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Estimation of Utilization Index and Excess Lifetime Cancer Risk in Soil Samples Using Gamma Ray Spectrometry in Ibolo-Oraifite, Anambra State, Nigeria

Anekwe Uzochukwu Leonard[1], Odezuligbo Ikenna Emmanuel[2]

[1]Department of Physics, Federal University, Otuoke, Nigeria

[2]Department of Physics, Creighton University, Nebraska, USA

Email address:

uzanekwe@yahoo.co.uk (A. U. Leonard)

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Abstract: Ionizing radiations emanating from human natural environment could have serious negative effects at certain exposure level. Therefore the evaluation of radioisotopes of natural origin becomes very important in order to achieve specific objective to quantifying the radiological parameters and their respective health implications. Hence the estimation of Activity Utlization Index (AUI) and Excess Lifetime Cancer Risk (ELCR) has been done using gamma spectroscopy method. The results showed that the mean activity concentrations of ^{238}U, ^{232}Th, and ^{40}K from which the AUI and ELCR were computed were 22.19, 9.70 and 543.80 $Bqkg^{-1}$ respectively. Activity Utilization Index ranged from 0.24 to 0.55 and Excess Lifetime Cancer Risk ranged from 0.07 to 0.17 x 10-3. The average value of AUI was 0.38 whereas that of ELCR was found to be 0.12×10^{-3} which implied that 0.38 < 2, 0.17 < 0.29, standard permissible limits. Mean values of Dose, Igamma, annual effective dose equivalent (AEDE), H_{in}, H_{ex} and annual gonadal equivalent dose (AGED) were 38.95nGh^{-1}, 0.61, 0.05, 0.27, 0.21 and 279.87μSvy^{-1} respectively. In conclusion, the empirical values of activity utilization index showed good air quality. Also, the computed values of the excess lifetime cancer risks indicated very low chances of potential carcinogenicity effect for a specific exposure to ionizing radiation in this environment.

Keywords: Estimation, Gamma Ray Spectrometry, Health Indices, Risk

1. Introduction

The qualitative and quantitative assessment of radiation exposure level within an environment is an important aspect of radiation protection since human being exposure to NORMs and TENORMs is a continuous and unavoidable feature of human existence. These exposures to ionizing radiation are from both terrestrial and extra-terrestrial sources. Ionizing radiations from extra-terrestrial sources are from cosmic ray particles and at sea level, and it is about 30 $nGyh^{-1}$ [1] while the terrestrial sources are from naturally occurring radioactive materials (NORMs) found in soil, rocks, riverbed, ocean, and building materials. The majority of radionuclides in NORMs (principally radium and radon) arise from uranium (U) and thorium decay (Th) [2]. Also these radioactive elements exist at a low concentration in the earth crust and are brought into the earth surface through human activities, such as solid mineral mining, oil and gas exploration, and borehole-water drilling.

Radioactive elements are those elements with atomic number greater than or equal to 83 that have the tendency to decay and lose some of their nucleus in other to become more stable. Each process of decay gives off gamma ray, a natural radioactive material which could affect human tissue due to its small wavelength. Gamma rays have the ability to interact with atoms in the human body, including DNA. When the cell cannot heal itself, the mutation leads to cancer. Therefore, the assessment of gamma radiation dose from natural sources is of particular importance as natural radiation is the largest contributor to the external dose of the world population [3]. The measurement of natural radioactivity due to gamma rays from the dose rate is needed to implement precautionary measures whenever the dose is

found to be above the recommended limits [4]. According to [5], researchers with special interest in the radiological impact that human activities and natural radioactive materials have on the ecosystem is growing day by day.

