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EVALUATION OF HEAVY METAL UPTAKE BY Ricinus communis AS A PHYTHOREMEDIATOR OF SOIL CONTAMINATED WITH SEWAGE SLUDGE

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EVALUATION OF HEAVY METAL UPTAKE BY *Ricinus communis* AS A PHYTOREMEDIATOR OF SOIL CONTAMINATED WITH SEWAGE SLUDGE

By

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DEDICATION

Dedicated to my beloved wife and family; lecturers and mentors; staff and friends; and, other people who relentlessly supported and inspired me during the entire study period.

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ABSTRACT

Phytoremediation is a biological treatment that removes pollution from soil and underground water using plants as the remediation agent. The objectives of this study were; to evaluate the potential of *Ricinus communis* in taking up heavy metals (copper, lead and zinc) from soil contaminated with sewage sludge and translocating of heavy metals in different plants parts (leaves, stems and roots). This study was conducted in a greenhouse at the Faculty of Forestry, Universiti Putra Malaysia for six months. The seedlings of *R. communis* were germinated for a period of 16 weeks prior transplanting into soil containing between 0% t0 100% sewage sludge in four replications. The results showed that there is significant difference heavy metal concentrations in the growth medium and accumulation in the plant parts throughout all treatments. The Bio-concentration factor (BCF) value of heavy metals was less than 1 while translocation factor (TF) value was more than 1 indicating that *R. communis* is a potential phytoremediator. Future studies to identify the potential of *R. communis* for eliminating other heavy metals in soils contaminated with domestic and industrial sludge need to be conducted in more details.

ABSTRAK

Fitopemulihan adalah rawatan biologi untuk menghapuskan pencemaran dari tanah dan air bawah tanah menggunakan tumbuh-tumbuhan sebagai ejen pemulihan. Tujuan kajian ini ialah; untuk menilai potensi *Ricinus communis* dalam mengambil logam berat (tembaga, plumbum dan zink) dari tanah yang tercemar dengan enapcemar kumbahan dan translokasi logam berat dalam bahagian tumbuhan yang berlainan (daun, batang dan akar). Kajian ini telah dijalankan dalam rumah hijau Fakulti Perhutaanan, Universiti Putra Malaysia selama enam bulan. Benih *R. communis* telah dicambah untuk tempoh 16 minggu sebelum diubah ke dalam tanah yang mengandungi antara 0% hingga 100% enapcemar kumbahan dalam empat ulangan. Hasil kajian menunjukkan bahawa terdapat perbezaan yang signifikan dalam kepekatan logam berat dalam medium pertumbuhan dan pengumpulan logam berat dalam bahagian tumbuhan di seluruh tahap rawatan. Faktor bio-kepekatan (BCF) adalah kurang dari 1 manakala faktor translokasi (TF) adalah melebihi 1 yang menunjukkan bahawa *R. communis* adalah berpotensi sebagai agen fitopemulihan. Pada masa hadapan kajian keupayaan *R. communis* dalam memulihkan tanah yang tercemar oleh logam berat yang lain amat diperlukan.

APPROVAL SHEET

I certify that this research project report entitled “EVALUATION OF HEAVY METAL UPTAKE BY *Ricinus communis* AS A PHYTHOREMEDIATOR OF SOIL CONTAMINATED WITH SEWAGE SLUDGE” by Azmi b. Abdul Rahman has been examined and approved as a partial fulfilment of the requirements for the Degree of Bachelor of Forestry Science in the Faculty of Forestry, Universiti Putra Malaysia,

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CHAPTER 1

INTRODUCTION

1.1 General Background

The term Phytoremediation is a combination of the Greek word *phyto* which means 'plant' and the Latin word *remedium* which means 'cure of evil' or 'to remedy'. Phytoremediation is a technique that that uses the natural system of certain plants that work together with soil organisms to transform contaminants into harmless and often, valuable forms. It emerged as a result of remarkable research demonstrating the extracting, metabolizing and accumulating features of plants (Dec & Bollag, 1994). This practice is increasingly used to remediate sites contaminated with heavy metals or toxic organic compounds.

Phytoremediation then, is defined as the use of plants to remove pollutants from the environment or to render them harmless (Salt et al., 1998). Phytoremediation is also means of using surrounding vegetation for the in situ or ex situ treatment of contaminated soil sediments and polluted water; detoxify inorganic and organic metals (Salt et al., 1995). Alkorta & Garbisu (2001) found that phytoremediation works by accumulating the metals in certain parts of the plant; however, Hansen & Tjell (1983) indicated that the success of phytoremediation in sludge-amended soils also depends on the type of species being planted and the characteristics of the sludge contents. Plant characteristics such as salt and drought resistance; biological nitrogen fixation; or oxygen transport into the rhizosphere may be of great importance

for the effective phytoremediation of organic contamination; however, the effectiveness of plants as phytoremediation agents for decontamination especially of heavy metals remains questionable and needs answering. Decades of research has shed light on the fact that phytoremediation can remove metals from water and is also quite effective for remediating soil and organic compounds.

