REFERENCES

Silalahi, F. T. R., Simatupang, T. M., & Siallagan, M. P. (2019). Biodiesel produced from palm oil in Indonesia: current status and opportunities. ((Silalahi et al., 2019)

Hao, H., Liu, Z., Zhao, F., Ren, J., Chang, S., Rong, K., & Du, J. (2018). Biofuel for vehicle use in China: Current status, future potential and policy implications. *Renewable and Sustainable Energy Reviews*, *82*, 645-653.

Al-Zuhair, S. (2007). Production of biodiesel: possibilities and challenges. *Biofuels, Bioproducts and Biorefining: Innovation for a sustainable economy*, *1*(1), 57-66. (Al-Zuhair, 2007)

Christison, T. T., De Borba, B. M., & Rohrer, J. S. (2011). Determination of Free and Total Glycerol in Biodiesel. *lc Gc North America*, (FEV).

Gan M, Pan D, Ma L, Yue E and Hong J 2009 The kinetics of the esterification of free fatty acids in waste cooking oil using Fe2 (SO4)3/C catalyst Chin. J. Chem. Eng. 17 83–7

Jiang J J and Tan C S 2012 Biodiesel production from coconut oil in supercritical methanol in the presence of co-solvent J. Taiwan Inst. Chem. Eng. 43 102–7 (Jiang & Tan, 2012)

Manh D V, Chen Y H, Chang C C, Chang M C and Chang C Y 2011 Biodiesel production from tung oil and blended oil via ultrasonic transesterification process J.Taiwan Inst. Chem. Eng. 42 640–44 (Chen et al., 2011)

Zhou C, Wang C, Wang W, Wu Y, Yu F, Chi R and Zhang J 2010 Continuous production of biodiesel from soybean oil using supercritical methanol in a vertical tubular reactor: I. Phase holdup (Cheng et al., 2010)

Lee M, Wu Z, Wang R, Li K. Micro-structured alumina hollow fibre membranes - Potential applications in wastewater treatment. Journal of Membrane Science. 2014;461:39-48.

Li, L., Chen, M., Dong, Y., Dong, X., Cerneaux, S., Hampshire, S., ... & Liu, J. (2016). A low-cost alumina-mullite composite hollow fiber ceramic membrane fabricated via phase-inversion and sintering method. *Journal of the European Ceramic Society*, *36*(8), 2057-2066.

Zahan, K. A., & Kano, M. (2018). Biodiesel production from palm oil, its by-products, and mill effluent: a review. *Energies*, *11*(8), 2132.

Abbaszaadeh, A., Ghobadian, B., Najafi, A., & Omidkhah, O. (2012). Current biodiesel production technologies: A comparative review. Energy Conversion and Management, 63, 138-148

Mittelbach, M., Pokits, B., & Silberholz, A. (1992, December). Production and fuel properties of fatty acid methyl esters from used frying oil. In liquid fuels renewable resource, proceedings of the alternative energy conference (pp. 74-78).

Peterson, C. L., Reece, D. L., Cruz, R., & Thompson, J. (1992). A comparison of ethyl and methyl esters of vegetable oil as diesel fuel substitutes. In liquid fuels from renewable resources. Proceedings of an Alternative Energy Conference held in Nashville, Tennessee, USA, 12-15 December 1992. (pp. 99-110). American Society of Agricultural Engineers.

Peterson, C. L., Reece, D. L., Hammond, B. L., Thompson, J., & Beck, S. M. (1997). Processing, characterization, and performance of eight fuels from lipids. Applied Engineering in Agriculture, 13(1), 71-79.
(Mittelbach et al., 1992; C L Peterson et al., 1992; Charles L Peterson et al., 1997)

Vellguth, G. (1983). Performance of vegetable oils and their monoesters as fuels for diesel engines. SAE transactions, 1098-1107.

Chang, D. Y., Van Gerpen, J. H., lee, I., Johnson, L. A., Hammond, E. G., & Marley, S. J. (1996). Fuel properties and emissions of soybean oil esters as diesel fuel. Journal of the American Oil Chemists' Society, 73(11), 1549-1555.
(Vellguth, 1983; Chang et al., 1996).

Pahl, G., & McKibben, B. (2005). Biodiesel: growing a new energy economy, White River Junction. Vt: Chelsea Green Publishing. (Pahl & McKibben, 2005).

Schwaiger, H., Pena, N., Mayer, A., & Bird, D. N. (2011). Technologies to produce liquid biofuels for transportation: An overview. CIFOR.

Birol F (2014) world energy outlook 2013–2035. Rotterdam: International Energy Agency, IEA.

Koh, M. Y., & Ghazi, T. I. M. (2011). A review of biodiesel production from Jatropha curcas L. oil. Renewable and sustainable energy reviews, 15(5), 2240-2251.

Ibeto, C. N., Ofoefule, A. U., & Ezugwu, H. C. (2011). Analytical methods for quality assessment of biodiesel from animal and vegetable oils. Trends in Applied Sciences Research, 6(6), 537.

da Silva, W. L., Souza, P. T. D., Shimamoto, G. G., & Tubino, M. (2015). Separation of the glycerol-biodiesel phases in an ethyl transesterification synthetic route using water. Journal of the Brazilian Chemical Society, 26(9), 1745-1750.
Rahmat, B., Setiasih, I., & Kastaman, R. (2013). Biodiesel reactor design with glycerol separation to increase biodiesel production yield. Makara Journal of Technology, 17(1), 11-16.

Ferrari, R. A., Pighinelli, A. L. M. T., & Park, K. J. (2011). Biodiesel production and quality. Biofuel's Engineering Process Technology, 1, 221-240.

Atadashi, I. M., Aroua, M. K., Aziz, A. A., & Sulaiman, N. M. N. (2011). Refining technologies for the purification of crude biodiesel. Applied energy, 88(12), 4239-4251.

Saleh, J., Tremblay, A. Y., & Dubé, M. A. (2010). Glycerol removal from biodiesel using membrane separation technology. Fuel, 89(9), 2260-2266.

Nakpong, P., & Wootthikanokkhan, S. (2010). Roselle (Hibiscus sabdariffa L.) oil as an alternative feedstock for biodiesel production in Thailand. Fuel, 89(8), 1806-1811.

Atadashi, I. M., Aroua, M. K., Aziz, A. A., & Sulaiman, N. M. N. (2012). The effects of water on biodiesel production and refining technologies: A review. Renewable and sustainable energy reviews, 16(5), 3456-3470.

Zioui, D., Tigrine, Z., Aburideh, H., Hout, S., Abbas, M., & Merzouk, N. K. (2015). Membrane Technology for water treatment applications. International Journal of Chemical and Environmental Engineering, 6(3).

Wei, Y. (2015, November). Application of inorganic ceramic membrane in wastewater treatment: membrane fouling control and cleaning procedure. In 2015 International Symposium on Material, Energy and Environment Engineering. Atlantis Press.

Li K., Tan X., Liu Y., "Single step fabrication of ceramic hollow fibers for oxygen permeation", Journal of Membrane Science, 272 (1-2), 1-5, (2006).

Li K., "Ceramic membranes for separation and reaction", ISBN: 978-0-470-31946-8, John Wiley & Sons, Inc, (2007).

Li Y., Ding W., Jin X., Yu J., Hu X., Huang Y., "Toward extensive application of Pd / ceramic membranes for hydrogen separation: A case study on membrane recycling and reuse in the fabrication of new membranes", International Journal of Hydrogen Energy, 40 (8), 3528-3537, (2015)

Cao, P., Tremblay, A. Y., Dube, M. A., & Morse, K. (2007). Effect of membrane pore size on the performance of a membrane reactor for biodiesel production. Industrial & engineering chemistry research, 46(1), 52-58.

Aryanti, N. (2020). Fouling behavior of polyethersulphone ultrafiltration membrane in the separation of glycerin-rich solution as byproduct of palm-oil-based biodiesel production.

APPENDIX

Appendix 1. Membrane Module Design

These are the technical drawing of tubular membrane module.

