RADIOLOGICAL ASSESSMENT OF GRAINS, VEGETABLES, FRUITS AND TUBER CROPS CULTIVATED IN OKEMESI TOWNSHIP, EKITI STATE, NIGERIA

Paulinah Oyindamola FASANMI

Department of Physics, Ekiti State University, Ado-Ekiti, Ekiti State Nigeria

Stephen Friday OLUKOTUN

Department of Physics and Engineering Physics, Obafemi Awolowo University, Ile-Ife,

Osun State

Charity Adaeze ONUMEJOR

Department of Physics, Convenant University, Otta, Ogun State

Pascal TCHOKOSSA

Department of Orthopaedic Surgery and Traumatology, Obafemi Awolowo University, Ile-Ife, Osun State

Olayinka ADEGBEHINGBE

Geliş Tarihi / Received:24.04.2021
Kabul Tarihi / Accepted:25.05.2021
Araştırma Makalesi/Research Article
DOI: 10.38065/euroasiaorg.554

ABSTRACT

Exposure to radiation is a natural phenomenon in the human environment. This is received from naturally occurring radionuclides in water, air, soil and food. Ingestion is one of the two major pathways through which these nuclides enter the human systems. Radiological assessment of fruits, vegetables, grains and tuber crops cultivated and consumed in Okemesi township, Ekiti State has been carried out using a 76mm by 76mm lead-shielded Sodium Iodide detector (NaI(Tl)) located at the Centre for Energy, Research and Development (CERD), Obafemi Awolowo University, Ile-Ife, Nigeria. The mean activity concentration of the radionuclides in the food samples was 155.76 ± 14.22 $Bqkg^{-1}$ for ^{40}K, 8.00 ± 0.24 $Bqkg^{-1}$ for ^{238}U and 7.39 ± 0.21 $Bqkg^{-1}$for ^{232}Th.The value obtained for Annual Effective Dose due to intake of the food crops (D_{ing}) ranged from 104.32 to 687 µSv yr^{-1} while values for Excess Lifetime Cancer Risks (ECLR) ranged from 0.365 t0 2.407. Although the radioactivity levels in the food crops were lower than the world-wide limits, some values obtained for the A_{ED} and the ELCR were significantly higher than the recommended limits of UNSCEAR 2000. The rank order of D_{ing} and ELCR in the food types was tubers > fruits > vegetables > grains. Consumption of food cultivated in the area over a long period of time may induce a degree of health risks which should not be overlooked.

Keywords: Natural radioactivity, Food, Okemesi, Gamma spectrometry, Nigeria

1. INTRODUCTION

An atom whose nucleus is unstable is referred to as a radionuclide. The excess energy possessed by this nucleus is transmitted to newly created radiation particles, resulting in the release of gamma, alpha or beta particles or radiation (Oluyide *et al*., 2019). Energetic particle or wave which navigates vacuum or medium that contains matter, which is not necessary for its movement is known as radiation (Kwan- Hoong, 2003). Effects of radiation on man is dependent on the absorbed or ingested dose among other factors. These effects could be somatic or genetic, stochastic or deterministic (Hall, 2000). Researches regarding the analysis of natural radioactivity in foodstuff have been propelled to the forefront in recent years, and it has become an important aspect of the environmental monitoring program. Food is one of the major pathways through which radionuclide is transferred to man. It is therefore necessary to estimate the radiation doses obtained from the ingestion of contaminated food (Syarbaini *et al*., 2014). Cultivation of crops meant for consumption on contaminated soils result in the transfer of radioactivity from soil to the roots of such crops, which is consequently shifted to human diet (Fasanmi *et al*., 2020). The two major pathways by which natural radionuclides enter into man are ingestion and inhalation (Tawalbeh *et al*., 2012). This ingested radionuclide could be concentrated in certain parts of the body thereby causing damage (Linares *et al*., 2006) With the aforementioned facts in mind, this study aimed to extensively investigate the concentration of ^{40}K, ^{238}U and ^{232}Th in some food samples and provide adequate information about the Annual Effective Dose due to the consumption of food grown in the study area.

2. MATERIALS AND METHODS

2.1. Study Area

Okemesi, the area of study is a major town in Ekiti-West local government area in Ekiti State, South-western Nigeria with a population of about 79,563 residents (Sun, 2014). It is situated on latitude 7.82N and longitude 4.92E and sits 541 metres above sea level. The town lies between two ridges rich in quartzite running approximately north-south with lands rich in agriculture (Sun, 2014). The town forms a conglomerate of undulating valley and low lands. Since hills and rocks are natural reservoirs of radionuclides and rich in Uranium, Okemesi a town with a hilly terrain becomes an interesting site for this research. The schematic map of the study area is displayed in Figure 1.

