



UNIVERSITI PUTRA MALAYSIA

**TREATMENT OF SECONDARY OXIDATION POND
EFFLUENT USING HOLLOW FIBRE CROSSFLOW
MICROFILTRATION AND MORINGA
OLEIFERA SEEDS EXTRACT AS
COAGULANT**

WAI KIEN TAT

FK 2003 2

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By

WAI KIEN TAT

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,
in Fulfilment of the Requirement for the Degree of Master of Science**

April 2003



**This work, I specially dedicated to
My beloved wife, Kuay Chew Yit
My parents, brother and sister.**



Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science.

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Chairman : Dr. Thamer Ahmed Mohamed

Faculty : Engineering

A secondary oxidation pond effluent was treated using hollow fibre crossflow microfiltration and coagulation process. Preliminary experiments were carried out to find optimum dosage of *Moringa oleifera* and alum as coagulants. Optimum dosage of *Moringa oleifera* in treating low turbid (30-70 NTU) and high turbid (70-100 NTU) secondary oxidation pond effluent was 100 mg/L respectively. About 50% turbidity removal was achieved when using 100 mg/L *Moringa oleifera*. At optimum dosage of 200 mg/L of alum, 97% turbidity removal was achieved for high turbid samples while 93% turbidity removal was achieved for low turbid samples. Both *Moringa oleifera* and alum were found to be more efficient in treating high turbid samples. However, alum was more effective in removing turbidity in secondary oxidation pond effluent than *Moringa oleifera*. Using 10,000 mg/L *Moringa oleifera* as a stock solution was more suitable than using 5,000 mg/L and 20,000 mg/L *Moringa oleifera* in removing turbidity in kaolin solution.

Next, the performance of microfiltration coupled with coagulation using optimum dosage of *Moringa oleifera* was investigated. Better flux performance and lower rate of fouling were achieved when combining microfiltration with coagulation. Pseudo-state flux at 3 L/m².hr and constant suction pressure within 0.6 bar were obtained after 300 hours of filtration time. Removal of COD, BOD₅, alkalinity, residual turbidity, TSS, VSS, TDS, TS, temperature and pH in filtrate were not influenced by incorporation of coagulation using *Moringa oleifera*. Filtrate with quality lower than 50 mg/L COD, 25 mg/L BOD₅, 2 mg CaCO₃/L alkalinity, 1 NTU turbidity, 1 mg/L TSS and VSS respectively was produced with microfiltration both with and without coagulation.

Abstrak tesis yang dikemukakan kepada Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

**RAWATAN AIR KUMBAHAN NAJIS SEKUNDER DENGAN
MENGUNAKAN MIKROTURASAN ALIRAN SILANG HOLLOW FIBER
DAN EKSTRAK BIJI *MORINGA OLEIFERA* SEBAGAI PENGGUMPAL**

Oleh

WAI KIEN TAT

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Pengerusi : Dr. Thamer Ahmed Mohamed

Fakulti : Kejuruteraan

Air kumbahan najis sekunder telah dirawat dengan menggunakan mikroturasan aliran silang hollow fiber dan proses penggumpalan. Pra-eksperimen telah dijalankan untuk mencari dos optimum *Moringa oleifera* dan alum sebagai penggumpal. Dos optimum *Moringa oleifera* dalam merawat air kumbahan najis sekunder berkekeruhan rendah (30-70 NTU) dan berkekeruhan tinggi (70-100 NTU) masing-masing ialah 100 mg/L. Lebih kurang 50% pengurangan kekeruhan berjaya dicapai apabila menggunakan 100 mg/L *Moringa oleifera*. Pada kepekatan optimum 200 mg/L alum, 97% pengurangan kekeruhan berjaya dicapai bagi sampel berkekeruhan tinggi manakala 93% bagi sampel berkekeruhan rendah. Kedua-dua *Moringa oleifera* dan alum didapati adalah lebih berkesan untuk merawat sampel berkekeruhan tinggi. Namun, alum adalah lebih efektif dalam merawat kekeruhan dalam air kumbahan najis sekunder berbanding dengan *Moringa oleifera*. Menggunakan 10,000 mg/L *Moringa oleifera* sebagai larutan stok terbukti lebih sesuai jika dibandingkan dengan menggunakan 5,000 mg/L dan 20,000 mg/L *Moringa oleifera* dalam merawat kekeruhan di dalam larutan kaolin.