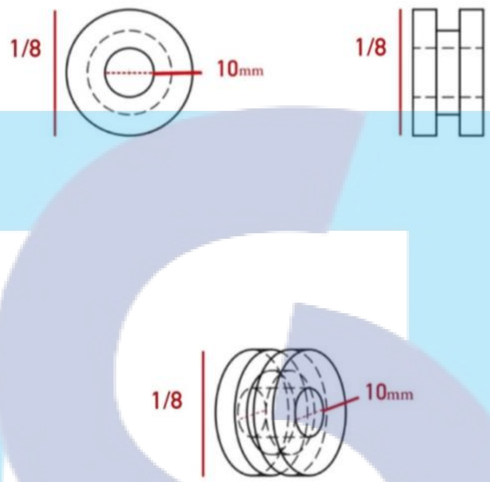

Fig 1. The Design of Rubber Ball Joints Dimension

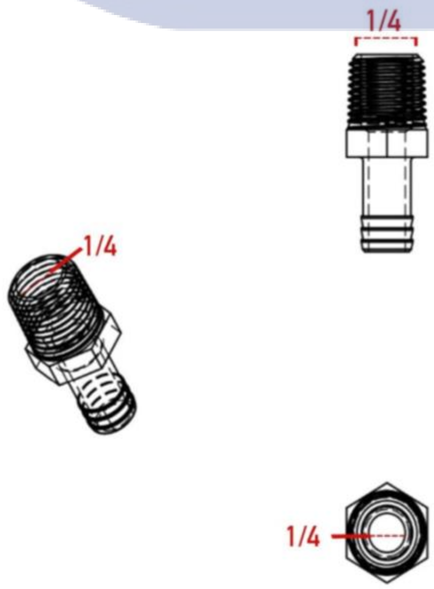

Fig 2. The Design of Tubbing Connectors Dimension

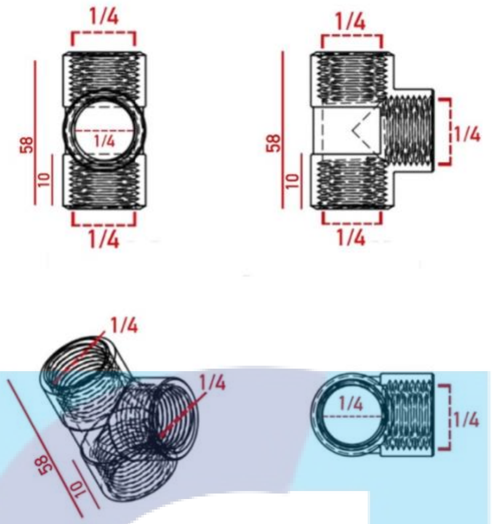

Fig 3. The Design of Tee Pipes Dimension

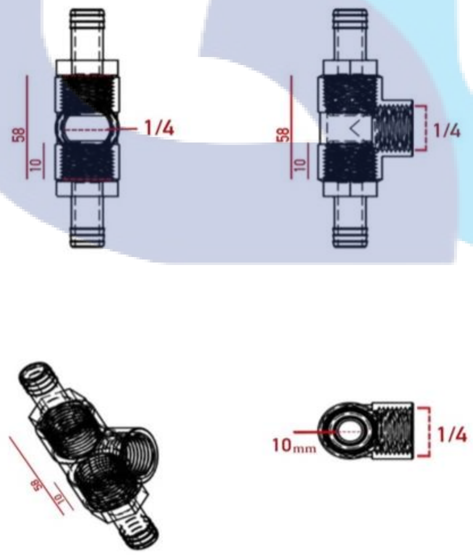

Fig 4. The Design of Module Membrane Dimension

Appendix 2. Microfiltration Experiment

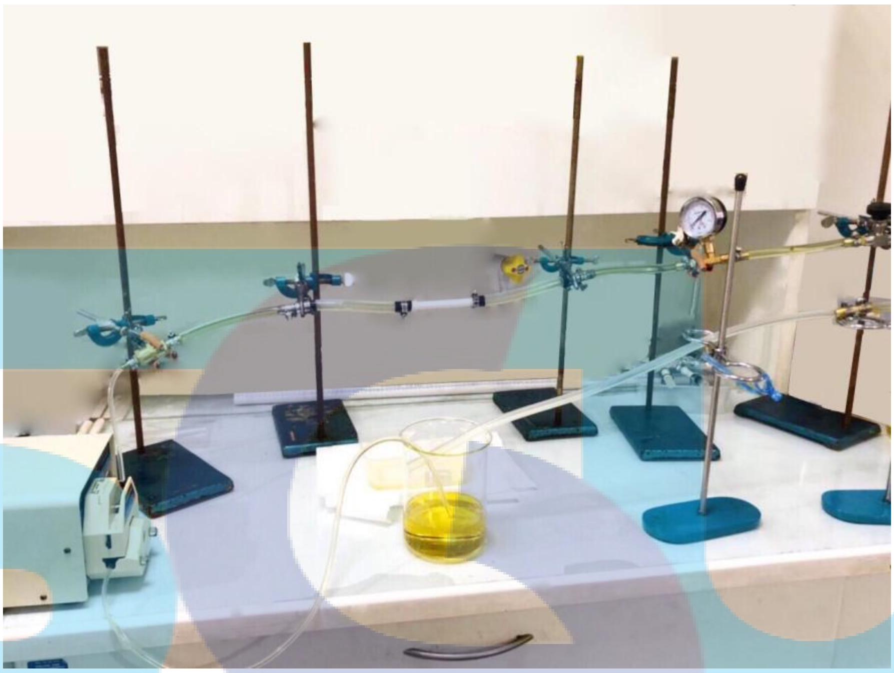

Fig 5. Assembled Microfiltration Setup for Pure Biodiesel

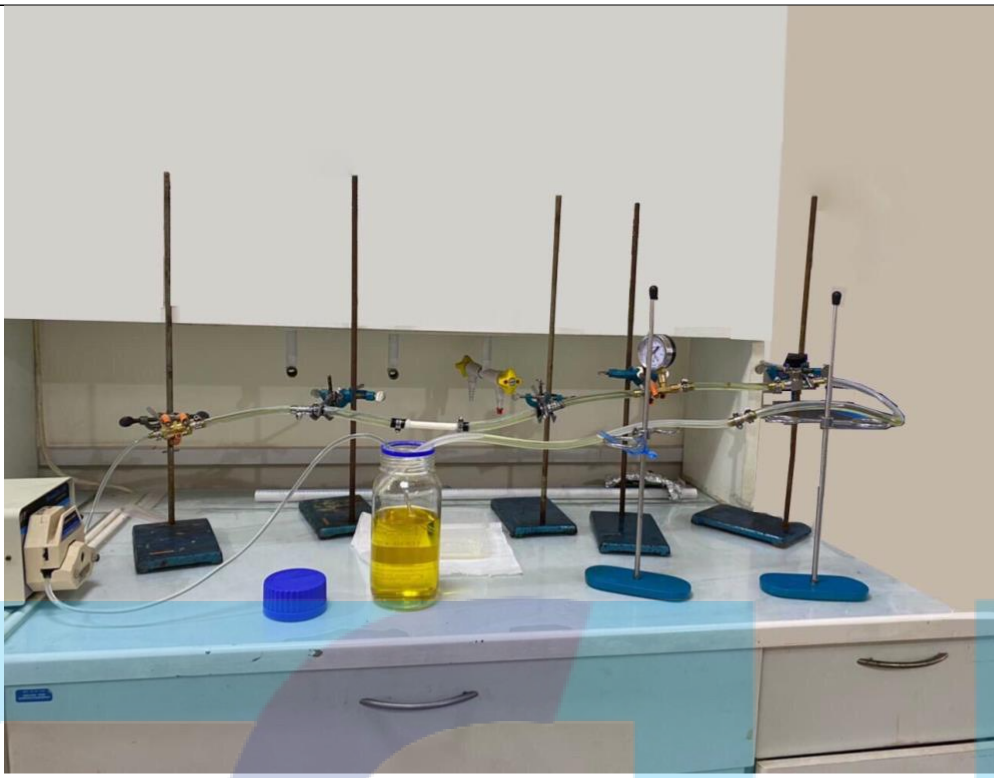

Fig 6. Assembled Microfiltration Setup for Biodiesel & Glycerol

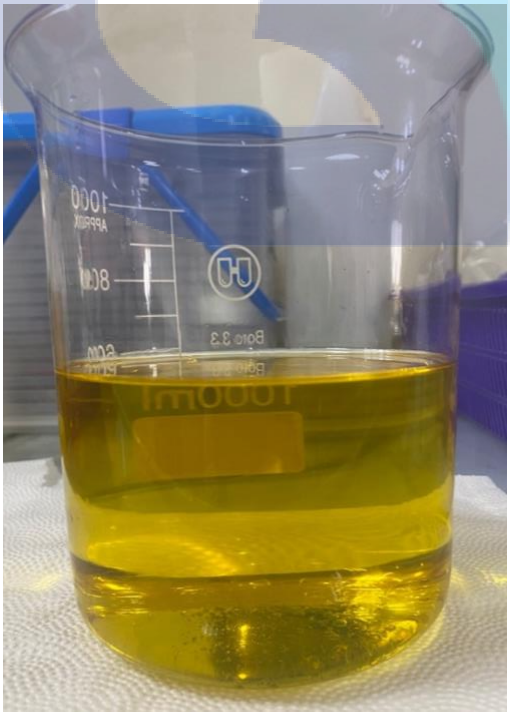

Fig 7. Biodiesel and GlyceroI as Feed Solution

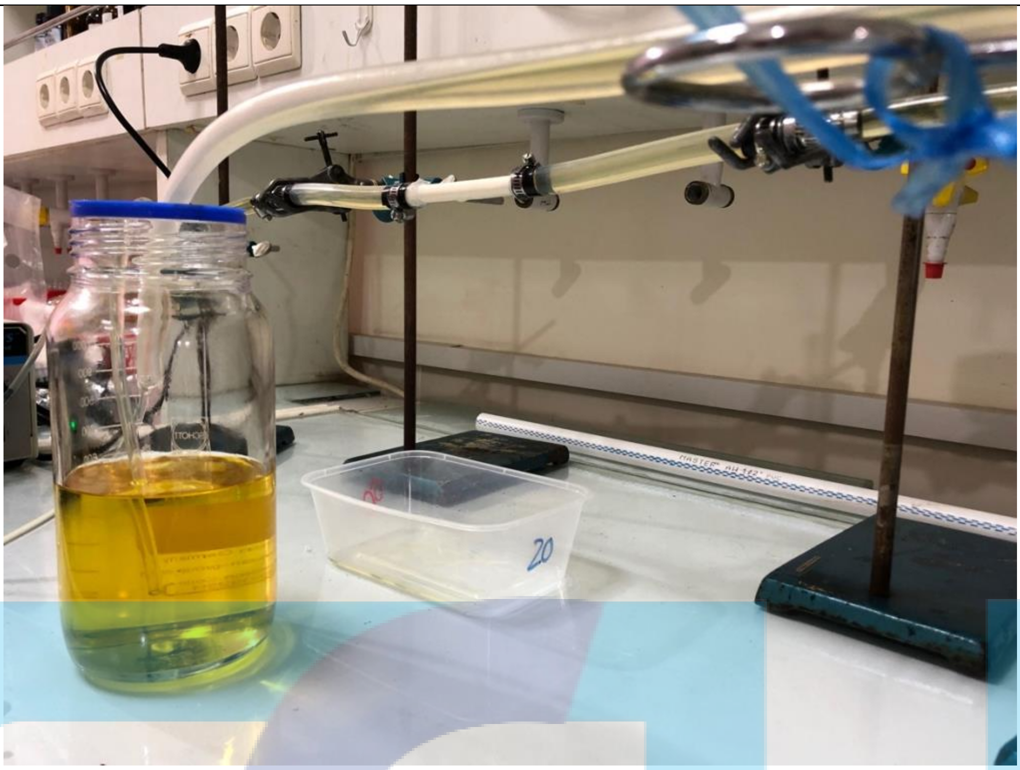

Fig 8. The Permeate is being collected every 10 minutes

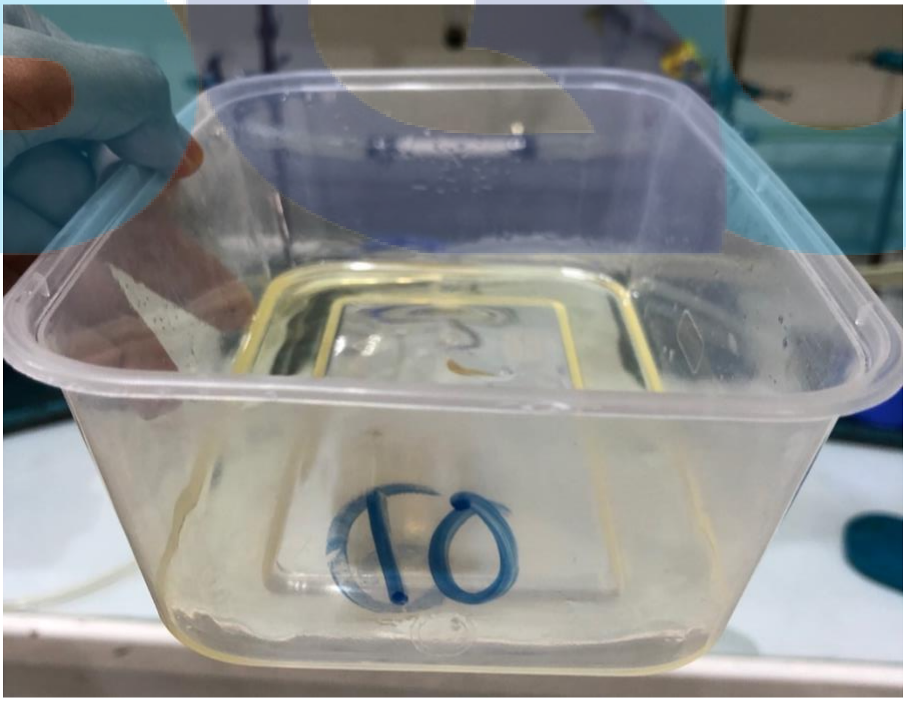

Fig 9. The collection of the Permeate

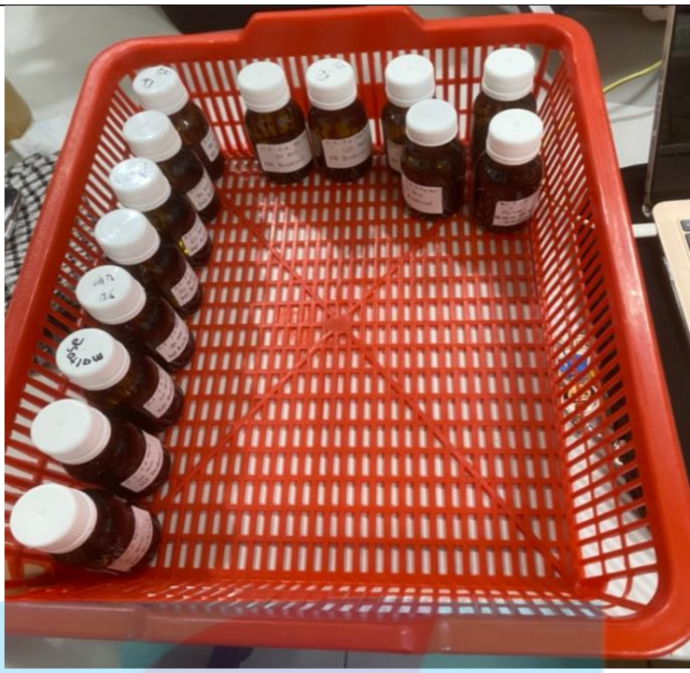

Fig 10. The collection of the Permeate

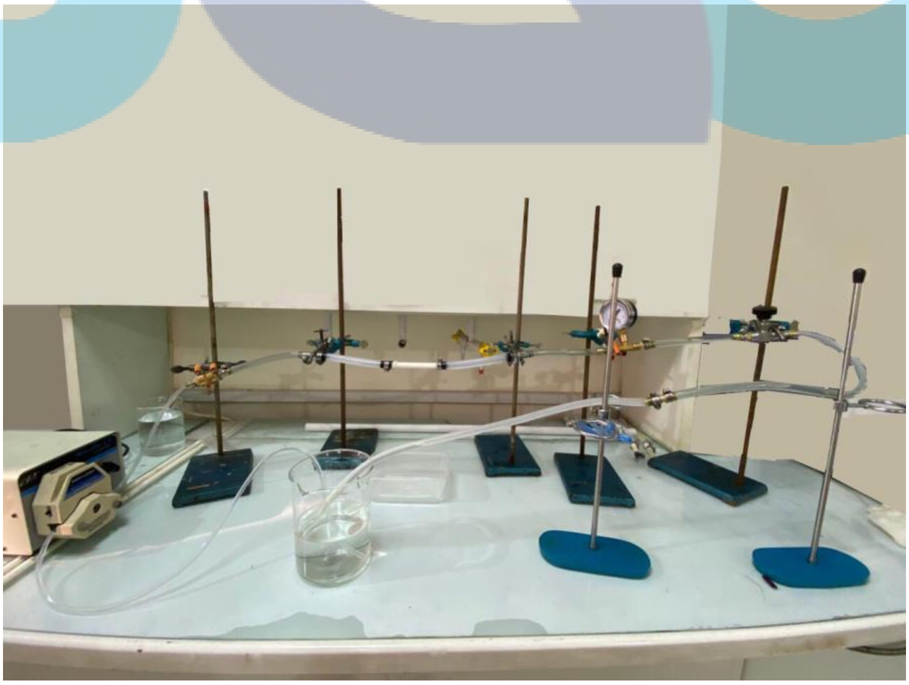

Fig 11. Assembled Microfiltration Setup of Washing with Pure Water

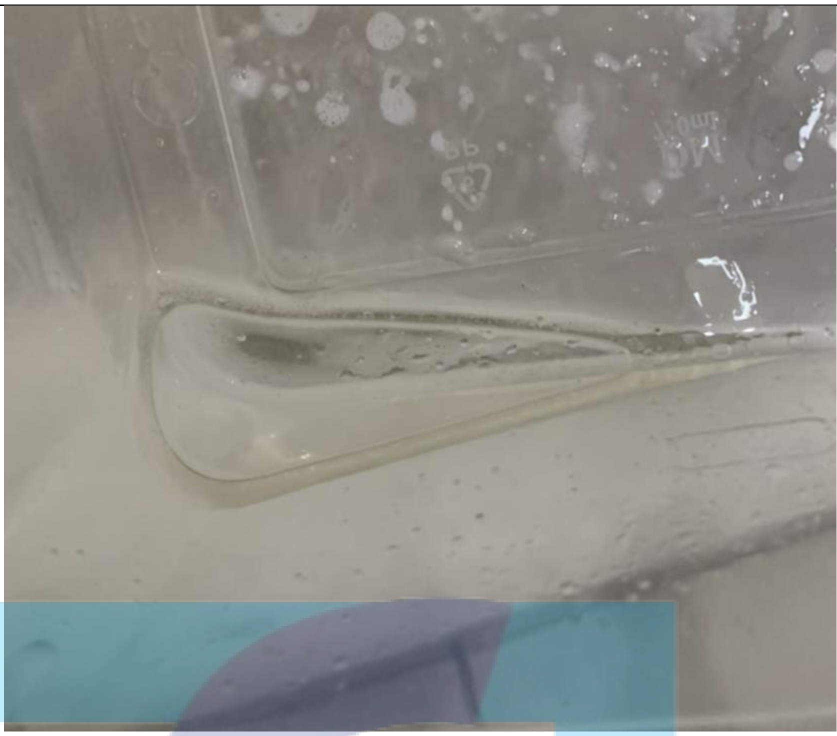