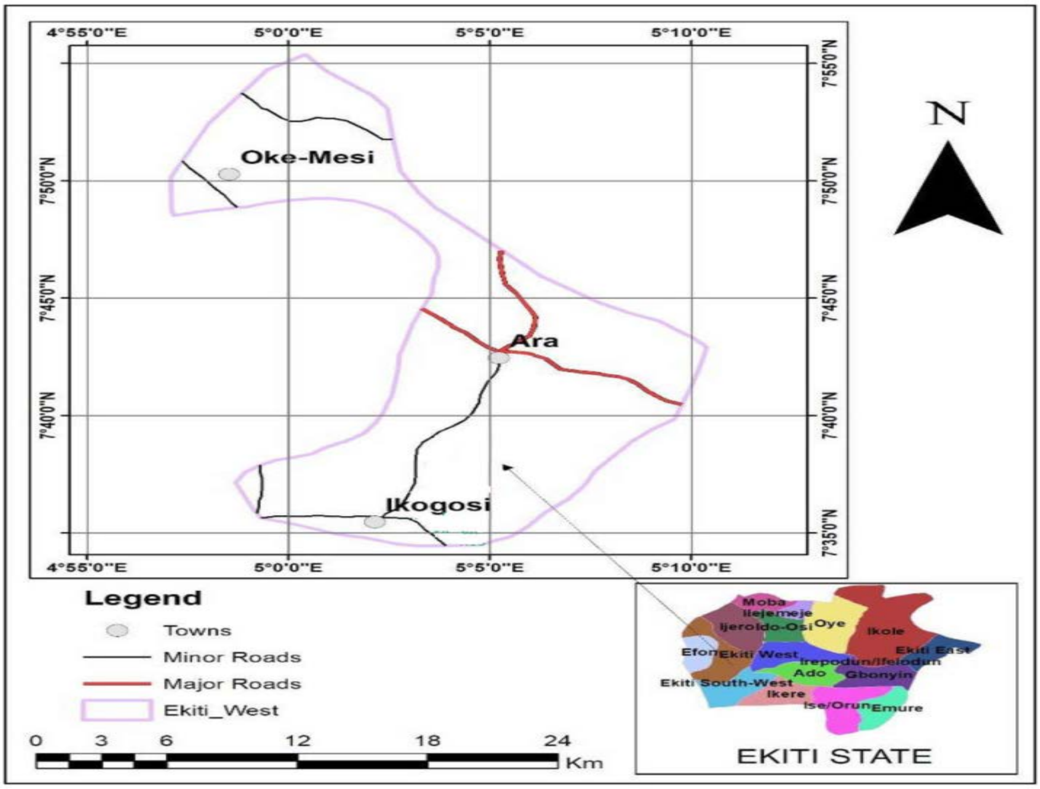

Figure 1. Map of the study area (Digitized from Faweya *et al*., 2018)

2.2. Sampling procedure

Selection of food samples is supposed to be based on thorough understanding of agricultural practices and food consumption pattern in a study area (IAEA, 1989) Agriculture is a major source of livelihood in the area therefore it was easy to obtain food samples cultivated on the farms in the area. Three (3) samples each of fruits, vegetables, grains and tubers crops were collected. A total of twelve (12) samples were collected for the investigation. At the point of collection, each sample was carefully placed in separate polythene bags, labelled and transferred to the laboratory for due processing. The samples were air dried, oven dried to constant weight and then pulverized. Samples were sieved to ensure uniform particle size after which they were sealed in containers made air tight. Sealing was done for minimum of 28 days for secular equilibrium to take place. Samples are described in Table 1.

