



**UNIVERSITI PUTRA MALAYSIA**

**CHARACTERIZATION OF MAJOR ELEMENTS, HEAVY METALS, AND  
RARE EARTH ELEMENTS IN SOILS OF MARDI STATION AT CAMERON  
HIGHLANDS, MALAYSIA USING NEUTRON ACTIVATION ANALYSIS**

**AHMADREZA ASHRAF**

**FPAS 2011 8**

**CHARACTERIZATION OF MAJOR ELEMENTS, HEAVY METALS, AND  
RARE EARTH ELEMENTS IN SOILS OF MARDI STATION AT  
CAMERON HIGHLANDS, MALAYSIA USING NEUTRON ACTIVATION  
ANALYSIS**

**AHMADREZA ASHRAF**

**MASTER OF SCIENCE  
UNIVERSITY PUTRA MALAYSIA**

**2011**

**CHARACTERIZATION OF MAJOR ELEMENTS, HEAVY METALS, AND  
RARE EARTH ELEMENTS IN SOILS OF MARDI STATION AT  
CAMERON HIGHLANDS, MALAYSIA USING NEUTRON ACTIVATION  
ANALYSIS**

By

**AHMADREZA ASHRAF**

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

**December 2011**

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

**CHARACTERIZATION OF MAJOR ELEMENTS, HEAVY METALS, AND RARE EARTH ELEMENTS IN SOILS OF MARDI STATION AT CAMERON HIGHLANDS, MALAYSIA USING NEUTRON ACTIVATION ANALYSIS**

By

**AHMADREZA ASHRAF**

**December 2011**

**Chairman: Assoc. Professor Shaharin Ibrahim, PhD**

**Faculty: Environmental Studies**

The present thesis reports on the result of an investigation of elemental concentrations present within the topsoil and the granitic bedrock of MARDI Station, Cameron Highlands. The elemental concentrations had been obtained by using instrumental neutron activation analysis which was done at the nuclear reactor of the Instrumental Technology Division, Nuclear Agency of Malaysia (MINT), Bangi. All together there are 34 elements that had been identified, which includes Cr, Zn, K, Mg, Mn, Na, Al, Rb, Ca, Br, Ta, Co, V, Ti, Ba, Ga, Sb, As, Fe, Hf, Cs, Th, U, Zr, Sm, Ce, Eu, La, Lu, Sc, Yb, Nd, Tb, and Dy. The research work begins by establishing the applicability and the accuracy of the technique by analyzing the standard certified reference materials IAEA-Soil-7 and IAEA-SL-1 and also the two multi-element certified standard solutions PTS15 and PTS16 which were provided

by International Atomic Energy Agency (IAEA), Vienna, Austria. The concentrations of the elements as obtained by the facility in MINT were compared to the established published values given by IAEA, Vienna. The accuracy of the results as obtained by MINT facilities are comparable to that values published by IAEA, Vienna. Hence, the method was proven acceptable. After the accuracy of the method was established, the concentration of the various elements present within the top soil of MARDI Station and also within the granitic bedrock from which the soil was derived was determined. Four samples from each station were used to ensure repeatability and accuracy. The result on the concentration of the elements obtained by the present research were compared to the result of similar work within Malaysia and internationally. To achieve the objective of the present work, the concentrations of the elements found in the top soil of MARDI Station were compared to the concentration of the same elements found in the granitic bed rock, their enrichment factors were calculated, geoaccumulation index of each element at each station were computed to assess the level of pollution due to each element based on Müller's criteria. The level of pollution due to each element had also been compared to the target value and intervention value of the Dutch Standard for Soil. Based on the present research and using the Dutch Standard as a guide, it was found that the top soil of MARDI Station in Cameron Highlands does not have the concentrations of elements in excess of the intervention concentration, except only for Th. Thus it can be concluded that the top soil are not polluted by major, minor, heavy metal, trace elements or actinides except for Thorium. The result of the present investigation also shows that certain elements had been introduced anthropogenically into the top soil of MARDI station at certain locations. The anthropogenicity of the elements had been assessed using Kolmogorov-Smirnov tests and box plot tests. The

anthropogenicity of the elements had been tested at 95% confidence level. The stations which show anthropogenic inputs of pollutants are at M1, M2, M8, M9, M10, M12, M13, M14 and M15. Different suite of elements which includes Al, Cs, Th, Lu, Fe, Ta, K, Tb, Sb, Ca, Sm, Nd, Eu, Dy, Ga, Br and Sb were introduced at different stations within the top soil of MARDI Station. However, the concentrations of these elements do not exceed the intervention values as stipulated by the Dutch Soil Standard, except for Th.