Fig 12. after washing with Pure Water

1) Permeate Flux

Calculation of the permeate flux:

- Flow rate of the feed = $\frac{feed\ volume\ (mL)}{time\ (sec)} = \frac{59.5}{42.32}$ = 1.41 $^{mL}/_{sec}$
- Area of the membrane = π x length of membrane x diameter of membrane

  Area of the membrane = 3.14 x 80 mm x 5 mm = 1256 mm^2 ≅ 12.560 cm^2 ≅ 0.0012560 m^2

- Permeate Flux = $\frac{m}{A\ \Delta t}$

  Permeate Flux = $\frac{0.01260\ L}{0.0012560\ m2\ x\ 0.1667\ h}$

  Permeate Flux = 60.191 l/m^2h

Table 1. Pure Biodiesel Permeate Flux at 0.2-0.3 kg/cm^2

time (min)	∆time (min)	∆time(hr)	permeate volume (mL)	permeate volume (L)	permeate flux (L/m^{2}h)
10	10	0.1667	12.60	0.01260	60.191
20	10	0.1667	13.60	0.01360	64.968
30	10	0.1667	13.10	0.01310	62.580
40	10	0.1667	12.60	0.01260	60.191
50	10	0.1667	13.20	0.01320	63.057
60	10	0.1667	13.30	0.01330	63.535
70	10	0.1667	13.10	0.01310	62.580
80	10	0.1667	13.50	0.01350	64.490
90	10	0.1667	13.20	0.01320	63.057
100	10	0.1667	13.60	0.01360	64.968
110	10	0.1667	13.50	0.01350	64.490
120	10	0.1667	12.60	0.01260	60.191

