboratory. The process of production starts with the LVW collection. After the collection, it continues with the preparation of leachate reactor as the storage of the leachate. Preparation of LVW in the meantime should be done so that it can be stored directly into the leachate reactor. This is because leafy vegetables have high tendency to damage and to avoid the volume of leachate generated affected it should be stored directly. As the LVW stored in the reactor, it will decompose and form raw leachate. Then, the leachate produced in the reactor is collected once in two days. The raw leachate produced is tested to characterise the quality of the leachate.

B. Fabrication of Flat Sheet Membrane

There are several steps in membrane fabrication process including preparation of the dope solution, casting of the membrane, coagulation bath process and solvent exchange drying process. Each step needs to be done accordingly so that the membrane with the suitable condition could be made. This membrane fabrication had been done at room temperature on Membrane Laboratory, Faculty of Civil Engineering UiTM. The membrane that has been produced from the fabrication process should be characterised based on the membrane pore size produced. Membrane pore size is determined by the experimental method of the rejection polymeric molecules by using Polyethylene Glycol (PEG) which has a range of sizes. In this study, five different of molecular weight cut off has been used to determine the membrane pore size.

C. Treatment of Leachate by Using Flat Sheet Membrane

The sample of leachate is taken from each of the reactors. Chemical and physical parameters were tested on the raw leachate before and after the treatment in Environmental Laboratory. Then, the membrane used to filter the sample of the

leachate. This step is repeated by using another sample of leachate.

RESULT AND DISCUSSION

The first part of the result quantifies the amount of leachate produced from a different amount of leafy vegetable waste. Then, the second part discussed the effect of leafy vegetables waste age on quality of leachate generated. The third part discussed the effective treatment using flat sheet membrane for organic removal in vegetable waste leachate.

D. Effect of Waste Age on Leachate Production

Volume generated from leachate production is depending on the amount of leafy vegetable waste used in this study.

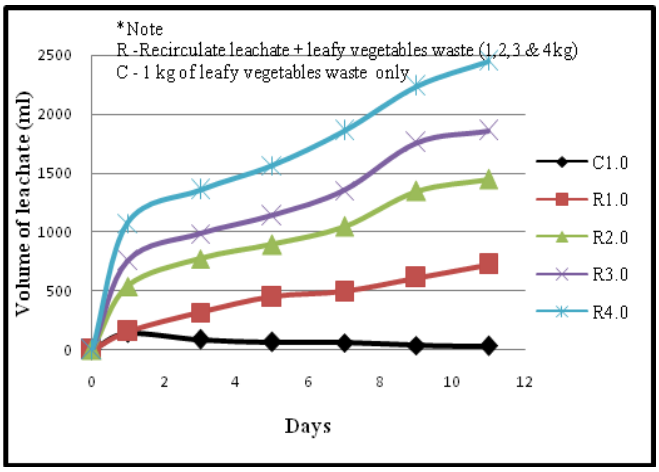


Figure 1: Production of Leachate

Based on Figure 1, it shows that production of leachate is rapidly increased within 11 days of the experiment. Low production of leachate is shown on the first day as the small portions only degradation process occurs. A study state that organic matter is changed into carbon dioxide and water by aerobic decomposition process [6]. Besides that, moisture content in the leafy vegetable waste caused the leachate generated instead of the decomposition process. The increasing production of leachate because in the early stage leafy vegetable waste has a vast amount of biodegradable organic matter.

Amount of waste used in this study affects the generation of leachate production. Maximum production of leachate is sample R4 which has the highest quantity of waste and a maximum period of decomposition of waste compared to another sample. Sample R4 with 4kg of waste on Day 11 produced 2,450 ml of leachate. Since leafy vegetable waste has a characteristic of high water content, it indicates that large quantity of waste will produce a high amount of leachate due to the high water content in the waste [5].

