APPLICATION OF NANOFILTRATION MEMBRANE IN AQUACULTURE WASTEWATER TREATMENT

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2005

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By

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Research Report submitted in partial fulfillment of
the requirements for the degree of
Bachelor of Technology (Environmental)

Department of Engineering Science
Faculty of Science and Technology
KOLEJ UNIVERSITI SAINS DAN TEKNOLOGI MALAYSIA
2005

KUSTEM

JABATAN SAINS KEJURUTERAAN
FAKULTI SAINS DAN TEKNOLOGI
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ACKNOWLEDGEMENTS

Firstly I would like to express my deepest and warmest gratitude to my supervisor Dr. Nora'aini binti Ali, co-supervisor En Asmadi bin Ali and my external advisor En Zul for their assistance throughout the duration of this study. Besides that, I'm greatly obliged to quite a number of punch lines from them, especially on those advices in academic studies.

On top of that, I would like to express my thankfulness to all the staff in Department of Engineering Science (Mr. Mahmood, Mr. Razman, Mr. Wan Azhar, Madam Zulaikha, Miss Mazalina, Mr. Razali, Mr Rozimi) and Mr Nasir (INOS staff) for their help and assistance. It's a great pleasure indeed to have the opportunity to work along with them.

Last but least, I would like to thank my parents and family members for their moral support and continues encouragement all this years. Also, I would like to thank all my course mates, Environmental Technology students (2002-05), for their assistance and support.

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LIST OF ABBREVIATIONS / SYMBOLS

Abbreviations

BOD	Biological oxygen demand
C	Carbon
COD	Chemical oxygen demand
DO	Dissolved Oxygen
DSPM	Donnan Steric Pore Model
H_2O	Water
KUSTEM	University College Science and Technology Malaysia
MW	Molecular Weight
N	Nitrogen
NaCl	Natrium Chloride
NF	Nanofiltration
NMP	N-Metyl-2-pyrrolidone
N_2	Nitrogen gas
NH_3^+	Ammonia gas
NH_3-N	Ammonium Nitrogen
NH_4^+	Ammonium ion
NO_2	Nitrite
NO_3	Nirate

Abbreviations

P	Phosphorus
PEG	Polyethyleneglycols
PES	Polyether Sulfone
pH	Hidrogen consentration
PO_4^{-3}	Ion phosphorus
PSF	Polysulfone
PVP	Polyvinylpyrrolidone
RBC	Rotating Biological Contactors.
RO	Reverse Osmosis
SEM	Scanning Electron Microscope
SS	Suspended Solid
UF	Ultrafiltration,

Symbols

A	Membrane area (m^2)
A_k	Porosity of the membrane
C_b	Concentrations in the bulk solution (mol m^{-3})
C_p	Concentrations of permeate solution (mol m^{-3})
C_r	Concentrations of feed solutions (mol m^{-3})
C_w	Wall concentration
$D_{eff\infty}$	Effective bulk diffusivity (m^2/s)
Jw	Water flux (m/s)
k	Transfer coefficient
Q	Quantities of permeate (m^3)
r	Radius of stirred cell

Symbols

r_p	Effective pore radius (m)
R	Gas conctant, (J mol^{-1})
v	Kinetic viscosity ($m^2 s^{-1}$).
T	Absolute temperature, (K)
T_g	Thermal Stability
X_d	Membrane charge
Δx	Effective membrane thickness (m)
$\Delta\pi$	Osmotic pressure
ΔP	Applied pressure drop (kN m^{-2})
ω	Stirring speed
γ	Shear rate

