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THE REMOVAL OF IRON AND MANGANESE IN
GROUNDWATER BY ASYMMETRIC NANOFILTRATION
MEMBRANE

By

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Research Report submitted in partial fulfillment
of the requirements for the degree of
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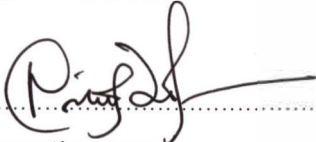
**PENGAKUAN DAN PENGESAHAN LAPORAN
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Adalah ini diakui dan disahkan bahawa laporan bertajuk:

The Removal of Iron and Manganese in Groundwater by Asymmetric Nanofiltration Membrane.

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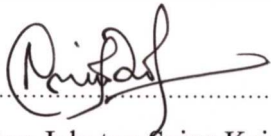
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LIST OF CONTENT

	PAGE
CONTENT	iv
LIST OF TABLES	ix
LIST OF FIGURES	xi
LIST OF ABBREVIATIONS/SYMBOLS	xiii
LIST OF APPENDICES	xv
ABSTRACT	xvi
ABSTRAK	xvii
CHAPTER 1 INTRODUCTION	
1.1 Water and the public health	1
1.2 Groundwater as a source of water supplies	2
1.2.1 <i>Groundwater quality</i>	3
1.2.1 <i>Overview of Groundwater Utilization in Malaysia</i>	6
1.3 Membran technology	7
1.4 Problem statement	10
1.5 Research objectives	13
1.6 Scopes of research	14

	3.2.1	<i>Preparation of Dope</i>	40
	3.2.2	<i>Fabrication of PSF Flatsheet Membrane</i>	41
	3.3	Scanning electron microscope (SEM)	43
	3.4	Membrane performance measurement	44
	3.4.1	<i>Pure Water Permeation</i>	44
	3.4.2	<i>NaCl Permeation</i>	46
	3.4.3	<i>Preparation for Iron and Manganese</i>	51
	3.4.4	<i>Steric Pore Hindrance (SHP) Model</i>	54
CHAPTER	4	RESULTS AND DISCUSSION	
	4.1	Membrane characterization	56
	4.1.1	<i>Pure Water Permeability</i>	57
	4.1.2	<i>Sodium Chloride (NaCl) Rejection</i>	59
	4.1.3	<i>Theoretical Approach – SHP Model</i>	62
	4.1.4	<i>Membrane Morphology</i>	69
	4.2	Membrane Performance : Application on Iron and Manganese Removal	70
	4.2.1	<i>Effects of Applied Pressure</i>	70
	4.2.2	<i>Separation Mechanism</i>	75
CHAPTER	5	CONCLUSION AND RECOMMENDATION	
	5.1	Conclusion	84
	5.2	Recommendation	86

REFERENCES

89

APPENDICES

92

VITAE

105

LIST OF TABLES

NO. TABLE		PAGE
1.1	International Standard For Drinking Water Supplies	5
1.2	Water Resources in Malaysia	7
2.1	Groundwater as share of drinking water by region	16
2.2	Raw water resources in Malaysia, 2001.	17
2.3	The Physical Data of Iron	20
2.4	The Physical Data of Manganese	23
3.1	Volume of salt solution and distilled water for making 500 ml of salt solution at different concentration ranging from 0 to 0.01 M.	47
3.2	Linear equation for calibration curve of conductivity versus Concentration	48
3.3	The solute radius and diffusivity of each ions of NaCl	51
4.1	Pure Water Fluxes	58
4.2	Flux and percentage of rejection of electrolytes (0.01M NaCl)	60
4.3	NaCl rejection by commercial membrane	62
4.4	The modelling results	63
4.5	Relation between reflection coefficient and pore radius	65
4.6	Summary of the characteristic of 29 commercial NF	66
4.7	Diffusivities and Stokes radii of ions	76
4.8	Average pore radius for each type of membrane	76
4.9	The relation between membrane pore radius for each membrane and ions rejections.	77
4.10	The molecular weight and diffusion coefficient of ion	79

4.11	Rejection values and hydration energy of ions	80
4.12	Ion valence for iron and manganese	81
4.13	Percentage of Fe and Mn removals by conventional treatments	83

LIST OF FIGURES

NO. FIGURE	PAGE
1.1 Groundwater Contamination Routes	4
1.2 The filtration Spectrum	9
2.1 Flow diagram of a softening plant (groundwater)	19
3.1 Molecular structure of Polysulfone (PSF)	38
3.2 Molecule structure of <i>N</i> -methyl-2-pyrrolidone	38
3.3 A schematic diagram of membrane preparation flow	40
3.4 Apparatus set up for dope solution preparation	41
3.5 The electrical casting machine	42
3.6 Autocoater (Model JFC 1600) apparatus	43
3.7 Scanning Electron Microscopy (SEM)	44
3.8 Dead-End Cell Filtration (Sterlitech HP4750 Stirred Cell)	45
4.1 Pure water flux vs. pressure at different evaporation time	58
4.2 Influence of applied pressure on the rejection of sodium chloride	61
4.3 Pore radius and membrane thickness vs. different evaporation time at 10 bars	64
4.4 Pore radius and porosity vs. different evaporation time at 10 bars	64
4.5 Scanning electron micrographs of membrane cross section for NF-PSF 18.3% at evaporation time 0s, 5s, 10s and 15s	69
4.6a. Influence of applied pressure on the flux of iron	70
4.6b. Influence of applied pressure on the rejection of iron	71
4.6c. Influence of applied pressure on the flux of manganese	71
4.6d. Influence of applied pressure on the rejection of manganese	72
4.7. Iron flux and rejection vs. different evaporation time at 10 bars	74

