UNIVERSITI PUTRA MALAYSIA

MICROBIAL TREATMENT OF DOMESTIC WASTEWATER TREATMENT PLANT SLUDGE BY LIQUID STATE BIOCONVERSION PROCESS

MD. ZAHANGIR ALAM

MICROBIAL TREATMENT OF DOMESTIC WASTEWATER TREATMENT PLANT SLUDGE BY LIQUID STATE BIOCONVERSION PROCESS

By

MD. ZAHANGIR ALAM

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia in Fulfillment of the Requirement for the Degree of Doctor of Philosophy

July 2002

DEDICATION

TO MY PARENTS AND WIFE

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Doctor of Philosophy

MICROBIAL TREATMENT OF DOMESTIC WASTEWATER TREATMENT PLANT SLUDGE BY LIQUID STATE BIOCONVERSION PROCESS

By

MD. ZAHANGIR ALAM

July 2002

Chairman: **Associate Professor Fakhru'l-Razi Ahmadun, Ph. D.**

Faculty: **Engineering**

The study of microbial treatment of domestic wastewater treatment plant (DWTP) sludge by liquid state bioconversion (LSB) process was conducted by several approaches. A total of 70 strains of filamentous fungi were isolated from three different sources (wastewater, DWTP sludge and landfill leachate), which belonged to the genera of *Penicillium* (39 strains), *Aspergillus* (14 strains), *Trichoderma* (12 strains), *Spicaria* (3 strains) and *Hyaloflorae* (2 strains). In the screening test, the fungal strains WWZP1003 (*Penicillium corylophilum*), SCahmA103 (*Aspergillus niger*), SCahmT105 (*Trichoderma harnianum*) and PC-9 (*Phanerochaete chrysosporium*), among their respective groups of *Penicillium*, *Aspergillus*, *Trichoderma* and Basidiomycete, played potential roles in terms of separation, biodegradation and filtration of treated DWTP sludge. The results of the compatible mixed culture optimization study showed a compatible growth of the mixed culture for *P/A, P/PC* and *A/PC* and the combinations *P/T*, *A/T* and *T/PC*

were observed to be incompatible cultures for the bioconversion of the sludge. Among the combinations, the potential compatible mixed culture of *P/A* was selected for DWTP sludge treatment in LSB process. The results obtained in optimum LSB processes indicated that wheat flour (WF) at a concentration of 1.5-2% (w/w) was a better co-substrate in sludge containing medium, with optimum initial pH of 4.5-5.5, temperature of 33-35^{0}C and inoculum size of 2-3% (v/w). Bioconversion of DWTP sludge was highly influenced by agitation and aeration rate that were 150-200 rpm and 0.5 vvm, respectively. In a settleability and dewaterability study, 86.45% of TSS was settled in treated sludge while 4.35% in untreated sample after one minute of settling operation. The results for specific resistance to filtration (SRF) showed that the fungal inoculum had significant potentiality to reduce SRF by 99.8% and 98.7% for 1% and 4% of sludge, respectively. Bioconversion efficiency was higher by 0.2-20% in fermenter than in the shake flask in terms of biosolids accumulation and biodegradation of organic matters in sludge. In developed bioconversion processes, 93.75 g/kg of biosolids was enriched with fungal biomass protein and nutrients (NPK), and 98.84% of TSS, 98.22% of TDS, 97.33% of turbidity, 80.24% of soluble protein, 98.81% of reducing sugar and 92.66% of COD in treated sludge supernatant were removed after 8 days of treatment. SRF ($1.39x10^{12}$ m/kg) was decreased tremendously by the microbial treatment of DWTP sludge after 6 days of fermentation. LSB process for microbial treatment of DWTP sludge is a new biotechnological approach that has economic value and is non-hazardous as well as environmental friendly, and therefore may be encouraging to sludge management strategy in future applications.

Abstrak tesis yang disertakan kepada Senat Universiti Putra Malaysia bagi memenuhi syarat untuk mendapatkan ijazah Doktor Falsafah

RAWATAN MIKROBIAL TERHADAP SISA ENAPCEMAR LOJI KUMBAHAN AIR SISA DOMESTIK MELALUI PROSES KEADAAN CECAIR PENUKARANBIO

Oleh

MD. ZAHANGIR ALAM

July 2002

Pengerusi: **Profesor Madya Fakhru'l-Razi Ahmadun**
Fakulti: **Kejuruteraan**

Kajian tentang rawatan microbial terhadap sisa enapcemar loji kumbahan air sisa domestik melalui proses keadaan cecair penukaranbio (LSB) tetah di jalankan secara pendekatan di dalam makmal. Sejumlah seventy jaringan filamen kulat telah diasingkan dari tiga sumber yang berbeza (air sisa, sisa enapcemar DWTP dan air sisa) dimana ia berada didalam keluarga *Penicillium* (39 jaringan), *Aspergillus* (14 jaringan), *Trichoderma* (12 jaringan), *Spicaria* (3 jaringan) dan *Hyaloflorae* (2 jaringan). Di dalam ujian pemantanan, jaringan kulat WWZP1003 *(Penicillium corylophilum*), SCahmA103 (*Aspergillus niger*), SCahmT105 (*Trichoderma harzianum*) dan PC-9 (*Phanerochaete chrysosporium*), diantara tersebut masing-masing berada di dalam kumpulan *Penicillium*, *Aspergillus*, *Trichoderma* dan Basidiomycete, memainkan peranan di dalam process pemisahan, biodegradasi dan penapisan bagi sisa enapcemar DWTP terawat. Keputusan bagi kajian perbandingan pengoptimuman kultur campuran menunjukkan perbandingan pertumbuhan kultur campuran bagi *P/A* dan *P/PC* dan *A/PC* serta kombinasi *P/T*, *A/T* dan *T/PC* diperhatikan tidak sesuai bagi kultur di dalam penukaranbio bagi sisa enapcemar. Di antara kombinasi tersebut, perbandingan keupayaan kultur campuran bagi *P/A* telah dipilih bagi rawatan sisa enapcemar DWTP di dalam