Seterusnya, prestasi mikroturasan digabung dengan proses penggumpalan dengan menggunakan dos optimum *Moringa oleifera* telah dikaji. Fluks yang lebih baik serta kadar sumbatan yang lebih rendah telah berjaya dicapai apabila menggabungkan mikroturasan dan penggumpalan. Fluks malar pada 3 L/m².hr dan tekanan sedutan konstan sekitar 0.6 bar telah didapati setelah 300 jam masa turasan. Pengurangan COD, BOD₅, alkalinity, baki kekeruhan, TSS, VSS, TDS, TS, suhu dan pH dalam hasil turasan tidak dipengaruhi oleh penggabungan penggumpalan dengan menggunakan *Moringa oleifera*. Hasil turasan dengan kualiti yang lebih rendah daripada 50 mg/L COD, 25 mg/L BOD₅, 2 mg CaCO₃/L alkalinity, 1 NTU kekeruhan, 1 mg/L TSS dan VSS masing-masing dapat dihasilkan dengan mikroturasan dengan dan tanpa penggumpalan.

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TABLE OF CONTENTS

	Page
DEDICATION	ii
ABSTRACT	iii
ABSTRAK	v
ACKNOWLEDGEMENTS	vii
APPROVAL	viii
DECLARATION	x
LIST OF TABLES	xiii
LIST OF FIGURES	xv
CHAPTER	
I INTRODUCTION	1
Historical Perspective of Sewerage Development in Malaysia	1
Problem Statement	3
Objectives of the Research	9
II LITERATURE REVIEW	10
General Concept of Microfiltration	10
Crossflow Microfiltration	13
Hollow Fibre in Membrane Separation	16
Advantages and Disadvantages of Membrane Separation	19
Development in Microfiltration Research	21
Microfiltration in Treating Domestic Wastewater	21
Effect of Aeration	31
Fouling Studies	32
Oxidation Pond and Effluent	38
Processes Related With Coagulation	42
General Concept of Coagulation	43
<i>Moringa oleifera</i> As a Natural Coagulant	45
<i>Moringa oleifera</i> in Wastewater Treatment	47
Alum As a Coagulant	53
III MATERIALS AND METHODS	55
System Design	56
Holding Tank	57
Aeration Tank	58
Hollow Fibre Membrane Module	59
Effluent Tank	60
Materials and Apparatus	61
Preparation of <i>Moringa oleifera</i> Solution As Coagulant	63
Preparation of Alum Solution As Coagulant	65
Collection of Sample	65



	Jar Test	67
	Effect of Different <i>Moringa oleifera</i> Stock Solution Concentration on Turbidity Removal	68
	Determination of Clean Flux	68
	System Operation	70
	Membrane Cleaning	73
IV	RESULTS AND DISCUSSION	74
	General	74
	Part One: Coagulation	74
	Secondary Oxidation Pond Effluent Characteristic	74
	Jar Test Using <i>Moringa oleifera</i>	76
	Jar Test Using Alum	77
	Variation of Residual pH of the Sample With Alum Concentration	79
	Effect of <i>Moringa oleifera</i> Stock Solution on Turbidity Removal	80
	Part Two: Microfiltration Incorporated With Coagulation	82
	Secondary Oxidation Pond Effluent Characteristic	82
	Testing on Membrane Module's Clean Flux Using Distilled Water	83
	Variation of Flux and Pressure With Time	84
	Variation of COD and Alkalinity With Time	87
	Variation of BOD ₅ With Time	91
	Variation of Turbidity With Time	92
	Variation of TSS and VSS With Time	95
	Variation of TDS and TS With Time	98
	Variation of pH and Temperature With Time	101
	Variation of DO With Time	104
V	CONCLUSION	107
VI	RECOMMENDATION	109
	REFERENCES	110
	APPENDICES	115
	Appendix A: Plates Showing Field Work of Sample Site & Experimental Model	116
	Appendix B: Plates for Scanning Electron Microscope (SEM) Photo of Hollow Fibre	118
	Appendix C: Plates Showing Microorganism Present in Raw Wastewater	125
	Appendix D: Table of Results	128
	Appendix E: Table of Processed Data for Final Effluent From Taman Sri Serdang Oxidation Pond	151
	Appendix F: Table of Monitoring Data (Final Effluent) from Other Oxidation Ponds in Serdang Area	152
	BIODATA	153