Table 1. Description of food samples analysed in the study

Sample code.	Crop type	Trade name	Scientific names
F1	Fruit	Local sugar cane	*Sacharumofficinarum*
F2	Fruit	Banana	*Musa sapientum*
F3	Fruit	Plantain	*Musa paradisaca*
V1	Vegetable	African spinach	*Amaranthushybridus*
V2	Vegetable	African spinach	*Amaranthushybridus*
V3	Vegetable	African spinach	*Amaranthushybridus*
G1	Grain	Maize	*Zea mays*
G2	Grain	Maize	*Zea mays*
G3	Grain	Maize	*Zea mays*
T1	Tuber	Yam	*Dioscoreaspp*
T2	Tuber	Yam	*Dioscoreaspp*
T3	Tuber	Yam	*Dioscoreaspp*

2.3. Radioactivity measurements

The activity concentrations of the natural radionuclides in the food samples were determined

using a well calibrated 76 mm x 76 mm NaI(Tl) scintillate detector (Bicron Corp model 3M/3) shielded from background radiation by a 5 cm thick Lead shield located at the Centre for Energy Research and Development (CERD), Obafemi Awolowo University, Ile-Ife. The detector was coupled with a preamplifier (Bicon Corp Model PA-14), an amplifier (CanberraModel 2022), and an analogue-to-digital converter (ADC) (Canberra Model 8075) and multichannel analyzer (MCA) card slotted in a desktop computer. The output is displayed on the desktop through a Canberra S100 multichannel analyzer (MCA) software. Standard sample with reference number IAEA-375 for radionuclides and trace elements from International Atomic Energy Agency (IAEA), Vienna, Austria was used for the detector calibrations. The gamma-ray energy lines of 1460 keV for ^{40}K; 1120.30 keV for ^{214}Bi; and 911keV for ^{228}Ac were used to measure activity concentration of ^{40}K; ^{238}U and ^{232}Th, respectively. The system was preset to 25,200 seconds counting time. The activity concentrations for a particular radionuclide in the measured samples were evaluated using the following equation (IAEA, 1996):

$$A_c = \frac{N}{G_\gamma m\, T\, \varepsilon} \quad (1)$$

Where the activity concentration of radionuclide in the sample is depicted by A_c, N represents the net area covered by the spectrum, G_γ is thegamma yield, m is the mass of individual sample (kg), T is the counting time, while ε is the detector's efficiency. The expression below, given by Scheibel and Appoloni in 2013 was used to estimate the lower limit of detection at 95% degree of confidence.

$$\text{LLD} = \frac{N_{min}}{\varepsilon G_\gamma \text{T}} \quad (2)$$

Where N_{min} stands for the minimum net area of the spectrum measured

$$N_{min} = 4.66\, (\text{S}_\text{b})^{1/2} \quad (3)$$

Where S_b is the calculated standard error of the net count as a result of Compton scattering and effect. The Minimum Detectable Activity Concentration (MDA) was calculated using the following formular after introducing the food samples,

$$\text{MDA} = \frac{4.66\,(S_b)^{1/2}}{\varepsilon G_\gamma \text{MT}} \quad (4)$$

Where M is the mass of the sample (kg).

2.4. Estimation of Health Risks

The level of health risks which consumers of the food analysed in the study could be exposed to was estimated using the Annual effective dose due to intake of food and the Excess life time cancer risks of their exposure.

2.5. Annual effective dose due to ingestion of food cultivated in the area.

The Annual effective dose due to ingestion (D_{ing}) was determined with the Equation 2 (UNSCEAR 2000);

$$D_{ing}\,(\text{Svyr}^{-1}) = A \times C_R \times D_F \quad (5)$$

Where A (Bq kg^{-1}) is the activity concentration of radionuclide, C_R is the consumption rate per year (kg yr^{-1}), and D_F (Sv Bq^{-1})is the standard dose conversion factor which is equal to 0.28 μSv Bq^{-1} for ^{226}Ra, 0.23 μSv Bq^{-1} for ^{232}Th and 0.0062 μSv Bq^{-1} for ^{40}K for the persons who live over 17 years. The food consumption rates for maize, vegetables, fruits and yams obtained from Food Balance Sheet Nigeria, 2014 were 31.10,46.70, 59.50, 100.40 kg y^{-1} respectively.

2.6. Excess lifetime cancer risk (ELCR)

The excess lifetime cancer risk (ELCR) was calculated using Equation 3

$$\text{ELCR} = D_{ing} \times D_L \times R \quad (6)$$

Where D_{ing}, is the annual effective dose due to ingestion, D_L is theduration of life (70 years) (WHO, 2018) and risk factor R is 0.05 Sv^{-1} which is fatal cancer risk per sievert.