E. Effect of Waste Age on Quality Leachate Production

The leachate generates from decomposition process had been analysed based on water quality parameter. The quality of leachate is highly variable. A parameter that had been analysed were pH, turbidity, colour, SS, BOD5, COD, nitrate and Cd. For physical properties, parameters that had been studied were pH, colour, turbidity and total suspended solids. pH values for leafy vegetable leachate were varied between 6.14-8.33.

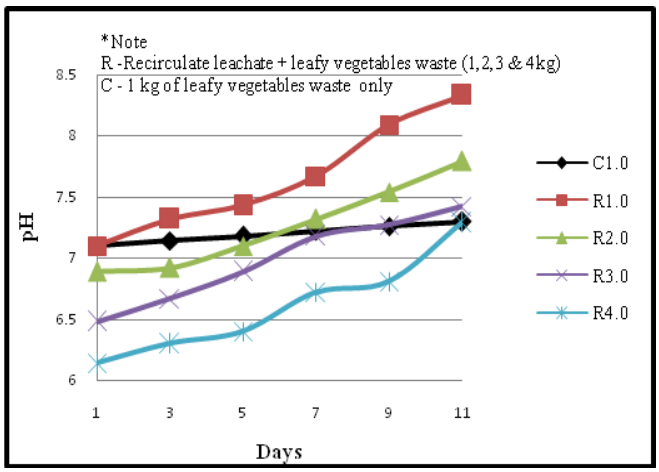
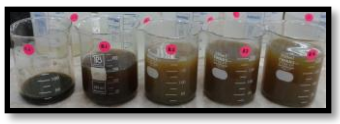


Figure 2: Effect on pH

The first leachate physical property is pH. During first three days, it shows low of pH value as it is in the young stage of leachate. Young leachate pH is less than 6.5 which is acidic while old landfill leachate is higher than 7.5 which is alkaline [7]. Besides that, young waste has low pH because when high content of food waste in MSW, the rapid food waste hydrolysis results in the imbalance of anaerobic metabolism in the waste layer and indicate VFA accumulation and a decrease of pH value.pH value for all the sample is increasing based on Figure 2. pH value of the leachate continues to increase as the decomposition process going on. Besides that, this pH value was depending on the age of the leachate been produced.

a) Day 1



b) Day 11

Figure 3: Colour observation on a) day 1 and b) day 11

Next leachate physical property is colour. Based on the results obtained, the leachate colour is turning from light brown to blackish brown. Figure 3 shows the change in colour of leachate for sample C1, R1, R2, R3 and R4 from day 1 and day 11. Physical colour observation of sample leachate on day 1 shows light brown colour while on day 11 it turns to blackish brown colour. Presence of humic substance in landfill leachate, which accounts for most organic components cause changing colour of leachate to dark colour [8].

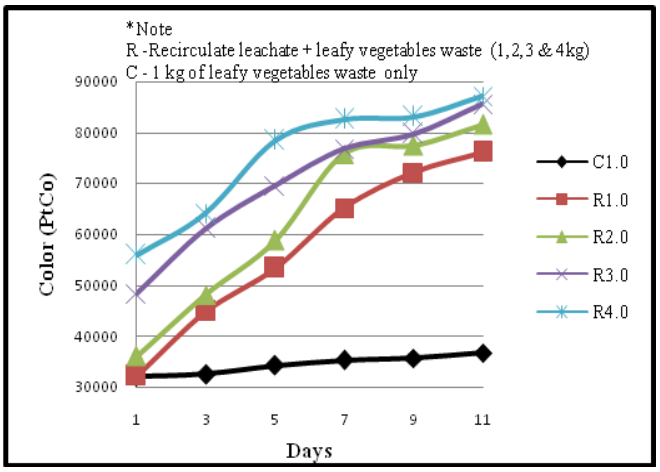


Figure 4: Effect of Colour

Based on Figure 4, R4 has the highest colour of leachate with 87,200 PtCo on day 11. While the lowest value of colour was recorded for C1 on day 1 with a value 32,200 PtCo. Based on Figure 4, it shows that the colour of leachate sample rapidly increases as the amount of waste increase except for the sample C1. The high leachate colour indicates that the leachate contains a high level of an organic substance such as humic and fluvic compounds [7].