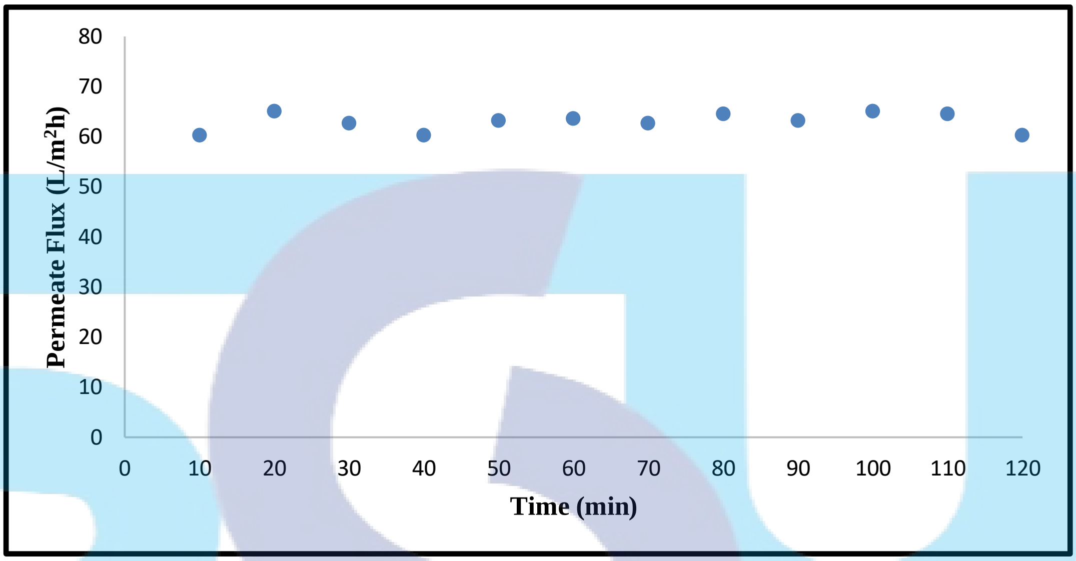

Fig 13. Pure Biodiesel Permeate Flux at 0.2-0.3 kg/cm^2

Table 2. Pure Biodiesel Permeate Flux at 0.5-0.6 kg/cm^2

time (min)	∆time (min)	∆time(hr)	permeate volume (mL)	permeate volume (L)	permeate flux (L/m^{2}h)
10	10	0.1667	14.00	0.01400	66.879
20	10	0.1667	14.50	0.01450	69.268
30	10	0.1667	14.70	0.01470	70.223
40	10	0.1667	14.20	0.01420	67.834
50	10	0.1667	14.40	0.01440	68.790
60	10	0.1667	13.80	0.01380	65.924
70	10	0.1667	13.20	0.01320	63.057
80	10	0.1667	13.50	0.01350	64.490
90	10	0.1667	13.70	0.01370	65.446
100	10	0.1667	13.50	0.01350	64.490
110	10	0.1667	13.20	0.01320	63.057
120	10	0.1667	12.70	0.01270	60.669

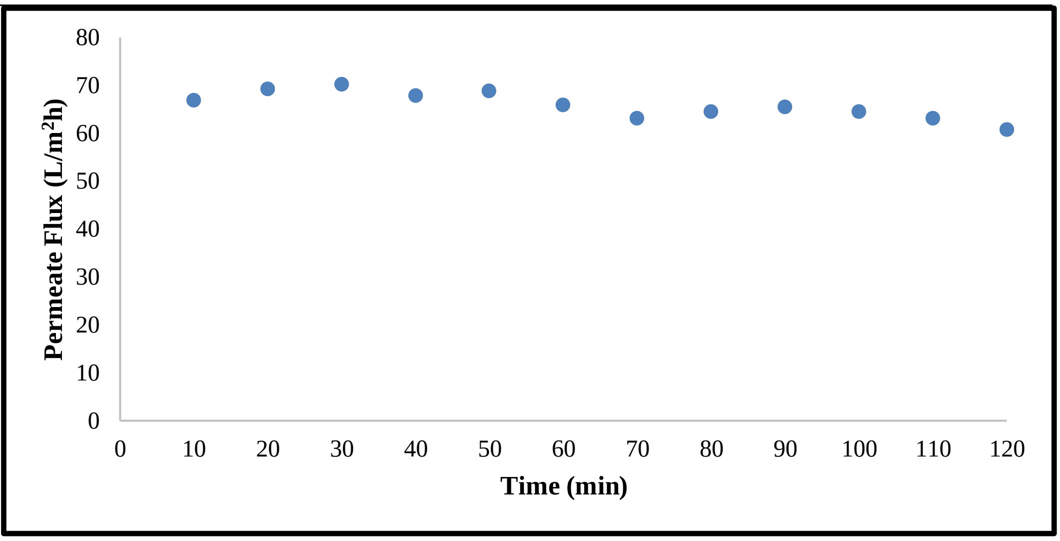

Fig 14. Pure Biodiesel Permeate Flux at 0.2-0.3 kg/cm^2

Table 3. Biodiesel and Glycerol Permeate Flux at 0.5-0.6 kg/cm^2

time (min)	△time (min)	△time(hr)	permeate volume (mL)	permeate volume (L)	permeate flux (L/m^{2}h)
10	10	0.1667	12.70	0.01270	60.669
20	10	0.1667	12.40	0.01240	59.236
30	10	0.1667	11.60	0.01160	55.414
40	10	0.1667	11.10	0.01110	53.025
50	10	0.1667	10.00	0.01000	47.771
60	10	0.1667	9.40	0.00940	44.904
70	10	0.1667	9.20	0.00920	43.949
80	10	0.1667	9.30	0.00930	44.427
90	10	0.1667	9.40	0.00940	44.904
100	10	0.1667	9.30	0.00930	44.427
110	10	0.1667	9.10	0.00910	43.471
120	10	0.1667	8.70	0.00870	41.561

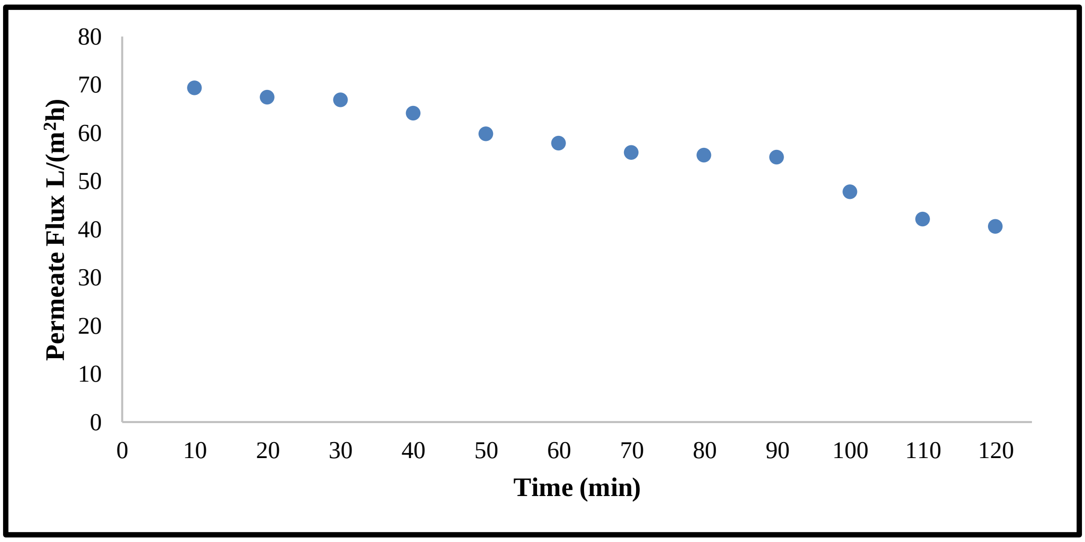

Fig 15. Biodiesel and Glycerol Permeate Flux at 0.5-0.6 kg/cm^2

Table 4. Washing with Pure Biodiesel Permeate Flux at 0.5-0.6 kg/cm^2

time (min)	△time (min)	△time(hr)	permeate volume (mL)	permeate volume (L)	permeate flux (L/m^{2}h)
10	10	0.1667	12.70	0.01270	60.669
20	10	0.1667	12.40	0.01240	59.236
30	10	0.1667	11.60	0.01160	55.414
40	10	0.1667	11.10	0.01110	53.025
50	10	0.1667	10.00	0.01000	47.771
60	10	0.1667	9.40	0.00940	44.904
70	10	0.1667	9.20	0.00920	43.949
80	10	0.1667	9.30	0.00930	44.427
90	10	0.1667	9.40	0.00940	44.904
100	10	0.1667	9.30	0.00930	44.427
110	10	0.1667	9.10	0.00910	43.471
120	10	0.1667	8.70	0.00870	41.561