3. RESULTS AND DISCUSSIONS

3.1. Radioactivity levels in food samples

Radioactivity levels in the food samples are presented in Table 1 and illustrated in figure 2. In all the food samples collected and analysed, the specific activity of ^{40}K ranged from 44.06 ± 4.29 Bq/kg (maize) to 259.16 ± 20 Bq/kg (yam). ^{238}U varied from 3.03 ± 0.09 Bq/kg to 10.59 ± 0.21 Bq/kg, both in maize while the minimum and maximum value of ^{232}Th were 4.08 ± 4.29 Bq/kg (Plantain) and 12.23 ± 0.21 Bq/kg (yam), respectively. A thorough appraisal of the presented result reveals that ^{40}K is a major contributor to the radioactivity level in the food samples. This has been attributed to the fact that ^{232}Th and ^{238}U migrates poorly from soil to plants. (Syarbaini and Iskandar, 2014). However despite its elevated concentration, it is of little significance because it is an essential element metabolically controlled by human cells hence unduly elevated values are taken care of. Highest value for ^{40}K was recorded in fruit crops while ^{238}U and ^{232}Th had the highest mean value in the tuber crops. This trend has been reported by previous studies who inferred that elevated radioactivity levels in tubers compared to other food crops could be attributed to their direct touch with soil unlike other food crops as well as their high water content, leading to accumulation of radionuclides dissolved in water. (Avwiri and Alao, 2013; Tchokossa *et al*., 2013)

Table 2. Specific activity of radionuclides in the food samples and health impact parameters

Sample I.D.	Specific Activity (Bq kg^{-1})			D_{ing}(μSv yr^{-1})	ELCR x 10^{-3}
	^{40}K	^{238}U	^{232}Th		
F1	230.079 ± 20.83	8.66 ±0.31	4.47 ± 0.16	290.33	1.016
F2	223.25 ± 19.20	7.44 ± 0.23	5.05 ± 0.15	275.35	0.964
F3	183.87 ± 14.39	9.47 ± 0.19	4.08 ± 0.09	281.38	0.985
Mean (Fruits)	212.40 ± 18.14	8.52 ± 0.24	4.53 ± 0.13	282.35	0.988
V1	121.24 ± 16.36	8.80 ± 0.24	9.07 ± 0.51	247.57	0.867
V2	75.44 ± 10.69	6.40 ± 0.41	6.19 ± 0.37	172.13	0.602
V3	158.42 ± 19.47	7.79 ± 0.51	4.70 ± 0.31	198.30	0.694
Mean (*Veg)	118.37 ± 15.51	7.67 ± 0.50	6.65 ± 0.40	206.00	0.721
G1	175.43 ± 13.75	10.59 ± 0.21	8.47 ± 0.15	186.62	0.653
G2	124.98 ± 9.98	3.03 ± 0.09	7.52 ± 0.13	104.32	0.365
G3	44.06 ± 4.29	7.56 ± 0.18	9.86 ± 0.18	144.85	0.507
Mean (Grains)	114.82 ± 9.34	7.06 ± 0.16	8.62 ± 0.15	145.26	0.508
T1	259.16 ± 20.00	8.68 ± 0.18	12.23 ± 0.21	687.79	2.407
T2	144.34 ± 11.50	8.68 ± 0.18	9.83 ± 0.17	560.72	1.963
T3	128.85 ±10.22	8.90 ± 0.18	7.26 ± 0.13	498.10	1.743
Mean (Tubers)	177.45 ±13.91	8.75 ± 0.18	9.77 ± 0.17	582.20	2.038
Overall Mean	155.76 ± 14.22	8.00 ± 0.24	7.39 ± 0.21	303.96	1.064
(UNSCEAR 2008)	412	33	45	290	0.2