The growing interest among environmental physicists and medical scientists in natural radiation exposure has led to extensive surveys in many countries. [6] in their study with 162 *in situ* measurements of ^{238}U, ^{232}Th, and ^{40}K radionuclide concentrations dataset taken by the gamma-ray spectrometer in Gümüşhane, Turkey. The gamma ray measurements were performed by a 512-channel, three-window gamma-ray spectrometry equipment made by GF Instruments. In Gümüşhane, the average activity concentrations of radionuclides of ^{238}U, ^{232}Th, and ^{40}K were measured as 58.7± 34.3 Bq kg^{-1}, 62.7±37.2 Bq kg^{-1}, and 1026.8±486.0 Bq kg^{-1}, respectively. The average outdoor annual effective dose equivalent and ELCR values were 132.2±63.2 mSvyr^{-1} and 0.40±0.19 $\times 10^{-3}$ respectively. Numerical results indicated that the radiological parameters, annual effective dose equivalent (AEDE) and excess lifetime cancer risk (ELCR) obtained for Gümüşhane Province were greater than the world's mean values. [7] study was carried out in the playgrounds of selected basic schools in the Ga East municipal l district of Accra, Ghana, to determine the exposure of school children to the radiation emitted by Naturally Occurring Radioactive Materials and trace elements. The activity concentrations of different radionuclides were determined using high purity germanium (HPGe) detector. The average activity concentrations of ^{238}U, ^{232}Th and ^{40}K were found to be 19.8±8.7, 29.1±16.3 and 119.4±97.9 $Bqkg^{-1}$ respectively. The average annual effective dose calculated from these activity concentrations was 0.04 *mSv* which is below the dose limit of 1 mSv/yr^{-1} recommended by the International Commission on Radiological Protection (ICRP) for public exposure control. [8] assessed environmental radioactivity in the Federal University Otuoke, Bayelsa State, Nigeria and reported that the average exposure rates ranged from 9.0 to 29.0μRh^{-1}. The exposure dose rate (D), annual effective dose equivalent (AEDE), excess lifetime cancer risk (ELCR) were computed and they ranged from 87.0 to 252.3nGyh^{-1}, 0.107 to 0.309mSvy^{-1}, 0.005 to 0.15×10^{-3} respectively. [9] determined the activity concentrations of primordial radionuclides in Nigerian coal using the gamma spectrometric technique with the aim of evaluating the radiological implications of coal utilization and exploitation in the country. Mean activity concentrations of ^{226}Ra, ^{232}Th, and ^{40}K were 8.18±0.3, 6.97±0.3, and 27.38±0.8 Bq kg^{-1}, respectively; which were lower than their respective precautionary limits set by UNSCEAR. Average excess lifetime cancer risk calculated to be 0.04×10^{-3} was insignificant compared with 0.05 prescribed by ICRP for low level radiation. Also, cumulative mean occupational dose received by coal workers via the three exposure routes was 7.69×10^{-3}mSvy^{-1}, with inhalation pathway accounting for about 98%, with all radiological hazard indices evaluated showing values within limits of safety. Their result indicates that there is no likelihood of any immediate radiological health hazards to coal workers, final users, and the environment from the exploitation and utilization of Maiganga coal. Since natural radioactive materials under certain conditions can reach hazard radiological levels, [10] used 20 cm soil samples collected beside Assiut fertilizer plant, Assiut government in south Upper Egypt to assess contributions of ^{226}Ra, ^{232}Th and ^{40}K to external dose exposure. [11] performed a radiological study in the soapstone quarries of Tabaka region of Kisii district in the Southern Nyanza province, Kenya, where soapstone has been mined and used as a carving medium for hundreds of years. 14 soil and rock samples collected from five quarries were analyzed using high-resolution gamma-ray spectroscopy. The activity concentrations of ^{232}Th, ^{40}K and ^{226}Ra in the samples as well as other radiological parameters were determined. The internal and external hazard indices (1.03 and 1.27, respectively) were found to be more than unity, hence slightly exceeding the permissible limits set by the [12].

The objective of this study is to estimate utilization Index and Excess Lifetime Cancer Risk from ^{238}U, ^{232}Th and ^{40}K Activity Concentrations gotten from gamma ray spectrometry in Ibolo-Oraifite, Anambra State, Nigeria.

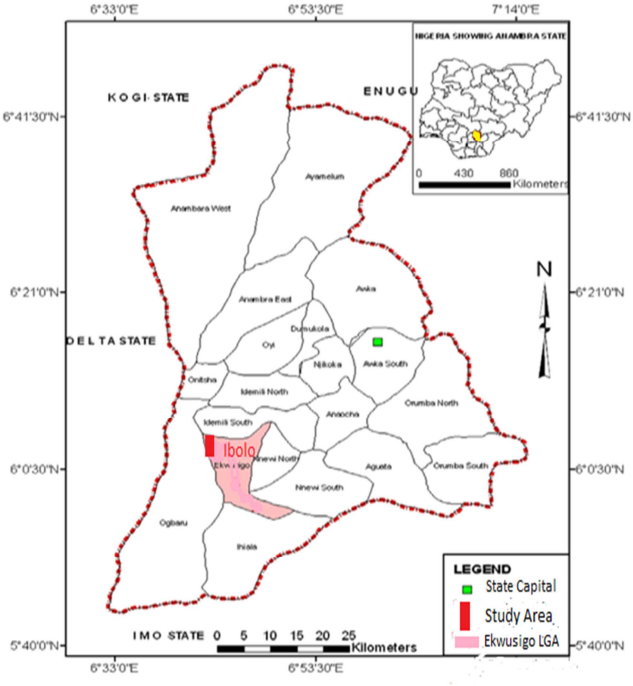

Figure 1. *The map of Anambra State showing Ibolo in Ekwusigo LGA.*

The study Area

Figure 1 shows the map of Anambra State of Nigeria containing Ibolo, a village in Oraifite town, located in Ekwusigo local government area. The geographic location of the study area is between latitude 5°30'45" and 5°30'10"N and longitude 7°00'05" and 7°00'25"E. Pre-Nigeria civil war, the residents of Ibolo were mainly farmers and wine tappers. In the mid 90s the federal government of Nigeria search for oil and gas along the coastal region of River Niger which boarders the village rafier palm and agricultural farm land, accessible through Onitsha Owerri road, Ose Olioba street, Nnukwu Ose, Ose Ogwugwu, Nkwo Ozulogu road, Afiauzo Ogbeobi road, Afiauzo Okpuno road.

