UNIVERSITI PUTRA MALAYSIA

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

WAI KIEN TAT

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

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.

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

By

WAI KIEN TAT

April 2003

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 $L/m^2.hr$ and constant suction pressure within 0.6 bar were obtained after 300 hours of filtration time. Removal of COD, BOD_5, 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 BOD_5, 2 mg $CaCO_3$/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 MENGGUNAKAN MIKROTURASAN ALIRAN SILANG HOLLOW FIBER DAN EKSTRAK BIJI *MORINGA OLEIFERA* SEBAGAI PENGGUMPAL

Oleh

WAI KIEN TAT

April 2003

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 $L/m^2.hr$ dan tekanan sedutan konstan sekitar 0.6 bar telah didapati setelah 300 jam masa turasan. Pengurangan COD, BOD_5, 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 BOD_5, 2 mg $CaCO_3$/L alkalinity, 1 NTU kekeruhan, 1 mg/L TSS dan VSS masing-masing dapat dihasilkan dengan mikroturasan dengan dan tanpa penggumpalan.

ACKNOWLEDGEMENTS

The author wishes to express his highest gratitude and appreciation to the chairman of the supervisory committee, Dr. Thamer A. Mohamed, ex-chairman, Prof. Madya Ir. Megat Johari Megat Mohd. Noor, and to the members of the supervisory committee, En. Abdul Halim Ghazali and Pn. Badronnisa Yusuf for their excellent supervision, valuable guidance as well as comments during the duration of this research.

A same appreciation and deepest thank to the lab technician in the Public Health Engineering Lab, Mr. Zainuddin Ismail, all staff in Biochemical Lab, Department of Chemical and Environmental Engineering, staff especially En. Saparis and Cik Faridah in Scanning Electron Microscope (SEM) Unit, Faculty of Veterinary Medicine, Pn. Zaiton Basar in Aquatic Ecology Lab as well as Cik Ruhaidah , Faculty of Science and Environmental Studies.

Deepest thank to Mr. Ahmed H. B. Mohammed for his valuable direct or indirect help.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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).

		Percentage of Samples Complied			
Year	Total No. of STPs*	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