



UNIVERSITI PUTRA MALAYSIA

**PERFORMANCE OF THREE TROPICAL PLANT SPECIES AS
PHYTOREMEDIATORS FOR SELECTED HEAVY METALS IN
SEWAGE SLUDGE**

MARYAM GHAFOORI

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By

MARYAM GHAFOORI

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

July 2011

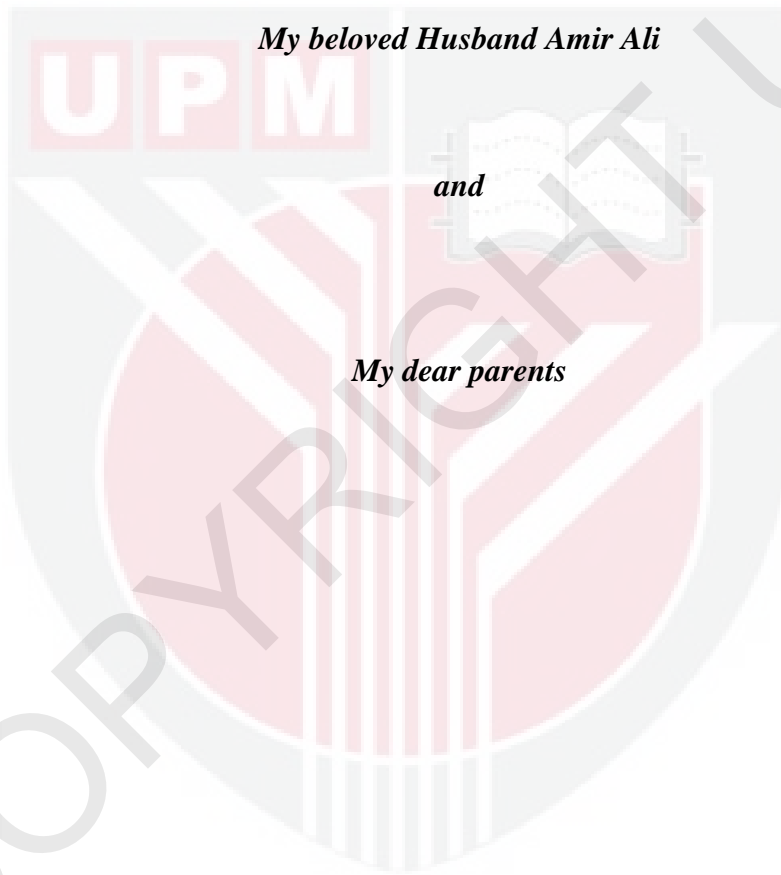
DEDICATION

To

My beloved Husband Amir Ali

and

My dear parents



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

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Chairman : Professor Dato Nik Muhamad Nik Ab. Majid, PhD

Faculty : Forestry

Heavy metal contamination is one of the most pressing threats to water and soil resources as well as human health. Unlike organic compounds, metals cannot be degraded. Most of the conventional remedial technologies are expensive and also cause negative impact on the environment. Phytoremediation is a cost effective, environmental friendly and aesthetically pleasing approach most suitable to remediate metal-contaminated soils. This study was to 1) determine the concentrations of Cu, Pb and Zn in different plant parts (stem, leaf, root) growing on soils contaminated with sewage sludge and 2) evaluate the potential of the three different tropical species as phytoremediators for Cu, Pb and Zn in sewage sludge on the basis of BCF and TF. Three plant species namely *Jatropha curcas* L., *Acacia mangium* Willd. and *Hopea odorata* Roxb. were used to investigate the phytoextraction efficiency for Cu, Pb and Zn. The experiment was laid out a