2. Materials and Methods

Background ionizing radiation measurement

An in-situ approach of measurement was adopted to measure the BIR exposure rate measurement. A Radalert 100X radiation monitoring meter with Geiger counter was used. This instrument is capable of measuring the background ionizing radiation (BIR) rates in one count per minutes (CPM). The meter detects alpha, beta, gamma and X-ray radiations using the ionization effect produced in a Geiger–Müller tube. The meter detector is a halogen-quenched Geiger-Mueller tube with mica end window LND712 of density 1.5 - 2.0 mg/cm^2 and side wall of 0.012 inches #446 stainless steel. The main components of a digital Geiger – Muller counter is a tube which is a chamber filled with a noble gas. This tube contains two electrodes (anode and cathode) which are coated with graphite. The anode is represented by a wire in the centre of the chamber. Radiation particles enter through the window and knocks of inert gas, thereby creating free electrons and positively charged ions. Electrons rush towards the positively charged wire and ions towards the negatively charged tube wall. The positively charged ions will collide with the noble gas to produce more ions through an avalanche effect. The avalanche of electrons reaches the wire, creating an electrical pulse that could be measured. During measurement, the measuring instrument was held at a height of 1.0 m above the ground level [13]. Seventeen (17) measurement points were strategically selected for adequate coverage of the study area. At each point, the total count was recorded for 60 seconds. Three successive readings were taken at each point so that the mean could be obtained. A geographical positioning meter was used to take the coordinates and elevation /altitude of each sampled point.

Soil sample collection and preparation

Soil samples were collected from randomly selected undisturbed spots in Ibolo, and packed in a black polythene bags using a steel hand geological auger at a depth between 0 and 15 cm. After removing extraneous materials like stones and roots, the samples were dried by spreading samples on polyethylene sheets at ambient temperature for seven days in a controlled environment to prevent dust contamination. This was followed by another stage of oven drying for 24 hours at 60 ^{o} C to ensure that moisture is completely removed, and were then grounded into powdered form using pestle and mortar. The powdered form was filtered using 100- mesh sieve. Prior to gamma spectrometric measurement, 250g of dried homogeneously pulverized sample was weighed, filled in a skin-tight Marinelli beaker, and sealed with masking tape in a radon impermeable airtight condition. The containers with their contents were kept for 28 so as to ensure secular equilibrium between ^{222}Ra and its short-lived progenies with ^{226}Ra [14]. At the end of the four weeks in-growth period, the samples were subjected to gamma-ray spectroscopy.

Spectrometry

The samples were analysed using gamma ray (γ-ray) spectrometer analysis. A 7.6 cm × 7.6 cm geometry sodium iodide doped with thallium [Na(TI)] by Canberra Inc. was used as the detector. The spectrometer was tested for its linearity and calibrated for energy and efficiency using the well calibrated standard gamma source obtained from an International Atomic Energy Agency (IAEA), laboratories, Vienna, Austria [15]. Accuracy of efficiency calibration of detector is necessary in other to obtain the high precision measurements with radioactive samples. Each sample was placed on the detector coupled to an ORTEC 456 amplifier and a computer program MAESTRO window was connected to the detector data acquisition and analysis of the gamma spectra taken. Interference from ecological background radiation was eliminated by allowing the counting to be done in the Canberra lead castle of 100 mm thick. The γ-ray photo-peaks corresponding to ^{214}Pb at (242.0 keV, 295.2 keV & 351.9 keV), ^{214}Bi (609.3 keV, 768.4 keV, 806.19 keV, 1120.3 keV, 1377.669 keV and 1401.516 keV respectively) and ^{234}Pa (1001.025 keV) were considered for identifying ^{238}U. The γ - ray photo-peaks of ^{228}Ac at (209.3 keV, 338.3 keV, 409.5 keV and 911.1 keV), ^{208}Ti at (277.4 keV, 583.2 keV and 860.6 keV), ^{212}Bi at (727.33 keV and 785.37 keV), ^{212}Pb (238.6 keV and 300.1 keV and ^{224}Ra (240.986 keV) were used to identify ^{232}Th in the samples. The radioisotope ^{40}K were estimated from emitted gamma ray with energy of 1460.8 keV.

The activity concentration (A_c) of ^{238}U, ^{232}Th and ^{40}K in Bq/kg was computed using the relation in Eq. (1):

$$A_C = \frac{Cn}{P_\gamma M \varepsilon} \quad (1)$$

Where A_c is the activity concentration of the radionuclide in the sample given in Bqkg^{-1}, C_n is the net count rate under the corresponding peak, P_γ is the absolute transition probability of the specific γ-ray, M is the mass of the sample (kg) and ε is the detector efficiency at the specific γ-ray energy.

