Evaluation of Lifetime Cancer Risk in Some Vegetables and Soil Samples in Two Main Cities in Ogun State: Human and Ecological Risk

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EVALUATION OF LIFETIME CANCER RISK IN SOME VEGETABLES AND SOIL SAMPLES IN TWO MAIN CITIES IN OGUN STATE: HUMAN AND ECOLOGICAL RISK

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Abstract

The spate of health challenges via the ingestion of radionuclides is still of concern especially in regions that have no clear documentation of background of radioactive sources. The present study evaluated the activity concentrations of naturally occurring radioactive nuclides in plants and their corresponding soil collected at Ibeshe and Covenant University community areas of Ogun State, Nigeria. The activity concentrations and other radiological risks from consuming the leafy vegetables were also estimated. The results show that the mean concentration of ^{226}Ra, ^{232}Th, ^{40}K in the agricultural soil were found to be 24.18±2.31, 20.93±2.27, 20.95±1.9 for Ibeshe and 58.76±4.84, 26.06±1.93, 33.87±2.23, respectively for Covenant University. Whereas, for the leafy vegetables, the mean concentration of ^{226}Ra, ^{232}Th, ^{40}K were found to be 5.02±0.9, 7.98±1.70, 427.82±29.75 for Ibeshe and 17.57±2.35, 22.19±3.0, and 424.17±25.15 for Covenant University Community. In comparison, all these values are within the recommended limits of 32.00 and 45.00, 420.00, Bqkg-1for ^{226}Ra, ^{232}Th, ^{40}K according to the United Nations Scientific Committee on the Effect of Atomic Radiation (UNCEAR) except the mean value for Covenant University soil for ^{232}Th which is slightly higher. The values obtained were comparable to the internationally recommended values. The mean value for excess lifetime cancer risk (ELCR) for Ibeshe North is 31.08, while that of Canaanland (CU) is 239.03, respectively is lower than the recommended limits of other published papers 1.72 x 10^4 according to International Commission on Radiological Protection (ICRP). These lower radiological risks indicate apparently that the chemical carcinogenic pollutants in the samples may be the major risk, inducing chemical parameters in the study area. This study will serve as a baseline data for any radiologically induced diseases. Significantly, it will serve as a baseline data for any radiologically induced diseases from vegetables in Nigeria and suggests further research on chemical toxicity risks on the same samples.

Keywords: Food safety; Natural Radionuclides; Toxicity; Soil; Leafy vegetables

1.0 Introduction

Natural radionuclides such as ^{238}U, ^{232}Th, their descendants, and non-systems ^{40}K are generally spreading on Earth. A significant amount of these radionuclides is present in many mineral locks, including granite [9]. Therefore, granite can have significant amounts of natural radionuclides such as ^{238}U, ^{232}Th, its offspring, and non-class ^{40}K [22, 28, 31]. The concentration of these radionuclides does not spread uniformly on the specific granite bricks. The naturally existing radionuclides that block ionizing radiation are present in the environment. Invariably they are present on the ground, rocks, sand, water, and other land minerals for architecture and construction purposes [22, 34, 21, 32, 24]. These radionuclides release hazardous ionized radiation known to cause cancer and other effects of radiation health and the critical body. [5, 22, 23, 7, 28]. Radionuclides in mineral soils, such as granite, enter through the waterways (drinking water) and possibly could be incorporated into plants, therefore, there is the possibility of a greater redistribution in the dietary chain. Consequently, they can eventually go to humans through food chains and may present an environmental threat to the health of the local population. Therefore, information on these radionuclides in the environment is basic to estimate the level of public exposure to ionizing radiation. Research on the level of natural radionuclides and their offspring are carried out in various parts of Nigeria [11, 3, 2, 15, 4, 30, 32, 14, 25, 1]. The absorption of radionuclides by soil occurs in many ways. The prediction of radionuclides, heterogeneity and land composition, and radionuclide predictions are some problems. Radiation protection of the public via ingestion through foodstuff has generated more interest owing to the spate of diseases and infant deformation that ensued from the release of radiation exposure to the public in any environment. Several studies had documented radioactive concentrations within their locality to aid health workers and environmental experts on salient decisions to protect the public. The aim of this present study was to ascertain the signature of the carcinogenic risks due to the presence of naturally occurring radionuclides in selected vegetables and soil samples from some parts of Ota, Ogun State, and the potential health effects to the consumers.

