



UNIVERSITI PUTRA MALAYSIA

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

MD. ZAHANGIR ALAM

FK 2002 24

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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

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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 33-35⁰C 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 (1.39×10^{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
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Kajian tentang rawatan microbial terhadap sisa enapcemar loji kumbahan air sisa domestik melalui proses keadaan cecair penukaranbio (LSB) telah 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 33-35°C 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 secara berturutan. Di dalam ujian pemendakan dan pengairan, 86.45% bagi TSS telah mendak di dalam sisa enapcemar terawat, manakala 4.35% pula di dalam sample tidak terawat selepas satu minit di dalam ujian pemendakan. Keputusan bagi ketahanan khusus untuk tapisan (SRF) menunjukkan bahawa 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 penggongcang dari sudut pengumpulan pepejal bio (biosolid) dan biodegradasi bahan organik 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 (1.39×10^{12} m/kg) menurun secara mendadak dengan rawatan microbial bagi sisa enapcemar DWTP selepas 6 hari penapaian. Proses LSB untuk rawatan microbial sisa enapcemat DWTP adalah pendekatan baru bagi biotechnology yang mempunyai nilai ekonomi dan tidak berbahaya dan juga mesra alam, seterusnya menggalakkan strategi pengurusan sisa enapcemar di dalam penggunaan di masa hadapan.

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I certify that an Examination Committee met on 29th June 2002 to conduct the final examination of Md. Zahangir Alam on his Doctor of Philosophy thesis entitled “Microbial Treatment of Domestic Wastewater Treatment Plant Sludge by Liquid State Bioconversion Process” in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

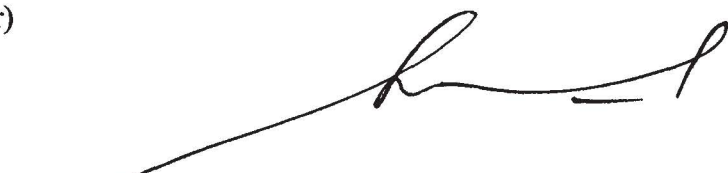
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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Putra Malaysia or other institutions.



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Date: 11/07/2002

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