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ASSESSMENT OF RADIONUCLIDE CONTENT IN SOME SELECTED TUBERS IN OGBOMOSO METROPOLIS OF SOUTH-WESTERN NIGERIA.

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Abstract

A radioactivity concentration survey was conducted in some commonly consumed tubers (Yam, Cassava and Sweet Potatoes) within Ogbomosho metropolis area of South Western Nigeria. The study area was divided into four zones (ABCD) based on soil formations of the study area and the tubers were collected from agricultural farms where they were produced. Food crop/tubers were dried at room temperatures until mass would change, powdered with the aid of pestle and mortar and then sieved with a 1.00 mm mesh. Gamma spectroscopy analysis of all the samples was done after they had attained secular equilibrium. Mean specific activity values obtained for ⁴⁰K, ²³⁸U and ²³²Th are 1190.76 ± 77.10 Bq/kg, 37.84 ± 6.22 Bq/kg and 17.52 ± 1.15 Bq/kg respectively for cassava (*Manihot esculenta*), 779.05 ± 43.36 Bq/kg, 40.49 ± 6.89 Bq/kg and 10.47 ± 0.84 Bq/kg respectively for Yam (*Discorea spp*) and 1282.83 ± 71.33 Bq/kg, 37.80 ± 6.51 Bq/kg and 21.13 ± 1.37 Bq/kg respectively for Potato (*Ipomoea batatas*). With these known, absorbed dose rate, radium equivalent activity, activity concentration index, external hazard index and effective dose rate were obtained. However, with the obtained values, the tubers are not expected to be harmful as consumed.

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Introduction

The earth contained varied levels of radioactivity due to chain decay of natural radio nuclides ^{238}U , ^{232}Th and ^{40}K (Saleh, 2011.). The effect of soil features, geological formations and human activities (farming, bush burning and mining) have correlation with the background levels of natural radiation (Jwanbot *et al.*, 2012). Significant contribution is done by the naturally occurring radionuclides of ^{238}Th and ^{238}U to ingestion dose and are present in the biotic system of plant, animal, soil, water and air (Jwanbot *et al.*, 2012). The exposures of Humans to naturally occurring radioactive materials (NORM) are through the environmental media such as; air, intake food, soil, water (through drinking, washing and bathing) and even within the bodies (Ademola, 2008, Avwiri *et al.*, 2013). The presence of radionuclides in food is at various level and it is enhanced by radioactivity content in soil and the transfer potentials through the environmental medium, food stuff and man linkages (Avwiri *et al.*, 2013). The common types of naturally occurring radionuclides series formed in the food chain are ^{238}U and ^{232}Th and their progenies, while the non-series one is the ^{40}K (the principal naturally occurring source of internal radiation), though it has a few isotopic abundances (ICRP, 2008, Avwiri *et al.*, 2013).

In this work, the radionuclides and the activity concentration of ^{238}U , ^{232}Th and ^{40}K were examined in some selected tubers (Yam (*Discorea spp*), Cassava (*Manihot esculenta*) and Sweet Potato (*Ipomoea batatas*)) in Ogbomoso area of Nigeria. It is important that the accessed food by the people is non-toxic and nutritionally sufficient (Jibiri *et al.*, 2007, Avwiri et al 2011). Natural radioactive element continues to exist in the various environmental compartment by entering into the ecosystem and food chain (Avwiri *et al.*, 2011).

Materials and Methods

Ogbomoso land which is approximately located between latitude $8^{\circ}1'11''\text{N}$ and longitude $4^{\circ}9'21''\text{E}$ of the Oyo North senatorial district of

Oyo state, Nigeria (Olafisoye *et al.*, 2013). It is one of the largest cities in the southern Nigeria. It comprises of Ogbomoso North, Ogbomoso south, Surulere, Ogo-Oluwa and Orire local governments area. Fig. 1 shows the geologic formation of the area.

The study area was divided into four zones (ABCD) based on the soil formations and a total of twelve (12) samples of Yam (*Discorea spp*), Cassava (*Manihot esculenta*) and sweet potato (*Ipomoea batatas*) were collected directly from the farm lands that fell within each soil formation. Substantial quantity of the tuber samples that would be sufficient for analysis was collected. All these food samples were native to this study and represent the common food crops and choice of daily food needs and requirements of the population.

The tubers were sliced into pieces and washed firstly with bore hole water and then in distilled water shortly after collection from the study area. The samples (A, B, C, D) were then sun dried for a week to attain a constant weight after which they were crushed in wooden mortal with pestle, homogenized and sieved through a 1.00 mm mesh size. They were then transferred into uncontaminated uniform plastic containers which were tightly sealed for a period of 28 days (4 weeks). This was done in order to allow Radon and its progenies to assume secular equilibrium prior to gamma spectroscopy. The specimens were exposed to spectrometry system that consisted of a shielded and calibrated 3 inches by 3 inches NaI(Tl) detector (a product of Gamma Tech., USA). This detector was coupled to GS -2000 – Gamma spectacular multi-channel analyzer for data analysis. An empty container was ab-initio counted for 10 hours to determine the background count. After attaining secular equilibrium, the samples were then introduced one after the other and counted for the same period as it was done with the empty container. The radionuclides characteristics for the measurement of the activity concentrations of the samples are 1460.0 keV, 1764.5 keV and 2614.7 keV for ^{40}K , ^{238}U and ^{232}Th respectively.