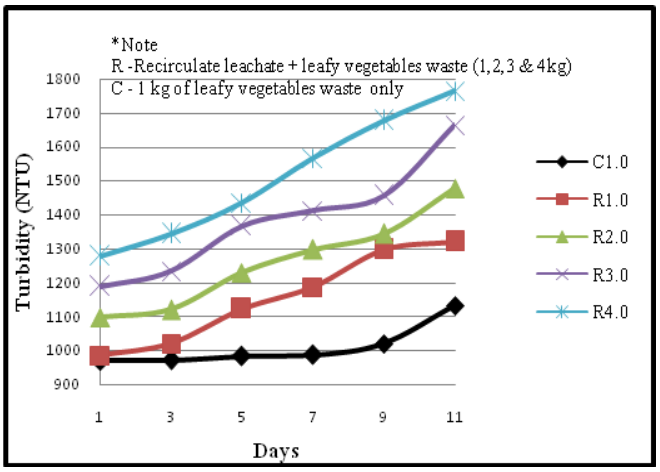


Figure 5: Effect on Turbidity

For the third leachate physical properties is turbidity. From Figure 5 turbidity of all sample leachate increase significantly except for sample C1. Sample R4 shows the highest turbidity with 1765 NTU on day 11 while the lowest turbidity is sample C1 with 970 NTU. High turbidity of leachate due to the landfill age and stabilisation of leachate [9].Since the production leachate in this study for 11 days, it proved that the highest turbidity is R4 on day 11. High turbidity also affects the amount of waste used as the sample R4 use 4kg of waste. High organic matter in leachate also caused the high in turbidity [10].

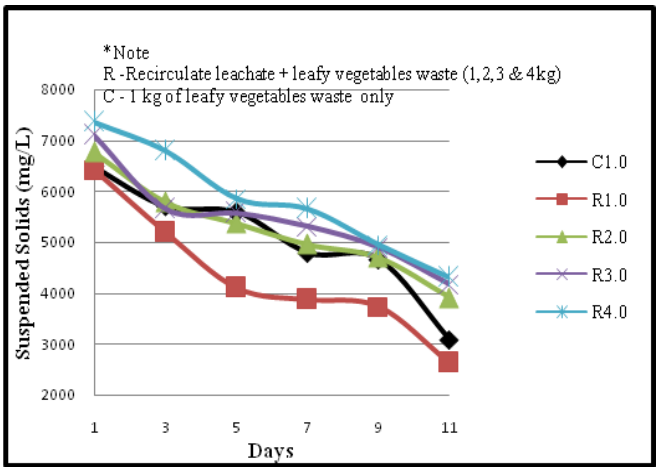


Figure 6: Effect on Suspended solids

The last leachate physical property is suspended solids. The value of suspended solid ranged from 2,650 mg/L to 7,370 mg/L. Based on Figure 6, suspended solid in all sample decrease steeply. All samples gives high result of SS on day 1 which are 6,430 mg/L, 6,500 mg/L, 6,780 mg/L, 7,120 mg/L and 7,370 mg/L for sample C1, R1, R2, R3 and R4 respectively. But in day 11 suspended solid for all sample decrease steeply with the result 2,650 mg/L, 3,100 mg/L, 3,920 mg/L, 4,320 mg/L and 7,370 mg/L for sample C1, R1, R2, R3 and R4 respectively.The high amount of waste reduced the suspended solid in each of the samples. This is because the high amount of waste needs longer time to decompose the waste. In similar to deeper landfill require a longer time for decomposition process [6].