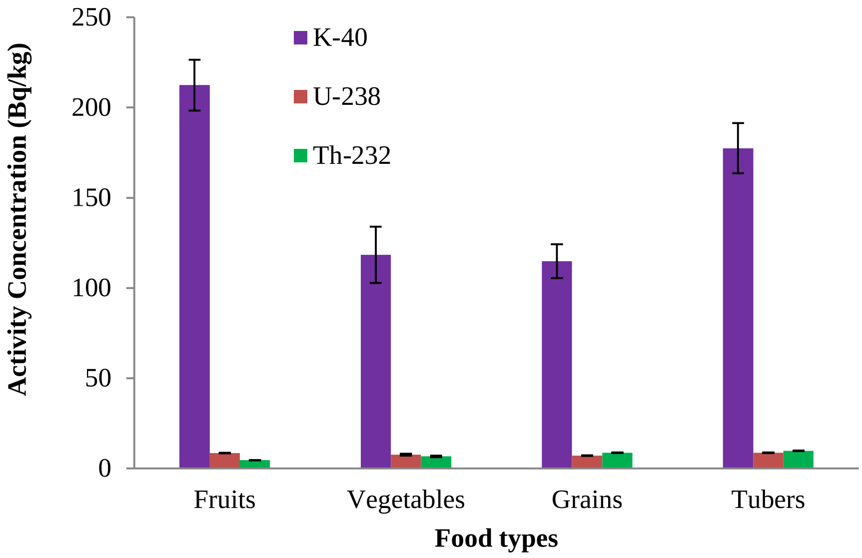

Figure 2. Illustration of radioactivity levels in the food samples analysed.

3.2. Estimation of Health Risk

Sufficient assessment of the health impact of the intake of food collected for analysis cannot be done without adequately estimating the Annual effective dose due to ingestion (D_{ing}) of ^{40}K, ^{238}U and ^{232}Th in the food crops. D_{ing} were determined using the activity concentration of the radionuclides presented in table 2. The values obtained for the D_{ing} and the ELCR are also presented in table 2 and illustratively compared in figure 3. Values for D_{ing}ranged from 104.32 µSvyr^{-1} (grains) to 687.79 µSvyr^{-1} (tubers). About 33% of the analysed food samples had values exceeding the safe limit of UNSCEAR 2008. In order to investigate the relationship and association between D_{ing} and the measured activity of radionuclides, the Pearson's correlation coefficient analysis was carried out. The results are presented in table 3as a linear correlation matrix and illustrated in figure 4 a,b,and c. D_{ing} had a moderate positive correlation with ^{40}K, ^{238}U and ^{232}Th. This signifies that all the nuclides contributed equally to the D_{ing} and consequently, the Excess Life Time Cancer Risk (ELCR). ^{232}Th however had a weak negative correlation with ^{40}K. Elevated mean values for D_{ing} were found in tuber crops. Other food crops had mean values lower than the recommended safe limit. The ELCR from consumption of food samples varied from 0.365 (grains) to 2.407 (tubers). All the values obtained were significantly higher than the limit specified by UNSCEAR 2000.

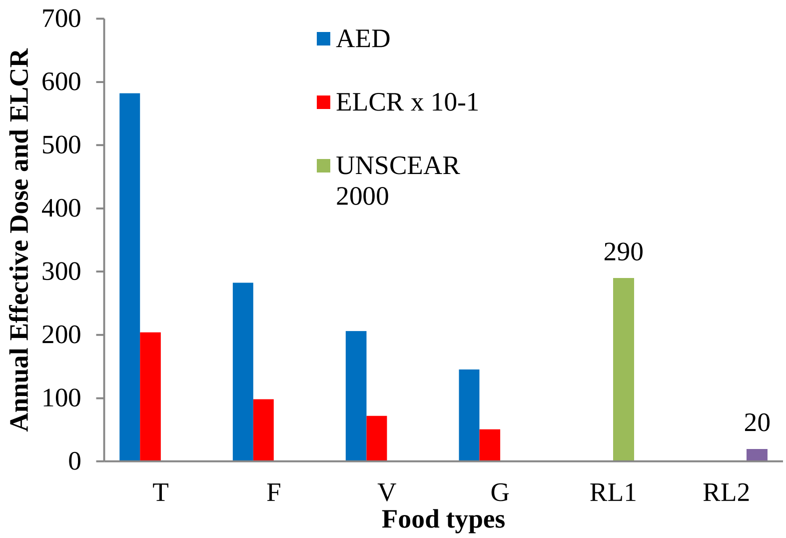

Figure 3: Annual Effective Dose and Excess Life Time Cancer Risks due to food consumption (RL_1 and RL_2 are Recommended Limits for D_{ing} and ELCR respectively)

Table 3. Correlation of D_{ing} with the specific activity of radionuclides

	^{40}K	^{238}U	^{232}Th	D_{ing}	ELCR
^{40}K	1				
^{238}U	0.338	1			
^{232}Th	-0.122	0.079	1		
D_{ing}	0.490	0.404	0.474	1	
ELCR	0.490	0.404	0.474	1.000**	1

