UNIVERSITI PUTRA MALAYSIA

ASSESSMENT OF Bambusa vulgaris Schrad. ex J.C.Wendl. AS POTENTIAL PHYTOREMEDIATION AGENT FOR HEAVY METALS

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IPTPH 2016 2

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

March 2016

Abstract of thesis presented to the senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Master of Science

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March 2016

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Heavy metal pollution had becoming one of the most serious environmental problems today. These pollutants have highly affected agricultural productivity, human health as well as disrupting the world's ecological biodiversity system. Experimental research conducted had undergone the phytoremediation process which is bio-based low cost alternative technology, environmental friendly and represents the efficiency of using plants for treatment of heavy metal. Bamboos are potentially good plants for phytoremediation due to their widespread distribution, simple and well-known propagation mode, the full range of species and their potential as an additional use for raw material. They are fast-growing, grow more rapidly than other timber species and have various actual and possible applications for income generation and environmental conservation. This study aims in evaluate the potential of B. vulgaris as phytoremediation agent for heavy metal. The plants were grown up uniformly in lysimeter pot for three months in the presence of heavy metal copper, zinc and iron with different level of concentration to quantify the toxic effects of these metals on morphological and physiological attributes of B. vulgaris. Leachates from lysimeter were being collected periodically and undergoing screening process to determine the contents of remaining heavy metal in samples. The close positive relationship of heavy metal analysis that exhibits low concentration of metal before and after treated or infiltrated by *B. vulgaris* indicates that it can be used as bioaccumulator plants of heavy metal pollution by absorbing excess heavy metal from the polluted soils and water. From the study, *B. vulgaris* most efficient in uptake iron compared to zinc and copper. The findings indicated that heavy metals copper zinc and iron are considered to be important for plant growth due to the positive response in morphological and physiological attributes of *B. vulgaris* at low concentration however brings phytotoxicity effects at high level of concentration and time. *B.vulgaris* performance was increased at early weeks and in low concentration metal level indicated it's tolerance to the heavy metals, making it a prospective phytoremediator species. Thus, we can conclude that *B. vulgaris* has potential to be a phytoremediator plant and can be grown up on moderately heavy metal contaminated soil.

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

PENILAIAN KEATAS *Bambusa vulgaris* Schrad. *ex* J.C.Wendl. YANG BERPOTENSI SEBAGAI AGEN FITOPEMULIHAN UNTUK LOGAM BERAT

Oleh

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Pencemaran logam berat telah menjadi salah satu masalah alam sekitar yang paling serius pada hari ini. Pencemaran ini telah mempengaruhi produktiviti pertanian, kesihatan manusia dan juga mengganggu sistem biodiversiti ekologi di dunia. Kajian dijalankan mengunakan proses fitopemulihan yang merupakan teknologi alternatif yang melibatkan kos rendah berasaskan biologi, mesra alam sekitar menggunakan tumbuh-tumbuhan untuk rawatan logam berat. Buluh berpotensi untuk digunakan dalam fitopemulihan kerana ianya tumbuh secara meluas, pembiakannya yang mudah dan terkenal, mempunyai banyak spesies dan sebagai penggunaan tambahan untuk bahan mentah. Ianya tumbuh lebih cepat daripada spesies kayu lain dan mempunyai pelbagai kelebihan untuk menjana pendapatan dan pemuliharaan alam sekitar. Kajian ini bertujuan menilai potensi *B. vulgaris* sebagai ejen fitopemulihan untuk logam berat. Pokok buluh ditanam secara seragam di dalam lysimeter selama tiga bulan dengan kehadiran logam berat tembaga, zink dan besi dengan tahap yang berbeza untuk mengukur kesan toksik logam ini ke atas sifat-sifat morfologi dan fisiologi *B. vulgaris*. Air larut resap dari lysimeter dikumpul secara berkala dan menjalani proses saringan untuk menentukan kandungan baki logam berat dalam sampel. Hubungan positif analisis logam berat yang mempamerkan kepekatan rendah logam sebelum dan selepas dirawat oleh *B. vulgaris* menunjukkan bahawa ia boleh digunakan sebagai tumbuhan biopengumpul pencemaran logam berat dengan menyerap logam berat yang berlebihan dari tanah tercemar dan air. Dari kajian ini, *B. vulgaris* paling berkesan dalam pengambilan besi berbanding zink dan tembaga. Dapatan

kajian menunjukkan bahawa logam berat tembaga, zink dan besi dianggap penting untuk pertumbuhan tumbuhan berikutan keputusan yang positif dalam sifat-sifat morfologi dan fisiologi *B. vulgaris* pada kepekatan yang rendah tetapi membawa kesan fitotosik di kepekatan yang tinggi dalam tempoh masa yang lama. Pertumbuhan *B.vulgaris* telah meningkat pada minggu-minggu awal dan pada tahap kepekatan logam rendah menunjukkan toleransi kepada logam berat, menjadikannya satu spesies yang boleh digunakan untuk fitopemulihan. Oleh itu, kesimpulan boleh dibuat bahawa *B. vulgaris* mempunyai potensi untuk fitopemulihan dan boleh ditanam di atas tanah yang sederhana tercemar dengan logam berat.