Randomized Complete Block Design (RCBD) with four replications and was conducted in a green house. The growth medium was sewage sludge biosolid applied at six different levels in the following ratios of soil to sludge: 100% soil (control), 80:20, 60:40, 40:60, 20:80 and 100% sludge. Cu, Pb and Zn concentrations in the growth medium and plants were analyzed by EPA Method 3051 using Inductively Coupled Plasma-Optical Emission Spectrometer (ICP/OES). Results showed that total concentrations of Cu, Pb and Zn in the growth medium before planting were in the range of 13.67 mg kg⁻¹ to 122.13 mg kg⁻¹, 6.18 mg kg⁻¹ to 69.87 mg kg⁻¹ and 43.51 mg kg⁻¹ to 1206 mg kg⁻¹, respectively. Cu absorption was in the range of 0.5 to 11.62 mg kg⁻¹ for *Jatropha curcas*, 0.3 to 6.62 mg kg⁻¹ in *Acacia mangium* and 0.4 to 11.52 mg kg⁻¹ for *Hopea odorata*. Pb absorption was in the range of 0.3 to 141.6 mg kg⁻¹ for *Jatropha curcas*, 0.15 to 102.7 mg kg⁻¹ in *Acacia mangium* and 0.25 to 123.2 mg kg⁻¹ in *Hopea odorata*. Zn absorption was in the range of 12.4 to 1617 mg kg⁻¹ for *Jatropha curcas*, 6.6 to 1435 mg kg⁻¹ in *Acacia mangium* and 26.07 to 438.4 mg kg⁻¹ for *Hopea odorata*. In all the species, the concentrations of Cu, Pb and Zn were significantly ($P \leq 0.05$) different among the different levels of biosolids and different plant parts. For Cu, values of bioconcentration factor (BCF) and translocation factor (TF) for all three species were less than one which indicates that they are not suitable for phytoextraction of Cu. In *Jatropha curcas* TF and BCF values ranged from 0.34 to 0.87 and 0.09 to 0.26, respectively. For *Acacia mangium* TF was in the range of 0.24 to 0.99 and BCF was in the range of 0.05 to 0.24. In *Hopea odorata* TF and BCF values ranged from 0.72 to 0.98 and 0.09 to 0.19, respectively. For Pb, BCF values were more than one and TF values were less than one for all three species which indicates that they

are not suitable for phytoextraction of Pb. In *Jatropha curcas* TF and BCF values ranged from 0.06 to 0.09 and 2.02 to 6.80, respectively. For *Acacia mangium* TF was in the range of 0.02 to 0.06 and BCF was in the range of 1.46 to 4.02. In *Hopea odorata* TF and BCF, values ranged from 0.01 to 0.04 and 1.76 to 8.98, respectively. In the case of Zn, values of bioconcentration factor (BCF) and translocation factor (TF) for *Acacia mangium* were more than 1. The highest BCF value for this species was 1.33 and the highest TF value was 1.93 which indicates that *Acacia mangium* is suitable for phytoextraction. In *Jatropha curcas* BCF values were more than one and also the highest at 3.13 but TF values were less than one indicating that this species is not suitable for phytoextraction of Zn. Both BCF and TF values in *Hopea odorata* were less than one which indicates that this species is not an effective phytoextractor of Zn contaminated soil. This study showed that Malaysian sewage sludge contains high amounts of heavy metals particularly Cu, Pb and Zn and it has to be remediated before using it as a fertilizer. Among the three heavy metals, Zn was present in the highest concentration in the sludge. Between the three plant species tested for this research, *Acacia mangium* showed the ability of phytoextraction for Zn. In order to confirm the results of this study a field experiment should be conducted.

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

**PENILAIAN POTENSI TIGA SPESIES POKOK TROPIKA SEBAGAI
FITOREMEDASI LOGAM DALAM SISA PEJAL KUMBAHAN**

Oleh

MARYAM GHAFORI

Julai 2011

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Pencemaran logam berat adalah salah satu ancaman kepada sumber air dan tanah selain kesihatan manusia. Logam adalah bahan yang tidak boleh diuraikan seperti sebatian organik. Kebanyakan teknologi pembersihan konvensional adalah mahal dan juga menyebabkan akibat yang buruk terhadap persekitaran. Fitoremediasi berkos rendah, mesra alam sekitar dan pendekatan yang amat sesuai untuk membersihkan tanah tercemar daripada logam berat. Kajian ini mengkaji potensi tiga spesies *Jatropha curcas* L., *Acacia mangium* dan *Hopea odorata* sebagai tumbuhan pengekstrak bagi logam Cu, Pb dan Zn. Eksperimen ini dijalankan secara rawak (RCBD) di rumah hijau dengan empat replikasi. Media yang digunakan adalah sisa kumbahan pejal diaplikasikan secara enam peringkat yang berbeza bergantung dengan nisbah tanah kepada sisa kumbahan pejal: 100% tanah