2.0 Geology and Geographical Location of the Study Area

The study areas of this work covered Ibeshe community and Covenant University. Ibeshe is located in Yewa North Local government of Ogun State while Covenant University (CU) is located in Ado Odo/ Ota Local Government area of Ogun State. Ibeshe is home to Dangote Cement Factory which is the largest cement factory in Sub-Saharan Africa. Covenant University is based in Ota which is a densely populated city in Ogun State with a lot of urban development and factory presence.

2.1 Geology and Geographical Location of the Study Area

The study area is located within the eastern Dahomey Basin in Ogun State, Nigeria. The coordinates are within Latitude and Longitude of 6.6726° N, 3.1612° E and 6.9528° N, 3.0388° E for Covenant University area and Ibeshe community respectively. The site is characterized by Late Cretaceous to Early Tertiary sedimentary and basement complex rocks [17, 18]. The Abeokuta group formation, Imo group formation, Ewekoro formation, Ilaro formation, Benin formation and Oshosun formation are stratigraphically represented in Ogun State's sedimentary. The Ise, Afowo, and Araromi formations are part of the Abeokuta group, which is located above the basement complex. The Ewekoro, Oshosun, and Ilaro groups are all overlain by the Benin formation group of coastal plain sands, which is overlain by the Abeokuta Formation group [18,19] as shown in Figure 1.