3.3. Comparison of radioactivity levels in the food samples with similar studies in Nigeria and beyond

The radioactivity levels in the different types of food crops were compared with similar studies within and outside Nigeria. The radioactivity levels in the fruit crops were comparable with values obtained in fruits from Iraq (Abojassim *et al*, 2016) but exceeded values reported from high background radiation area in India (Shanthi *et al*., 2009). Values obtained for tuber crops were lower than values reported from oil and gas producing area in Niger delta (Avwiri and Alao, 2013) but higher than report form Ghana (Darko *et al*, 2015). Radioactivity levels in the in the grain crops exceeded values reported from Ile-Ife except for ^{232}Th (Oluyide *et al*., 2018) but were however lower than values obtained in Jos from tin mining town (Jibiri and Agomuo, 2007). Values obtained for the vegetable crops were comparable with values from vegetables cultivated in the vicinity of a iron and steel smelting company at Ile-Ife (Oluyide *et al*., 2018), but exceeded values from Lagos (Adedokun et al., 2019) and Iraq except for ^{40}K (Abojassim *et al*., 2016). In general, areas where activities that contribute to the elevation of natural radioactivity in the environment are prevalent, reported higher values than this study.

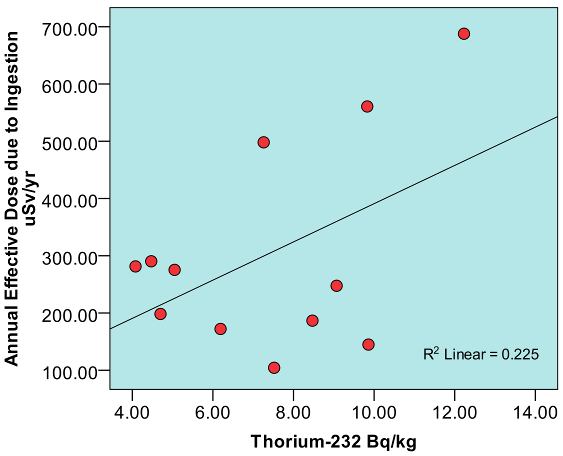

Figure 4a. Correlation of D_{ing} with ^{232}Th

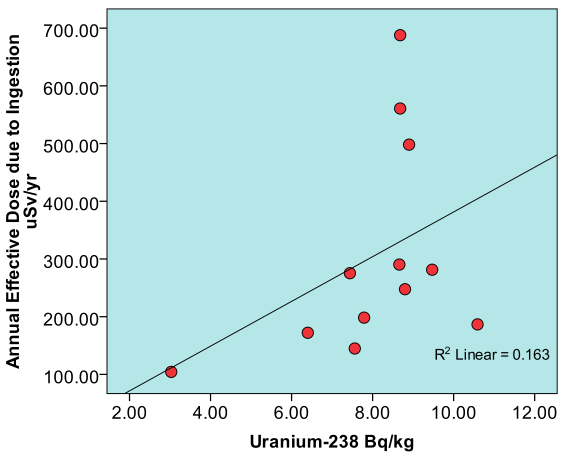

Figure 4b. Correlation of D_{ing} with ^{238}U

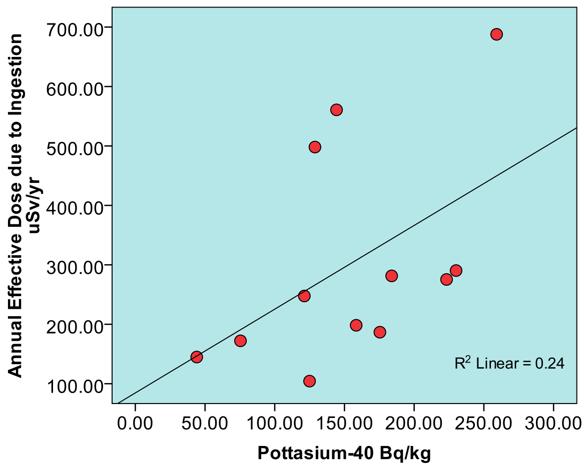

Figure 4c. Correlation of D_{ing} with ^{40}K

Table 4. Comparison of radioactivity levels in the food samples with similar studies in Nigeria and beyond