(kawalan), 80:20, 60:40, 40:60, 20:80 dan 100% sisa kumbahan pejal. Kepekatan Cu, Pb dan Zn pada media dan tumbuhan dianalisis merujuk kepada Kaedah EPA 3051 dengan menggunakan Coupled Plasma-Mass Spectrometry (ICP-MS). Keputusan menunjukkan bahawa nilai kepekatan bagi Cu, Pb dan Zn pada media sebelum menanam adalah diantara 13.67 ke 122.13 mg kg⁻¹, 6.18 ke 69.87 mg kg⁻¹ dan 43.51 ke 1206 mg kg⁻¹. Penyerapan Cu bagi *Jatropha curcas* diantara 5 ke 11.62 mg kg⁻¹, *Acacia mangium* adalah 0.3 ke 6.62 mg kg⁻¹ manakala bagi *Hopea odorata* adalah 0.4 ke 11.52 mg kg⁻¹. Penyerapan Zn bagi *Jatropha curcas* adalah diantara 12.4 ke 1617 mg kg⁻¹, manakala 6.6 ke 1435 mg kg⁻¹ pada *Acacia mangium*, dan 26.07 ke 438.4 mg kg⁻¹ pada *Hopea odorata*. Kepekatan Cu, Pb dan Zn pada ketiga-tiga spesies menunjukkan perbezaan ketara ($P \leq 0.05$) diantara sisa kumbahan pejal berlainan peringkat dan berlainan bahagian tumbuhan. Bagi Cu, nilai Faktor Biokepekatan (BCF) dan Faktor Translokasi (TF) untuk semua spesies harus kurang dari satu untuk menunjukkan ketidaksuaian sebagai tumbuhan pengekstrak Cu. Nilai TF dan BCF bagi *Jatropha curcas* adalah dari 0.34 ke 0.87 mg kg⁻¹ dan dari 0.095 ke 0.26 mg kg⁻¹. Manakala nilai TF dan BCF bagi *Acacia mangium* adalah diantara 1.007 ke 1.022 mg kg⁻¹ dan 1.49 ke 4.02 mg kg⁻¹. *Hopea odorata* menunjukkan nilai TF dan BCF diantara 0.72 ke 0.98 mg kg⁻¹ dan 0.09 ke 0.19 mg kg⁻¹. Bagi Pb, nilai TF dan BCF lebih daripada satu menunjukkan ketiga-tiga spesies adalah sesuai tumbuhan pengekstrak Pb. Nilai TF dan BCF pada *Jatropha curcas* diantara 1.007 ke 1.19 mg kg⁻¹ dan 2.09 to 6.80 mg kg⁻¹. Manakala nilai TF dan BCF bagi *Acacia mangium* adalah diantara 1.007 ke 1.022 mg kg⁻¹ dan 1.49 ke 4.02 mg kg⁻¹. Nilai TF dan BCF bagi *Hopea odorata* adalah diantara 1 ke 1.01 mg kg⁻¹ dan 1.76 ke 8.98 mg kg⁻¹. Nilai BCF dan TF untuk Zn bagi *Acacia*

mangium adalah 1.33 dan nilai tertinggi bagi TF adalah 1.93, menunjukkan spesies ini sesuai untuk tumbuhan pengekstrak. Nilai BCF pada *Jatropha curcas* adalah lebih daripada satu iaitu nilai tertinggi, 3.13 namun nilai TF adalah kurang dari satu menunjukkan spesies ini tidak sesuai menjadi tumbuhan pengestrak Zn. Kedua-dua nilai BCF dan TF bagi *Hopea odorata* adalah kurang dari satu menunjukkan spesies ini tidak efektif sebagai tumbuhan pengekstrak Zn. Kajian ini membuktikan sisa kumbahan pejal rakyat Malaysia mempunyai perbezaan peringkat logam berat seperti Cu, Pb dan Zn, dan perlu dibersihkan sebelum digunakan sebagai baja. Kepekatan Zn adalah tertinggi berbanding logam berat yang lain di dalam sisa kumbahan pejal. Kajian ini juga menunjukkan *Acacia mangium* mempunyai kebolehan sebagai tumbuhan pengestrak Zn. Kajian lapangan harus dijalankan untuk membuktikan ketepatan eksperimen ini.