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ABSTRACT

The developments of the aquaculture activities were well known to be the major contributor to the increasing level of pollutants such as ammonium and phosphorus in the industry wastewater. The increasing demand for the aquaculture wastewater treatment was the driving force for the use of membrane technology to treat these intensive aquaculture pollutants within this study. Two polyether sulfone (PES) membranes, PES18PVP (18%PES/77%NMP/5%PVP) and PES18H2O (18%PES/75%NMP/7%H_2O) were prepared using ternary dope system. Both membranes were fabricated into flat sheet membrane based on dry/wet phase inversion technique, using a semi automated electrical casting machine, which was built in-house at KUSTEM Environmental Laboratory. The aquaculture water from the *Clarias gariepinus* hatchery pond of University College Science and Technology Malaysia, were tested to determine the potential for aquaculture wastewater treatment using nanofiltration membrane. The experiments were undertaken with these PES18PVP and PES18H2O membrane to get data needed for the membrane treatment process considerations. There are three ways to identify the membrane performance during this experiment, which are pure water flux test, sodium chloride (NaCl) permeation test and aquaculture wastewater permeation performance. All the experiments were done in dead-end membrane pressure test module. Based on the results of pure water flux, the permeability of PES18PVP is 5.4666 ms^{-1} bar^{-1}, higher than PES18H2O, that is 1.8904 ms^{-1} bar^{-1}. Further more, in the aquaculture wastewater performance experiments at the applied pressure of 0 bar until 20 bar. have shown very high retentions of total phosphorus, up to 96% and total ammonium, up to 44% by the PES18PVP membrane. The PES18H2O membrane also shows a very high retention of total phosphorus, up to 92% and total ammonium, up to 41%. These finding show the great potential for the membrane technology to be used for this particular application in the future.

ABSTRAK

Perkembangan dan kemajuan dalam bidang akuakultur telah dikenalpasti sebagai penyumbang kepada peningkatan aras bahan pencemar seperti ammonium dan fosforus di dalam air sisa industri tersebut. Peningkatan permintaan untuk merawat air sisa akuakultur merupakan daya pemangkin dalam penggunaan teknologi membran untuk merawat sisa bahan pencemar intensif akuakultur dalam kajian ini. Dua jenis membran polieter sulfon (PES), PES18PVP (18%PES/77%NMP/5%PVP) dan PES18H20 (18%PES/75%NMP/ 7%H2O) telah dihasilkan menggunakan larutan pacuan sistem ternari. Kedua-dua membran telah dihasilkan dalam bentuk sekeping membrane nipis menggunakan teknik fasa kering/basah dan mesin pengacuan elektik separa automatik. Air sisa akuakultur dari kolam penternakan *Clarias gariepinus* di Kolej Universiti Sains dan Teknologi Malaysia, telah digunakan untuk menguji dan mentukan potensi untuk merawat air sisa akuakultur menggunakan membran penuras nano. Eksperimen ini dijalankan menggunakan hanya PES18PVP dan PES18H2O untuk mendapatkan data yang diperlukan untuk mempertimbangkan proses rawatan menggunakan membran. Terdapat tiga kaedah untuk mengenalpasti prestasi membran sepanjang eksperimen ini, iaitu pengujian ketelapan air tulen, pengujian ketelapan menggunakan natrium klorida (NaCl) dan pengujian ketelapan menggunakan air sisa akuakultur. Kesemua eksperimen telah dilakukan dalam modul pengujian aliran tertutup membran bertekanan tinggi. Berdasarkan keputusan pengujian ketelapann air tulin, kadar ketelapan membran PES18PVP ialah 5.4666 ms^{-1} bar^{-1}, lebih tinggi berbanding PES18H2O iaitu 1.8904 ms^{-1} bar^{-1}. Selain itu, di dalam pengujian prestasi menggunakan air sisa akuakultur pada tekanan 0 bar hingga 20 bar, menunjukkan penyingkiran jumlah fosforus yang tinggi, mencapai 96%, dan jumlah ammonium mencapai 44% penyingkiran untuk membran PES18PVP. Manakala membran PES18H2O turut meninjukakan penyingkiran jumlah fosforus yang tinggi, sehingga 92%, dan jumlah ammonium sehingga 41%. Penemuan ini mempunyai potensi yang cerah bagi teknologi membran untuk digunakan dalam aplikasi ini pada masa akan datang.