

**UNIVERSITI TEKNOLOGI MARA**

**CORRELATION OF NATURALLY  
OCCURRING RADIOACTIVE  
MATERIALS (NORM)  
CONCENTRATION IN LANGAT  
RIVER AND BASIN SEDIMENT**

**TUAN ASMAA BINTI TUAN RESDI**

Thesis submitted in fulfillment  
of the requirements for the degree of  
**Doctor of Philosophy**  
**(Civil Engineering)**

**College of Engineering**

**November 2022**

## ABSTRACT

Naturally occurring radioactive material (NORM) comprises long-lived nuclides which can be harmful to human due to long-term exposure. Furthermore, correlation of observed natural radionuclides concentration in the river sediment with river sediment discharge will allow its spatial and temporal distribution to be predicted. NORM studies in Malaysia are reviewed and compiled to provide the spatial observation of naturally occurring radioactive material in the country and to identify hotspot locations. There is strong correlation between Ra-226 and Ra-228 but no discernible correlation between radioactivity concentration in catchment soil and river sediment sample for the same element. In general, radionuclide activity increases in river sediment in the down-river direction which may be attributed to catchment soil loss. There is insufficient data on river sediment discharge to support the claim conclusively. Linear log-transformed equation is found to give the best correlation between river sediment discharge and streamflow with 1-day lead. The river sediment discharge derived shows good agreement with the monsoonal effect and total basin sediment yield is validated against published literature where errors are primarily attributed to extreme events. Over a four-year period, the Langat River basin has been investigated for the correlation between natural radionuclide activity concentrations in river sediment and suspended sediment discharge. Analysis of long-term correlation between quarterly natural radionuclides concentration observation with river sediment discharge is generally poor. However, examination of the seasonal variation shows good correlation of natural radionuclides concentration and river sediment discharge in the months of March and August/September, corresponding to the pre-storm seasons.

## ACKNOWLEDGEMENT

Firstly, I wish to thank Allah swt for giving me the opportunity to embark on my PhD and for completing this long and challenging journey successfully. My gratitude and thanks go to my main supervisor Assoc. Prof. Ir Dr. Lee Wei Koon and also thanks to my co-supervisor Ts. Dr. Janmaizatulriah binti Jani.

I would like to express my gratitude to the Department of Irrigation and Drainage Malaysia (DID) and Malaysian Nuclear Agency (MNA) for providing the data station in this project.

My appreciation goes to the Dr. Zal U'yun Wan Mahmood, Mr Khairuddin Mohammad Kontol and staff members of the Malaysian Nuclear Agency, Bangi, Selangor. who provided the facilities and assistance during sampling and laboratory works in the Radiochemistry and Environment Laboratory (Malaysian Nuclear Agency, Bangi, Selangor). Special thanks to my husband Mohd Hakimi Che Ali for support and motivates me with this project and my lovely son Muhammad Hamiz Amsyar Mohd Hakimi. My mother (Maisharah Zakaria), my father (Tuan Resdi Tuan Ibrahim), mother-in-law (Halimatuaiyah Yunus) and father-in-law (Che Ali Mat Yaacob) and to all my siblings (Tuan Luqman, Tuan Nurul Hafiza and Tuan Zafran Zharif) who's non-stop doa in their pray for my PhD studies. Alhamdulillah.

# TABLE OF CONTENTS

	<b>Page</b>
<b>CONFIRMATION BY PANEL OF EXAMINERS</b>	<b>ii</b>
<b>AUTHOR'S DECLARATION</b>	<b>iii</b>
<b>ABSTRACT</b>	<b>iv</b>
<b>ACKNOWLEDGEMENT</b>	<b>v</b>
<b>TABLE OF CONTENTS</b>	<b>vi</b>
<b>LIST OF TABLES</b>	<b>x</b>
<b>LIST OF FIGURES</b>	<b>xii</b>
<b>LIST OF PLATES</b>	<b>xv</b>
<b>LIST OF SYMBOLS</b>	<b>xvi</b>
<b>LIST OF ABBREVIATIONS</b>	<b>xviii</b>
<b>CHAPTER ONE: INTRODUCTION</b>	<b>1</b>
1.1 Research Background	1
1.2 Problem Statement	3
1.3 Research Questions	3
1.4 Research Objectives	4
1.5 Scope of Study	4
1.6 Significance of Study	5
<b>CHAPTER TWO: LITERATURE REVIEW</b>	<b>6</b>
2.1 Naturally occurring radioactive material (NORM)	6
2.2 Decay Series	7
2.2.1 Uranium Decay Series (U-238)	8
2.2.2 Thorium Decay Series (Th-232)	9
2.2.3 Potassium (K-40)	9
2.3 Types of ionizing radiation	10
2.3.1 Alpha particle ( $\alpha$ )	10
2.3.2 Beta ray ( $\beta$ )	10

2.3.3	Neutron radiation (n)	11
2.3.4	High-Energy Photon Radiation (Gamma ray ( $\gamma$ ) and X-Rays)	11
2.4	Radiation in Environment	12
2.5	NORM distribution in Malaysia	13
2.5.1	Southern Peninsular State (Johor)	25
2.5.2	West Coast Peninsular States	25
2.5.3	East Coast Peninsular States	26
2.5.4	East Malaysian States	27
2.6	NORM detection of radiometric methods	27
2.6.1	Alpha Spectrometry	29
2.6.2	Alpha/Beta Counting System	30
2.6.3	Gamma ray Spectrometry	30
2.7	NORM detection of mass spectrometry methods	32
2.7.1	Inductively coupled plasma mass spectrometry (ICP-MS)	32
2.7.2	Accelerator mass spectrometry (AMS)	33
2.7.3	Thermal ionization mass spectrometry (TIMS)	35
2.7.4	Resonance ionization mass spectrometry (RIMS)	36
2.7.5	Secondary ion mass spectrometry (SIMS)	36
2.7.6	Glow discharge mass spectrometry (GDMS)	37
2.8	NORM mobilization and transport	38
2.8.1	NORM mobilization and transport	39
2.8.2	Correlation of NORM and sediment yield	41
2.9	Langat basin	44
2.10	Research gap	46
<b>CHAPTER THREE: RESEARCH METHODOLOGY</b>		<b>47</b>
3.1	Overview	47
3.2	Preparation of NORM Inventory	48
3.3	Radioactivity Concentration (RC) Field Data Collection and Analysis	49
3.3.1	Locations of Monitoring Station	49
3.3.2	Field Observations	50
3.3.3	Field sample collection	51
3.3.4	Sample Pre-treatment	52