proses LSB. Keputusan di dapati di dalam pingoptimuman proses LSB menunjukkan bahawa tepung gandum (WF) dan kepekatan optimumnya 1.5-2% (w/w) adalah pemangkin yang baik di dalam sisa enapcemar yang mengandungi media dengan pH optimum awal 4.5-5.5, suhu 33-350C dan saiz inokulum 2-3% (v/w). Penukaranbio bagi sisa enapcemar DWTP memberi kesan yang tinggi dengan nisbah proses pengocakan dan pengudaraan diantara 150-200 rpm, 0.5 vvm secar berturutan. Di dalam ujian pemendakan dan dan pengairan, 86.45% bagi TSS telah mendak di dalam sisa enapcemar terawat, manakala 4.35% pula di dalam sample tidak terawat selapas satu minit di dalam ujian pemendakan. Keputusan bagi ketananan khusus untuk tapisan (SRF) menunjukkan bahawn inokulum kulat mempunyai keupayaan untuk mengurangkan SRF sebanyak 99.8% dan 98.7% bagi 1% dan 4% sisa enapcemar, secara berturutan. Keupayaan penukaranbio adalah tinggi sebanyak 0.2-20% di dalam alat penapaian berbanding dengan di dalam flask penggoncang dari sudut pengumpulan pepejal bio (biosolid) dan biodegradasi bahan organic dalam sisa enapcemar. Di dalam perkembangan proses penukaran bio, 93.75% bagi pepejal bio diperkaya dengan jisim nutrient dan protein kulat (NPK) dan 98.84% TSS, 98.22% TDS, 97.33% kekaruhan, 80.24% protein terlarut, 98.81% gula penurun dan 92.66% COD di dalam cecair sisa enapcemar terawat telah disingkirkan setelah 8 hari rawatan. SRF ($1.39x10^{12}$ m/kg) menurun secara mendadak dengan rawatan microbial bagi siza enapcemar DWTP selepas 6 hari penapaian. Proses LSB untuk rawatan microbial sisa enapcemat DWTP adalah pendekatan baru bagi biotechnologi yang mempunyai nilai ekonomi dan tidak berbahaya dan juga mesra alam, seterusnya menggalakkan strategi pengurusan sisa enapcemar di dalam penggunaan di masa hadapan.

ACKNOWLEDGEMENTS

I would like to extend my heartiest gratitude and appreciation to Associate Professor Dr. Fakhru'l-Razi Ahmadun, chairman of the supervisor committee for providing invaluable advice, untiring assistance, encouragement, motivation and his social support that enabled me to accomplish the PhD program smoothly and efficiently.

I am deeply indebted to Associate Professor Dr. Azni Idris and Dr. Suraini Abd-Aziz, members of supervisory committee for their constructive suggestions, proper guidance and encouragement through my study period. Sincere grateful to Dr. Pradip Roychoudhury, Associate Professor, IIT, Delhi for his suggestions and encouragement in preparation of the thesis proposal during early stage of the study.

I am also grateful to the staff members of all laboratories (Biochemical, Environmental, Process and computer), Mr. Termizi, Cik Maslinda, Mr. Ismail, Mr. Zoha, Mr. Haridan for their gently assistance throughout the course of the study. My special thanks and appreciation to Pn Rafia and Mr. Raja Mohammed for helping me to use their personal rotary shaker and supplying research materials toward the completion of my study. Also special thanks to Cik Shafreeza and Pn Syahada for their help to translate the abstract of my thesis to Bahasa Melayu. Grateful acknowledges are extended to the staff members of the Department of Chemical and Environmental Engineering for their sincere help and cooperation.

My heartfelt appreciation goes to my father, mother, father-in-law, mother-in-law, brothers, sisters, brother-in-law, and other relatives and friends who always encouraged and supported me during the study period. I would also like to special thanks to my friends and Bangladeshi fellows Mr. K. A. K. Azad, Mr. Abul Hossain Molla, Dr. Abul Hossain Mollah and Dr. Mahmud Hasan, for their cooperation and encouragement during my staying and study period in Malaysia. Special thanks also goes to my younger brother Jakir Hossen and Parvez who staying with me and their company and help encouraged me to finish the study smoothly.

I am also grateful to Indah Water Konsortium (IWK) for providing financial support by a grant (67116-P6) and supplying the wastewater/sludge samples during the study period.

Last but not the least, very special thanks to my wife Mosammamt Sultana for her constant encouragement, sacrifices, patience, understanding, and a lot of helping as typing, editing and washing (glassware) etc, that stepped up me to finish the study smoothly and timely.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES