UNIVERSITI PUTRA MALAYSIA

CO-COMPOSTING OF OIL PALM MESOCARP FIBER AND PALM OIL MILL EFFLUENT ANAEROBIC SLUDGE

LIM SIONG HOCK

CO-COMPOSTING OF OIL PALM MESOCARP FIBER AND PALM OIL MILL EFFLUENT ANAEROBIC SLUDGE

By

LIM SIONG HOCK

Thesis Submitted to the School of Graduates Studies, Universiti Putra Malaysia in Fulfilment of the Requirements for the Degree of Masters of Science

January 2011

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

CO-COMPOSTING OF OIL PALM MESOCARP FIBER AND PALM OIL MILL EFFLUENT ANAEROBIC SLUDGE

By

LIM SIONG HOCK

January 2011

Chairman: **Professor Mohd Ali Hassan, PhD**

Faculty: **Faculty of Engineering**

Utilization of oil palm mesocarp fiber (OPMF) in an alternative way as composting substrate for biocompost production was studied. Palm oil mill effluent (POME) anaerobic sludge is used as the nitrogen source and microbial seeding for the co-composting process. The windrow composting system was applied in this study due to lower operation cost and higher flexibility in controlling. In physicochemical study, POME anaerobic sludge additions promoted thermophilic condition (50 – 68°C) in compost piles and maintain moisture content around 50 - 60%. The pH was slightly alkaline throughout composting process. However, the compact and oily properties of OPMF have limited oxygen transfer (below 10 mg/L) and water absorption in the substrates, thus requiring extensive turning and mixing in composting piles for optimum composting process. The final compost with final C/N

ratio of 12.6 and high nutrients content is obtained after 50 days composting. For microbial succession study during composting process, polymerase chain reaction–denaturant gel gradient electrophoresis (PCR-DGGE) analysis was carried out. The molecular finger printing analysis indicated that the dominant microbe communities shifted from *Pantoea* and *Termitomyces* at the beginning of the composting process to *Proteobacteria* like *Cupriavidus gilardii* and *Ralstonia basilensis*. It has been observed that strong hydrolytic microbes were dominant in thermophilic phase of composting process. For structural degradation study in composting material, scanning electron microscopic (SEM) revealed the penetration of microbial community and removal of silica body on composting material. The microbial penetrations disrupted the hard surface of OPMF and promote the exposure of more easily degradable compound for active metabolic activity. After all, OPMF and POME anaerobic sludge co-composting make a good combination for substrates degradation. The nitrogen sources in sludge support microbial growth and a number of active degrader microbes have been identified. The removal of oily substance has been suggested capable in accelerating composting process.

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

PENGKOMPOSAN SABUT MESOKARP KELAPA SAWIT DENGAN ENAP CEMAR EFLUEN KILANG KELAPA SAWIT

Oleh

LIM SIONG HOCK

Januari 2011

Pengerusi: **Profesor Mohd Ali Hassan, PhD**

Fakulti: **Fakulti Kejuruteraan**

Pengkomposan sabut mesokarp secara alternatif bagi penghasilan baja kompos telah diselidiki. Enap cemar efluen kilang kelapa sawit telah digunakan sebagai penyumbang unsur nitrogen dan benih mikroorganisma bagi proses pengkomposan. Sistem pengkomposan batas telah digunakan dalam experiment ini sebab kos operasi yang rendah dan lebih fleksibel dalam pengawalan system. Dalam penyelidikan fizikal-kimia, penambahan enap cemar efluen buangan kilang sawit didapati mengalakan keadaan termofilik (50 – 68°C) dan mengekalkan kandungan air sebanyak 50%. pH adalah sedikit alkali dalam proses pengkomposan. Walaubagaimanapun, ciri-ciri padat dan berminyak dalam sabut mesokarp kelapa sawit telah menghadkan pengangkutan oksigen dan penyerapan air untuk proses pengkomposan yang optima, malah memerlukan kekerapan mengacau dan

mencampur aduk substrak dalam proses pengkomposan. Kompos akhir dengan nisbah C/N akhir sebanyak 12.6 serta kandungan nutrisi yang tinggi telah diperolehi dalam 50 hari pengkomposan. Dalam penyelidikan perubahan profil mikroorganisma, analisis tindak balas rantaian polimerasi – elektroporasi kecerunan gel denaturasi (DGGE) telah digunakan. Analisis mikrob telah menunjukan bahawa mikroorganisma mutlak telah berubah dari *Pantoea* dan *Termitomyces* pada permulaan proses pengkomposan kepada *Proteobacteria* seperti *Cupriavidus gilardii* dan *Ralstonia basilensis*. Ini secara tidak langsung menunjukan mikroorganisma hidrolitik telah menjadi dominan dalam fasa termofilik proses pengkomposan. Bagi perubahan struktur, mikroskop pengimbas elektron menunjukan gambaran penembusan mikroorganisma dan penyingkiran badan silica dalam bahan pengkomposan. Penembusan mikroorganisma telah memecahkan permukaan kasar sabut dan mengalakan pendedahan bahan yang mudah degradasi untuk aktiviti metabolic yang aktif. Secara amnya, pengkomposan sabut mesokarp dan enap cemar kilang sawit merupakan kombinasi yang baik untuk degradasi substrak. Unsur nitrogen dalam enap cemar membantu pertumbuhan mikrob dan banyak aktif degradasi mikrob telah ditemui. Penyingkiran minyak dicadangkan dapat mempercepatkan proses pengkomposan.

ACKNOWLEDGEMENTS

A special appreciation and sincere thanks to my main supervisor, Prof. Dr. Mohd Ali Hassan and the members of the supervisory committe, Prof. Dr Yoshihito Shirai, Associate Prof. Dr. Suraini Abd Aziz, and Dr. Farah Saleena Talip for all invaluable advice, encouragement and patience throughout the master study.

I would like to express my sincere gratitude to my main supervisor, Prof. Dr. Mohd Ali Hassan for giving the opportunity to do research work in UPM. I really appreciate his frequent suggestions and comments and also arranging the facilities and financial support throughout my study. Also, his kind advice and willingness to share his personal view let me learn more in this learning curve. A special thanks to Dr. Nor' Aini Abdul Rahman for giving full support and assistance during paper writing.

I also would like to express my sincere thanks to Mr. Azhari Samsu Baharuddin, Mr Najib Ahmad and Mr Zulkhairi Yusoff for their motivation and guidance during the difficult moments of the project. I would also like to express my deep appreciation to Mr. Chairil Anuar, Mr. Rosli Aslim, and Kak Ida for their generous guidance and help during my work.

Last but not least, my deepest thanks to my beloved parents and sister for their love, sacrifice and encouragement that will remain in my mind forever. It is my pleasure to thank all my friends and lecturers with whom I enjoyed working.

I certify that a Thesis Examination Committee has met on 3 January 2011 to conduct the final examination of Lim Siong Hock on his thesis entitled "Co-composting of Oil Palm Mesocarp Fiber and Palm Oil Mill Effluent Anaerobic Sludge" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

Members of the Thesis Examination Committee were as follows:

Azni bin Hj Idris, PhD
Professor
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Chin Nyuk Ling, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Ling Tau Chuan, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Teng Tjoon Tow, PhD
Professor
School of Industrial Technology
Universiti Sains Malaysia
(External Examiner)

_____
SHAMSUDDIN SULAIMAN, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 24 March 2011

This Thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement to the Master of Science. The members of the Supervisory Committee were as follows:

Mohd Ali Hassan, PhD
Professor
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Suraini Abd Aziz, PhD
Associate Professor
Faculty of Biotechnology and Biomolecular Sciences
Univertiti Putra Malaysia
(Member)

Farah Saleena Talip, PhD
Faculty of Engineering
Universiti Putra Malaysia
(Member)

Yoshihito Shirai, PhD
Professor
Graduate School of Life Sciences and Systems Engineering,
Kyushu Institute of Technology (KIT)
Kitakyushu, Japan
(Member)

_____

HASANAH MOHD GHAZALI, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

DECLARATION

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

_____

LIM SIONG HOCK

Date: 3 January 2011

TABLE OF CONTENTS