Vol-8, Issue-5 PP. 144-149 ISSN: 2394-5788

GLOBAL JOURNAL OF ADVANCED RESEARCH
(Scholarly Peer Review Publishing System)

ASSESSMENT OF NATURAL RADIOACTIVITY CONCENTRATIONS AND ITS EFFECTIVE DOSE IN SOME COMMONLY CONSUMED FRUITS AND VEGETABLES IN OYO STATE, SOUTH-WESTERN, NIGERIA

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ABSTRACT

Fruits and vegetables are important part of human diets due to their nutritional values. The contamination of these plants via the cyclic transfer of naturally occurring radionuclides materials from soil may erode these benefits. This study assessed the radioactivity concentration in fruits and vegetables in Ogbomoso markets using a well shielded and calibrated NaI(Tl) detector. The identified radionuclides are ^{40}K, ^{238}U and ^{232}Th. The activity concentration of ^{40}K was found to be high in all samples compared with ^{238}U and ^{232}Th. The annual committed effective doses estimated in the samples across the age classifications are considerably higher than the recommended reference level. Thus, the results of this work have shown that the continuous ingestion of radiation from these samples for a long period of time may leads to internal exposure, which is a major radiological concern. Hence effort such as public awareness should be in place to mitigate consequences.

Keywords: Assessment, Fruits, Vegetables, Radionuclides, Radiological hazard, Ogbomoso

1. INTRODUCTION

People are exposed to ionizing radiation from the radionuclides that are present in different types of natural sources (Isola *et al.*, 2015) of which soil is one of the most important one. Hence, humans can be exposed to radiation either externally by a close source of radiation or internally by a radioactive material that has entered the body. Thus, exposure to natural sources of radiation is inevitable and unending process on Earth (Akinloye *et al.*, 2018). Vegetables and fruits are very important in human diets because of their dietary values, which are needed for proper body metabolism. They help build the immune system thereby improving the li fespan of humans (Amao, 2020). Consumption of fruits and vegetables help reduce high blood pressure, heart disease and cancer. Vegetables and fruits are plentiful in nutrients and minerals which help in building an energetic and healthy lifestyle. The contaminati on of fruits and vegetables via the cyclic transfer of naturally occurring radionuclides materials (NORM) from soil through various geochemical processes, gravitational settling, atmospheric dispersion and a host of others may erode these benefits (Akhter *et al.*, 2007; Jibiri *et al.*, 2007; Adeniji *et al.*, 2013).

The NORM arises from the decay series headed by ^{238}U and ^{232}Th and the singly occurring non decay series ^{40}K (UNSCEAR, 2000). The implication of these radionuclides is a consequence of gamma ray exposure of the body and irradiation of lung tissue that may occur through the ingestion of these potentially harmful radionuclides. The knowledge of radionuclides concentrations and its distribution in the environment have provided useful information from which environmental radioactivity in several matrices can be monitored. Several studies such as Akhter *et al.* (2007); Jibiri *et al.* (2007); Harb, (2009); Awudu *et al.* (2012); Adeniji *et al.* (2013); Al-Absi *et al.* (2015), El-Gamal *et al.*, (2019) and many more, have been reported in literatures, showing its significance as related to human health. Hence, this study assessed the radioactivity concentration in fruits and vegetables in selected towns in Oyo State so as to determine and quantify its radiological implications on consumers.

2. MATERIALS AND METHODS

2.1 Sampling, Collection and Preparation

The study was carried out in some local markets in Ogbomoso, one of the major city in Oyo State, Nigeria. The study was conducted during November/December period of the year 2019. From the selected markets, ten bunches of leafy vegetables and five fruits were collected. The collected samples were rinsed with ordinary water to remove any impurities, cleaved into little parts, oven dried at a temperature of 84°C for 4 days, pulverized to fractional size and sieved through 2 mm mesh. The processed samples were packed inside polyethylene containers of approximately 500 cm^3 volume, labeled accordingly and completely sealed with adhesive tape and stored for 28 days to achieve radioactive secular equilibrium between the radon gas and its progenies. Thereafter, the sealed samples were transferred to the laboratory pending the spectrometry analysis.