Region	Food type	Specific activity ^{40}K	^{238}U	^{232}Th	References
Jos,Nigeria	Maize	102 ± 6	19 ± 6	40 ± 1	Jibiri and Agomuo, (2007)
Niger Delta,	Tubers	229.35 ± 27.19	15.75 ± 4.53	10.90 ± 3.72	Avwiri and Alao (2013)
Nigeria	Cereals	39.25 ±8.37	11.39 ± 3.45	7.87 ± 2.72	
Ile-Ife, Nigeria	African spinach	111.55 ± 39.31	7.86 ± 2.41	16.28 ± 6.01	Oluyide *et al*., (2018)
	Yellow maize	87.25 ± 17.25	5.27 ± 1.70	8.99 ± 1.88	
Lagos	African spinach	90.69 ± 5.87	1.62 ± 0.44	0.38 ± 0.09	Adedokun *et al*., (2019)
Plateau	Spinach	479.34 ± 10.80	10.89 ± 1.96	2.58 ± 0.97	Lubis *et al*, (2019)
Iraq	Vegetable	186.15	5.21	4.76	Abojassim *et al*., (2016)
	Fruits	211.64	*BLD	2.53	
India	Banana	136.2 ± 41.1	0.12 ± 0.04	0.965 ± 0.4	Shanthi *et al*., (2009)
Ghana	Yam	14.19 – 35.07	0.47 – 4.89	0.93 – 5.03	Darko *et al*., ()2015
Okemesi, Ekiti	Fruits	212.40 ± 18.14	8.52 ± 0.24	4.53 ± 0.13	Present study
	African spinach	118.37 ± 15.51	7.67 ± 0.50	6.65 ± 0.40	
	Maize	114.82 ± 9.34	7.06 ± 0.16	8.62 ± 0.15	
	Yam	177.45 ± 13.91	8.75 ± 0.18	9.77 ± 0.17	

*BLD - Below Detection Limit

4. CONCLUSION

Natural radioactivity levels of ^{40}K, ^{238}U and ^{232}Th, Annual Effecctive Dose (D_{ing}) and Excess Life Time Cancer Risks (ECLR) due to consumption of food cultivated in Okemesi township, Ekiti State Nigeria has been measured and determined in this study. Specific activity of the radionuclides in the samples were within the limit of UNSCEAR 2008. However 33% of the values obtained for the D_{ing} exceeded the specified limits while all the estimated values obtained for the ELCR were higher than the limit 0.2 x 10^{-3} (UNSCEAR 2008). It can be concluded from the study that consumption of food grown in the study area over a long period of time can induce harmful effects on humans. This should not be alarming because averagely, individuals relate or interfere with other communities or regions during their life time (Obaseki et al, 2015). However, regular monitoring of radioactivity levels in food in the area is recommended.

5. REFERENCES

Abojassim, A., Hady, H., & Mohammed, Z. (2016). Natural Radioactivity Levels in Some Vegetables and Fruits Commonly Used in Najaf Governorate, Iraq. *Journal Of Bioenergy And Food Science, 3*(3) 113-123. DOI:10.18067/jbfs.v3i3.108.

Addo M.A., Darko E.O., Gordon C, Nyarko B.J.B. (2013) "A preliminary study of natural radioactivity ingestion from cassava grown and consumed by inhabitants around a cement production facility in the Volta region, Ghana"*International Journal of Environmental Sciences*; 3(6) 2312-2323.

Adedokun M. B., Aweda M. A., Maleka P. P.,Obed R. I., Ogungbemi K. I., and IbitoyeZ. A., (2019) Natural radioactivity contents incommonly consumed leafy vegetables cultivated through surface water irrigation in Lagosstate, Nigeria, *Journal of Radiation Research and Applied Sciences*, 12:1, 147-156, DOI:10.1080/16878507.2019.1618084

Avwiri, G.O., Alao, A.A., (2013) "Natural Radioactivity and Associated Radiation Hazards in Some Commonly Consumed Tubers and Cereals in Oil Mining Lease (OML) 58 and 61, Oil and Gas Producing Areas, Niger Delta Region of Nigeria" *International Journal of Science and Research;* 2 (1)

Darko G., Faanu A., Akoto O., Acheampong A., Goode E. J and Gyamfi O., (2015) Distibution of natural and artifical radioactivity in soils, water and tuber crops. *Environ Monit Assess*, 187:1-11

Emumejaye K., (2015) Activity Concentration in Cassava Tubers Grown In Ebedei Community, an Oil Producing Area of Delta State, Nigeria; *International Journal of Science and Research (IJSR)*(4)11

Fasanmi P. O.,Olukotun S. Fb., Akinyemi O. A., Gbenu S. T., Owojori A. A, Oladejo O. F., Omamegbe D. O., Maza D. D. (2020) "Determination of natural radioactivity levels in some foodstuffs available in a popular market in Ipetumodu, Osun State, Nigeria" *Nigerian Institute of Physics Journal* (In Press)