As a conclusion for physical properties, colour and turbidity concentration are increasing for all sample for the 11 days of the decomposition process. From the data obtained, it shows that R4 sample with the highest amount of waste that is 4kg generate the highest concentration of colour and turbidity. This is true for the high value of turbidity would affect to value of colour for sample R4. However, these two parameters do not affect suspended solids. The measured suspended solids show decreasing as the time of decomposition process is increasing. Besides, pH value of all sample also increase throughout the decomposition process as well as colour and turbidity concentration, but sample R1 shows the higher value of pH instead of sample R4. The behaviour of control sample shows the most different compared to another sample for all the physical properties.

For chemical properties, the concentration of nitrate and cadmium were measured. Figure 7 shows the effect of different amount leafy vegetables waste to nitrate. Nitrate (NO_3) concentration in this production of leachate was recorded between ranges 1-35 mg/L. During the first day, the results show a low concentration of NO_3 for all samples with concentration 4 mg/L, 5mg/L, 6 mg/L, 7 mg/L and 10 mg/L for sample C1, R1, R2, R3 and R4 respectively. The concentration increases significantly until the fifth day and then decreased gradually until the eleventh day.

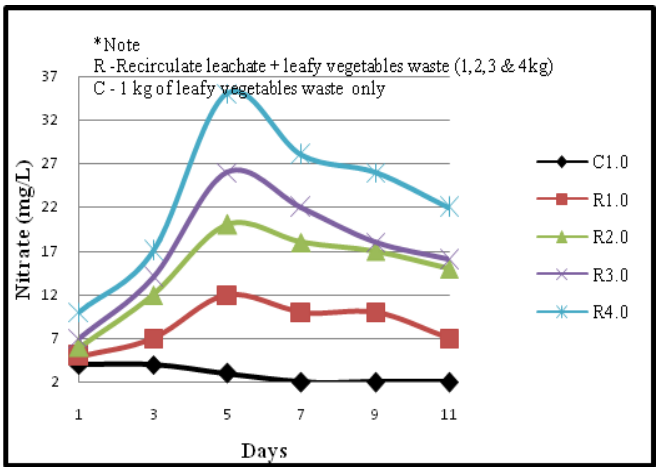


Figure 7: Effect on Nitrate

The highest NO_3 were recorded at sample R4 during the fifth day of leachate production with concentration 35 mg/L while the lowest NO_3 were recorded at sample C1 during the first day with concentration 4 mg/L. Thus, it proved that amount of waste affects the concentration of nitrate as a significant amount of waste gives a high concentration of nitrate. The second of leachate chemical property is Cd. Figure 8 shows the result of different effect amount of leafy vegetable waste to Cd. Cd concentration in this production of leachate was recorded between ranges 520-14,750mg/L. Based on the data recorded, it shows that leafy vegetable waste has very high of Cd concentration. Cd concentration increases significantly until the fifth day and then decreased gradually until the eleventh day.

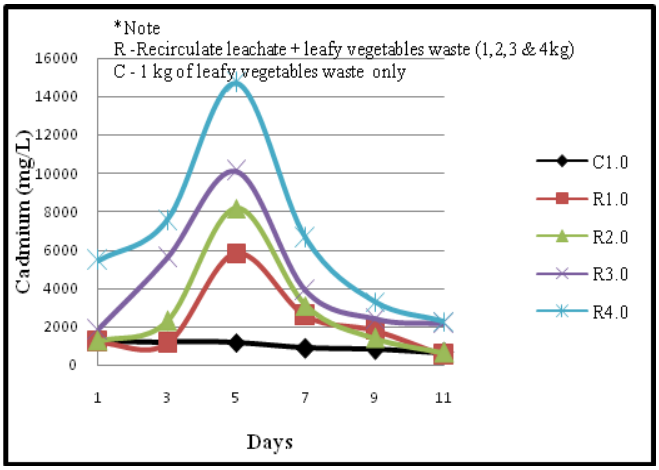


Figure 8: Effect of Cadmium

The maximum concentration of Cd shows in sample R4 during the fifth day with 14,750 mg/L. High concentration of Cd in sample R4 because R4 contains a significant amount of vegetable waste compared to another sample. Leafy vegetable waste has a high accumulation of Cd compared to other heavy metal [11]. Thus, it is proved when sample R4 contain a high concentration of Cd since R4 has a large amount of vegetable waste.