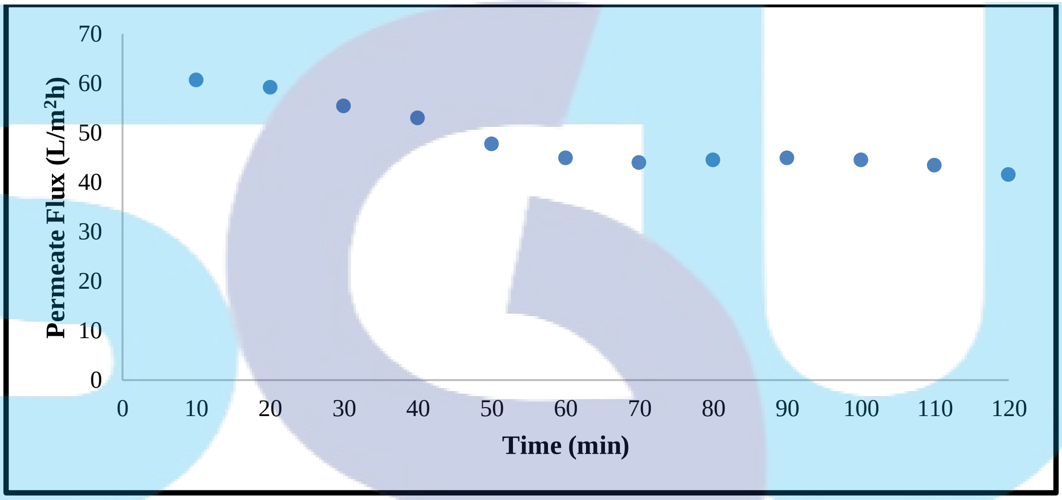

Fig 15. Washing with Pure Biodiesel Permeate Flux at 0.5-0.6 kg/cm^2

Table 5. Washing with Pure Water Permeate Flux at 0.5-0.6 kg/cm^2

time (min)	△time (min)	△time(hr)	permeate volume (mL)	permeate volume (L)	Permeate Flux (L/m^{2}h)
10	10	0.1667	2.70	0.00270	12.896
20	10	0.1667	2.60	0.00260	12.418
30	10	0.1667	2.00	0.00200	9.552
40	10	0.1667	2.00	0.00200	9.552
50	10	0.1667	2.10	0.00210	10.030
60	10	0.1667	2.00	0.00200	9.552
70	10	0.1667	1.70	0.00170	8.119
80	10	0.1667	1.60	0.00160	7.642
90	10	0.1667	1.70	0.00170	8.119
100	10	0.1667	1.70	0.00170	8.119
110	10	0.1667	1.50	0.00150	7.164
120	10	0.1667	1.50	0.00150	7.164

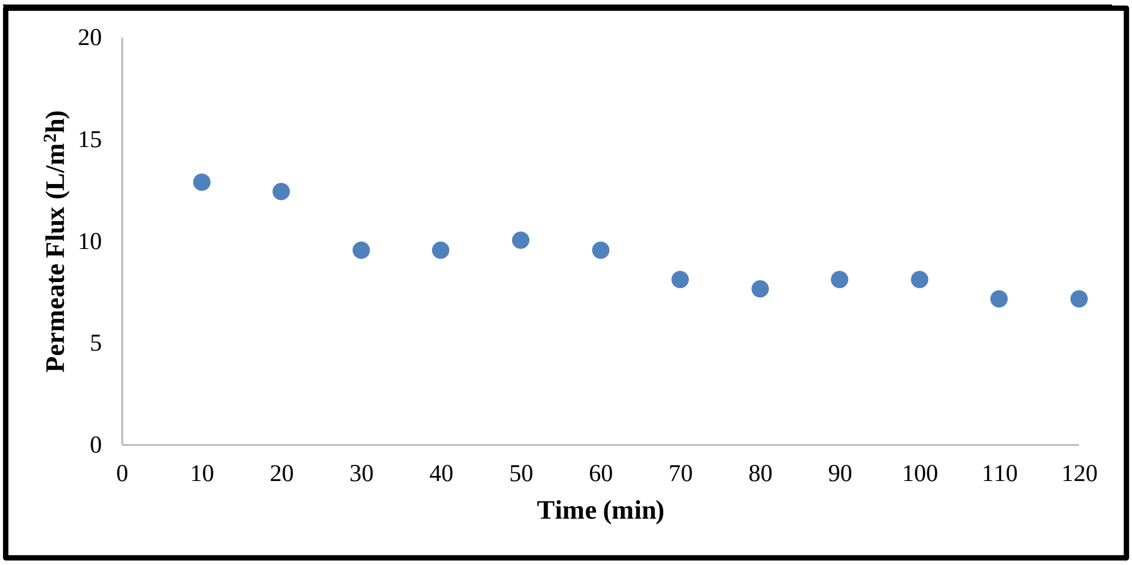

Fig 16. Washing with Pure Water Permeate Flux at 0.5-0.6 kg/cm^2

Table 6. Washing with Pure Biodiesel Permeate Flux at 0.5-0.6 kg/cm^2

time (min)	∆time (min)	∆time(hr)	permeate volume (mL)	permeate volume (L)	permeate flux (L/m^{2}h)
10	10	0.1667	5.10	0.00510	24.358
20	10	0.1667	5.50	0.00550	26.269
30	10	0.1667	5.20	0.00520	24.836
40	10	0.1667	6.10	0.00610	29.134
50	10	0.1667	7.70	0.00770	36.776
60	10	0.1667	7.90	0.00790	37.731
70	10	0.1667	8.80	0.00880	42.030
80	10	0.1667	9.20	0.00920	43.940
90	10	0.1667	10.00	0.01000	47.761
100	10	0.1667	10.00	0.01000	47.761
110	10	0.1667	10.00	0.01000	47.761
120	10	0.1667	10.20	0.01020	48.716

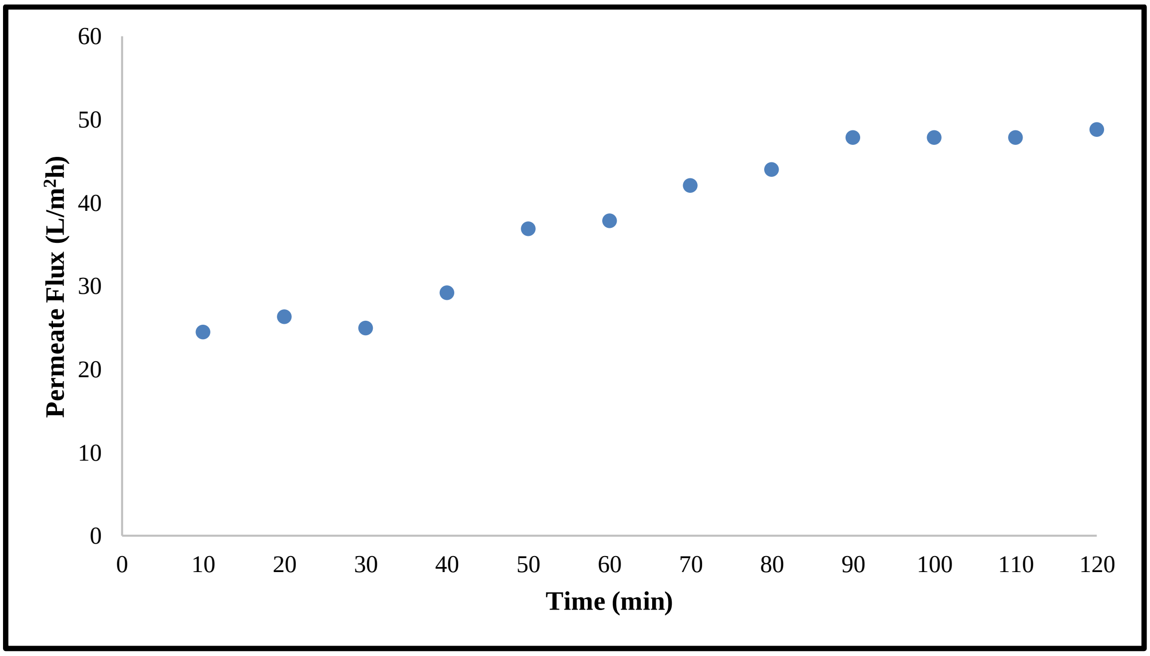

Fig 17. Washing with Pure Biodiesel Permeate Flux at 0.5-0.6 kg/cm^2

Table 7. Pure Biodiesel Permeate Flux at 0.2-0.3 kg/cm^2

time (min)	∆time (min)	∆time(hr)	permeate volume (mL)	permeate volume (L)	permeate flux (L/m^{2}h)
10	10	0.1667	5.60	0.00560	26.746
20	10	0.1667	5.50	0.00550	26.269
30	10	0.1667	6.60	0.00660	31.522
40	10	0.1667	7.10	0.00710	33.910
50	10	0.1667	7.50	0.00750	35.821
60	10	0.1667	7.60	0.00760	36.298
70	10	0.1667	7.70	0.00770	36.776
80	10	0.1667	8.20	0.00820	39.164
90	10	0.1667	8.90	0.00890	42.507
100	10	0.1667	9.00	0.00900	42.985
110	10	0.1667	9.30	0.00930	44.418
120	10	0.1667	9.50	0.00950	45.373

