OBAFEMI AWOLOWO UNIVERSITY

SYNERGISTIC EFFECT OF MYCORRHIZA AND ROCK PHOSPHATE ON PHYTOREMEDIATION POTENTIAL OF *SOLENOSTEMON MONOSTACHYUS* IN A HEAVY METAL POLLUTED SOIL.

BY

Oluwaseun Esther DUROTOYE

B.Sc. (Microbiology) Ife

A THESIS SUBMITED TO THE INSTITUTE OF ECOLOGY AND ENVIRONMENTAL STUDIES IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE (M. Sc.) IN ENVIRONMENTAL CONTROL AND MANAGEMENT OF THE OBAFEMI AWOLOWO OF OBAFEMI AWOLOWO UNIVERSITY, ILE-IFE, NIGERIA.

2015

© Obafemi Awolowo University, Ile-Ife, Nigeria
For more information contact **ir-help@oauife.edu.ng**

CERTIFICATION

This is to certify that this research was carried out by Oluwaseun Esther DUROTOYE (SCP12/13/H/0084) of the Institute of Ecology and Environmental Studies, in partial fulfilment of the requirements for the award of the degree of Master of Science (M.Sc) in Environmental Control and Management, Obafemi Awolowo University, Ile – Ife, Nigeria.

Professor O. O. Awotoye	………………………	……........……
SUPERVISOR	Signature	Date

Professor O. O. Awotoye	…………………...	……………………….
Director, Institute of Ecology and Environmental Studies,	Signature	Date.

© Obafemi Awolowo University, Ile-Ife, Nigeria
For more information contact **ir-help@oauife.edu.ng**

DEDICATION

This research work is dedicated to God Almighty and to my parents Elder and Mrs Ezekiel Durotoye.

OBAFEMI AWOLOWO UNIVERSITY

© Obafemi Awolowo University, Ile-Ife, Nigeria
For more information contact **ir-help@oauife.edu.ng**

OBAFEMI AWOLOWO UNIVERSITY

ACKNOWLEDGEMENTS

My profound gratitude goes to God Almighty who has given me the grace to complete the work. I sincerely appreciate my supervisor, the Director of the Institute of Ecology and Environmental Studies Prof. O.O. Awotoye for his fatherly support, guidiance and encouragements towards the success of this work. I also want to appreciate Dr M.B. Adewole for his keen interest, support and advice towards this work. I am grateful for the assistance received from Dr A.O. Eludoyin when the going was tough. I appreciate Prof. V.O Olarewaju for his advice and encouragements.

My sincere gratitude goes to my parents Elder and Mrs Ezekiel Durotoye for their financial support and encouragements and my brothers, sisters for their encouragement.

I specially appreciate my sweetheart, Olawale Aloko for his Cooperation and support. My sincere gratitude goes to sis Bukola Olofinjana, Mr Paul Awoniyi, Sis Yetunde Bulu and all the non teaching staff members of the Institute of Ecology and Environmental Studies.

I would like to appreciate my friends Ibukun Aina, Saanu Kosemani, Bisi Adekambi, Bayo Moradeyo, Tega Aghoghovbia, Tope Sowunmi for their support towards the completion of this work thank you, God bless you all.

Durotoye Oluwaseun Esther.

OBAFEMI AWOLOWO UNIVERSITY

OBAFEMI AWOLOWO UNIVERSITY

TABLE OF CONTENTS

OBAFEMI AWOLOWO UNIVERSITY

© Obafemi Awolowo University, Ile-Ife, Nigeria
For more information contact **ir-help@oauife.edu.ng**

OBAFEMI AWOLOWO UNIVERSITY

© Obafemi Awolowo University, Ile-Ife, Nigeria
For more information contact ir-help@oauife.edu.ng

OBAFEMI AWOLOWO UNIVERSITY

© Obafemi Awolowo University, Ile-Ife, Nigeria
For more information contact **ir-help@oauife.edu.ng**

OBAFEMI AWOLOWO UNIVERSITY

© Obafemi Awolowo University, Ile-Ife, Nigeria
For more information contact ir-help@oauife.edu.ng

OBAFEMI AWOLOWO UNIVERSITY

© Obafemi Awolowo University, Ile-Ife, Nigeria
For more information contact ir-help@oauife.edu.ng

OBAFEMI AWOLOWO UNIVERSITY

LIST OF TABLES

Table **Description** **Page**

OBAFEMI AWOLOWO UNIVERSITY

© Obafemi Awolowo University, Ile-Ife, Nigeria
For more information contact ir-help@oauife.edu.ng

OBAFEMI AWOLOWO UNIVERSITY

© Obafemi Awolowo University, Ile-Ife, Nigeria
For more information contact ir-help@oauife.edu.ng

