

**SOIL-TO-PLANT TRANSFER FACTORS OF NATURAL RADIONUCLIDES
IN FOUR COMMON NIGERIAN MEDICINAL PLANTS**

BY

**FAYOMI EMMANUEL ADELEKE
MTECH/SPS/2017/7267**

**DEPARTMENT OF PHYSICS
FEDERAL UNIVERSITY OF TECHNOLOGY
MINNA**

OCTOBER, 2021

**SOIL-TO-PLANT TRANSFER FACTORS OF NATURAL RADIONUCLIDES
IN FOUR COMMON NIGERIAN MEDICINAL PLANTS**

BY

**FAYOMI EMMANUEL ADELEKE
MTECH/SPS/2017/7267**

**A THESIS SUBMITTED TO THE POSTGRADUATE SCHOOL, FEDERAL
UNIVERSITY OF TECHNOLOGY, MINNA, NIGERIA IN PARTIAL
FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE
DEGREE OF MASTER OF TECHNOLOGY IN APPLIED NUCLEAR PHYSICS**

OCTOBER, 2021

ABSTRACT

The use of medicinal plants to prevent or cure common diseases in Nigeria has increased over the years. These plants can be a source of internal radiological contamination if their radionuclide contents are high. This research investigates the activity concentration of three naturally occurring radionuclides - ^{238}U , ^{232}Th and ^{40}K in the soil and edible parts of four common medicinal plants in Nigeria. Also the soil-to-plant transfer factors of the radionuclides were investigated. The plants considered for their radioisotopes burden were *Moringa oleifera*, *Zingiber officinale*, *Indian saffron* and *Ageratum conyzoides* all of which were cultivated in Nigeria. The specific activity concentration of ^{238}U , ^{232}Th and ^{40}K in these plants and corresponding cultivated soil were measured using gamma spectrometric analysis via a well calibrated HpGe detector. The measure activity concentration of ^{238}U in farm soil ranged from $23.513 \pm 3.527 \text{ Bq kg}^{-1}$ to $58.984 \pm 8.847 \text{ Bq kg}^{-1}$, ^{232}Th ranged from $33.455 \pm 5.018 \text{ Bq Kg}^{-1}$ to $63.735 \pm 9.560 \text{ Bq Kg}^{-1}$ and ^{40}K ranged from $336.669 \pm 50.500 \text{ Bq kg}^{-1}$ to $729.451 \pm 109.417 \text{ Bq kg}^{-1}$. The activity concentration of ^{40}K in the medicinal plants ranges from $1.70 \pm 0.26 \text{ Bq Kg}^{-1}$ to $239.77 \pm 30.95 \text{ Bq Kg}^{-1}$ with an average value of $89.64 \pm 10.15 \text{ Bq Kg}^{-1}$. The highest activity concentration of ^{40}K was recorded for *Moringa oleifera* while *Indian saffron* had the lowest activity concentration. ^{238}U activity ranged from $10.37 \pm 1.56 \text{ Bq Kg}^{-1}$ to $1.34 \pm 0.20 \text{ Bq Kg}^{-1}$ with an average value of $4.62 \pm 0.66 \text{ Bq Kg}^{-1}$. The lowest activity concentration recorded in *Moringa oleifera* while the highest activity was recorded in *Ageratum conyzoides*. Also, ^{232}Th activity ranges from $4.621 \pm 0.693 \text{ Bq Kg}^{-1}$ to $13.752 \pm 2.063 \text{ Bq Kg}^{-1}$ with average value of $8.18525 \pm 1.177091667 \text{ Bq Kg}^{-1}$. The lowest activity concentration was recorded for *Indian saffron* while the highest activity concentration was recorded in *Moringa oleifera*. It was further observed that ^{232}Th was higher in Goat weed, Ginger, and Turmeric compared to ^{232}Th and ^{40}K . Also, for both ^{232}Th and ^{40}K , samples of leaves had the highest activity concentrations compared to ^{238}U . The average transfer factors of ^{238}U , ^{232}Th and ^{40}K were 0.09, 0.19, and 0.20; 0.49, 0.40 and 0.31; 0.45, 0.17, and 0.29; 0.24, 0.15 and 0.06 for *Moringa oleifera*, *Ageratum conyzoides*, *Zingiber officinale*, and *Indian saffron* respectively.