LIST OF TABLES

Table		Page
1.1	Classification of public sewage treatment plants maintained by IWK, 1994 – 1997	6
1.2	Compliance of effluent quality with Environmental Quality Act 1974 as of December, 1997	7
2.1	Some application areas of microfiltration	12
2.2	Characteristic of the 2 nd stage oxidation pond effluent in comparison with the environmental quality regulation for sewage and industrial (1979) for Malaysia	24
2.3	Standards for sewage and industrial effluents	40
2.4	Coagulation-sedimentation typical process removal	45
3.1	Timetable for measurement of raw sample, tank sample and filtrate for the first 48 hours of the experiment	71
4.1	Secondary oxidation pond effluent characteristic (Part One)	75
4.2	Turbidity of the high turbid samples coagulated using <i>Moringa oleifera</i>	128
4.3	Turbidity of the low turbid samples coagulated using <i>Moringa oleifera</i>	128
4.4	Turbidity of the high turbid samples coagulated using alum	129
4.5	Turbidity of the low turbid samples coagulated using alum	129
4.6	Variation of pH with alum concentration	129
4.7	Turbidity of kaolin suspension by testing different stock solution of <i>M. oleifera</i>	130
4.8	Secondary oxidation pond effluent characteristic (Part Two)	82
4.9	Correlation between flux and pressure with pump speed using distilled water	130
4.10	Variation of flux and pressure with time with coagulation	131



4.11	Variation of flux and pressure with time without coagulation	133
4.12	Variation of COD and Alkalinity with time with coagulation	134
4.13	Variation of COD and Alkalinity with time without coagulation	136
4.14	Variation of Total BOD ₅ with time with coagulation	137
4.15	Variation of Total BOD ₅ with time without coagulation	138
4.16	Variation of Turbidity with time with coagulation	139
4.17	Variation of Turbidity with time without coagulation	141
4.18	Variation of TSS and VSS with time with coagulation	142
4.19	Variation of TSS and VSS with time without coagulation	144
4.20	Variation of TDS and TS with time with coagulation	145
4.21	Variation of TDS and TS with time without coagulation	145
4.22	Variation of pH and temperature with time with coagulation	146
4.23	Variation of pH and temperature with time without coagulation	148
4.24	Variation of DO (dissolved oxygen) with time with coagulation	149
4.25	Variation of DO (dissolved oxygen) with time without coagulation	150



LIST OF FIGURES

Figure		Page
2.1	Size separation capability of the membrane types	11
2.2	Spiral wound membrane	16
2.3	Arrangement of hollow fibre permeator and piping assembly (Permasep Eng. Manual, The Du pont Co.)	17
2.4	Simple tubular membrane arrangement	17
2.5	Typical plate and frame RO arrangement	18
2.6	Membrane process	19
2.7	Schematic presentation of the three stages in flux decline	35
3.1	Schematic diagram of overall methodology (microfiltration incorporated with coagulation)	55
3.2	Schematic diagram of the model (a) side view of the model and (b) plan view of the model	56
3.3	Vertical view of the hollow fibre membrane module	60
3.4	Schematic plan view of the sample site	66
4.1	Variation of turbidity of treated water samples with dosage of <i>Moringa oleifera</i> as a coagulant	77
4.2	Variation of turbidity of treated water samples with dosage of alum as a coagulant	79
4.3	Variation of alum concentration with low turbid and high turbid pH sample in jar-test	80
4.4	Variation of residual turbidity of kaolin solution with different stock solution of <i>Moringa oleifera</i> in jar-test	81
4.5	Correlation between flux and pressure with pump speed using distilled water	84
4.6	Variation of filtrate flux with time with and without coagulation	86
4.7	Variation of filtrate pressure with time with and without	