ACKNOWLEDGEMENTS

Bismillahirrahmanirrahim, first and foremost, all praise to Allah S.W.T, the most Gracious and the most Merciful, for His blessing and for giving me mental and physical strengths to accomplish this project.

I would like to express my special gratitude and respect to my supervisor, Associate Professor Dr. Hazandy Abdul Hamid for the valuable advices, guidance, suggestions, encouragement and support during my project including the preparations of this thesis. I am also grateful and sincerely thankful to other committee member Dr Azmy Mohamed and Associate Professor Dr Arifin Abdu who gave me a guide and constructive comment for the project implementation.

I wish to thank plant physiology lab members in Faculty of Forestry, UPM, assistant science officer Mr Kamil Ismail and Ms Yap Mei Ling also Mr Alagan for their cooperation in providing me equipments, their guidance and continuous assistance throughout this study. I am also greatly indebted to Mr Jamil, for his assistance in guiding me during laboratory analysis works at Faculty of Agriculture, UPM. My deepest appreciation to be extended as well to late Mr. Zakaria and staff from Forest Research Institute Malaysia Nursery for their kindness and assistance in provide the materials.

To all my friends, Noor Haslidawati, Nurul Rusmida, Asmaa' Widad, Nurul Hijrah, Kiasatina and all staffs of Institute Tropical Forestry & Forest Product especially Mrs Shuhada, thank you very much for being helpful, gives me courage and technical support during this study.

Finally, a very sincere gratitude to my family especially my dearest father, mother and siblings for their love, prayers and unconditional support that I always needed and makes me focused throughout this endeavor. Without the invaluable assistance of the people mentioned above, this study would have never reach completion. Thank you very much and all supports were deeply appreciated. May Allah S.W.T bless and repay all your kindness.

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

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LIST OF ABBREVIATIONS

PPM	Part per million
ANOVA	Analysis of variance
AAS	Atomic absorption spectrometer
SPAD	Soil plant analysis development
ATP	Adenosine triphosphate
DNA	Deoxyribonucleic acid
VOC	Volatile organic compounds
FRIM	Forest Research Institute Malaysia
CRD	Completely randomized design
SPSS	Statistical package social science
HSD	Honest significant difference
$ZnSO_4$	Zinc (II) sulphate
$CuSO_4$	Copper (II) sulphate
$FeSO_4$	Fe (II) sulphate
CO_2	Carbon dioxide
F_0	Constant minimal fluorescence in dark-adapted plant
F_m	Maximum fluorescence in dark-adapted plant
F_v	Variable fluorescence for a plant in dark-adapted
F_v/F_m	Maximum yield of photosystem II
PSII	Photosystems II
A_{net}	Net photosynthesis rate
G_s	Stomatal conductance
E	Transpiration rate

C_i	Intercellular carbon dioxide
VpdL	Air vapor pressure deficit
Eh	Oxidation potential
pH	Potential of Hydrogen
RNA	Ribonucleic acid
ROS	Reactive oxygen species

CHAPTER 1

INTRODUCTION

This chapter highlighted the background of the study, problem statement and objectives of the study. The background of the study discusses generally about the environmental pollution by heavy metals and the role or functions of bamboo to environment. The problem statement discusses the importance of the study and why it was conducted.

1.1 Background

Environment defined as the communities we are living in. It also can be described as total circumstances surrounding a living thing or group of living things, the mix of external physical conditions which influence the growth, development and survival of them (Gore, 1997). Pollution is an accidental or deliberate contamination of the environment by waste contains pollutant due to the human activities. These pollutant substances mostly exist over a set or tolerance limit. Therefore, environmental pollution occurs with the presence of a pollutant at poisonous level in land, water and air likely causes objectionable impacts, lessening the quality of life and harmful to the other organisms in those polluted environment.

Our environment has been contaminated with organic and inorganic pollutants, because they are easily discharged into the surroundings through wide range of ways. Surface water is easily polluted by domestic wastewater effluent, runoff, and rainwater. Due to the phenomenal growth of industrialization, urbanization, and population, many surface water systems become highly contaminated (Qian *et al*., 2007).

Chehregani (2009) states that environmental contamination by heavy metals is a worldwide catastrophe that happen because of human activities like mining, energy and fuel production, power transmission, melting operations, sludge dumping, and intensive agriculture. High concentrations of heavy metals that bring harmful toxic effects to the environment are known as environmental pollutants. Copper (Cu), zinc (Zn), cadmium (Cd), lead (Pb), nickel (Ni) and chromium (Cr) metals normally known to be severe environmental pollutants.