In summary of the chemical properties, the first five days of decomposition process shows the highest concentration of nitrate and Cd, especially for R4 sample. Then during the fifth day until the eleventh day, both of the chemical properties show a decline in concentration. In contrast, Cd concentration shows steeply decline compared to nitrate gradually decline. This phenomenon happened because of the transformation process of ammonia to nitrite through oxidation process is very slow. It was known that the nitrite is transformed through this process. This also happens to the control sample that is C1.

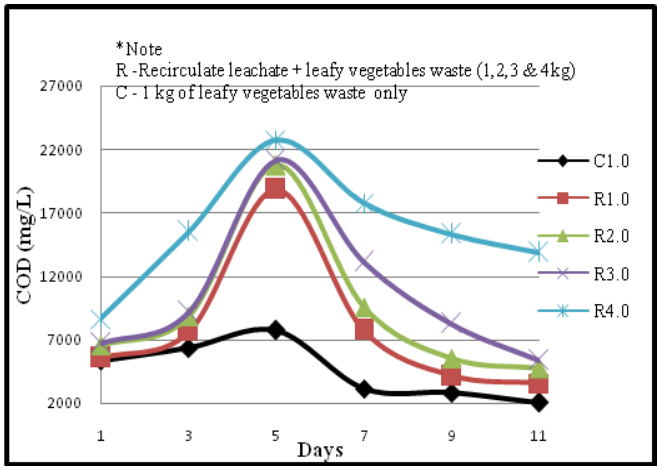


Figure 9: Effect on COD

Based on Figure 9 it shows that the result of COD for the first five days it increases noticeably. During first day, all samples gives low result of COD which are 5,400 mg/L, 5,600 mg/L, 6,600 mg/L, 6,780 mg/L and 8,700 mg/L for C1, R1, R2, R3 and R4 respectively. While the highest COD is on the fifth day for all sample especially sample R4 with 20,800 mg/L. This is because a large amount of waste contains in sample R4. The fifth day shows the highest COD because it indicates that the decomposition process undergoes acid phase [7].

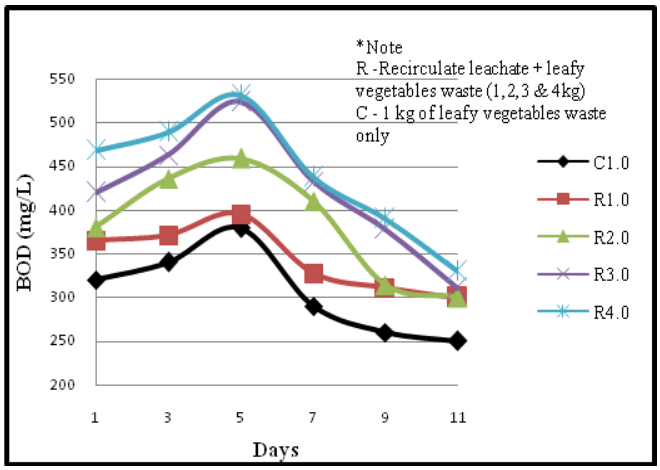


Figure 10: Effect on BOD

BOD measures the amount of oxygen required for microbiological decomposition of organic material in water or wastewater [7]. During first day production of leachate, low concentration of BOD is a show for all the samples based on Figure 10. BOD concentration begins to increase during the fifth day of production leachate for all samples. Based on the Figure 10, during the fifth day, all samples give a high concentration of COD which are 379 mg/L, 395 mg/L, 495 mg/L, 523.8 mg/L