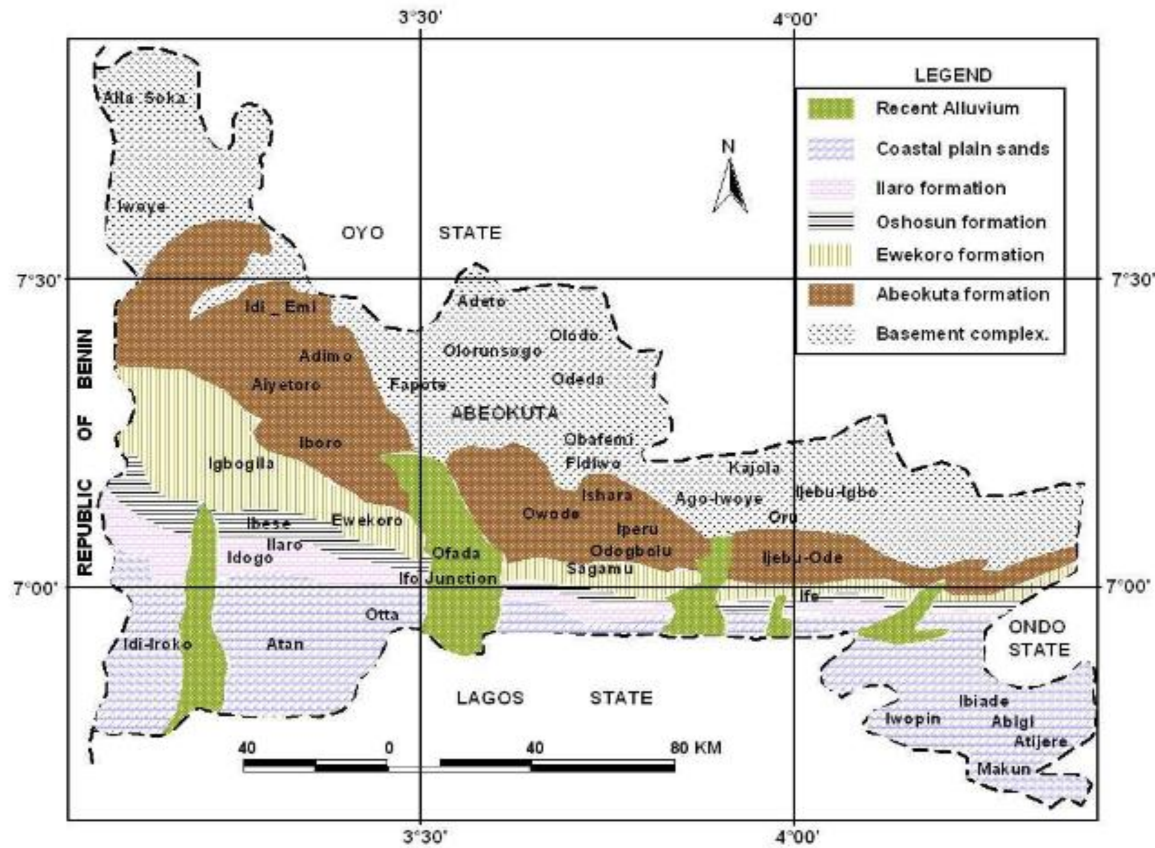

Figure 1: Geologic Map of the Study Area (Source: Nigeria Geological Survey Agency)

3.0 Materials and Methods

3.1 Sample Collection and Preparation

Samples of *Cnidoscolous aconitifolius* (Chaya leaves), *Telfaria occidentalis* (Fluted pumpkin), *Corchorus olitorius* (Jew's mallow), *Moringa Oleifera* (Moringa), *Talinum triangulare* (Gbure) and *Moringa oleifera* (Moringa) were cultivated in these two locations, Covenant University area and Ibeshe. The plants (leaves and stems) were collected by permission from the farmers in the areas as shown in Figure 1, the plants were identified by Dr. Popoola, a Botanist in the Department of Biological Sciences, Covenant University, Ota, Ogun State, Nigeria. The plants were collected and washed with distilled water and chopped into minute sizes before they were put in an oven and dried at 80^oC according to [6] for four days, crushed to powder and sieved to collect the appropriate sizes through a sieve mesh of 250µm. They were sealed for four weeks to allow radioactive equilibrium to be reached. Also, soil samples which were collected from the locations where the leafy vegetables were collected were oven dried, crushed to powder and sieved the same way as the vegetable and sealed for four weeks secular equilibrium.

High Purity Germanium (HPGe) gamma ray detector with 10 cm x 10 cm thick lead shielding on all sides with inner Cu and Sn lining, to reduce the background activity to about 95%. The efficiency of the ϒ-ray spectrometer was 52.3% relatively to ϒ-ray spectrometer. Minimum detection limit of the g-ray spectrometer was 6.35, 3.25 and 2.15 Bqkg-11 for ^{226}Ra, ^{232}Th and ^{40}K respectively. The choice of gamma-ray peaks of the radionuclides to be used for measurements was made considering the fact that the NaI (Tl) detector used in this study had a modest energy resolution. This was to ensure that the photons emitted by the radionuclides would only be sufficiently discriminated if their emission probability and their energy were high enough, and the surrounding background continuum low enough. Therefore, the activity concentration of ^{214}Bi was chosen to provide an estimate of ^{226}Ra (^{238}U) in the samples, while that of the daughter radionuclide ^{208}Ti was chosen as an indicator of ^{228}Th (^{232}Th). Potassium-40 was determined by measuring the 1460 KeV emitted during its decay.

3.2 Calculation of Radium Equivalent Activity Ra_{eq} and External Radiation Hazards H_{ex}

The radium equivalent (Raeq) activity allows a single index or number to describe the gamma output from different mixtures of ^{238}U, ^{232}Th, and ^{40}K in a sample.

$$Ra_{eq} = A_{RA} + 1.43\ A_{Th} + 0.077\ A_K \qquad (1)$$

$$H_{ex} = A_{RA}/370 + A_{Th}/259 + A_K/4810 \leq 1 \quad (2)$$

3.2.1 Calculation of the external gamma dose rate

Determination of the external gamma dose was calculated using the following equation by [9] by using equation 3

$$D_c = 0.462\ A(^{238}U) + 0.604\ A(^{232}Th) + 0.0417\ A(^{40}K) \quad (3)$$

3.2.2 Estimation of the annual effective dose rate (AEDR)

The estimation of the annual effective dose rate is estimated using equation 4 [28]

$$AEDR = D_c(nGy\ h^{-1}) \times 8760\ h \times 0.2 \times 0.7\ Sv\ Gy^{-1} \times 10^{-3} \quad (4)$$