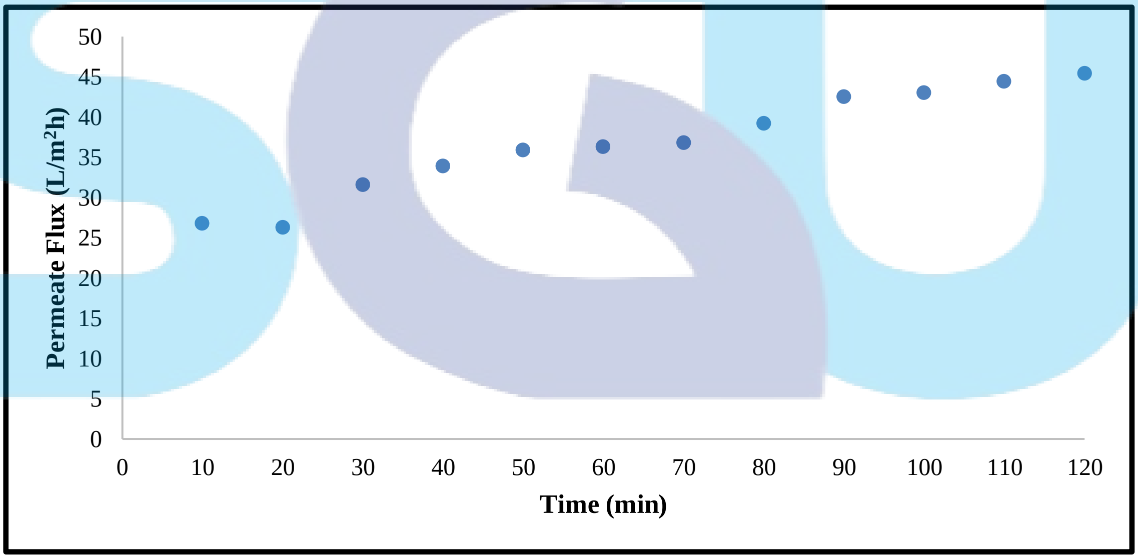

Fig 18. Pure Biodiesel Permeate Flux at 0.2-0.3 kg/cm^2

Table 8. Pure Biodiesel Permeate Flux at 0.7-0.8 kg/cm^2

time (min)	△time (min)	△time(hr)	permeate volume (mL)	permeate volume (L)	permeate flux (L/m^{2}h)
10	10	0.1667	6.20	0.00620	29.612
20	10	0.1667	6.20	0.00620	29.612
30	10	0.1667	6.70	0.00670	32.000
40	10	0.1667	6.80	0.00680	32.478
50	10	0.1667	7.30	0.00730	34.866
60	10	0.1667	7.40	0.00740	35.343
70	10	0.1667	7.80	0.00780	37.254
80	10	0.1667	8.10	0.00810	38.687
90	10	0.1667	8.70	0.00870	41.552
100	10	0.1667	8.90	0.00890	42.507
110	10	0.1667	9.50	0.00950	45.373
120	10	0.1667	11.00	0.01100	52.537

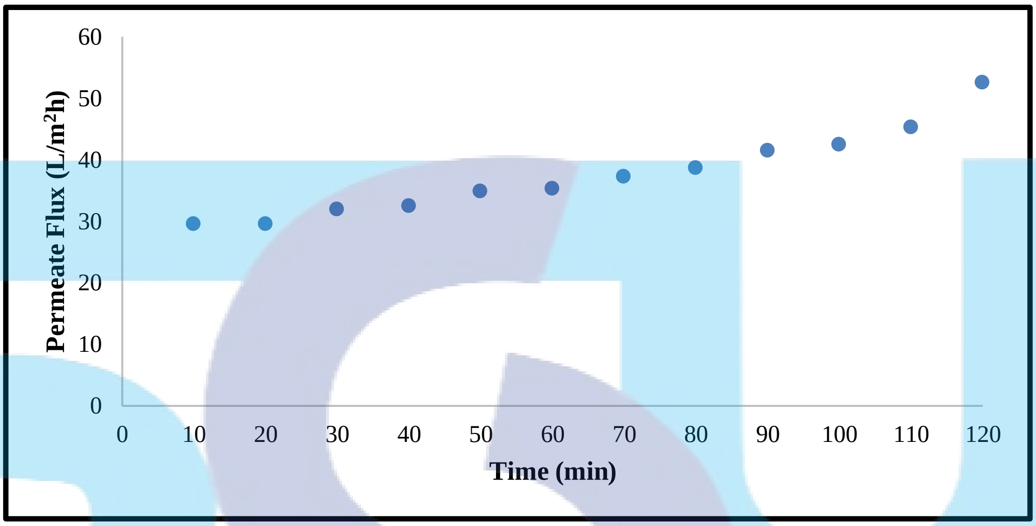

Fig 19. Pure Biodiesel Permeate Flux at 0.7-0.8 kg/cm^2

Table 9. Pure Biodiesel Permeate Flux at 0.2-0.3 kg/cm^2

time (min)	△time (min)	△time(hr)	permeate volume (mL)	permeate volume (L)	permeate flux (L/m^{2}h)
10	10	0.1667	4.60	0.00460	21.970
20	10	0.1667	5.20	0.00520	24.836
30	10	0.1667	5.10	0.00510	24.358
40	10	0.1667	5.20	0.00520	24.836
50	10	0.1667	5.30	0.00530	25.313
60	10	0.1667	5.30	0.00530	25.313
70	10	0.1667	5.50	0.00550	26.269
80	10	0.1667	5.80	0.00580	27.701
90	10	0.1667	6.00	0.00600	28.657
100	10	0.1667	6.20	0.00620	29.612
110	10	0.1667	6.30	0.00630	30.090
120	10	0.1667	6.50	0.00650	31.045

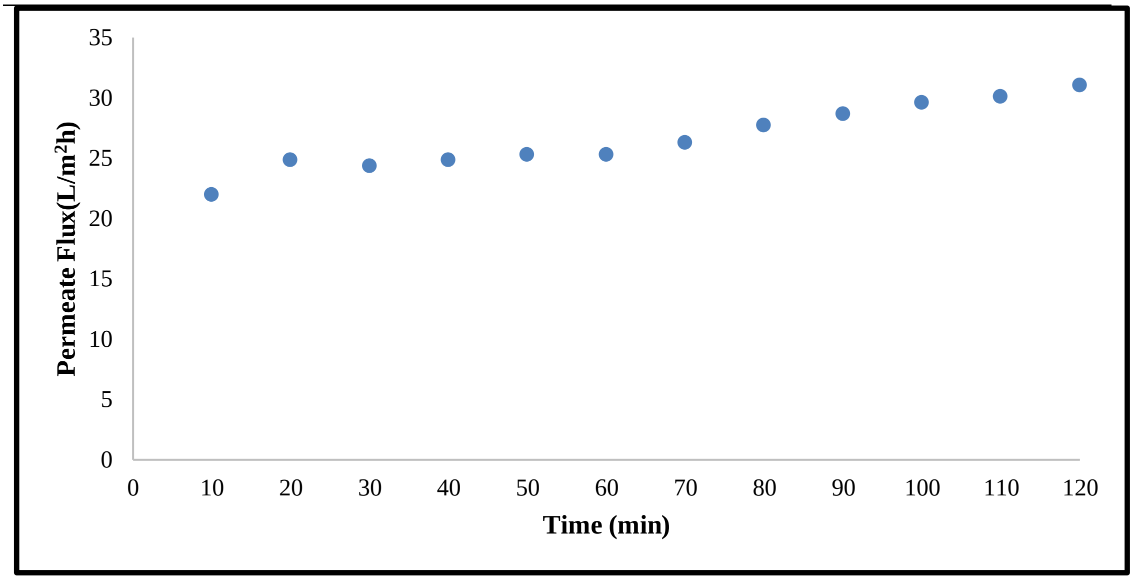

Fig 20. The Pure Biodiesel Permeate Flux at 0.2-0.3 kg/cm^2

Table 10. The Pure Biodiesel Permeate Flux at 0.5-0.6 kg/cm^2

time (min)	∆time (min)	∆time(hr)	permeate volume (mL)	permeate volume (L)	permeate flux (L/m^{2}h)
10	10	0.1667	5.20	0.00520	24.836
20	10	0.1667	5.40	0.00540	25.791
30	10	0.1667	5.70	0.00570	27.224
40	10	0.1667	5.80	0.00580	27.701
50	10	0.1667	6.00	0.00600	28.657
60	10	0.1667	6.20	0.00620	29.612
70	10	0.1667	6.30	0.00630	30.090
80	10	0.1667	6.50	0.00650	31.045
90	10	0.1667	6.70	0.00670	32.000
100	10	0.1667	7.00	0.00700	33.433
110	10	0.1667	7.20	0.00720	34.388
120	10	0.1667	7.30	0.00730	34.866

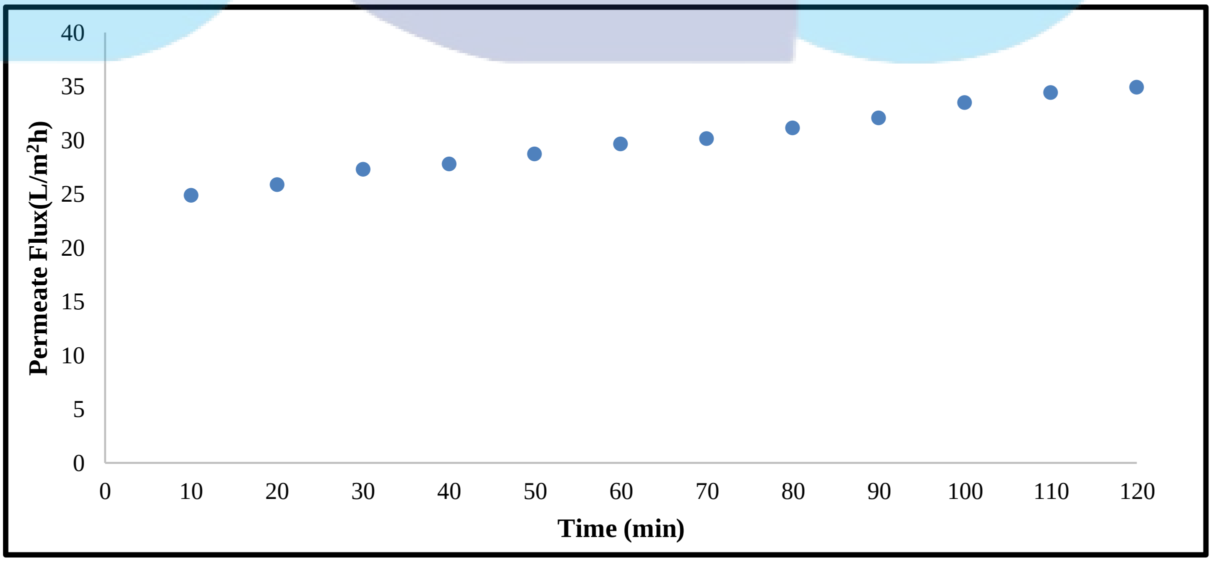

Fig 21. The Pure Biodiesel Permeate Flux at 0.5-0.6 kg/cm^2

Table 11. The Pure Biodiesel Permeate Flux at 0.7-0.8 kg/cm^2

time (min)	△time (min)	△time(hr)	permeate volume (mL)	permeate volume (L)	permeate flux (L/m^{2}h)
10	10	0.1667	5.20	0.00520	24.836
20	10	0.1667	5.40	0.00540	25.791
30	10	0.1667	5.60	0.00560	26.746
40	10	0.1667	6.40	0.00640	30.567
50	10	0.1667	6.90	0.00690	32.955
60	10	0.1667	7.30	0.00730	34.866
70	10	0.1667	7.80	0.00780	37.254
80	10	0.1667	8.00	0.00800	38.209
90	10	0.1667	8.30	0.00830	39.642
100	10	0.1667	8.60	0.00860	41.075
110	10	0.1667	8.50	0.00850	40.597
120	10	0.1667	8.90	0.00890	42.507