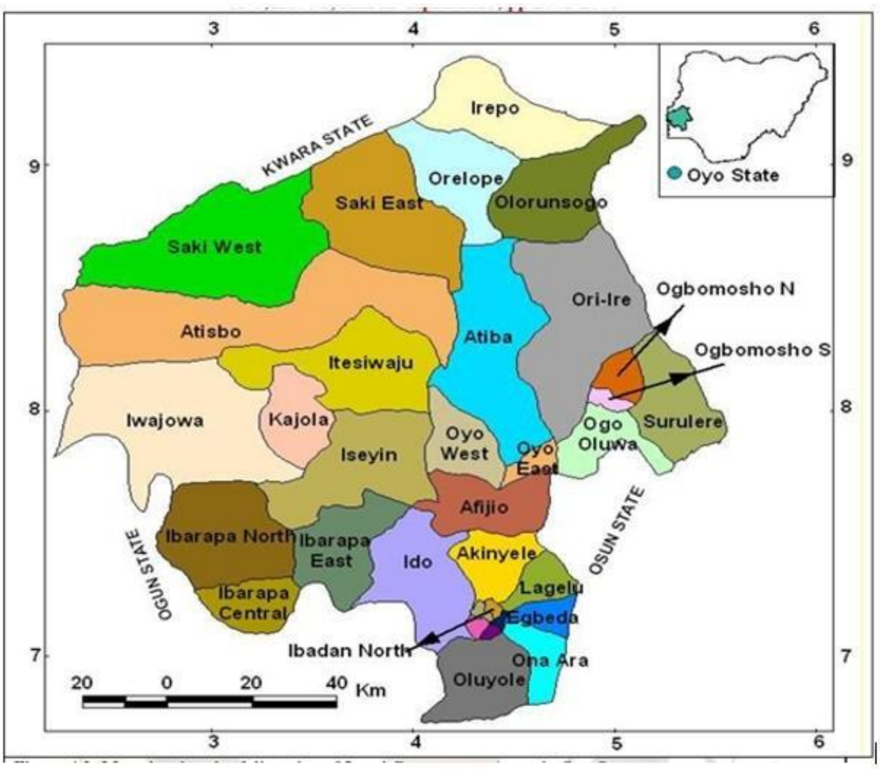

Figure 1: Map of Oyo State indicating sampling location (Ogbomoso) [Inset: Map of Nigeria showing Oyo state].

2.2 Instrumentation and Measurement

The identification and quantification of the natural radionuclides present in the processed samples were undertaken using a gamma spectrometry method. The spectrometry system comprises of a well shielded and calibrated NaI(Tl) detector, coupled to a multichannel analyser, and further linked to a computer for display. Data acquisition and analysis of gamma-ray spectra were achieved using Theremino software. Prior to the sample measurement, an empty container was counted for 36000 s so as to determine the background gamma-ray distribution count. The sealed samples after attaining a state of secular equilibrium were each placed on the detector one after the other for analysis. Each sample was counted for the same period of time as that of the empty container. The characteristics of the radionuclides used in determining the most prominent radionuclides identified in the samples are: 1460.0 keV (^{40}K), 1764.5 keV of ^{214}Bi (^{238}U), and 2614.7 keV of ^{208}Tl (^{232}Th). The activity concentration A ($Bqkg^{-1}$) of each identified radionuclide in the sample was estimated using Equation 1:

$$A = \frac{C_{net}}{P_{\gamma} \times s \times m \times t} \quad (1)$$

where C_{net} is the net peak count for each radionuclide present in the sample after subtracting the background count from the gross count, Pγ is the absolute gamma ray emission probability of the identified radionuclide, ε is the obtained full energy peak efficiency for each identified radionuclide, m is sample mass and t is the counting time.