TABLE OF CONTENT

Content	Page
Cover page	i
Title page	ii
Declaration	iii
Certification	vi
Dedication	v
Acknowledgement	vi
Abstract	vii
Table of content	viii
List of Tables	x
List of Figure	xi
Chapter one	
1.0 INTRODUCTION	1
1.1 Background to the Study	1
1.2 Statement of Research Problem	6
1.3 Aim and Objective of the Study	7
1.4 Justification of the Study	7
1.5 Scope of the study	7
1.6 Study Area	8
Chapter Two	
2.0 LITERATURE REVIEW	10
2.1 Review of Related Literature	10
2.2 Radionuclides in Medicinal Plants	17
2.3 Medicinal Plants	18

2.4 Internal Sources of Radiation Exposure	21
2.5 Fundamentals of Gamma-ray Spectrometry	24
2.6 Gamma Radiation Sources	30
2.7 Properties of Gamma-ray Spectra	31
2.8 Gamma-ray Sources in the Environment	31
2.9 Simple Radioactive decay, Decay constant. Half-life, Activity	36
2.10 Types of Radiation	37
2.11 Sources of Radiation	41
2.12 Natural Decay Series	47
2.13 Instruments and detectors	51
2.14 Radiation quantities and units	60
Chapter Three	
3.0 Materials and Methods	63
3.1 Materials	65
3.2 Study Area	66
3.3 Sampling Technique	66
3.4 Sample Preparation	66
3.5 Sample Measurement and Analysis of Spectra	68
3.6 Calibration of Gamma Spectrometry System	68
3.7 Energy Calibration	69
3.8 Efficiency Calibration	69
3.9 Calculation of Activity Concentration	71
3.10 Minimum Detectable Activity	71
3.11 Transfer Factor	72
3.12 Dose Assessment	72
Chapter four	
4.0 Results and Discussion	75
4.1 Specific Activities in Farm Soils	75

4.2 Hazard Indices Assessment due to NORM Concentration	80
4.3 Specific Activities in Medicinal Plants	83
4.4 Transfer Factors	83
Chapter five	
5.0 Conclusion and Recommendations	86
5.1 Conclusion	86
5.2 Recommendations	88
References	89

LIST OF TABLES

Table	Page
1.1 Typical Sources and Radiation Exposure Level	2
2.1 SI Derived Quantities and Units of Radioactivity	61
3.1 Description of study Areas, Location, and Samples Collected	64
3.2 Materials Required for the Experiment	65
4.1 Activity conc. (Bq kg ⁻¹ , dry weight) of ²³⁸ U, ²³² Th and ⁴⁰ K in soils samples	76
4.2 Comparison of average activity	79
4.3 Radiological Hazard indices due to NORM conc. in Farm Soil Samples	82
4.4 Activity conc. of ²³⁸ U, ²³² Th and ⁴⁰ K in medicinal plants	82
4.5 Individual radionuclides soil-to-plant transfer factors	85

LIST OF FIGURES

Figure	Page
1.1 Map of Nigeria showing the study area	9
2.1 Block diagram of the experimental setup	14
2.2 The uranium and thorium decay series	50
2.3 Sodium iodide gamma spectrum of caesium-137	53
2.4 Sodium iodide gamma spectrum of cobalt-60	54
2.5 Block diagram of a gamma-ray spectrometer	67
3.1 Energy calibration for 1000ml Marinelli geometry	70
3.2 Efficiency calibration curve	57
4.1 Mean distribution of ^{238}U , ^{232}Th and ^{40}K specific activity conc. in soil samples	76