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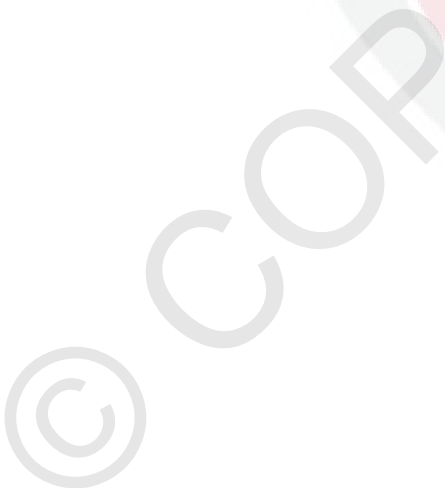
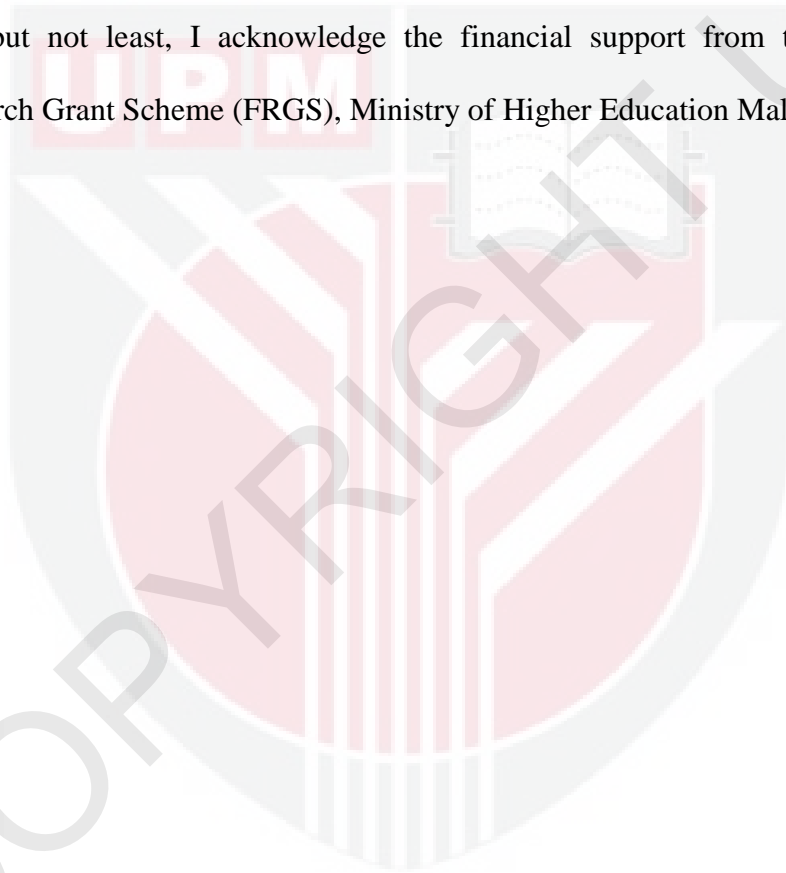
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I certify that a Thesis Examination Committee has met on 4 June 2011 to conduct the final examination of Maryam Ghafoori on her thesis entitled “Performance of Three Tropical Plant Species as Phytoremediators for Selected Heavy Metals in Sewage Sludge” 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.

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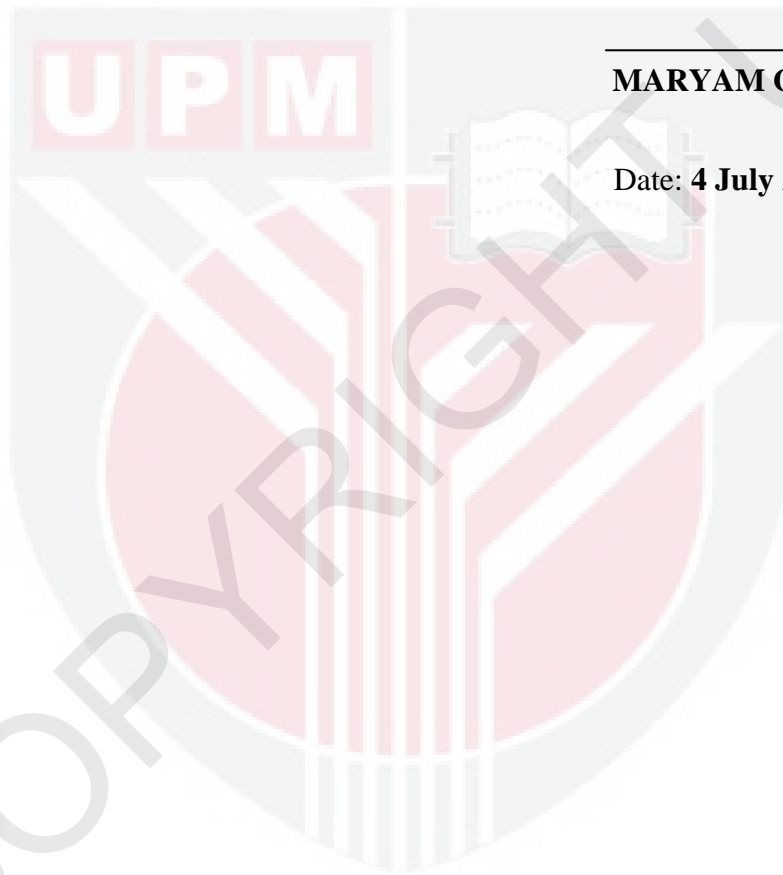
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DECLARATION

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 other institutions.

MARYAM GHAFoori

Date: **4 July 2011**



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