2.3 Estimation of Annual Committed Effective Dose

The annual committed effective dose (ACED) resulting from the ingestion of the radionuclides in the assayed samples was estimated using Equation 2:

$$ACED\ (mSva^{-1}) = \sum_i^n (A_i \times C_{Ri} \times D_c) \quad (2)$$

Where A_i is the activity concentration ($Bqkg^{-1}$) for each of the identified radionuclide present in each (n) sample, C_{Ri} (kga^{-1}) is the annual food consumption rate for vegetables and fruits as given by UNSCEAR (2000) for the age group classified as infants, children and adults and D_c ($\mu SvBq^{-1}$) is the dose conversion factor for each of the identified radionuclide as given by UNSCEAR (2000) and modified by ICRP (2012).

3. RESULTS AND DISCUSSION

The results obtained for the radionuclides present in the vegetables and fruits are as presented in Tables 1 and 2. The results revealed that the identified radionuclides are the singly occurring series ^{40}K and the decay series headed by ^{238}U, ^{232}Th, all of which belongs to the natural radionuclides. The activity concentration obtained for ^{40}K ranges from 125.45 ± 5.06 $Bqkg^{-1}$ to 434.50 ± 7.71 $Bqkg^{-1}$, with the lowest concentration in Okra and the highest concentration in Amaranthus. The activity concentration of ^{238}U ranges from 6.79 ± 0.73 to 22.33 ± 0.45 $Bqkg^{-1}$, with the lowest concentration in Onion and the highest concentration in African Basil, while the activity concentration of ^{232}Th ranges from 13.63 ± 0.46 in Onion to 47.08 ± 1.43 $Bqkg^{-1}$ in Amaranthus.

The activity concentration of ^{40}K ranges from 144.21 ± 4.76 $Bqkg^{-1}$ to 442.47 ± 7.75 $Bqkg^{-1}$, with the lowest concentration in Pawpaw and the highest in Banana. The activity of ^{238}U ranges from 18.26 ± 0.45 $Bqkg^{-1}$ to 21.39 ± 0.45 $Bqkg^{-1}$, with the lowest concentration in Banana and the highest concentration in Pineapple. The activity concentration of ^{232}Th ranges from 15.85 ± 1.56 in Pawpaw to 35.85 ± 1.25 $Bqkg^{-1}$ with the highest concentration in Water melon. Figures 2 and 3 shows the comparison of the radioactivity. The concentration of ^{40}K was found to be high in all vegetables and fruits assayed compared with other radionuclides present. This can be attributed to the high background radiation of the study area (Awudu *et al.*, 2012).

The annual committed effective dose estimated due to the radionuclide concentrations of assayed vegetables and fruits samples are as presented in Tables 3 and 4. The results revealed that for the vegetables samples, the ACED of onion is considerable lower, while that of Amaranthus has the highest dose across the age classifications. Also, for the fruit samples, the ACED of pawpaw is considerable lower, while that of banana has the highest dose across the age classification. The average ACED estimated for the vegetables and fruits samples across the age classifications are considerable higher than 0.29 $mSva^{-1}$ reference level due to the ingestion of ^{40}K and the decay series of ^{238}U and ^{232}Th from natural sources (UNSCEAR, 2000). This can be attributed to the vast distribution of radionuclides in these samples and other environmental samples of the study area. Continuous ingestion of radiation from these radionuclides may leads to internal exposure, which is a major radiological concern.