Activity Utilization Index

This is the parametric model that enables one to determine the radionuclides (Ra, Th, K) dose levels in the atmosphere from the soil samples. The equation of the activity utilization index is expressed as in the equation below [16]:

$$AUI = 0.462\frac{A_{Ra}}{50} + 0.604\frac{A_{Th}}{50} + 0.041\frac{A_K}{500} \quad (2)$$

where 0.462, 0.604 and 0.041 are the fractional contributions of each radionuclide to the overall dose level in air attributable to gamma radiation.

Excess lifetime cancer risk (ELCR):

This is estimation of the probability of cancer incidence in a population of individuals on potential carcinogenic effect for a specific lifetime exposure.

$$ELCR = AEDE \times DL \times RF \quad (3)$$

where AEDE is the annual effective dose equivalent, DL is the average duration of life taken to be 52years in Nigeria [17] and RF is the risk factor (fatal cancer risk factor which is 0.05) [18].

Absorbed dose rate (D)

The absorbed dose rates in outdoor (D) due to gamma radiations in air at 1m above the ground surface for the uniform distribution of the naturally occurring radionuclides (^{226}Ra, ^{232}Th and ^{40}K) were calculated based on guidelines provided by [1]. The conversion factors used to compute absorbed - dose rate (D) in air per unit activity concentration in Bq/kg (dry weight) corresponds to 0.462 nGh^{-1} for ^{226}Ra (of U – series), 0.621 nGh^{-1} for ^{232}Th and 0.0417 nGh^{-1} for ^{40}K [1, 19].

$$D\ (nGh^{-1}) = 0.462C_{Ra} + 0.621C_{Th} + 0.0417C_K \quad (4)$$

Absorbed dose rate is a measure of energy deposited in a medium by ionizing radiation. It is equal to the energy deposited per unit mass of the medium, and so has the unit J/kg, which is given by special name Gray (Gy). Absorbed dose rate therefore is absorbed dose divided by the time it takes to deliver that dose unit Gy/s.

Annual gonad equivalent dose (AGED)

This is a measure of threat to sensitive cells from exposure to a particular level of radiation. These sensitive cells include the gonads, surface cells and the bone marrow. Annual gonadal equivalent dose is calculated using the equation [20].

$$AGED\ (mSvyr\text{-}1) = 3.09C_{Ra} + 4.18C_{Th} + 0.314C_K \quad (5)$$

where C_{Ra}, C_{Th}, C_K are activity concentrations of ^{226}U, ^{232}Th, and ^{40}K respectively.

Annual Effective Dose Equivalent, AEDE (mSvy^{-1})

Annual effective dose (E_{ff}) is estimated from absorbed dose rate (D) by using the following relation;

$$E_{ff}(mSvyr^{-1}) = D \times 8760 \times 0.2 \times 0.7\ 1 \times 10^{-6} \quad (6)$$

where D is the absorbed dose rate in air in nGyh^{-1}, 8760 is the total hours in a year; 0.7 SvGy^{-1} is the dose conversion factor from absorbed dose in air to the effective dose and 0.2 is the occupancy factor for outdoor exposure [1].

By this, equation (6) is modified as equation (7).

$$E_{ff} = D \times 1.2264 \times 10^{-3} \quad (7)$$

Effective dose rate (D_{organ}) to different body organs and tissues.

The effective dose rate delivered to a particular organ and tissue can be calculated using the expression.

Radium Equivalent Activity, Ra_{eq} (Bqkg^{-1})

Ra_{eq} is a single index or number used to describe the gamma output from different radionuclides in a material. Activity concentration of 259 Bq/kg of ^{232}Th and 4810 Bq/kg of ^{40}K are equal to 370 Bq/kg of ^{226}Ra.

$$Ra_{eq} = A_{Ra} + 1.43A_{Th} + 0.077A_K \quad (8)$$

where A_{Ra}, A_{Th} and A_K are the radioactivity concentration in Bq/kg of ^{238}U, ^{232}Th, and ^{40}K, respectively.

Radiological Hazard Index

(a) Internal hazard Index

Inhalation of alpha particles emitted from the short-lived radionuclides is hazardous to the respiratory organs. The hazardous impact of these particles was quantified by the internal hazard index (H_{in}) which is given by the following equation.

$$H_{in} = \frac{CRa}{185} + \frac{CTh}{259} + \frac{CK}{4810} \quad (9)$$

(b) External Hazard index

The external hazard index (H_{ex}) is the excess gamma radiation emanating from the soil samples. It can be calculated using the following equation by [21].

$$H_{ex} = \frac{CR}{370} + \frac{CTh}{259} + \frac{CK}{4810} \quad (10)$$

The values of the indices (H_{ex} H_{in}) must be less than unity for the radiation hazard to be negligible [22]

Igamma

This index is used to estimate the gamma radiation hazard associated with the natural radionuclide in an investigated samples. It is given by the [23] equation:

$$I_r = \frac{CRa}{150} + \frac{CTh}{100} + \frac{CK}{1500} \quad (11)$$

where C_{Ra}, C_{Th} and C_K are the radioactivity concentration in Bq/kg of ^{238}U, ^{232}Th, and ^{40}K.