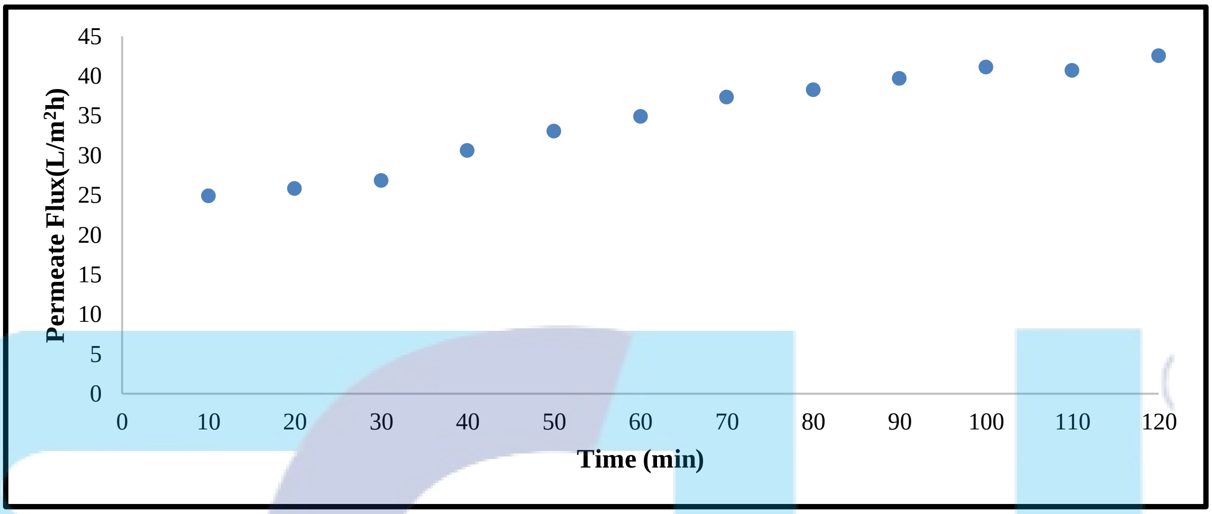

Fig 22. The Pure Biodiesel Permeate Flux at 0.7-0.8 kg/cm^2

2) Calibration Curve

Calculation of the calibration curve:

- Concentration of Glycerol reference working solution: 3 mg/ml x 1000 ppm

  Concentration of Glycerol reference working solution: 3000 ppm

- Concentration of feed solution = 0.5 gram of glycerol x 1 g of distilled water x 498.5 g of biodiesel

  Concentration of feed solution = $\frac{0.5\ g\ of\ glycerol}{500\ g\ of\ biodiesel}$ x1000000 = 0.001%

  Concentration of feed solution = 1000 ppm

- Concentration Glycerol reference solution: $m_1v_1 = m_2v_2$

  For example:

  Concentration Glycerol reference solution: $m_2 = \frac{m1v1}{m2}$

  Concentration Glycerol reference solution: $m_2 = \frac{3000\ mg/L - 0.25\ mg/mL}{2mL}$

Concentration Glycerol reference solution: m_2 = 375 ppm

Table 12. Glycerol Standard Calibration Curve

Standard	Concentration Glycerol reference solution (mg/ml)	Concentration Glycerol reference solution (ppm)	Absorbance of Calibration curve
1	0.00	0	0.000
2	0.25	375	1.255
3	0.50	750	2.527
4	0.75	1125	3.163
5	1.00	1500	4.635
6	1.25	1875	5.265
7	1.50	2250	6.637
8	1.75	2625	7.909
9	2.00	3000	8.468

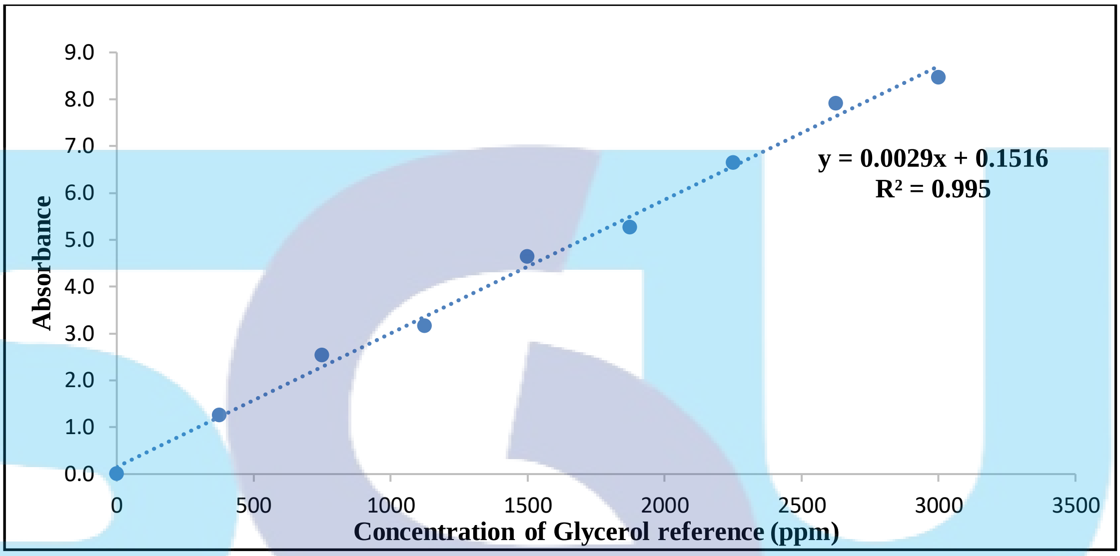

Fig 21. Glycerol Standard Calibration Curve

3) Glycerol Rejection

linear regression of Glycerol standard calibration curve as shown is:

$$y = 0.0029x + 0.1516$$

Where:

x = concentration of Biodiesel & Glycerol given in ppm

y = Absorbance of Biodiesel & Glycerol

- Calculation for converting concentration of Biodiesel & Glycerol:

$$y = m\,x + c$$

$$x = \frac{y-c}{m}$$

Example of calculation for numbers of glycerol in the sample, y = 0.000

$$x = \frac{0.000-(-0.1516)}{0.0029} = 52 \text{ ppm}$$

- Calculation of Glycerol Rejection:

$$\% R = \left(1 - \frac{C_P}{C_f}\right) \times 100\%$$

Example:

$$\%R = \left(1 - \frac{52}{1000}\right) \text{ x } 100\%$$

$$\%R = 94.8\%$$

Table 13. Glycerol rejection at 0.5-0.6 kg/ms^2

time (min)	Absorbance of Biodiesel & Glycerol (y)	Concentration of Glycerol in Biodiesel (ppm)	Concentration of Glycerol in Biodiesel (mg/kg)	Glycerol rejection (%)
10	0.000	52	59.4	94.8%
20	0.121	94	106.8	90.6%
30	0.172	112	126.8	88.8%
40	0.198	121	137.0	87.9%
50	0.230	132	149.5	86.8%
60	0.254	140	158.9	86.0%
70	0.290	152	173.0	84.8%
80	0.299	155	176.6	84.5%
90	0.363	177	201.6	82.2%
100	0.381	184	208.7	81.6%
110	0.467	213	242.4	78.7%
120	0.500	225	255.3	77.5%