3.2.3 Gamma Activity Index Representations (I_γ)

The gamma index (Iγ) was used to estimate the gamma radiation hazard associated with the natural radionuclide in specific investigated samples. The representative gamma index was estimated using Equation 7 [8, 29]. It should be less than unity for the radiation hazard to be negligible

$$I\gamma = \frac{C_{Ra}}{300BqKg^{-1}} + \frac{C_{Th}}{200BqKg^{-1}} + \frac{C_K}{3000BqKg^{-1}} \quad (5)$$

3.2.4 Alpha Index (Iα)

$$I\alpha = \frac{C_{Ra}}{200BqKg^{-1}} \quad (6)$$

3.2.5 Activity Utilization Index (AUI)

The use of the utilization activity index (UAI) for soil can be estimated through the sum of the radionuclides such as $^{238}U^{232}$,Th and ^{40}K and this can be estimated by the use of equation 7 to be the activity in a unit of mass (Bqkg^{-1}) [16].

$$AUI = (\frac{C_{Ra}}{50\ \mathrm{Bqkg-1}})fRa + (\frac{C_{Th}}{50\ \mathrm{Bqkg-1}})fTh + (\frac{C_K}{500\ \mathrm{Bqkg-1}})fk \qquad (7)$$

3.2.6 Excess Lifetime Cancer Risk (ELCR)

AED is the annual equivalent dose equivalent, DL is the average duration of life (estimated to 70 years), and RF is the risk factor (S/v), for stochastic effects, ICRP uses RF as 0.05 for public [8]. The recommended limit for ELCR is 0.2×10^3 [29] below which there is no cancer risk to the populace.

$$ELCR = AEDR\ X\ DL\ X\ RF \qquad (8)$$

3.3 STATISTICAL ANALYSIS

Statistical significance was determined by two-way analysis of variance (ANOVA). For all statistical tests, data are expressed as mean ± standard error of mean (SEM); $P < 0.05$ was considered significant.

4.0 Results and Discussion

4.1 Radioactivity Level of ^{232}Th, ^{40}K and ^{226}Ra in the Vegetable and Soil Samples

The radioactivity concentrations of ^{226}Ra, ^{232}Th, and ^{40}K for leafy vegetables and soil samples are presented in Tables 1 and 2. Results of the activity concentrations of radionuclide contents in the soil and leafy vegetables at Covenant University and Ibeshe ranged between (Th^{-232}) 14.40-45.09, (K^{-40}) 9.09-38.82, (Ra^{-226}) 13.74-31.56. Covenant University (Th^{-232}) 40.20-76.47, (K^{-40}) 14.13-30.84, (Ra^{-226}) 23.23-43.61, leafy vegetables Ibeshe Ra^{-226} 0.75-11.89, (Th^{-232}) 0.81-20.17, K^{-40} 191.06-709.88, CU (Ra^{-226}) 10.83-31.34, (Th^{-232}) 7.58-39.50, (K^{-40}) 112.69-939.30. Mean values were estimated to be Ibeshe (Th^{-232}) 24.18, (K^{-40}) 20.93, (Ra^{-226}) 20.95, CU (Th^{-232}) 58.76, K^{-40} 21.71, (Ra^{-226}) 33.87. Covenant University soil was higher than the mean value of the World average standard values of 35, 30, and 400 Bqkg-1respectively except CU soil which was 58.76. Considering the collective statistical analysis presented in this study, it was observed that the absorption of radionuclide in different plants depends on the background radionuclide concentrations, absorption mechanism in plants, and sorption ability of the plants in soil-water interaction.

Table 1-The Radioactivity Levels of ^{232}Th, ^{40}K and ^{226}Ra in the soil samples for Covenant University and Ibeshe

S/N	**Sample codes**	**Th^{-232} ($Bqkg^{-1}$)**	**K^{-40} ($Bqkg^{-1}$)**	**Ra^{-226}**
1	*Telfaria occidentalis* (Ibeshe)	25.56±1.43	9.09±1.41	23.23±1.37
2	*Corchorous olitorus* (Ibeshe)	22.74±1.68	38.82±3.33	18.88±1.60
3	*Cnidoscolous aconitifolius* (Ibeshe)	14.55±2.06	18.16±3.29	17.56±2.28
4	*Moringa oleifera* Ibeshe	14.40±1.48	14.54±2.51	13.74±1.44
5	*Manihot esculenta* (Ibeshe)	45.09±3.44	24.61±1.58	31.56±1.67