3. Results and Discussion

Results

The results of the study are presented in Tables 1 to 3. Table 1 shows the result of assessment of BIR and Activity concentrations of the radionuclides. Table 2 shows ECLR and UI values on the 17 sampled points, Table 3 shows Health Risk indices. Table 4 compares activity concentration, Dose and Radium Equivalent with reports on similar studies.

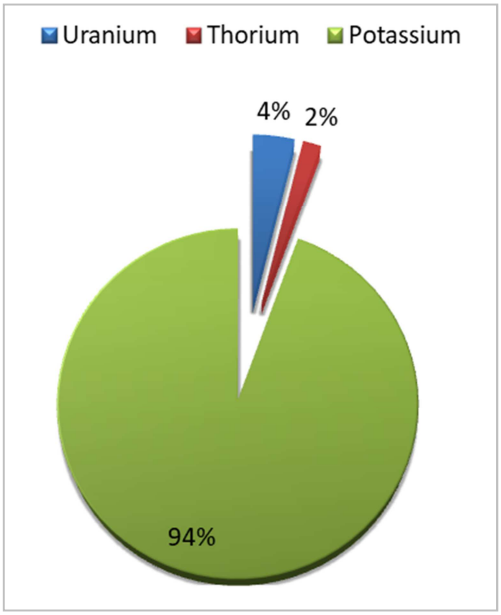

Figure 2. *Relative contributions of ^{238}U, ^{232}Th and ^{40}K to total activity concentration in Ibolo soil.*

Table 1. *BIR and Activity concentration.*

S/N	code	BIR (mRh^{-1})	Lat. N(°)	Long. E(°)	Alt. (m)	Activity Concentration ($Bqkg^{-1}$)		
						^{238}U	^{232}Th	^{40}K
1	IBOL1	0.016	6.02408333	6.80597222	23	27.65±5.52	13.49±3.94	117.18±5.21
2	IBOL2	0.018	6.02016667	6.81430556	62	16.12±5.15	13.66±1.70	407.48±3.43
3	IBOL3	0.017	6.01761111	6.81508333	70.3	40.34±4.23	10.14±1.73	598.97±4.21
4	IBOL4	0.019	6.01536111	6.82244444	70	16.12±5.03	7.31±1.12	523.77±3.92
5	IBOL5	0.014	6.00844444	6.81558333	67.4	16.70±4.82	8.65±1.89	231.45±2.50
6	IBOL6	0.014	6.01844444	6.82622222	80	14.97±3.21	8.00±1.92	445.33±5.63
7	IBOL7	0.012	6.02269444	6.82627778	82.6	43.80±3.71	8.33±1.90	571.43±4.11
8	IBOL8	0.013	6.02625000	6.81833333	68	21.89±3.94	13.44±1.78	791.58±4.87
9	IBOL9	0.009	6.03052778	6.81741667	65.3	14.97±4.96	8.96±1.86	517.07±5.26
10	IBOL10	0.011	6.03488889	6.81691667	68.8	33.42±3.80	11.49±1.60	606.90±4.24
11	IBOL11	0.014	6.03130556	6.81263889	64	16.70±5.18	10.97±1.84	590.77±4.18
12	IBOL12	0.012	6.02794444	6.81325000	67	15.55±4.30	6.58±1.91	221.54±2.43
13	IBOL13	0.012	6.02316667	6.81950000	75	14.39±5.19	5.80±1.90	581.09±4.14
14	IBOL14	0.011	6.02238889	6.81452778	73.5	19.58±4.43	1.66±1.86	1003.39±5.51
15	IBOL15	0.010	6.02116667	6.81363889	67	29.38±4.18	13.44±1.72	713.79±6.08
16	IBOL16	0.011	6.02605556	6.81252778	64	16.70±5.18	13.44±1.76	469.57±3.70
17	IBOL17	0.011	6.02485833	6.81245000	56.6	19.00±4.26	9.56±1.87	853.33±6.18
Mean		0.013			66.15	22.19±4.53	9.70±1.90	543.80±4.45