	coagulation	86
4.8	Variation of COD with time with coagulation	88
4.9	Variation of COD with time without coagulation	89
4.10	Variation of Alkalinity with time with coagulation	90
4.11	Variation of Alkalinity with time without coagulation	90
4.12	Variation of BOD ₅ with time with coagulation	91
4.13	Variation of BOD ₅ with time without coagulation	92
4.14	Variation of Turbidity with time with coagulation	93
4.15	Variation of Turbidity with time without coagulation	94
4.16	Variation of TSS with time with coagulation	96
4.17	Variation of TSS with time without coagulation	96
4.18	Variation of VSS with time with coagulation	97
4.19	Variation of VSS with time without coagulation	97
4.20	Variation of TDS with time with coagulation	99
4.21	Variation of TDS with time without coagulation	99
4.22	Variation of TS with time with coagulation	100
4.23	Variation of TS with time without coagulation	101
4.24	Variation of pH with time with coagulation	102
4.25	Variation of pH with time without coagulation	102
4.26	Variation of temperature with time with coagulation	103
4.27	Variation of temperature with time without coagulation	104
4.28	Variation of DO (dissolved oxygen) with time with coagulation	105
4.29	Variation of DO (dissolved oxygen) with time without coagulation	106



CHAPTER 1

INTRODUCTION

Water is one of the fundamental requirements for the life on the earth. Before human exists, balance between population of fauna and flora with the environment was controlled by climates and changes in water supply. When pollution of surface water occurred due to natural phenomenon such as volcanic eruptions or dust storms, living things which dependant on that particular water source will either moved or died. Human emergence on the earth then had a pronounced effect on the water supply. Earlier human population which was relatively small, tend to concentrate around water source such as river or stream but as population grew the quality of water resources deteriorates. Deterioration of the water resources restricts its use for domestic purposes. Usage of polluted water supply sources in the past centuries caused death and infection diseases to propagate and this affects population growth. Recently, the control measures and water treatments as well as tests technologies have improved and made the water usage safer than before.

Historical Perspective of Sewerage Development in Malaysia

A modern and efficient sewerage system is vital for a developing nation such as Malaysia especially when we are gearing towards Vision 2020. A reliable system is not only ensuring our increasing population is protected from unnecessary health risks but also preserving our water resources for future generations.



Under the Malaysian constitution, both Federal and State Government have responsibilities in sanitation and public health matters. Emphasis on health and sanitation started in the urban areas as reflected in the existence of Sanitary Boards in the early part of the century which were the fore-runner of the present day Municipal Authorities (DGSS, 1998). However, with the diversification and growth of urban services which need to be provided, this emphasis on health and sanitation has been downgraded.

This is shown in the sanitation status of the country as ascertained by the 1970 census where only 3.4% of the population of the country was served by central sewerage systems, mainly in Kuala Lumpur, Georgetown and the major towns in Sabah, whereas 17.2% were on septic tanks, 19.8% on bucket latrines and 29.9% on pit latrines. While a small percentage of 2.6% were on pour-flush latrines, 27.1% had either no facilities or resort to defecating in the river or sea (DGSS, 1998). Therefore, prevalent technology used for wastewater disposal in the urban area as at 1970 are mostly septic tank and bucket latrines while people in rural areas were still using pit latrines or resort to the natural environment.