OBAFEMI AWOLOWO UNIVERSITY

OBAFEMI AWOLOWO UNIVERSITY

© Obafemi Awolowo University, Ile-Ife, Nigeria
For more information contact ir-help@oauife.edu.ng

OBAFEMI AWOLOWO UNIVERSITY

ABSTRACT

This study determined the growth of *Solenostemon monostachyus* under different levels of Pb and Cd contamination in the soil, assessed the uptake of lead and cadmium by *Solenostemon monostachyus* as well as determined the synergistic effect of mycorrhiza and rock phosphate applications on lead and cadmium accumulation in *S. monostachyus*. This was with a view to determining the effect of augmentation of mycorrhiza and rock phosphate on the phytoremediation potential of *Solenostemon monostachyus* in a polluted soil.

The experiment was carried out at the screenhouse of the Faculty of Agriculture, Obafemi Awolowo University, Ile-Ife. The experimental design consisted of factorial combination of two heavy metals Pb and Cd in triplicates in a completely randomised design with four treatments (non inoculated, *Glomus mosseae*, rock phosphate, *G. mosseae* and rock phosphate (GM+RP)). Metal solutions of Pb and Cd of known concentrations were prepared at the following levels : Pb (0, 25, 50, 75,100) mg/kg^{-1} and Cd (0, 25, 50, 75,100) mg/kg^{-1} using $PbCl_2$ and $CdCl_2$ soluble compounds respectively. These concentrations were used to contaminate 3 kg by weight of soil of 120pots. The experiment consisted of 30 pots each of non

© Obafemi Awolowo University, Ile-Ife, Nigeria
For more information contact **ir-help@oauife.edu.ng**

inoculated, *G.mosseae*, rock phosphate and GM+RP treatments. Soil inoculum of *Glomus mosseae* was applied at the rate of 20 g per pot and rock phosphate at the rate of 0.15 g per pot. Five seeds of *Solenostemon monostachyus* was planted per pot and thinned to two stands per pot at two weeks after planting. The pots were maintained weed free and watered regularly to field moisture capacity. Parameters such as plant height, number of leaves and stem girth were determined fortnightly for a period of twelve weeks. Percentage of root colonization by arbuscular mycorrhizal fungi was determined. Pre - soil and plant test were carried out to determine soil physical and chemical properties using standard methods. At twelve weeks after planting, *Solenostemon monostachyus* plant was harvested and analysed for lead and cadmium uptake using Atomic Absorption Spectrophotometer (AAS). The data collected were analysed using descriptive and inferential statistics.

Comparative assessment of Cd content in soil and plant indicated that *Glomus mosseae* and rock phosphate treated plants absorbed more Pb and Cd than those with non inoculated, sole treatment with either *Glomus mosseae* or rock phosphate at all levels of contamination (0-100 $mgkg^{-1}$). Similarly, the plants treated with *Glomus mosseae* and rock phosphate also absorbed more lead from the soil than other treatments. The uptake of Pb by *Solenostemon monostachyus* increased with the increase in the concentration. However, application of *Glomus mosseae* or rock phosphate alone or in combinations enhanced the Pb uptake. The effect of single application of either *Glomus mosseae* or rock phosphate on the plant dry weight in a Pb contaminated soil was similar .The concentration of Pb in the soil increased with increase in Pb contamination except at 50-100 mg/kg under dual application of *Glomus mosseae* and rock phosphate.

OBAFEMI AWOLOWO UNIVERSITY

© Obafemi Awolowo University, Ile-Ife, Nigeria
For more information contact **ir-help@oauife.edu.ng**

In conclusion phytoremediation potential of *Solenostemon monostachyu*s in lead and cadmium contaminated soils could be enhanced through the combination of *Glomus mosseae* and rock phosphate.

OBAFEMI AWOLOWO UNIVERSITY

© Obafemi Awolowo University, Ile-Ife, Nigeria
For more information contact **ir-help@oauife.edu.ng**

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Many anthropogenic activities generate wastes and tailings that have contributed to the elevation of heavy metals in the environment. Heavy metals are toxic to animals, humans and aquatic life. The ubiquitous nature of heavy metals, their toxicity even in trace quantities, and their tendency to bioaccumulate in the food chain have led to stricter environmental regulations in heavy metal discharges. Therefore, it is necessary to develop schemes to remove heavy metals from both waste waters and landfill leachates. It is also suitable and to remediate metal contaminated sites (Ma et al., 1993).