Table 2. *ECLR and AUI values on the 17 points from Ibolo.*

S/N	CODE	ELCR (x 10^{-3})	AUI
1	IBOL1	0.08	0.43
2	IBOL2	0.10	0.35
3	IBOL3	0.16	0.54
4	IBOL4	0.11	0.28
5	IBOL5	0.07	0.27
6	IBOL6	0.10	0.28
7	IBOL7	0.16	0.55
8	IBOL8	0.16	0.42
9	IBOL9	0.11	0.55
10	IBOL10	0.15	0.50
11	IBOL11	0.12	0.33
12	IBOL12	0.07	0.24
13	IBOL13`	0.11	0.25
14	IBOL14	0.17	0.28
15	IBOL15	0.16	0.49
16	IBOL16	0.11	0.35
17	IBOL17	0.16	0.37
	Av.	0.12	0.38

Table 3. *Health Risk Indices.*

	^{238}U (Bq/kg)	^{232}Th (Bq/kg)	^{40}K (Bq/kg)	Ra_{eq} (Bq/kg)	Dose (nGh^{-1})	Iγ	AEDE ($mSvy^{-1}$)	Hazard index		ELCR ($\times 10^{-3}$)	AUI	AGED ($\mu Svyr^{-1}$)
								H_{in}	H_{ex}			
Mean	22.19	9.70	543.80	77.93	38.95	0.61	0.05	0.27	0.21	0.17	0.37	279.87
ICPR (2003)	35	30	400	370	58	1	0.48	1	1	0.29	2	300

Table 4. *Comparison of activity concentrations, Dose and radium Equivalent with those found in similar studies.*

Location	^{238}U (Bq kg^{-1})	^{232}Th (Bq kg^{-1})	^{40}K (Bq kg^{-1})	D ($nGyhr^{-1}$)	Ra_{eq} (Bq kg^{-1})	Reference
Ibolo	22.19±4.53	9.70±1.90	543.80±4.45	38.95	77.93	Present study
Agbara	42.95±7.87	26.84± 2.20	111.05±7.98	40.69± 5.31	89.49± 11.67	Gbadamosi et al. (2017)
Port Harcourt	41.96±5.53	62.61± 18.97	643.10±5.94	84.02± 14.26	181.01± 33.12	Avwiri and Olatubosun (2014)
Osogbo	52±6	22±2	186±6	45.07± 4.23	97.78± 9.32	Faweya and Babalola (2010)
Ado Ekiti	36.57±2.70	25.73± 5.60	758.51±132.93	64.07± 10.17	131.77± 20.94	Isinkaye and Faweya (2006)
Oritaperin	27.93±10.52	44.93± 7.24	488.91±217	24 60.43± 7.41	92.26± 5.6	Jibiri et al. (2014)
Sango Ota	122.10±20.60	3.0± 1.23	3.30 ±9.8	58.36± 10.67	126.64± 23.11	Ademola et al. (2014)
Lagos	69.19±19.10	14.49± 3.22	409.44±86.08	57.80± 14.36	121.44± 30.33	Oladapo et al. (2012