Table 1: Radioactivity concentrations ($Bqkg^{-1}$) in the Vegetables

Sample	^{40}K	^{238}U	^{232}Th
Amarantus	434.50 ± 7.71	21.74 ± 0.45	47.08 ± 1.43
Yoruba Bologi	132.95 ± 4.26	8.78 ± 0.29	17.56 ± 0.87
Lagos Spinach	332.47 ± 6.75	19.74 ± 0.40	37.08 ± 1.48
Jutes Mello	263.86 ± 6.01	20.33 ± 0.45	19.40 ± 0.46
Okra	125.45 ± 5.06	7.71 ± 0.26	16.56 ± 0.82
African Basil	318.85 ± 5.01	22.33 ± 0.45	18.39 ± 0.45
Pumpkin	130.53 ± 4.20	9.08 ± 0.29	16.56 ± 0.23
Tomato	133.86 ± 6.65	17.65 ± 0.65	19.65 ± 0.46
Malabar Spinach	311.96 ± 6.36	16.11 ± 0.44	28.17 ± 1.27

Onion	132.29 ± 5.06	6.79 ± 0.73	13.63 ± 0.46
Range	**125.45 - 434.50**	**6.79 - 22.33**	**13.63 - 47.08**
Mean	**231.67 ± 5.71**	**14.95 ± 0.44**	**24.57 ± 0.79**

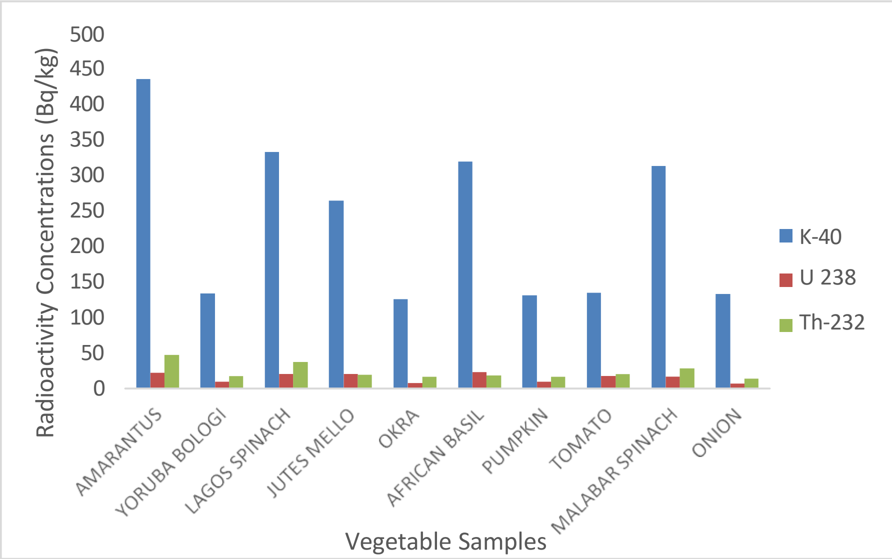

Figure 2: Comparison of radioactivity concentrations in vegetable samples.

Table 2: Radioactivity concentrations (Bqkg^{-1}) in the Fruits

Sample	40K	238U	232Th
Pineapple	363.86 ± 7.05	21.39 ± 0.45	30.25 ± 0.45
Watermelon	334.21 ± 6.76	20.72 ± 0.44	35.85 ± 1.25
Tangerine	344.29 ± 5.78	19.71 ± 0.49	33.88 ± 1.27
Pawpaw	144.21 ± 4.76	17.22 ± 0.44	15.85 ± 1.56
Banana	442.47 ± 7.75	18.26 ± 0.45	37.75 ± 1.89
Range	**144.21 - 442.47**	**18.26 - 21.39**	**15.85 - 35.85**
Mean	**316.53 ± 6.42**	**19.42 ± 0.45**	**29.60 ± 1.28**