and 530.7 mg/L for C1, R1, R2, R3 and R4 respectively. A research study found out that young leachate will be high in BOD as a result of decomposition of organic waste [12].The highest BOD is on the fifth day for all samples especially from sample R4 with 530.7 mg/L. BOD behaviour is same as the COD as the vast amount affect the concentration. The concentration of BOD increased with the passing of time till five days. While during the last six days, BOD decreased significantly. A decline in concentrations of BOD referred to the reduction in organic contaminants [12]. Therefore, BOD concentration shows similar behaviour to COD.

Based on the biological properties, sample R4 shows the highest concentration of both COD and BOD. This can be found on the fifth day of the decomposition process. The concentration of COD is higher compared to the concentration of BOD. This is because BOD needs more amount of oxygen for microbiological decomposition. While for C1 sample show differently compared to another sample for both of the biological properties. A sample of C1 of COD and BOD having little changing throughout the decomposition process.

F. Type of Membrane Fabricate

The membrane was classified by the experimental method of rejection polymeric molecules using Polyethylene Glycol (PEG) which has a range of size. By plotting the observed retention for each PEG in the mixture against its molecular weight, a retention curve was obtained. Then, fitting of this curve with the log-normal led to the determination of the MWCO. 90% retention of PEG mixture showed the molecular weight of the membrane which is Ultrafiltration membrane.

G. Treatment of Leafy Vegetables Leachate by Using Membrane

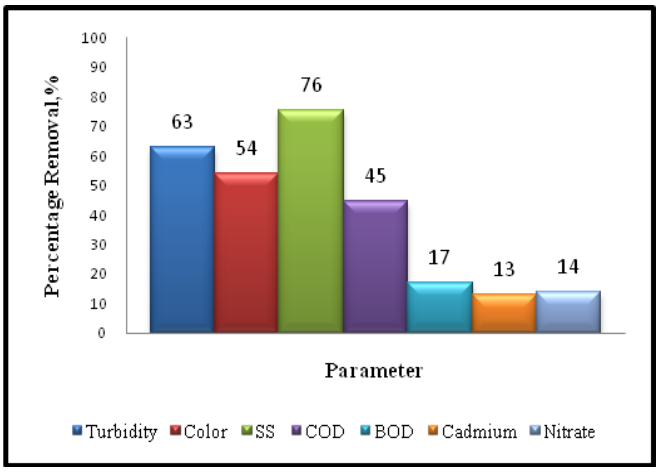


Figure 11: Percentage Removal Efficiency

Figure 11 shows the percentage removal efficiency each of the parameter. After leafy vegetable leachate had been characterized, the most severe of leachate had been treated by using UF flat sheet membrane. Based on the removal efficiency, UF membrane needs to combine with other treatment to achieve the standard requirement. UF is good to have pre-treatment process, especially the wastewater, containing high organic content [13].

Variation of casting dope solution such as concentration, temperature and organic and inorganic additives governed the sub-layer of the membrane which consists of macrovoids, pores and micropores [14]. Apart from that, polymer concentration which is PSF in a dope solution of the membrane also significantly influence the performance of the membrane and morphology [15]. They also reported that by increasing the polymer concentration, a denser membrane which led to the reduction of flux would be produced.

CONCLUSION

It was found that most of the parameters were not comply with the standard issued by DOE for the leachate discharge. Therefore, the membrane has been introduced to determine the effectiveness of the system to treat leachate. Since membrane that had been fabricated was classified as UF membrane, it only acts as pretreatment for another process of leachate treatment.

ACKNOWLEDGMENT

The author's thanks, RMC's UiTM for providing a grant (600-IRMI/GIP 5/3 (0003/2016)) and Faculty of Civil Engineering, Universiti Teknologi Mara (UiTM) for providing facilities to conduct this research.

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