Abstrak tesis yang dimajukan kepada Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Master Sains.

**PENCIRIAN UNSUR MAJOR, LOGAM BERAT, DAN UNSUR SURIH BUMI DALAM TANAH DI STESEN MARDI DI CAMERON HIGHLAND, MALAYSIA MENGGUNAKAN ANALISIS PENGAKTIFAN NEUTRON**

oleh

**AHMADREZA ASHRAF**

**Disember 2011**

**Pengerusi: Prof. Madya Dr Shaharin Ibrahim, PhD**

**Fakulti: Pengajian Alam Sekitar**

Tesis ini melaporkan hasil penyelidikan yang dijalankan berkenaan kepekatan unsur-unsur yang terdapat di dalam tanah baki dan batuan granit yang terdapat di Stesen MARDI, Cameron Highlands. Kepekatan unsur-unsur telah diperolehi dengan menggunakan kaedah peralatan analisis neutron teraktif yang terdapat di reaktor nuklear, Bahagian Teknologi Peralatan, Agensi Nuklear Malaysia (MINT), Bangi. Pada keseluruhannya sebanyak 34 unsur telah dikenalpasti, termasuk Cr, Zn, K, Mg, Mn, Na, Al, Rb, Ca, Br, Ta, Co, V, Ti, Ba, Ga, Sb, As, Fe, Hf, Cs, Th, U, Zr, Sm, Ce, Eu, La, Lu, Sc, Yb, Nd, Tb, dan Dy. Kerja penyelidikan telah dimulakan dengan memastikan kebolehpercayaan dan ketepatan bagi teknik tersebut dengan cara menganalisis bahan piawai terbukti IAEA-Soil 7 dan IAEA-SL-1 serta dua larutan piawai pelbagai unsur PTS15 dan PTS16 yang dibekalkan oleh Pusat Tenaga Atom

Antara Bangsa (IAEA) beribu pejabat di Vienna, Austria. Kepekatan unsur-unsur yang diperolehi dari pengukuran yang dilakukan di MINT, Bangi, dibandingkan dengan kepekatan unsur yang sama yang telah ditentukan oleh IAEA Vienna, dan didapati mempunyai nilai yang setara. Dengan yang demikian, kaedah mengesan kepekatan unsur dengan menggunakan kaedah peralatan analisis neutron teraktif telah dibuktikan boleh digunakan. Setelah memastikan kaedah yang akan digunakan boleh dipercayai, kajian selanjutnya adalah mengukur kepekatan setiap unsur yang terdapat dalam tanah baki dan granit dari kawasan Stesen MARDI, Cameron Highlands. Sebanyak 4 sampel digunakan bagi setiap stesen untuk memastikan ketepatan dan kejituan. Hasil kepekatan bagi unsur-unsur yang diperolehi dari kajian ini dibandingkan dengan hasil pengkaji-pengkaji lain yang melaksanakan kajian di Malaysia dan Antara Bangsa. Untuk mencapai objektif kajian ini, kepekatan unsur di dalam tanah baki Stesen MARDI dibandingkan dengan kepekatan unsur yang sama yang terdapat di dalam batuan granit yang menjadi sumber asal kepada tanah baki tersebut. Faktor pengkayaan serta indeks geoakkumulasi bagi setiap unsur pada setiap stesen telah dikira untuk menilai tahap pencemaran bagi setiap unsur berdasarkan kepada kriteria Müller. Tahap pencemaran bagi setiap unsur juga telah dibandingkan dengan nilai “sasaran” dan nilai “intervention” seperti mana yang digunakan di dalam Nilai Piawai bagi tanah negara Netherland. Berdasarkan kepada kajian yang dijalankan sekarang serta berpandukan Nilai Piawai Kepekatan Unsur Tanah Negara Netherland, didapati bahawa tanah baki di Stesen MARDI, Cameron Higlands tidak mempunyai kepekatan melebihi kepekatan “intervention” bagi negara Netherland, kecuali unsur Th. Dengan yang demikian, kajian ini merumuskan bahawa tanah baki di Stesen MARDI tidak tercemar oleh unsur-unsur major, minor, logam berat, unsur surih atau unsur aktinid, kecuali bagi unsur Th. Hasil kajian ini