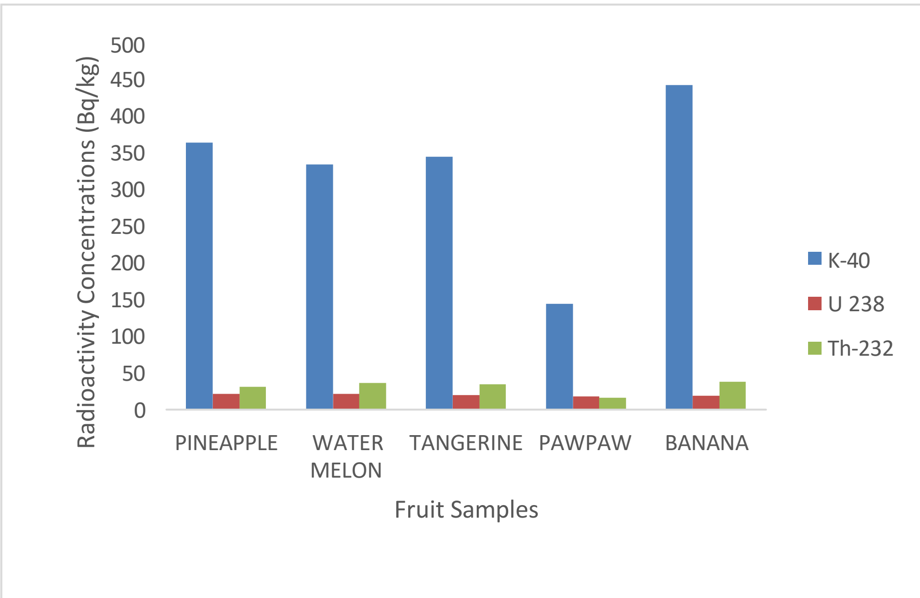

Figure 3: Comparison of radioactivity concentrations in fruit samples

Table 3: Annual Committed Effective Dose ($mSva^{-1}$) in the Vegetables

Samples	Infants	Children	Adults
Amarantus	0.84 ± 0.02	0.83 ± 0.02	0.86 ± 0.02
Yoruba Bologi	0.29 ± 0.01	0.30 ± 0.01	0.31 ± 0.01
Lagos Spinach	0.66 ± 0.02	0.66 ± 0.02	0.68 ± 0.02
Jutes Mello	0.45 ± 0.01	0.42 ± 0.01	0.42 ± 0.01
Okra	0.27 ± 0.01	0.28 ± 0.01	0.29 ± 0.01
African Basil	0.49 ± 0.01	0.44 ± 0.01	0.43 ± 0.01
Pumpkin	0.28 ± 0.01	0.28 ± 0.01	0.30 ± 0.01
Tomato	0.33 ± 0.01	0.35 ± 0.01	0.37 ± 0.01
Malabar Spinach	0.55 ± 0.02	0.53 ± 0.02	0.54 ± 0.02
Onion	0.25 ± 0.01	0.25 ± 0.01	0.25 ± 0.01
Range	0.25 – 0.84	0.25 – 0.83	0.25 – 0.86
Mean	0.46 ± 0.01	0.45 ± 0.01	0.47 ± 0.01

Table 4: Annual Committed Effective Dose ($mSva^{-1}$) in the Fruits

Samples	Infants	Children	Adults
Pineapple	1.89 ± 0.03	1.65 ± 0.03	1.72 ± 0.03
Watermelon	1.96 ± 0.05	1.78 ± 0.05	1.90 ± 0.06
Tangerine	1.92 ± 0.05	1.72 ± 0.05	1.83 ± 0.06
Pawpaw	0.92 ± 0.06	0.84 ± 0.06	0.90 ± 0.07
Banana	2.27 ± 0.07	1.97 ± 0.07	2.07 ± 0.09
Range	0.92 – 2.27	0.84 - 1.97	0.90 – 2.07
	1.73 ± 0.05	1.54 ± 0.05	1.63 ± 0.63

4. CONCLUSION

This study had elucidated on the intake of radioactivity in vegetables and fruits available in Ogbomoso local markets. The activity concentration of ^{40}K was found to be high in all vegetables and fruits compared with ^{238}U and ^{232}Th. This may be attributed to the geological formation of the study area. Additionally, it was discovered that annual committed effective doses estimated in all vegetables and fruits samples across the age classifications are considerably higher than the recommended reference level due to the ingestion of these radionuclides from natural sources. Continuous ingestion of radiation from these radionuclides may leads to internal exposure, which is a major radiological concern. Hence, despite the significances of vegetables and fruits in human dietary, the populace should take necessary precautions as regard the consumption of these plants within the study area. This is in a bid to mitigate the consequence due to ingestion.