6	*Talicum fruticosum* Ibeshe	22.71±3.77	20.33±1.53	20.70±3.04
	MEAN	24.18±2.31	20.93±2.27	20.95±1.9
1	*Telfaria occidentalis* CU	56.14±3.41	14.13±1.70	39.49±2.08
2	*Corchorous olitorius* CU	76.47±8.03	BDL	29.78±4.05
3	*Cnidoscolous aconitifolius* (CU)	59.98±4.10	28.55±2.20	23.23±1.37
4	*Moringa oleifera* CU	64.71±4.51	29.69±2.06	37.31±2.00
5	*Telfaria occidentalis* CU	56.14±3.41	14.13±1.70	39.49±2.08
6	*Manihot esculenta* CU	55.11±4.12	30.84±1.87	43.61±2.30
7	**MEAN**	58.76±4.84	21.71±1.61	33.87±2.23

Table 2–The Radioactivity Levels of ^{226}Ra, ^{232}Th, and ^{40}K in the Leafy Vegetables from Covenant University and Ibeshe of the leafy vegetables

S/N	**Sample codes**	**Ra^{-226} (Bqkg^{-1})**	**Th^{-232} (Bqkg^{-1})**	**K^{-40}(Bqkg^{-1})**
1	*Telfaria occidentalis* (Ibeshe)	2.44±0.47	7.16±2.41	BDL
2	*Corchorous olitorus* (Ibeshe)	11.89±1.98	3.95±0.76	BDL
3	*Cnidoscolous aconitifolius* (Ibeshe)	0.75±0.25	5.54±1.62	191.06±14.05

4	*Moringa oleifera* Ibeshe	BDL	20.17±3.19	709.88±48.97
5	*Manihot esculenta* (Ibeshe)	BDL	0.81±0.32	382.52±26.17
6	*Talicum fruticosum* Ibeshe	BDL	10.29±1.91	BDL
		14.455±0.45	7.98±1.70	213.91±14.86
1	*Telfaria occidentalis* CU	31.34±2.64	7.58±1.92	112.69±5.97
2	*Corchorous olitorius* CU	BDL	9.81±2.24	BDL
3	*Cnidoscolous aconitifolius* (CU)	14.12±2.09	39.75±3.28	133.82±7.08
4	*Moringa oleifera* CU	10.83±2.87	BDL	654.29±42.64
5	*Manihot esculenta* CU	14.01±1.83	39.50±3.38	939.30±49.70
6	*Talicum fruticosum* CU	BDL	14.32±4.19	280.78±20.39
		11.71±1.57	18.49±2.50	353.48±20.96

4.2 Radiological Risks Assessments of the Vegetables and Soils from the Study Area

In this study, Equation 1 was used to determine the absorbed dose rates from the obtained activity concentrations and the estimated results. The mean value for CU soil is 60 $nGyh^{-1}$, which is higher than the recommended world average value, and as well the value for Ibeshe plant.

Determination of Radium equivalent activity in the samples in this research was estimated using equation 2. Where AC_{RA}, $AC_{TH,}$ and AC_K are the activities concentration of ^{226}Ra, ^{232}Th, and ^{40}K measured in $Bqkg^{-1}$ respectively. The result of the radium equivalent activity obtained for the available soil and leafy vegetables varied between Ibeshe 12.75-76.26 $Bqkg^{-1}$, mean was 28.37, CU 14.10-142.82 $Bqkg^{-1}$ mean was 392.34. Soil samples for Ibeshe were 35.45-97.93, the mean was 56.91 CU is 89.41-139.209 mean is 120.218 (Table 3). Calculation of hazard index from gamma ray dose to ^{226}Ra, ^{232}Th, and ^{40}k could be estimated by equation 3, which is the equation for calculating the external hazard index. ARA, A_{TH}, and A_K are the average values of the activity concentrations ^{226}Ra, ^{232}Th, and ^{40}K in $^{Bqkg-1}$respectively. The standard recommended for the H_{ex} is a value less than one and at most equal to 1. From the result obtained, the H_{ex} varied between soil samples Ibeshe 0.0957-0.2645 and CU 0.1733-0.3757. The value for vegetables is from 0.0342-0.225 for Ibeshe and 0.0378-0.385 for CU. In this case, all the available leaf and soil samples considered for this parameter had acceptable values and within the acceptable standard. The estimated mean values were soil Ibeshe 0.154, CU was 0.3017. Leafy vegetables for Ibeshe are 0.0819 and Cu is 0.1762, respectively (Table 4).