juga menunjukkan bahawa terdapat sesetengah unsur yang telah ditambah kepada kandungan asal tanah baki akibat dari aktiviti manusia pada sesetengah tempat. Keadaan penambahan unsur kedalam tanah baki ini atau “anthropogenicity” telah dinilai dengan menggunakan ujian Kolmogorov-Smirnov serta plot kotak. “Anthropogenicity” unsur-unsur ini telah diuji pada tahap kebolehpercayaan 95%. Stesen yang menunjukkan input manusia terhadap unsur adalah di stesen-stesen M1, M2, M8, M9, M10, M12, M13, M14 dan M15. Gabungan pelbagai unsur termasuk Al, Cs, Th, Lu, Fe, Ta, K, Tb, Sb, Ca, Sm, Nd, Eu, Dy, Ga, Br dan Sb telah ditambahkan kepada tanah baki pada beberapa stesen yang terdapat di dalam Stesen MARDI. Walau bagaimana pun, kepekatan unsur-unsur yang ditambah ke dalam tanah baki ini tidak mencapai nilai “intervention” sepertimana yang digunakan di dalam Piawai Tanah Netherland, kecuali unsur Th.

## AKNOWLEDGMENTS

I would like to express the most thankful, grateful and deep appreciation to my **supervisor** and Chairman of the Supervisory Committee **Assoc. Prof. Dr. Shaharin Ibrahim** for his guidance, honestly encouragement throughout my research.

I would like to extend my gratitude to the member of my Supervisory Committee, **Prof. Dr. Elias Saion** for his guidance and honestly encouragement.

I would like to express the most thankful and grateful to the member of my Supervisory Committee, **Dr. Abdul Khalik Wood** for his invaluable contribution, and generous support.

I would like to express the most thankful to the Manager of MARDI Station Cameron Highlands, **Dr. Wan Abdullah Wan Yusuff** for his invaluable contribution in collecting topsoil samples.

Additionally, I would like to grateful to Madam Aini Hayati bt Ab.Rahman soil specialist at MARDI Station Cameron Highlands due to her aim for taking samples.

Thanksgivings are expressed to the Instrumental Technology Division, Nuclear Agency of Malaysia for their continuous supporting and the usage of their facilities.

I would like to express thanksgivings to Dr. Mohd Suhaimi Hamzah for his guidance.

I would like to grateful to Mr. MD Suhaimi Elias for his assistance. I am very much thankful and especial thanks to Mr. Ariffin Talib and Madam Pirmala Devi and Madam Jamailiah Mat Yatim for their help in collecting data in the laboratories.

I would like to extend my great thankful to the Dean of Faculty of Environmental Studies, **Associate Prof. Dr. Ramdzani Abdullah.**

I would like to extend my great thankful to the Deputy Dean of Faculty of Environmental Studies, **Assoc. Prof.Dr.Wan Nor Azmin Sulaiman.**

I would like to extend my great appreciative of the Head Department of Environmental Sciences, **Dr. Puziah Abdul Latif.**

I would like to extend my great thanks to the staff of the Department of Environmental Sciences, University Putra Malaysia.

Finally,I would like to express my great thanks to the staff of the Instrumental Technology Division, Nuclear Agency Of Malaysia and special thanks to the staff of MARDI Station Cameron Highlands.

