

UNIVERSITI TEKNOLOGI MARA

**NANO FLAT SHEET MEMBRANE
FILTRATION USING SILICA
SUGARCANE BAGASSE AS
ADDITIVE FOR LEACHATE
TREATMENT**

HAMIZAH BINTI MOKHTAR

Thesis submitted in fulfillment
of the requirements for the degree of
Doctor of Philosophy

Faculty of Civil Engineering

October 2018

AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

Name of Student : Hamizah Binti Mokhtar

Student I.D. No. : 2013876998

Programme : Doctor of Philosophy (EC950)

Faculty : Civil Engineering

Thesis Title : Nano Flat Sheet Membrane Filtration Using Silica
Sugarcane Bagasse As Additive For Leachate
Treatment

Signature of Student :

Date : October 2018

ABSTRACT

Membrane technology using ultrafiltration and nanofiltration membrane process had proven to be successful in treating physical and organic impurities from water and wastewater. However, this technology has its challenge due to its higher selectivity. The selectivity of membrane influenced by the materials used to fabricate a membrane. Recently, additive was added into membrane formulation to improve hydrophilicity, membrane charge and surface roughness. Silica is one of the additives in membrane formulation that has capability to resist chemical attack and high thermal stability. Silica can be extracted from various sources such as alkoxysilane, quartz, sand, silicon tetrachloride and tetraethyl orthosilicate. However, different types of silica produce different effects of membrane characteristics and performance. Therefore, this thesis is focused on the exploration of new membrane materials to develop a new flat sheet nanofiltration membrane using silica extracted from sugarcane bagasse as additives. The process involved in this study includes extraction of silica from sugarcane bagasse, characterization of silica sugarcane bagasse, dope formulation and fabrication using silica sugarcane bagasse, and characterization and performance of the newly developed nano flat sheet silica sugarcane silica bagasse additive membrane (SSAM). Morphology via Scanning Electron Microscopy (SEM) for SSAM showed that the addition of silica enhanced the macrovoid formation in sub layer of membrane and improve interconnectivity of the pore, hence, increase flux. High silica concentration increases solution viscosity and strong interaction with polymer able to delay dope precipitation and cause decreasing in size of pores, thus, increase salt rejection. Silica sugarcane bagasse is hydrophilic which can attract large amount of water which is 46 L/m²hr to pass through membrane and increased salt rejection from 65.80% to 77.50%. This SSAM with weight percent 21 wt.%, 71 wt.%, 5 wt.%, 3 wt.% of PSF:DMAc:PVP:Silica showed excellent performance in combination of aeration and membrane system for leachate treatment with the result of approximately 100% rejection of Copper (Cu), Chromium (Cr), Zinc (Zn), Nickel (Ni), Cadmium (Cd) and Iron (Fe). In conclusion, silica sugarcane bagasse is comparable to be as an alternative and sustainable source of membrane material which is additive. New membrane formulation determined from this research work tailored for leachate treatment, 21 wt.%, 71 wt.%, 5 wt.%, 3 wt.% of PSF:DMAc:PVP:Silica is able to discharged treated leachate effluent that satisfy the Standards A requirement of Environment Quality Act (EQA) 2009.

TABLE OF CONTENTS

	Page
CONFIRMATION BY PANEL OF EXAMINERS	ii
AUTHOR'S DECLARATION	iii
ABSTRACT	iv
ACKNOWLEDGEMENT	v
TABLE OF CONTENTS	vi
LIST OF TABLES	xi
LIST OF FIGURES	xiv
LIST OF SYMBOLS	xvii
LIST OF ABBREVIATIONS	xviii
CHAPTER: ONE INTRODUCTION	1
1.1 Research Background	1
1.2 Application of Organic Silica in Membrane Formulation and Fabrication	8
1.3 Problem Statement	10
1.4 Objectives	11
1.5 Significance of Study	11
1.6 Scope of Work	12
CHAPTER: TWO LITERATURE REVIEW	13
2.1 Introduction	13
2.2 Solid Waste Scenario in Malaysia	13
2.3 Leachate Generation	16
2.3.1 Composition of Leachate	18
2.3.2 Characteristics of Leachate generated from Landfill in Malaysia	19
2.3.2.1 Biological Oxygen Demand (BOD)	21
2.3.2.2 Chemical Oxygen Demand	21
2.3.2.3 Heavy Metals	21
2.3.2.4 pH	22

2.3.2.5	Total Solids	22
2.3.2.6	Total Suspended Solid (TSS)	23
2.3.3	Impact of Leachate to the Environment	23
2.3.4	Effects of Heavy Metals Released to the Environment	24
2.3.4.1	Iron	25
2.3.4.2	Nickel	25
2.3.4.3	Cadmium	25
2.3.4.4	Zinc	26
2.3.4.5	Chromium	26
2.3.4.6	Copper	26
2.3.5	Malaysian Regulations on Discharging of Effluent	27
2.3.6	Existing Treatment of Leachate	31
2.3.7	Technologies Associated with Heavy Metals Removal	35
2.4	Membrane Technology	36
2.4.1	History Development of Membrane	36
2.4.2	Membrane Processes	38
2.4.3	Membrane Application Worldwide	41
2.4.3.1	Microfiltration Membrane (MF)	41
2.4.3.2	Ultrafiltration Membrane (UF)	42
2.4.3.3	Nanofiltration Membrane (NF)	42
2.4.3.4	Reverse Osmosis (RO)	43
2.5	Membrane Fabrication	44
2.5.1	Phase Inversion	44
2.5.2	Dry Wet Phase Separation	46
2.6	Membrane Transport Theory	47
2.6.1	Solution Diffusion Model	48
2.6.2	Pore Flow Model	49
2.7	Filtration Process	50
2.7.1	Cross Flow Filtration	50
2.7.2	Dead End Filtration	51
2.8	Membrane Module	51
2.9	Membrane Materials	53
2.9.1	Based Polymer of Membrane	54
2.9.2	Solvent for Membrane	56