However, two-pronged programme launched in 1974 for achieving sanitation improvement in the country was found most successful in rural areas where in 1995, at least 90% of the population were adequately equipped with pour-flush latrines, which had increased from previous 2.6% in 1970. While in urban areas, technology considered appropriate for wastewater disposal was central sewerage system where the wastewater

is collected and brought to a sewage treatment plant located away from the community (DGSS, 1998).

In order to ensure that new developments are adequately provided with modern sewerage infrastructure, a policy that proposed in 1980 was accepted by the Federal Government. The policy stated that all new housing areas with more than 30 units will be required to develop a complete sewerage infrastructure with their own local sewage treatment plants. In most cases, oxidation pond was the preferred technology of treatment where factors like costs and simplicity of operations as well as maintenance within the context of taking-over by local authorities were considered despite of their very limited technical manpower. However, not all local authorities adhered to the policy since that Ministry of Health, Malaysia and the Ministry of Housing and Local Government, Malaysia are only advisory status to the local authorities. Therefore, by 1990, the coverage by central sewerage system had only increased from 3.4% in 1970 to 5.0% while septic tank coverage had grown from 17.2% in 1970 to 37.3% respectively (DGSS, 1998).

Problem Statement

Wastewater generally can be categorized into 2 types, namely domestic wastewater and industrial wastewater. In order to treat domestic wastewater, usually biological treatment is mostly applied whereas in treating industrial wastewater, chemical treatment is much more useful. In Malaysia, sewage comprises of various

pollutants, which not only enter the sewerage system from domestic but commercial and industrial premises. It is mainly comprised of organic and this includes urine, sewage or faeces from the toilet. Other wastes, which also enter sewerage system from household, are sink water and oil from kitchen as well as used water from bathroom and laundry (IWK, 1999).

Quite a number of our activities at home could generate pollutants, which find their way to the sewerage system. Unless they are treated at sewage treatment plant, these pollutants can end up in drains, rivers and coastal waters, posing public health, contaminating water resources as well as polluting the environment. In Malaysia, sewerage systems range from simple toilets providing little or no treatment at all to sewage to modern sewage treatment plants that employ mechanical means to treat large volumes of sewage to acceptable environmental standards (IWK, 1999).

In Malaysia itself, sewerage system treats only human waste and household wastewater comparing to the sewerage systems in certain countries which are designed to treat both commercial and industrial effluent such as industrial sewage, toxic waste and manufacturing waste. In the other hand, industrial and trade waste in Malaysia are treated separately either by on-site industrial waste treatment plants or sent by special tanker to Bukit Nanas central toxic waste treatment plant in Negeri Sembilan. Neither industrial waste nor trade effluent is allowed to be discharged into Malaysia's sewerage system.

Although IWK maintained only 467 oxidation ponds in 1997 (DGSS, 1998), however the number of actual oxidation ponds in Malaysia are definitely higher. Some of the ponds are either maintained by local authorities such as PKNS (Selangor Development Body) or developers of the concerned residential park. Inconsistent in coordination of maintaining oxidation ponds between these parties caused the treatment of domestic wastewater in Malaysia became unsystematic, hence effluent after treated still unable to comply national standards. Currently, oxidation pond or aerated lagoon are one of the famous biological treatments being practiced locally. According to the Sewerage Services Report 1994 -1997 (DGSS, 1998), there are 5 types of sewerage treatment processes being practiced in Malaysia which are classified as communal septic tank, Imhoff tank, oxidation pond, mechanical plant with media as well as without media.

Number of sewage treatment plants being built is expected to increase tremendously. This is true if the capability of the treatment plant is just designed for accommodating small population. This is totally different in other developed countries where it is more efficient to build bigger and advanced treatment plant to accommodate larger population. Number of treatment plant then can be greatly reduced to enhance better maintenance. According to Sewerage Services Report 1994-1997 (DGSS, 1998) also, between 1994 and 1997, number of sewage treatment plant at present designed for more than 5000 PE (Population Equivalent) was not more than 5% of the total treatment plant except for the year 1994 (6.0%). Out of 4,539 treatment plants taken over by IWK

as of December 1997, a total of 86.2% of the plants are small plants such as communal septic tanks and Imhoff tanks serving population of not more than 2000 each.