I certify that a Thesis Examination Committee has met on 21 December 2011 to conduct the final examination of Ahmadreza Ashraf on his thesis entitled " Characterization Of Major Elements, Heavy Metals And Rare Earth Elements in Soils Of MARDI Station at Cameron Highlands, Malaysia Using Neutron Activation Analysis" 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:

**Puziah binti Abdul Latif, PhD**

Associate Professor  
Faculty of Environmental Studies  
Universiti Putra Malaysia  
(Chairman)

**Halimah binti Mohamed Kamari, PhD**

Senior Lecturer  
Faculty of Science  
Universiti Putra Malaysia  
(Internal Examiner)

**Mohammad Firuz bin Ramli, PhD**

Associate Professor  
Faculty of Environmental Studies  
Universiti Putra Malaysia  
(Internal Examiner)

**Abdul Ghani Md.Rafek, PhD**

Professor  
Faculty of Science & Technology  
Universiti Kebangsaan Malaysia  
(External Examiner)

-----  
**SEOW HENG FONG, PhD**

Professor and Deputy Dean  
School of Graduate Studies  
Universiti Putra Malaysia

Date: 2 March 2012

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 Science**. The members of the Supervisory Committee were as follows:

**Shaharin Ibrahim, PhD**

Associate Professor  
Faculty of Environmental Studies  
Universiti Putra Malaysia  
(Chairman)

**Elias Saion, PhD**

Professor  
Faculty of Science  
Universiti Putra Malaysia  
(Member)

**Abdul Khalik Hj. Wood, PhD**

Dr  
Instrumental Technology Division,  
Nuclear agency Of Malaysia  
(Member)

---

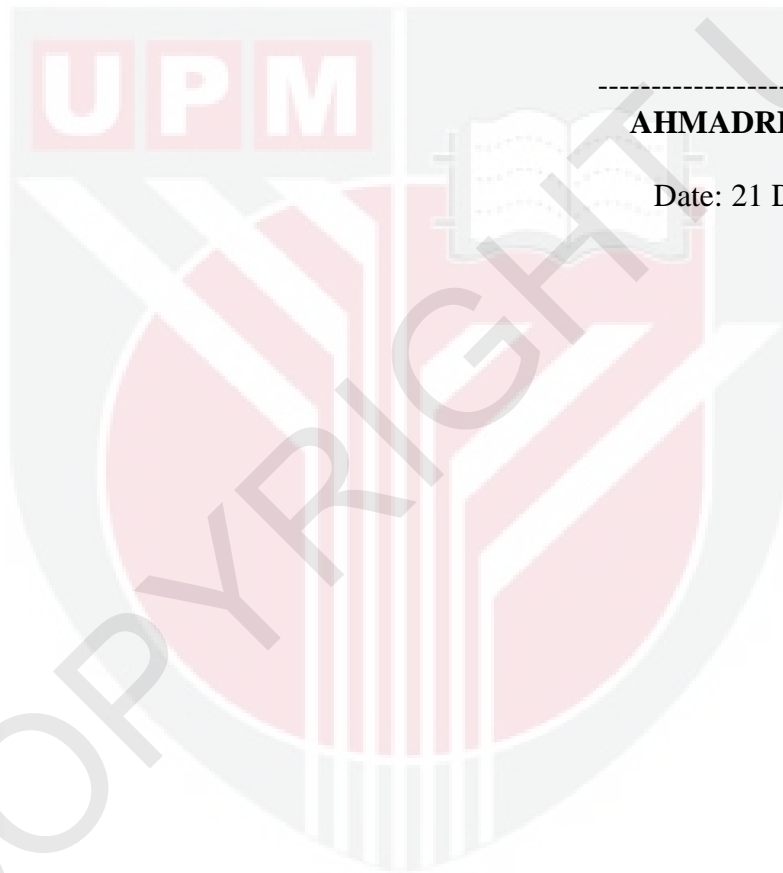
**BUJANG Bin KIM HUAT, PhD**

Professor and Dean  
School of Graduate Studies  
Universiti Putra Malaysia

Date:

## DECLARATION

I hereby 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 institution.