4.8	Manganese flux and rejection vs. different evaporation time at 10 bars	74
4.9	Molecular Structure of Polysulfone (PSF)	82

LIST OF ABBREVIATION / SYMBOLS

H ₃ PO ₄	-	Phosphoric acid
INOS	-	Institute of Oceanography
KMnO ₄	-	Potassium permanganate
MF	-	Microfiltration
MW	-	Molecular Weight
MWCO	-	Molecular weight cut off
NaCl	-	Sodium chloride
NF	-	Nanofiltration
NMP	-	N-methyl-2-pyrrolidone
PA	-	Polyamide
PES	-	Polyethersulfone
PSF	-	Polysulfone
PWD	-	Public Works Department
PWP	-	Pure water permeation
RO	-	Reverse osmosis
SEM	-	Scanning Electron Microscope
SHP	-	Steric Hindrance Pore
THM	-	Trihalomethane
TMS	-	Teorell-Meyer-Sievers
UF	-	Ultrafiltration

WHO	-	World Health Organization
WSB	-	Water Supply Board
WSC	-	Water Supply Company
WSD	-	Water Supply Department
ZnCl ₂	-	zinc chloride
r_p	-	pore radius
$A_k/\Delta x$	-	ratio of membrane porosity to membrane thickness
σ	-	reflection coefficient
P_s	-	solute permeability
J_v	-	flux
P_m	-	water permeability
C_p	-	concentration in permeate (mol/liter)
C_b	-	concentration in bulk (for dead end filtration) (mol/liter)
C_w	-	concentration in wall (mol/liter)
r	-	radius of stirred cell
ν	-	kinematic viscosity
D_{∞}	-	bulk diffusivity
k_B	-	Boltzmann's constant
H_F, H_D, S_F, S_D	-	steric and hindrance factors
η	-	ratio of solute radius to pore radius

LIST OF APPENDICES

APPENDIX		PAGE
A	Salt Calibration Curve	92
B	Calculation of Preparation of 500 mL of 0.01 M NaCl	93
C	Dilution of 0.01 M NaCl	94
D	Pure Water and Sodium Chloride Data	95
E	Iron and Manganese Data	101

ABSTRACT

Iron and manganese are common elements in groundwater. Excessive content of both metals in the groundwater will cause aesthetical and operational problems to human. Oxidation, ion exchange and adsorption are some of the conventional methods used to remove the iron and manganese in groundwater. However, these methods have their own merits and limitations and could not remove this metal effectively. The efficiency of iron and manganese removal from groundwater was investigated in this research by means of asymmetric nanofiltration (NF) membrane separation technology. DR/2500 Laboratory Spectrophotometer was used to analyze the concentrations of samples obtained. The effects of evaporation time in the formation of asymmetric nanofiltration membrane using a simple dry/wet phase inversion technique were also determined. Employing the combination of solution-diffusion model (Spiegler–Kedem equation) and steric-hindrance pore (SHP) model, the membrane structural properties were determined and have been characterized for different cases of the formation parameter. The experimental and modeling showed very promising results in terms of membrane performance with interesting structural details. The best evaporation time for the removal of iron and manganese was determined to be in the range of 5 seconds to 7.5 seconds. The iron was found to be 90% successfully removed while the manganese was 75% removed in which these removals were observed to comply with the WHO standard guidelines for drinking water.

ABSTRAK

Ferum dan mangan merupakan unsur yang biasa ditemui dalam air bawah tanah. Kandungan kedua-dua elemen ini yang berlebihan di dalam air akan menimbulkan banyak masalah sehingga menyebabkan nilai estetika air berubah. Terdapat beberapa kaedah rawatan untuk menyingkirkan ferum dan mangan ini. Contohnya pengoksidaan, pertukaran ion dan penjerapan. Walaubagaimanapun, terdapat beberapa kekurangan pada kaedah-kaedah ini dan ianya didapati tidak begitu berkesan. Kajian ini dijalankan untuk mengkaji keberkesanan membran penuras nano dalam menyingkirkan logam-logam berat ini. Alat *DR 2500 Spectrophotometer* digunakan untuk menganalisis sample-sampel yg diperolehi. Kesan jangkamasa evaporasi ketika formasi membran penuras nano ini turut dikaji. *Spiegler-Kedem Equation and Steric-Hindrance Pore (SHP) Model* telah digunakan dalam mengkaji struktur membran yang digunakan dan ciri-ciri membran untuk setiap parameter juga dikenalpasti. Sebanyak 90 peratus ferum dan 75 peratus mangan yang berjaya disingkirkan yang mana masa evaporasi yang terbaik ialah pada julat antara 5 saat hingga 7.5 saat. Penyingkiran ferum dan mangan ini didapati telah memenuhi garis panduan yang ditetapkan oleh *WHO*.