The exploitation of metal uptake into plant biomass as a method of soil decontamination however is limited by plant productivity and the concentrations of metals achieved (Baker et al., 1981; Baker & Brooks, 1989). It is clear that plant species differ dramatically in their potential for phytoremediation (Shann & Boyle, 1994; Liste & Prutz, 2006). Therefore, searching for the most effective remediating species for a particular compound is a critical step in phytoremediation trials, while mathematical modelling has been used to determine the most appropriate plant species for phytoremediation (Thoma et al., 2003). In general, the selection of phytoremediators for specific sites is empirical and based on preliminary results from pots experiments (Kirkpatrick et al., 2006; Liste & Prutz, 2006; Euliss et al., 2008).

Phytoremediation has been considered the most cost effective method for soil remediation compared to the conventional methods. The cost of phytoremediation has been estimated as $25-$100 per ton of soil, and $0.60-$6.00 per I000 gallons of polluted water with the remediation of organics being cheaper than remediation of metals (Indah Water Consortium, 2009).

Phytoremediation is an affordable technology most useful when contaminants are within the root zone of the plants. For sites with contaminations spread over a large area, phytoremediation may be the only economically feasible technology since trees are considered to be potentially the lowest cost plant type for use in phytoremediation applications (Alkorta & Garbisu, 2001).

The process is relatively inexpensive because it uses the same equipment and supplies used in agriculture. Plants generally absorb large amounts of the elements that they need for growth and only small amounts of toxic elements that could harm them. Therefore, phytoremediation is a cost-effective alternative to conventional remediation methods. On the other hand, immobilisation or extraction by physicochemical techniques can be expensive and physiochemical techniques are often appropriate only for small areas where rapid, complete decontamination is required (Martin & Bardos, 1997; Pulford & Watson, 2003). In addition, this technique is considered environmentally friendly because of its ability to utilize natural resources such as microorganisms (Jamil et al., 2009).

1.2 Problem Statement

Increase demand from society and environmental agencies for better environmental quality standards have manifested themselves in public and private sanitation service administration especially sewage disposal systems. Generally, the increasing accumulation of sewage sludge is related directly to

the expanding human population. According to Indah Water Consortium (2009), the volume of sewage sludge in Malaysia is likely to 6.6 million tonnes by year of 2020.

Due to its high contents of organic matter and nutrient, it is an undeniable fact that sewage sludge offers many benefits, especially in aiding plant growth and the remediation of nutrients deficient soil (Singh & Agrawal, 2008). However, sewage sludge contains heavy metals and is difficult and time consuming to be treated. The high heavy metal contents in sewage sludge may not negatively affect crops but, it can potentially harm humans if the crops are consumed. Hence, an environmentally friendly and cost effective method needs to be developed to remove these heavy metals while maintaining the beneficial traits of sewage sludge.

Since plants materials are easier and cheaper to acquire, phytoremediation has been known to be feasible and cost effective alternative to conventional methods of heavy metal contaminated soil remediation. Unfortunately, phytoremediation research on metal accumulating tropical tree species is still lacking (Campos et al., 2008). To address the ever increasing volume of domestic and industrial waste in the tropical region in particular; therefore, it is imperative that new metal accumulating tree species are identified.

Trees with characteristics such as rapid growth, a high translocation factor, a high biomass, a good assimilation rate, a high tolerance to large amount of metal, a vast root system and easy to grow are excellent candidates for

phytoremediation. Currently only a few tropical tree species such as *Jatropha curcas* (Ahmadpour et al., 2010), *Aquilaria malaccencis* (Rajoo et al., 2013), *Dipetrocarpus verrucosus* (Rajoo et al., 2013) and *Acacia mangium* (Justin et al., 2011) have been identified as effective phytoremediator. Hence, the genaral aim of this study was to discover other plant species that are capable of removing heavy metal from contaminated soils.

1.3 Objectives

For this study, *Ricinus communis* or locally known as Jarak Minyak has been selected as species for examination because it fulfilled all of the characteristics of an excellent phytoremediaror. The objectives of the study were as follows;

a. To quantify the heavy metal concentrations of sewage sludge in the growth medium (i.e.; soil contaminated with sewage sludge) before and after planting.
b. To evaluate the heavy metal uptake and translocation in specific plant parts especially roots, stems and leaves.
c. To examine the potential usefulness of *R. communis* as a phytoremediator by using translocation factor (TF) and bio-concentration factor (BCF).

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