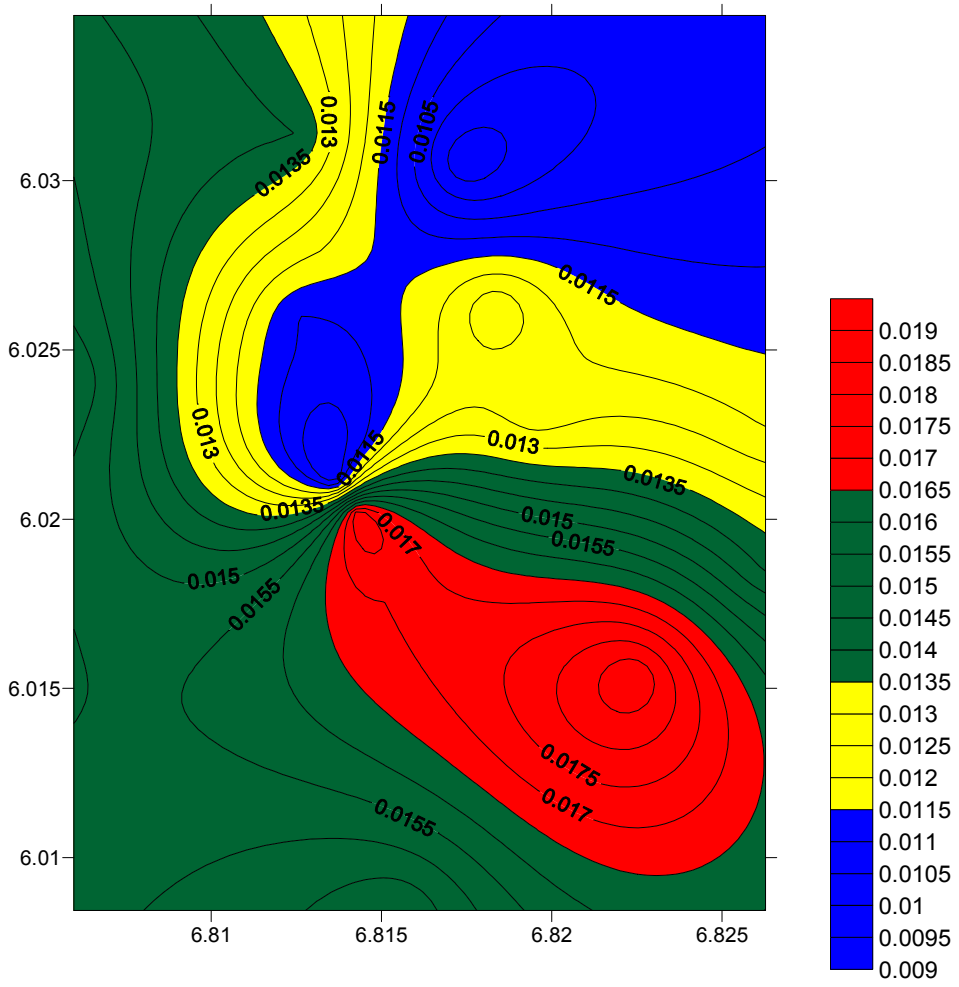

Figure 3. *Contour map of the community showing BIR in mR/hr.*

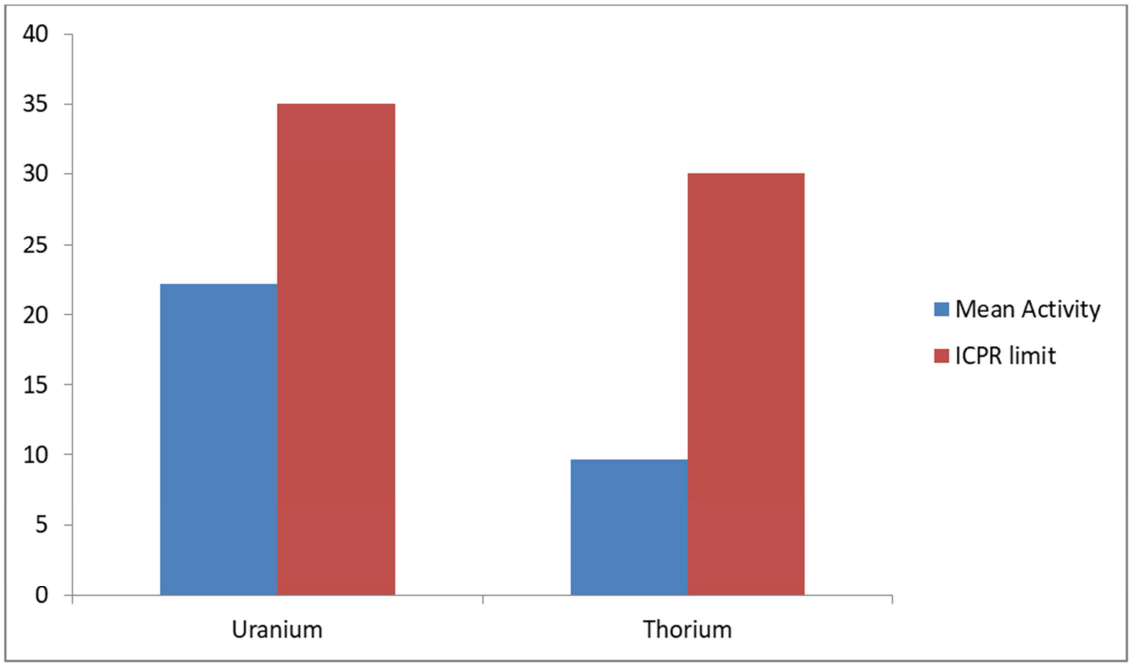

Figure 4. *Comparison of mean activity concentration of nuclide of ^{238}U and ^{232}Th with ICRP limit.*