The annual effective dose rate ranged between soil samples 19.19-52.54 mean 32.39, while CU was 48.06-936.882, while the mean is 213.055. Leafy vegetables, Ibeshe 7.622-196.224 mean is 83.17 while CU is 0.2027-71.24 while the mean is 39.56. Gamma Index Estimation is engaged to calculating the hazard of ɣ-radiation because of the presence of natural radionuclide in the samples being investigated. Soil samples, Ibeshe 0.122-0.338 while the mean is 0.197, CU is 0.309-0.4816 while the mean is 0.4147. The leafy vegetables for Ibeshe are 0.0439-0.337 Ibeshe, mean is 0.1195, for CU, the range is from 0.049-0.512 while the mean is 0.240. Determination of Alpha Index, the estimation of the alpha index is another essential part of hazard measurement that qualifies the amount of alpha radiation due to random inhalation. For soil, Ibeshe 0.122-0.338, the mean is 0.197, CU is 0.309-0.4816, and the mean is 0.4147. For the leafy vegetables, Ibeshe is 0.0439-0.337, and the mean is 0.1195, while that of CU is 0.049-0.512 while the mean is 0.240. The result of ^{226}Ra, ^{232}Th, ^{40}K activity concentration of absorbed dose rate recorded by the Hypergermanium detector as a result of the background radiation from the soil samples at Ibeshe and Covenant University, the study areas in which the soil samples were collected. The mean for ^{232}Th ranged from 24.46 $Bqkg^{-1}$, ^{40}K is 21.04 $Bqkg^{-1}$, ^{226}Ra is 20.99 $Bqkg^{-1}$for Ibeshe while that of CU is 34.69$Bqkg^{-1}$ for

^{232}Th, Ibeshe is 24.46Bqkg^{-1} while that of CU is 55.22 Bqkg^{-1}, ^{232}Th at CU is higher than the recommended limit of 35.0 and 30.0 [28, 29].

^{40}K is 26.06 Bqkg^{-1}for CU, while that of Ibeshe is 21.04Bqkg^{-1}. ^{226}Ra is 34.69Bqkg^{-1}. The limit of ^{238}Ra is 35.0Bqkg^{-1}, that of ^{232}Th is 30.0 Bqkg$^{-1,}$ and ^{40}K is 500.0 Bqkg^{-1} as recommended globally.

The following parameters were estimated for the soil samples for each study areas Radium Activity, External Radiation Hazards, Estimation of the annual effective dose rate, Activity Utilization index, Alpha index, Gamma Activity Index Representation, Excess Lifetime Cancer Risk (ELCR). The values of the gamma index ranged from 0.122-0.338 with a mean of 0.198 for Ibeshe, while that of CU is 0.309-0.457, mean of 0.4014. Values greater than 1 should be avoided [27]. The representative gamma index, is correlated with the annual dose rate due to the excess external gamma radiation caused by superficial material. The estimated mean radium activity index for Ibeshe is 57.33 that of CU is 116.419. This parameter allows a single index to describe the gamma output in the background radiation from the radionuclides present in ^{226}Ra, ^{232}Th, ^{40}K and must be 370 Bqkg-1for to be safe for the populace. The annual effective dose rate for Ibeshe is 16.65 $nGyh^{-1}$ to 42.84 $nGyh^{-1}$, and the mean is 25.34 $nGyh^{-1}$ while that of CU is 39.19 $nGyh^{-1}$ to 74.22v $nGyh^{-1}$ the mean is 55.68 $nGyh^{-1}$, the mean is lower than the permissible limit of 59 $nGyh^{-1}$. The mean annual effective dose rate for Ibeshe is 31.08 $mSvy^{-1}$, while that of CU is 68.29 $mSvy^{-1}$. The mean for ELCR for Ibeshe is 31.08 while that of CU is 239.03, respectively is lower than the recommended limits of other published papers, [11], (1.72 x 10^{4}).