Table 1.1: Classification of public sewage treatment plants maintained by IWK, 1994-1997 (DGSS, 1998)

Year	Communal Septic Tanks	Imhoff Tanks	Oxidation Ponds	Mechanical Plant With Media	Mechanical Plant Without Media	Marine	Total No. of STPs
1994	372 (35.7%)	352 (33.7%)	196 (18.8%)	33 (3.2%)	90 (8.6%)	-	1,043
1995	1,994 (61.4%)	547 (16.8%)	400 (12.3%)	80 (2.5%)	228 (7.0%)	-	3,249
1996	2,316 (56.9%)	717 (17.6%)	442 (10.9%)	179 (4.4%)	413 (10.2%)	1	4,068
1997	2,543 (56.0%)	724 (16.0%)	467 (10.3%)	220 (4.8%)	584 (12.9%)	1	4,539

From the Table 1.1, there is a reduction in term of percentage for oxidation pond from 18.8% in 1994 to 10.3% in 1997 but in term of number, as many as 196 oxidation ponds in 1994 has increased to 467 in 1997. Moreover, the increment was getting lower by each year. However, mechanical plant with or without media are gaining popularity due to its high efficiency in treating sewage compare to the ability and capability of the other types of treatment plants in serving the same purpose.

Declining popularity of oxidation pond is mainly due to difficulties in complying with the current discharge standards. In addition, oxidation pond is sometimes receiving unexpectedly large amount of sewage beyond their capacity and it may give out foul odor and even getting worse in rainy day. This phenomenon is mostly

found in dense-populated area. Overflow of effluent from oxidation pond especially after rain would cause eutrofication in the water nearby as well as decrement in oxygen concentration since that the effluent is almost made up of organic which is easily biodegradable.

In simple word, oxidation pond represents 12% of all treatment plants in Malaysia. A new oxidation pond can treat sewage to Standard B effluent level but however require maintenance and periodic desludging to maintain this standard (IWK, 1999). Table 1.2 shows compliance of effluent quality from sewage treatment plant in Malaysia for the year 1994 – 1997.

Table 1.2: Compliance of effluent quality with Environmental Quality Act 1974 as of December, 1997 (DGSS, 1998).

Year	Total No. of STPs*	Percentage of Samples Complied			
		pH	SS	BOD	Oil & grease
1994	1,043	99%	72%	58%	80%
1995	3,249	99%	60%	44%	77%
1996	4,068	99%	63%	42%	80%
1997	4,538	99%	75%	55%	87%

- Samples were taken from STP with PE > 150

For typical oxidation pond, sewage enters a large primary pond after passing through settling basin and screening chamber. After retention for several days, the flow is then diverted to secondary pond for further treatment before being discharged into water bodies. Bacteria in each pond break down organic matter in the sewage using oxygen from the surface of the pond or supplied by surface aerators installed in the

pond. Protozoa and rotifer, which present in the pond is functions to polish the effluent. Therefore, in order to remain effective treatment systems, oxidation pond must be desludged periodically.

The effluent quality from oxidation pond is poor and does not always meet with the secondary treatment criteria (Qasim, 2000). Oxidation pond has the advantages of low construction and operation costs but always offset by major disadvantages such as requirement of large land area, odor and insect problems, possible groundwater contamination and poor effluent quality.

According to Water Pollution Control Federation (1990), poor effluent quality in lagoon may be caused by

- a. Overloading
- b. Low ambient temperatures
- c. Toxic materials in influent
- d. Loss of liquid volume due to sludge deposition, leakage and evaporation
- e. Aeration equipment malfunction
- f. Interference of light penetration by high turbidity, algae mat or scum
- g. Blockage of light by plant growth on dikes

Anaerobic conditions in the lagoon can cause odor problems. Other possible nuisance problems include foaming, insect propagation, groundwater