REFERENCES

[1] Adeniji, A.E., O.O. Alatise and A.C. Nwanya, (2013): Radionuclide concentrations in some fruits juices produced and consumed in Lagos, Nigeria. American. Journal of Environmental Protection, 2(2), 37-41. DOI: http://dx.doi.org/10.11648/j.ajep.2013.0202.11/

[2] Akinloye M. K., Isola G. A, and Ayanlola P. S., (2018): Determination and Evaluation of Radionuclide Contents in the Soil of Oloru, Kwara State, Nigeria; *International Journal of Scientific and Research Publications (IJSRP); **8***(8); 628 - 634 (ISSN: 2250-3153), DOI: http://dx.doi.org/10.29322/IJSRP.8.8.2018.p8081

[3] Akhter, P., Rahman, K., Orfi, S. D., and Ahmad, N., (2007): Radiological impact of dietary intakes of naturally occurring radionuclides on Pakistani adults. Food and Chemical Toxicology, 45, 272 – 277.

[4] Al-Absi, E., Al-Abdullah, T., Shehadeh, H., & AI-Jundi, J., (2015): ^{226}Ra, ^{228}Ra, and ^{40}K activity concentration in some vegetables consumed in Jordan, and resultant annual ingestion effective dose. Radiation Protection and Environment, 38, 29-34.

[5] Amao, I. Health benefits of fruits and vegetables: Review from Sub-Saharan Africa http://dx.doi.org/10.5772/intechopen.74472 [Accessed: 2020-07-02]

[6] Awudu, A. R., Faanu, A., Darko, E. O., Emi-Reynolds, G., Adukpo, O. K., Kpeglo, D. O.,Agyeman, B. (2012): Preliminary studies on ^{226}Ra, ^{228}Ra, ^{228}Th and ^{40}K concentrations in foodstuffs consumed by inhabitants of Accra metropolitan area, Ghana. Journal of Radio-analytical and Nuclear Chemistry, 291, 635 – 641.

[7] Canbazoğlu, C., and Doğru, M. (2013): A preliminary study on ^{226}Ra, ^{232}Th, ^{40}K and ^{137}Cs activity concentrations in vegetables and Fruits frequently consumed by inhabitants of Elaziğ Region, Turkey. Journal of Radio-analytical and Nuclear Chemistry, 295, 1245 – 1249.

[8] El-Gamar H., Hussien M. T., Saleh E. E. (2019): Evaluation of natural radioactivity levels in soil and various foodstuffs from Delta Abyan, Yemen. Journal of Radiation Research and Applied Sciences 12(1);226-233

[9] Harb, S. and Michel, R., (2009): Uptake of U- and Th-series radionuclides by cereal crops in Upper Egypt. Nuclear Science and Techniques 20, 99 – 105.

[10] International Commission on Radiological Protection, (2012): Compendium of Dose Coefficients Based on ICRP Publication 60. ICRP Publication 119. Ann. ICRP 41.

[11] Jibiri N.N., Farai, I.P., Alausa, S.k., (2007): Estimation of annual effective dose due to natural radioactive elements in ingestion of foodstuffs in tin mining area of jos-plateau, Nigeria. J. Environ. Radioact. 94, 31 – 40.

[12] United Nations Scientific Committee on the effects of Atomic Radiation (2000). Report of UNSCEAR to the general assembly, United Nations, New York, USA.