Table 3 Radiological Parameters of the soil samples for Ibeshe and Covenant University

S/N	SAMPLES	Radium Equivalent Activity Ra_{eq}	External Radiation	Estimation of the annual	Calculation of the external gamma dose rate	Activity Utilization	Alpha Index (Iα)	Gamma Activity Index	Excess Lifetime

			Hazards H_{ex}	effective dose rate (AEDR) $mSvy^{-1}$	$nGyh^{-1}$	Index (AUI)		Representations (I_γ)	Cancer Risk (ELCR) $Bqkg^{-1}$
1	*T.occidentalis Ibeshe*	60.480	0.16336	32.560	26.549	24.024	0.116	0.208	0.113×10^{-3}
2	*C.olitorius Ibeshe*	53.0673	0.1467	29.49	24.05	20.44	0.094	0.189	0.103×10^{-3}
3	*C.aconitifolius* Ibeshe	39.764	0.1074	21.65	17.65	11.06	0.087	0.137	0.075×10^{-3}
4	*M.oleifera* Ibeshe	35.451	0.0957	19.19	15.65	8.34	0.068	0.122	0.067×10^{-3}
5	*M.esculenta* Ibeshe	97.933	0.2645	52.54	42.84	61.79	0.15	0.338	0.183×10^{-3}
6	*T.fruticosum* Ibeshe	54.7407	0.1478	38.94	31.75	19.711	0.1035	0.189	0.136×10^{-3}
	MINIMUM	35.451	0.0957	19.19	15.65	8.340	0.068	0.122	0.183×10^{-3}
	MAXIMUM	97.933	0.2645	52.54	42.84	61.79	0.116	0.338	0.067×10^{-3}
	MEAN	56.91	0.154	32.395	26.41	25.46	0.103	0.197	0.112×10^{-3}
1	*T. occidentalis* CU	120.858	0.3264	64.68	52.74	94.62	0.19	0.417	0.226×10^{-3}

2	*Corchorous olitorius* (CU)	139.209	0.3757	936.882	763.929	134.5710	0.1489	0.4816	3.279×10^{-3}
3	*C.aconitifolius* (CU)	114.909	0.1733	91.02	74.22	88.09	0.134	0.399	0.318×10^{-3}
4	*Moringa oleifera (CU)*	132.131	0.3568	70.59	57.56	113.35	0.18	0.457	0.247×10^{-3}
5	*Manihot esculenta* (CU)	124.791	0.3370	67.10	54.72	100.68	0.218	0.425	0.234×10^{-3}
6	*T.fruticosum* (CU)	89.410	0.2412	48.06	39.19	43.25	0.14	0.309	0.168×10^{-3}
	MINIMUM	89.410	0.1733	48.06	39.19	43.25	0.134	0.309	0.318×10^{-3}
	MAXIMUM	139.209	0.3757	936.882	763.929	134.5710	0.218	0.4816	3.27×10^{-3}
	MEAN	120.218	0.3017	213.055	173.726	95.76	0.1684	0.4147	0.745×10^{-3}

Table 4 Radiological Parameters of the leafy vegetables samples for Ibeshe and Covenant University

S/N	SAMPLES	Radium Equivalent Activity Ra_e q	External Radiation Hazards H_{ex}	Estimation of the annual effective dose rate (AEDR) $mSvy^{-1}$	Calculation of the external gamma dose rate $nGyh^{-1}$	Activity Utilization Index (AUI)	Alpha Index (Iα)	Gamma Activity Index Representations (I_γ)	Excess Lifetime Cancer Risk (ELCR) $Bqkg^{-1}$
1	*T.occidentalis Ibeshe*	12.7558	0.0342	87.523	71.366	1.1443	0.0122	0.04393	0.306×10^{-3}
2	*C.olitorius Ibeshe*	17.6095	0.0473	54.2583	44.242	3.1394	0.01975	0.05938	0.189×10^{-3}
3	*C.aconitifolius* Ibeshe	18.866	0.0631	102.208	83.34	73.63	0.0277	0.09388	0.357×10^{-3}
4	*M.oleifera* Ibeshe	76.26	0.225	51.23	41.78	1015.9	0	0.337	0.179×10^{-3}
5	*M.esculenta* Ibeshe	30.612	0.08265	196.224	160.00	292.65	0.00405	0.13155	0.686×10^{-3}
6	*T. fruticosum* Ibeshe	14.71	0.0397	7.622	6.215	2.117	0	0.0514	0.026×10^{-3}
	MINIMUM	12.7558	0.0342	7.622	6.215	2.117	0.0040	0.04393	0.686×10^{-3}