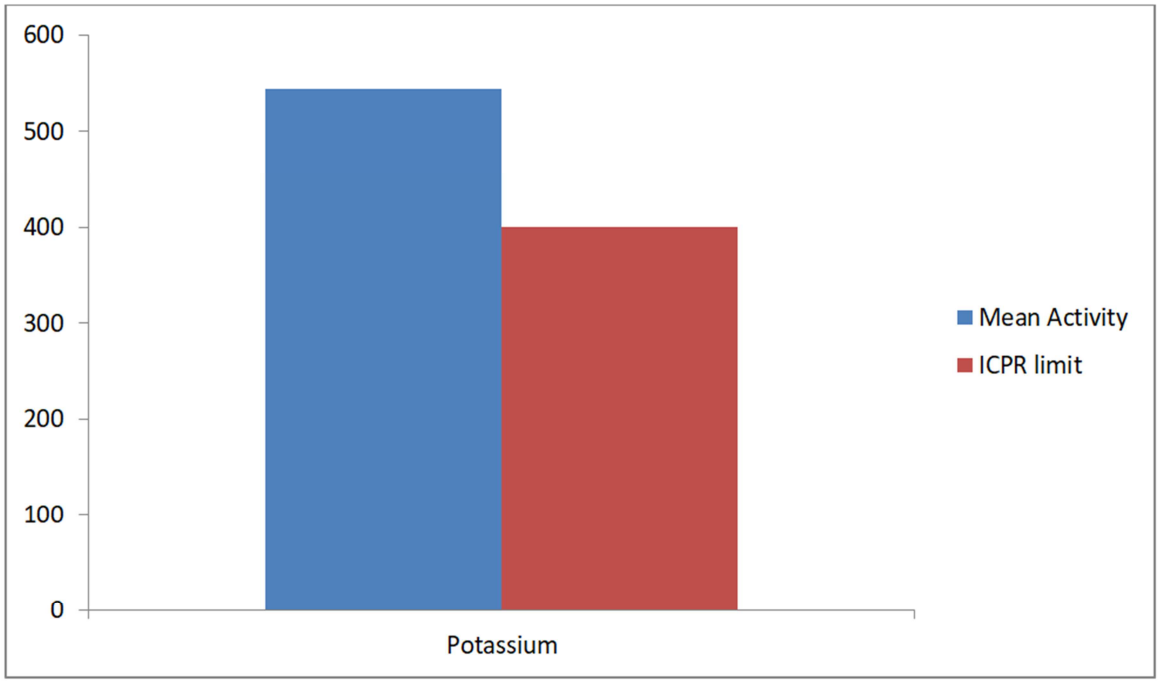

Figure 5. *Comparison of mean activity concentration of nuclide of ^{40}K with ICPR limit.*

4. Discussion

It is clear from Figure 3 which shows the relative contributions of ^{238}U, ^{232}Th and ^{40}K to the total activity concentration in Ibolo soil that ^{40}K leads followed by ^{238}U and ^{232}Th (that is $^{40}K > ^{238}U > ^{232}Th$). Figures 4 and 5 show a comparison between mean activities of the radionuclides with the ICRP set limit. It can be seen that mean activities of ^{238}U and ^{232}Th (22.19±4.53, 9.70±1.90) is less than ICPR limit (35, 30). On the other hand, the mean activity of ^{40}K (543.80±4.45) is greater than the set value of 400 $Bqkg^{-1}$. This is expected because ^{40}K is a naturally occurring radionuclide which abounds in the earth crust [24]. Comparing with similar work done by other researchers as highlighted in table 4, the radionuclides values of ^{238}U, ^{232}Th and ^{40}K in this study are less than the reported values in Ado Ekiti) and also Sango Ota [25]. The results obtained showed that the Ra_{eq} of all samples have values less than the permissible maximum value 370 Bq kg^{-1}. This value is less than the values recorded in Agbara, Port Harcourt and Osogbo by [26-28]. The value of Iγ, H_{ex} and H_{in} should be less than one to be within the safe limit. The calculated values of Iγ, H_{ex} and H_{in} are 0.67, 0.21 and 0.27 respectively, signifying that the investigated region is radiologically safe. More so, the calculated AEDE value of 0.05 is below ICPR mark of 0.48. Apart from this, the Excess lifetime cancer risk (ELCR) for the 17 soil samples ranged from 0.07 (IBOL12) to 0.17 (IBOL14). Even though the concentration of thorium is the lowest in IBOL14, the large amount of potassium contributed to the high ECLR value. Overall, the value of 0.17 is less than 0.29 limit set by UNSCEAR [1]. This result shows that lifetime cancer risk due to exposure from activities on the investigated soil, for a maximum duration of 52 years is very low. As well as that, the activity utilization index (AUI) which determines the radionuclides dose levels in the atmosphere from the soil samples ranges from 0.24 for IBOL12 to 0.55 for IBOL7 & IBOL9, with an average of 0.37. These values are far below the UNSCEAR benchmark of 2. Additionally, the AGED due to activities of ^{238}U, ^{232}Th and ^{40}K was computed as 279.87 $\mu Svyr^{-1}$ as shown in table 2. This value is less than the recommended level of 300$\mu Svyr^{-1}$. Furthermore, the absorbed dose rate (D) which is a measure of energy deposited in a medium by ionizing radiation was calculated using the equation (3) and results shown in Table 2. The absorbed dose rate (D) value is 38.95 nGh^{-1}. From the present study, it is clearly revealed that the absorbed dose rate (D) was below the recommended limits of 58 nGh^{-1}.

5. Conclusion

In this study, an estimation of utilization index and excess lifetime cancer risk in soil samples was carried out using results of gamma ray spectrometry on seventeen (17) soil samples gotten from Ibolo-Oraifite. The mean values of ^{238}U and ^{232}Th were within the recommended values but ^{40}K values were above 400$Bqkg^{-1}$. The radiological empirical values of AUI and ELCR showed that the areas do not constitute any immediate radiological health effect on the native dwellers since the hazard indices are less than the world set permissible levels. The results will serve as essential information to the government and public health agencies in planning and monitoring of radiation protection programs and as a base line data for future radiation studies within the area.

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