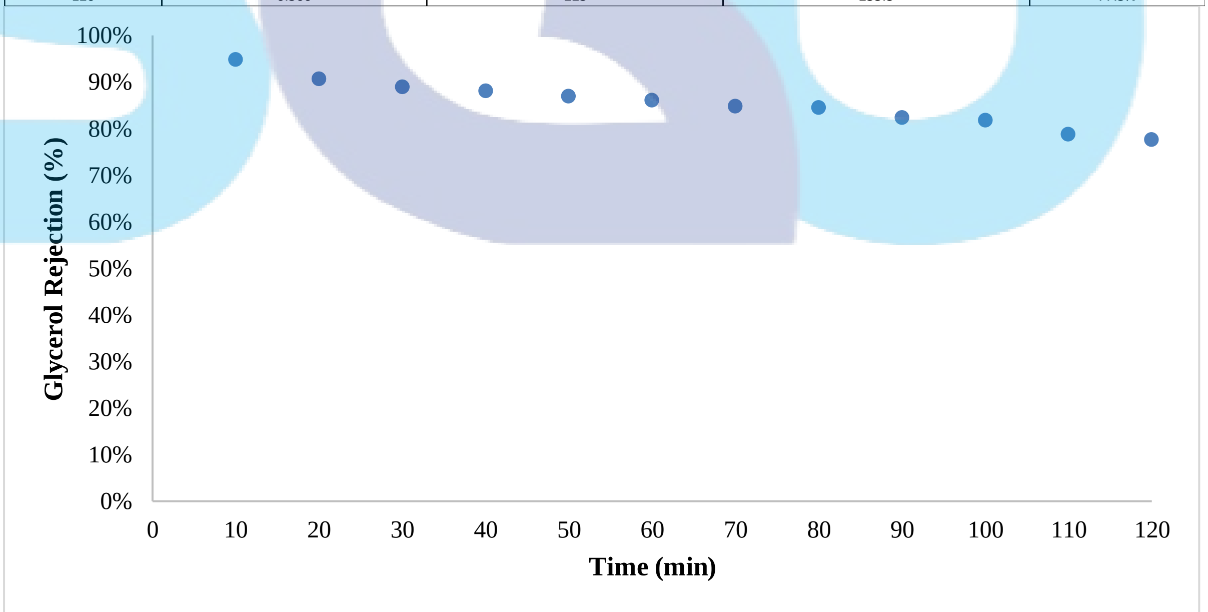

Fig 22. Glycerol Rejection at 0.5-0.6 kg/ms^2

Table 14. Glycerol Rejection in Various Pressure

- Pressure at 0.2-0.3 kg/cm^2

time (min)	∆time (min)	∆time(hr)	permeate volume (mL)	permeate volume (L)	permeate flux (L/m^{2}h)
10	10	0.1667	4.60	0.00460	21.970
20	10	0.1667	5.20	0.00520	24.836
30	10	0.1667	5.10	0.00510	24.358
40	10	0.1667	5.20	0.00520	24.836
50	10	0.1667	5.30	0.00530	25.313
60	10	0.1667	5.30	0.00530	25.313
70	10	0.1667	5.50	0.00550	26.269
80	10	0.1667	5.80	0.00580	27.701
90	10	0.1667	6.00	0.00600	28.657
100	10	0.1667	6.20	0.00620	29.612
110	10	0.1667	6.30	0.00630	30.090
120	10	0.1667	6.50	0.00650	31.045

- Pressure at 0.5-0.6 kg/cm^2

time (min)	∆time (min)	∆time(hr)	permeate volume (mL)	permeate volume (L)	permeate flux (L/m^{2}h)
10	10	0.1667	5.20	0.00520	24.836
20	10	0.1667	5.40	0.00540	25.791
30	10	0.1667	5.70	0.00570	27.224
40	10	0.1667	5.80	0.00580	27.701
50	10	0.1667	6.00	0.00600	28.657
60	10	0.1667	6.20	0.00620	29.612
70	10	0.1667	6.30	0.00630	30.090
80	10	0.1667	6.50	0.00650	31.045
90	10	0.1667	6.70	0.00670	32.000
100	10	0.1667	7.00	0.00700	33.433
110	10	0.1667	7.20	0.00720	34.388
120	10	0.1667	7.30	0.00730	34.866

- Pressure at 0.7-0.8 kg/cm^2

time (min)	∆time (min)	∆time(hr)	permeate volume (mL)	permeate volume (L)	permeate flux (L/m^{2}h)
10	10	0.1667	5.20	0.00520	24.836
20	10	0.1667	5.40	0.00540	25.791
30	10	0.1667	5.60	0.00560	26.746
40	10	0.1667	6.40	0.00640	30.567
50	10	0.1667	6.90	0.00690	32.955
60	10	0.1667	7.30	0.00730	34.866
70	10	0.1667	7.80	0.00780	37.254
80	10	0.1667	8.00	0.00800	38.209
90	10	0.1667	8.30	0.00830	39.642
100	10	0.1667	8.60	0.00860	41.075
110	10	0.1667	8.50	0.00850	40.597
120	10	0.1667	8.90	0.00890	42.507

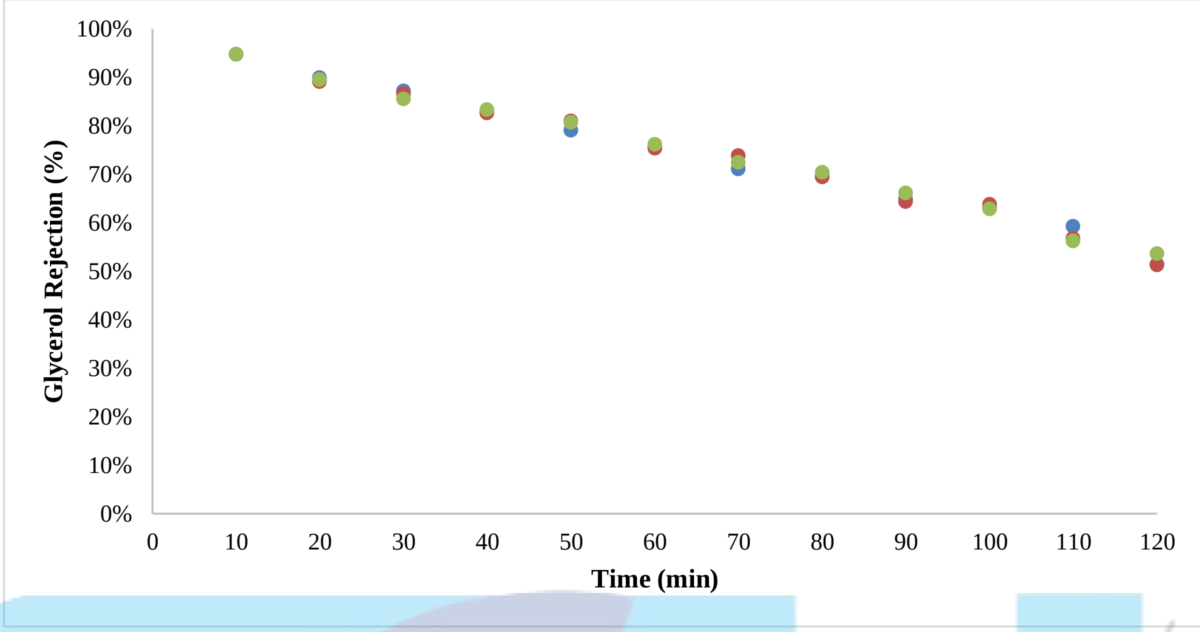

Fig 23. Glycerol Rejection in Various Pressure

4) Flux Decline Ratio (FDR) and Flux Recovery Ratio (FRR)

- **Before Membrane Washing:**

- Table 15. The data of Flux Decline Ratio (FDR)

Pure Biodiesel at 0.2-0.3 kg/cm^2 (L/m^2h)	Biodiesel and Glycerol 1000 ppm at 0.5-0.6 kg/cm^2 (L/m^2h)
60	69
65	67
63	67
60	64
63	60
64	58
63	56
64	55
63	55
65	48
64	42
60	41

- Table 16. The data of Flux Recovery Ratio (FRR)

Pure Biodiesel at 0.2-0.3 kg/cm^2 (L/m^{2}h)	Pure Biodiesel at 0.5-0.6 kg/cm^2 (L/m^{2}h)
60	61
65	59
63	55
60	53
63	48
64	45
63	44
64	44
63	45
65	44
64	43
60.2	42

$$\text{FRR} = \left(\frac{J_{w2}}{J_{w1}}\right) \times 100\%$$

$$\text{FRR} = \left(\frac{47}{60.2}\right) \text{ x } 100\%$$

$$\text{FRR} = 69.8\%$$

$$\text{FDR} = \left(\frac{J_1 - J_s}{J_1}\right) \times 100\%$$

$$\text{FDR} = \left(\frac{60.2-41}{41}\right) \text{ x } 100\%$$

$$\text{FDR} = 31.9\%$$

- **After Membrane Washing:**

- Table 17. The data of Flux Decline Ratio (FDR)

Pure Biodiesel at 0.2-0.3 kg/cm^2 (L/m^{2}h)	Biodiesel and Glycerol 1000 ppm at 0.5-0.6 kg/cm^2 (L/m^{2}h)
60	25
65	26
63	27
60	31
63	33

64	35
63	37
64	38
63	40
65	41
64	41
60.2	43

- Table 18. the data of Flux Recovery Ratio (FRR)

Pure Biodiesel at 0.2-0.3 kg/cm^2 (L/m^{2}h)	Pure Biodiesel at 0.2-0.3 kg/cm^2 (L/m^{2}h)
60	27
65	26
63	32
60	34
63	36
64	36
63	37
64	39
63	43
65	43
64	44
60.2	45

$$\mathrm{FRR} = \left(\frac{J_{w2}}{J_{w1}}\right) \times 100\%$$

$$\mathrm{FRR} = \left(\frac{42}{7}\right) \text{ x } 100\%$$

FRR = 70%

$$\mathrm{FDR} = \left(\frac{J_1 - J_s}{J_1}\right) \times 100\%$$

$$\mathrm{FDR} = \left(\frac{41-49}{41}\right) \text{ x } 100\%$$

FDR = 40%

SGU

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*

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Job Position

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in Internship handling PUE Data & Documentation laboratory Intern

UIMUN Participate

Diponegoro High School / Jaakarta / 2015

English Teacher Volunteer

Diponegoro High School / Jakarta / 2015

Volunteering for teaching English, chemistry, religion for orphanage

Orphanage Volunteer

Diponegoro High School / Jakarta / 2015

AWARDS RECEIVED

1st English Speaking & Debate

SMP Ikal Medan / 2012

2nd Poetry Contest

SMP Ikal Medan / 2012

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LANGUAGUE

Indonesia *(Mothertongue)*

English *(Moderate)*

Germany *(Basic)*

Arabic *(Basic)*

Greek *(Basic)*

ORGANISATION EXPERIENCE

Head of Design & Documentation LSNIGHT

Swiss German University / 2019

Head of Modern Dance

In Swiss German University / 2019

Head of Design & Documentation

Association of Chemical Engineering Student (ACES) / Swiss German University / 2019

Member of Choir

In Swiss German University / 2019

Member of Documentation LSNIGHT

Swiss German University / 2018

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Writing 10/10

Analyse 10/10

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Microsoft Excel 10/10

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Photoshop 10/10

Final-cut 10/10

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University

Swiss German University *(Majoring in Chemical Engineering)*

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