

Table of Content

Abstrak	.....	I
Abstract	.....	II
Acknowlegements	.....	III
Table of content	.....	IV
List of tables	.....	VII
List of figures	.....	VII
1.	Introduction	1
2.	Literature survey	
2.1	Overview	5
2.2	Crude palm oil extraction process	5
2.3	Waste generation during crude palm oil milling process	
2.3.1	Sources of wastes	10
2.3.2	Mass balance of the crude palm oil extraction process	12
2.3.3	Characteristics of combined POME	15
2.3.4	Content of combined POME	16
2.3.5	Biochemical components of combined POME	18
2.4	Treatment of POME	
2.4.1	Pre-treatment	19
2.4.2	Current biological treatment	20
2.4.3	Disposal of treated POME	22
2.4.4	POME reclamation by evaporation technology	22
2.5	Membrane technology	
2.5.1	Overview	26
2.5.2	Filtration process	29
2.5.3	Membrane classification	30
2.6	Ultrafiltration	
2.6.1	Overview	34
2.6.2	Membrane rejection	34
2.6.3	Transmembrane pressure	35
2.6.4	Molecular weight cut-off	36

2.6.5 Charge interaction	37
2.6.6 Solute rejection	38
2.6.7 Membrane application in oily wastewater treatment	39
2.6.8 Ultrafiltration of POME	40
3. Experimental studies	
3.1 Research objectives	42
3.2 Experimental methodology	43
3.3 Experimental procedures	
3.3.1 Sample collection	47
3.3.2 Pre-treatment of samples	48
3.3.3 Membrane ultrafiltration	50
3.3.4 Sample preservation	53
3.3.5 Analytical procedures	53
4. Results and discussions	
4.1 Overview	62
4.2 Effluent characterization	62
4.3 Pre-treatment studies	
4.3.1 Filtration results	64
4.3.2 Centrifugation results	66
4.3.3 Coagulation results	68
4.3.4 Comparison of pre-treatment efficiencies	74
4.4 Membrane ultrafiltration experiment	
4.4.1 Ultrafiltration of filtered sample	76
4.4.2 Ultrafiltration of centrifuged sample	82
4.4.3 Ultrafiltration of coagulated sample	87
4.4.4 Comparison of membrane treatment efficiencies	89
4.4.5 Permeate flux	91
4.5 Overall treatment efficiencies	93
4.6 Proposed new effluent discharge standard	103

5.	Conclusions	106
6.	Future recommendations	108
7.	References	109
8.	Appendices	
	Appendix I	Prevailing effluent discharge standards for crude palm oil mills 1984 (Environmental Quality Act)
	Appendix II	Results of pre-treatments
	Appendix III	Results of coagulation test
	Appendix IV	Flocculation Index
	Appendix V	Results of membrane stirred-cell treatment on filtered and centrifuged POME final discharge
	Appendix VI	Proposed parameter limits of effluent of Standards A and B for year 2005