Heavy metal pollution of soil is a significant environmental problem that has its negative impact on human health and agriculture. Unfortunately, natural resources have been subjected to maximum exploitation and are severely degraded or polluted due to anthropogenic activities. This pollution includes point sources such as emission, effluents and solid discharge from industries, vehicle exhaustion and metals from smelting and mining, while nonpoint sources are soluble salts (natural and artificial), use of insecticides/pesticides, disposal of industrial and municipal wastes in agriculture, and excessive use of fertilizers (McGrath.,1998). Each source of contamination has its own damaging effects on plants, animals and ultimately on human health, but those that add heavy metals to soils and waters are of serious concern due to their persistence in the environment and carcinogenicity to human beings. They cannot be destroyed biologically but can only be transformed from one oxidation state or organic complex to another (Garbisu and Alkorta, 2001). Therefore, heavy metal pollution poses a great potential threat to the

OBAFEMI AWOLOWO UNIVERSITY

© Obafemi Awolowo University, Ile-Ife, Nigeria
For more information contact ir-help@oauife.edu.ng

environment and human health. In order to maintain good quality of soil and water, also to keep them free from contamination, continuous efforts have been made to develop technologies that are easy to use, sustainable and economically feasible. Physicochemical approaches have been widely used for remediating polluted soil and water, especially at a small scale. However, they experience more difficulties for a large scale of remediation because of high costs and side effects. Some remediation technologies have been developed to treat contaminated soil, but a biology-based technology, phytoremediation, is emerging.Phytoremediation includes: phytovolatilization, phytostabilization, and phytoextraction using hyperaccumulator species or a chelate-enhancement strategy. To enhance phytoremediation as a viable strategy, microbiota from the rhizosphere can play an important role, but the use of genetic engineering can also increase the success of the technique. Due to their immutable nature, metals are a group of pollutants of much concern. The danger of toxic metals is aggravated by their almost indefinite persistence in the environment (Garbisu and Alkorta., 2001). Heavy metals cannot be destroyed but can only be transformed from one oxidation stage or organic complex to another. Pollution of the biosphere with toxic metals has accelerated dramatically since the beginning of the industrial revolution (Nriagu, 1996). The primary sources of this pollution are the burning of fossil fuels, mining and smelting of metalliferous ores, metallurgical industries, municipal wastes, fertilizers, pesticides, and sewage (Alloway, 1990). In addition to sites contaminated by human activity, natural mineral deposits containing particularly large quantities of heavy metals are present in many regions of the globe (Memon*et al.*,2001).

In response to a growing need to address environmental contamination, many remediation technologies have been developed to treat contaminated soil (Riser-Roberts, 1998), mainly mechanically or physio-chemically based remediation methods. However, these

© Obafemi Awolowo University, Ile-Ife, Nigeria
For more information contact **ir-help@oauife.edu.ng**

technologies are usually expensive and soil disturbing, sometimes rendering the land useless as a medium for further activities such as plant growth.

1.2 Phytoremediation of Heavy Metal Contaminated Soils

The basic idea that plants can be used for environmental remediation is very old and cannot be traced to any particular source (Raskin*et al*., 1997). Nevertheless, an interdisciplinary research approach combined with a series of fascinating scientific discoveries have allowed the development of this idea into an emerging technology, phytoremediation, which uses plants and their associated rhizospheric microorganisms to remove, degrade, or immobilize various contaminants from polluted soils. Early research indicates that phytoremediation is a promising clean-up solution for a wide variety of contaminated sites, although it has its restrictions. Many of the limitations and advantages of phytoremediation are a direct result of the biological aspect of this type of treatment system (Singh *et al*., 2003). Plant-based remediation technologies can function with minimal maintenance after its establishment, as the costs of growing a crop are minimal compared to those of soil removal and replacement. Because biological processes are ultimately solar-driven, phytoremediation is on average ten-fold cheaper than engineering-based Technologies for remediation of heavy metal contaminated soil (Khan et al., 2004).

The fact that phytoremediation is carried out in situ contributes to its cost-effectiveness and may reduce exposure of the polluted substrate to humans, wildlife, and the environment (Pilon-Smits, 2005). However, it is not always the best solution to contamination problem. The use of phytoremediation is limited by the climatic and geological conditions of the site to be cleaned, such as temperature, altitude, soil type, and the accessibility for agricultural equipment (Schmoger*et al*., 2000).

© Obafemi Awolowo University, Ile-Ife, Nigeria
For more information contact ir-help@oauife.edu.ng

Plants have a range of potential mechanisms at the cellular level that might be involved in the detoxification and tolerance to heavy metal stress. These all appear to be involved primarily in avoiding the build-up of toxic concentrations at sensitive sites

For more information, please contact **ir-help@oauife.edu.ng**

OBAFEMI AWOLOWO UNIVERSITY

© Obafemi Awolowo University, Ile-Ife, Nigeria
For more information contact **ir-help@oauife.edu.ng**