Heavy metal contamination to soil and water contributes a serious environmental and health issues. Metals accumulate in soil and water due to anthropogenic contamination through fertilizer, organic manure applications, irrigation, industrial and municipal wastes, and wet and/or dry deposits (Doelschet *et al.,* 2010). They are essential as micronutrient to plants and normally exist in the background of soils at different levels however they become toxic at higher concentrations. Plant roots excessively absorbed heavy metal ion which present at high level in the environment and trans located to other part of plants and lead to impaired metabolism and growth reduction of the plant. Besides that, contaminated soils with excess metal also resulted in the reduction of soil fertility, microbial activity, and yield.

Kleinhenz (2001) stated that plants have a unique capability to concentrate essential and non-essential elements from the environment into their tissues. Green plants normally use sunlight, the most important source of energy in photosynthesis to speed up the concentration process. Terrestrial plants have an extensive root system and an advanced uptake mechanism in their continuous search for water and mineral resources. Bamboo for example, a terrestrial plant that is known for its tolerance to a broad range of stressors, high biomass production and growth development rate as well as large and extended root system which probably shows good abilities for water filtration and nutrient absorption.

1.2 Problem Statement

Over the past several decades, health and pollution of the environment have becoming more apparent throughout the world. Industrialization, urbanization and rapid growth in population are the sources for the increasing of pollution rate. Metal pollution had becoming one of the most serious environmental problems today. Pollution of biosphere by toxic metals had accelerated dramatically since the beginning of the industrial revolution because of human activities such as mining and smelting of metals, energy and fuel production, electroplating, sewage, pesticide application, fertilizer, municipal waste generation and others (Srivastava S., 2007).

These organic and inorganic pollutants have highly affected agricultural productivity, human health as well as disrupting the world's ecological biodiversity system (Bridge, 2004). Contaminants can lead to land or groundwater and the toxic elements end up entered into the food chain. Due to the high public awareness regarding to this, environmental regulations have been developed to prevent pollution and also to remediate areas where contamination has occurred (Devos J., 2001).

The contamination of the water resource is a critical environmental issue. In many parts of the developing country, uncontrolled and inappropriate removal of wastewater causes severe pollution issues. However, by reusing wastewater, it can help to improve global water shortages mainly in developing country where there are no facilities for safe disposal of wastewater. In this way, phytoremediation was one of the potential outcomes on which effort were focused on, combining land cover and soil stabilisation, the utilization of the growing crops, and their possibilities on cleaning of the wastewater.

Experimental research conducted had undergone the phytoremediation process which is bio-based low cost alternative technology, environmental friendly and represents the efficiency of using plants for treatment of environmental contaminant. About 700 species of plants have been reported in accumulation of different contaminants (Xi et al., 2010). Metal accumulators are found in a large number of plant families, but most are the Brassicaceae family (Verbruggen et al., 2009) and are associated with slow plant growth and low biomass yields (Epelde et al., 2008), so there is an urgent need for identification of other plant species having fast growth and greater biomass production.

Bamboos are potentially good plants for phytoremediation due to their widespread distribution, simple and well-known propagation mode, the full range of species and their potential as an additional use for raw material. They are fast-growing, grow more rapidly than other timber species and have various actual and possible applications for income generation and environmental conservation. Because of these attributes, bamboo could have many offers in slum areas which it is usually being used to clean up waste water.

Bamboo species selected was *B. vulgaris* which is known as a highly useful plant, providing poles and timber for scaffolding, fencing, roofs, furniture, and many craft items but plays a very valuable environmental role. It is water loving plant and its extensive root system probably can take up nutrients such as nitrogen, phosphorous or dangerous contaminants such as heavy metals which some of them are locked in the root system. Hence, it suitable for disposal of effluents and reduce of waste water pollution. Planted close by waterways, ditches and creeks, *B. vulgaris* can catch the overabundance nutrients in the runoff water keeping from entering adjacent streams. Waste water from agricultural area, animal farming, manufacturing and sewerage treatment plants can be utilized to irrigate crops, consequently change it into valuable biomass. In perspective of these features, *B. vulgaris* was used as main materials for the study of the potential utilisation in plants to improve water and nutrient supplies, towards providing an environmentally compatible method for wastewater disposal.

1.3 Objectives

The main objective of this study was to evaluate the performance of *B.vulgaris* mechanism of pollutant removal and its potential for the elimination of metal contaminated through phytoremediation.

The specific objectives of this study were:

i. To identify the ability of *B. vulgaris* to take up heavy metals contaminants
ii. To evaluate the phytotoxicity effects of *B. vulgaris* on heavy metals towards their growth and physiological attributes

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