	MAXIMUM	76.26	0.225	196.224	160.00	292.65	0	0.13155	0.026×10^{-3}
	MEAN	28.37	0.0819	83.17	67.82	231.43	0.0106	0.1195	0.291×10^{-3}
1	*T.ocidentalis* (CU)	50.85	0.137	29.127	23.75	47.97	0.1567	0.179	0.101×10^{-3}
2	*C. olitorius* (CU)	14.1053	0.0378	7.2667	5.92524	1.9247	0	0.04905	0.0254×10^{-3}
3	*C.aconitifolius* (CU)	81.26	0.219	44.28	36.11	71.40	0.0706	0.290	0.154×10^{-3}
4	*Moringa oleifera (CU)*	61.210	0.1652	0.2027	0.1652	858.53	0	0.25419	0.007094×10^{-3}
5	*M. esculenta* (CU)	142.82	0.385	85.22	69.49	1799.69	0.07	0.512	0.298×10^{-3}
6	*T. Fruticosum* CU	42.097	0.1136	71.2407	58.089	161.77	0.0716	0.16151	0.249×10^{-3}
	MINIMUM	14.1053	0.0378	0.2027	0.1652	1.9247	0.0706	0.0490	0.298×10^{-3}
	MAXIMUM	142.82	0.219	85.22	69.49	858.53	0	0.512	0.007094×10^{-3}
	MEAN	392.34	0.1762	39.56	36.29	490.21	0.061	0.240	0.138×10^{-3}

5.0 Conclusion

In this study, we measured the activity concentrations for natural radioactive nuclides ^{226}Ra, ^{232}Th, ^{40}K in leafy vegetables and soil samples collected from Ibeshe and Covenant University areas of Ogun State. The activity concentration ranged from ^{226}Ra, ^{232}Th, and ^{40}K in soils were calculated. The mean value for the absorbed rate concentration results shows that, the mean concentration of ^{226}Ra, ^{232}Th, ^{40}K in the agricultural soil was for ^{232}Th 24.18±2.31, ^{40}K 20.93±2.27, ^{226}Ra 20.95±1.9 for Ibeshe and ^{232}Th 58.76±4.84 $Bqkg^{-1}$, ^{40}K 26.06±1.93 $Bqkg^{-1}$, ^{226}Ra 33.87±2.23 $Bqkg^{-1}$ respectively. And that of the leafy vegetables was ^{226}Ra 5.02±0.9, ^{232}Th 7.98±1.70 $Bqkg^{-1}$, ^{40}K 427.82±29.75 $Bqkg^{-1}$ for Ibeshe and ^{226}Ra 17.57±2.35 $Bqkg^{-1}$, ^{232}Th 22.19±3.0 $Bqkg^{-1}$ and 424.17±25.15 $Bqkg^{-1}$. The mean values for CU soil for ^{232}Th were higher than the World average standard values of 35 $Bqkg^{-1}$. Significantly, the statistical analysis presented in this study indicates that the absorption of radionuclide in different plants depends on the background radionuclide concentrations, absorption mechanism in plants, and sorption ability in aqueous phase. This study can be used as a template for the Ministry of Agriculture and Ministry of Environment and other agencies such as Federal Environmental Protection Agency, National Environmental Standards and Regulations Enforcement Agency, to monitor the radiological impact on the soil and other crops that share the soil features in Nigeria and beyond. In addition, this research provided more information on solution to the Goal 15 of the Sustainable Development Goals on the protection, restoration of the sustainable use of ecosystem, i.e., the plants and soils.

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