Faweya E.B., Olowomofe O. G., Akande H. T., and Adewumi T. A., (2018) Radon emanation and heavy-metals assessment of historical warm and cold springsin Nigeria using different matrices; *Environmental Systems Research;* 7(22) https://doi.org/10.1186/s40068-018-0125-x

Food Balance Sheet (2014). Open Data for Nigeria, African Development Bank Group

Hall, E.J., (2000) "Radiobiology for the Radiologist" Lippincott Williams & Wilkins 530 Walnut Street Philadelphia, PA 19106 USA

IAEA (1989) International Atomic Energy Agency, "Measurement of Radionuclides in Food and Environments" A guidebook, Technical Report Series No. 295, IAEA, Vienna.

Jibiri, N.N., Agomuo, J.C. (2007) "Trace elements and radioactivity measurements in some terrestrial food crops in Jos-plateau, north central, Nigeria" *Radioprotection*, 42: 29-42.

Kwan-Hoong, N. (2003)"Non-Ionizing Radiations-Sources, Biological Effects, Emissions and Exposures"*Proceedings of the International Conference on Non-Ionizing Radiation, Electromagnetic Fields and Our Health*UNITENICNIR.

Linares, V., Bellés, M., Albina, M. L., Sirvent, ., J. J., Sánchez, D. J. and Domingo, J. L. (2005), Assessment of the pro-oxidant activity of uranium in kidney and testis of rats, *Toxicology Letters*, 167, pp 152-161.

Lubis S., Shibdawa M. A., Adamu H., (2019) Determination of natural radioactive elements in vegetables irrigated with water from tin mining ponds around Dorowa in Barkin Ladi, Plateau State, Nigeria, *Science Forum (Journal of Pure and Applied Sciences)* 16:60 – 65

Obaseki P.O., Tchokossa P., Olomo J.B., Adegbehingbe O., (2015). "Radiological study of some vegetables and fruits commonly consumed in Ekiti State, Nigeria" *International Journal of Institute of Ecology and Environmental studies*, 3(2)61-73.

Oluyide S.O, Tchokossa P.,Akinyose F.C.,OrosunM.M. (2018). Assessment of radioactivity levelsand transfer factor of natural radionuclidesaround iron and steel smelting company locatedin Fashina village, Ile-ife, Osun state, Nigeria.*Facta Universities, Series: Working and Living Environmental Protection.* 15(3):241-256 DOI:https://doi.org/10.22190/FUWLEP1803241O

Oluyide S.O., TchokossaP., OrosunM. M.,AkinyoseF. C., LouisH., IgeS. O. (2019) "Natural Radioactivity and Radiological Impact Assessment of Soil, Food And Water around Iron And Steel Smelting Area in Fashina Village, Ile-Ife, Osun State, Nigeria" *J. Appl. Sci. Environ. Manage*; 23 (1) 135–143

Shanthi G., Maniyan C. G., Allan G. R.,and ThampiJ. T. K., (2009) Radioactivity in food crops from highbackgroundradiation area in southwest India; *Current Science*, 97(9)

Sun News (2014) " Ekiti: A rocky State and its untapped potentials" Sun News, September 11, 2014

Syarbaini, A. W. and Iskandar D. (2014) Natural Radioactivity in Some Food Crops from Bangka-Belitung Islands, Indonesia; *Atom Indonesia* 40(1)

Tawalbeh, A. A., Samat, S. B., Yasir,M. S. and Omar, M. (2012), Radiological impact of drinks intakes of naturally occurring radionuclides on adults of central zone of Malaysia, *Malaysian Journal of Analytical Sciences*, 16(2), pp187 – 193.

Tchokossa P., Olomo J.B., Balogun F. A., Adesanmi C. A. (2013) Assessment of Radioactivity Contents of Food in the Oil and Gas Producing Area in Delta State, Nigeria. *International Journal of Science and Technology* 3(4) 245 – 250

UNSCEAR (2000) United Nations Scientific Committee on the Effects of Atomic Radiation, "Sources and effects of ionizing radiation in Report to the General Assembly with Scientific Annexes" New York, United Nations.

UNSCEAR.(2008)United Nations scientific committee on the effect of atomic radiation, sources and effects of ionizing radiation. Report to the General Assembly. United Nations, New York.