---

**AHMADREZA ASHRAF**

Date: 21 Decemder 2011

## TABLE OF CONTENTS

	<b>Page</b>
<b>ABSTRACT</b>	i
<b>ABSTRAK</b>	iv
<b>ACKNOWLEDGEMENTS</b>	vii
<b>APPROVAL</b>	x
<b>DECLARATION</b>	xi
<b>LIST OF TABLES</b>	xv
<b>LIST OF FIGURES</b>	xviii
<b>LIST OF ABBREVIATIONS</b>	xx
<b>CHAPTER</b>	
<b>1</b>	
<b>INTRODUCTION</b>	
1.1	General Introduction 1
1.2	Sources of Heavy Metals in the soils 3
1.3	General vision and the Importance of Trace Elements 4
1.4	Definition of the Study Area 6
1.5	Problem Statement 9
1.6	Significance of the Study 10
1.7	The Scope of the present Study 12
1.8	Objectives of the Study 13
1.9	Outline of the Thesis 14
<b>2</b>	
<b>LITERATURE REVIEW</b>	
2.1	Introduction 16
2.2	Elemental pollution in the Cameron Highlands, Malaysia 16
2.3	Elemental Pollution in other Regions of Malaysia 19
2.4	Studies of Elemental Pollution in Different Regions over the World 20
<b>3</b>	
<b>MATERIALS AND METHODS</b>	
3.1	Introduction 26
3.2	Sample Collection 27
3.2.1	Collection of Top Soil 27
3.2.2	Collection of Granite Bedrock 29
3.3	Preparation of Samples 30
3.3.1	Preparation of Soil samples 30
3.3.2	Preparation of Granite Rock Sample 32
3.4	Preparation of Standards and Determination of Accuracy 38
3.4.1	Preparation of Standards 38
3.4.2	Determination of Lower Limit of Detection 41
3.5	Irradiation of Samples and Standards in PUSPATI TRIGA MARK II Reactor 42
3.6	Analyses of Irradiation Results 44
3.6.1	Comparative Method 44
3.6.2	Determination of Elemental Concentrations 46

<b>4</b>	<b>RESULTS AND DISCUSSION</b>	
4.1	Introduction	47
4.2	Applicability of INAA Method for Analysis of Soil Samples	47
4.3	Accuracy of Elemental Concentration Determined In the Present Work	49
4.3.1	Concentration of Elements in IAEA-SL-1	50
4.3.2	Concentration of Element in the Standard Solution	52
4.4	Elemental Concentration of MARDI topsoil	53
4.5	Elemental Concentration in the Granitic Bedrock	62
4.6	Comparison of Some Elemental Concentration in soil between the Present Work and Other Studies in Cameron Highlands	67
4.7	Comparison of Some Element Concentration between the Present Work and Other Studies in Malaysia	71
4.8	Comparison of Some Elements to the International Studies for Soils	77
4.9	Enrichment Factor of Each Element in the Soil at Each Sampling Station	81
4.10	Geo-Accumulation Index of Each Element at Each Sampling Station	92
4.11	The enrichment and/or depletion status and the determination of the Pollution Level of elements within the topsoil of MARDI Station	99
4.12	Determination of Anthropogenic – Non Anthropogenic Nature of Elements within the Top Soil of MARDI Station	111
<b>5</b>	<b>CONCLUSIONS AND FUTURE WORKS</b>	
5.1	Introduction	124
5.2	Assessment of pollution level of the top soil using geoaccumulation index and Muller’s Criteria	124
5.3	The Comparison of Elemental Concentration between the top soil of MARDI station and the granite bedrock	126
5.4	Comparison of Elemental Concentration in the top soil MARDI Station with the Dutch Standard for Soil	127
5.5	Anthropogenic – non anthropogenic nature of elements within the top soil of MARDI station	129
5.6	Over-all conclusion	129
5.7	Recommendation for Future works	130
	<b>REFERENCES</b>	132
	<b>APPENDICES</b>	142
	<b>Appendice A</b> Topography map of Cameron Highlands area	142
	<b>Appendice B</b> Geological map of Cameron Highlands area	143
	<b>Appendice C</b> Certificates photocopies of (CRM) that used in the quality control procedures	144
	<b>Appendice D</b> Distributions of concentrations elements in the topsoil	153