Fig. 1. Map of Nigeria and geologic map of Ogbomosho (Modified after Olafisoye *et al.*, 2013)

Result and Discussion

Radioactivity Concentration in Cassava (*Manihot esculenta*)

The Specific Activity for ^{40}K ranged from $748.74 \pm 41.68 \text{ BqKg}^{-1}$ in zone A to $1630.66 \pm 89.49 \text{ BqKg}^{-1}$ in zone C (Mean: $1190.76 \pm 77.10 \text{ BqKg}^{-1}$), ^{238}U ranged from BDL (Below Detection Level (0) BqKg^{-1}) in zone B to $94.81 \pm 15.18 \text{ BqKg}^{-1}$ in zone C (Mean : $37.84 \pm 6.22 \text{ BqKg}^{-1}$) and ^{232}Th ranged from $3.49 \pm 0.24 \text{ BqKg}^{-1}$ in zone B to $28.72 \pm 1.85 \text{ BqKg}^{-1}$ in zone C (Mean : $17.52 \pm 1.15 \text{ BqKg}^{-1}$) as presented in Table 1a. Absorbed Dose Rate (ADR) (Beck and Planque, 1968, Beck et al, 1972), ranged from

44.94 nGy/h in zone B to 115.03 nGy/h in zone C (Mean : 69.80 nGy/h). The Radium equivalent (Ra_{eq}) (UNCEAR, 1982), ranged from 90.94 BqKg^{-1} in zone B to 261.44 BqKg^{-1} in zone C (Mean : 154.59 BqKg^{-1}) as presented in Table 1b. The External Hazard Index (H_{ex}) (NEA, 1979, Shunga, 1988), ranged from 0.25 in zone B to 0.71 in zone C (Mean : 0.42) as presented in Table 1b. The Activity Concentration Index (ACI) (ECR, 1999), ranged from 0.38 in zone B to 1.00 in zone C (Mean : 0.61) as presented in Table 1b. The Effective Dose Rate (D_E), ranged from 31.46 mSv/y in zone B to 80.52 mSv/y in zone C (Mean : 48.86 mSv/y) as presented in Table 1b.

Table 1a. Specific Gamma activity concentration for Cassava (*Manihot esculenta*) in Ogbomoso, South western, Nigeria.

	^{40}K (Bq/kg)	^{238}U (Bq/kg)	^{232}Th (Bq/kg)
A	748 ± 41.68	54.07 ± 9.15	20.60 ± 67.49
B	1116.21 ± 62.73	BDL	3.49 ± 0.24
C	1630.66 ± 89.49	94.81 ± 15.18	28.72 ± 1.85
D	1267.44 ± 114.49	2.49 ± 0.54	17.28 ± 1.15
Mean	1190.76 ± 77.10	37.84 ± 6.22	17.52 ± 1.15

BDL means below detection level.

Table 1b. Absorbed Dose Rate (ADR), Radium equivalent activity (Ra_{eq}), External Hazard index (H_{ex}), Activity Concentration Index (ACI) and effective dose rate (D_E) for Cassava (*Manihot esculenta*) in Ogbomoso Southwestern, Nigeria.

	ADR (nGy/h)	REA (Bq/kg)	Hex	ACI	EDR (mSv/y)
A	60.83	141.18	0.38	0.53	42.58
B	44.94	90.94	0.25	0.38	31.46
C	115.03	261.44	0.71	1.00	80.52
D	58.38	124.79	0.34	0.52	40.87
Mean	69.80	154.59	0.42	0.61	48.86

Radioactivity Concentration in Yam (*Discorea spp*)

The Specific Activity for ^{40}K ranged from $285.75 \pm 16.63 \text{ BqKg}^{-1}$ in zone B to $1240.38 \pm 68.34 \text{ BqKg}^{-1}$ in zone C (Mean : $779.05 \pm 43.36 \text{ BqKg}^{-1}$), ^{238}U ranged from BDL (Below Detection Level (0) BqKg^{-1}) in zone B to $76.13 \pm 12.96 \text{ BqKg}^{-1}$ in zone C (Mean : $40.49 \pm 6.89 \text{ BqKg}^{-1}$) and ^{232}Th ranged from BDL (0) BqKg^{-1} in zone B to $28.99 \pm 1.87 \text{ BqKg}^{-1}$ in zone C (Mean : $10.47 \pm 0.84 \text{ BqKg}^{-1}$) as presented in Table

2a. Absorbed Dose Rate (ADR) (Beck and Planque, 1968, Beck et al, 1972), ranged from 11.03 nGy/h in zone B to 92.83 nGy/h in zone C (Mean : 51.37 nGy/h). The Radium equivalent (Ra_{eq}) (UNCEAR, 1982), ranged from 22.00 Bq/kg in zone B to 213.09 Bq/kg in zone C (Mean : 115.45 Bq/kg) as presented in Table 2b. The External Hazard Index (H_{ex}) (NEA, 1979, Shunga, 1988), ranged from 0.06 in zone B to 0.58 in zone C (Mean : 0.31) as presented in Table 2b. The Activity Concentration Index (ACI) (ECR, 1999), ranged from 0.10 in zone B

to **0.68** in zone C (Mean : **0.42**) as presented in Table 2b. The Effective Dose Rate (D_E), ranged from **7.72 mSv/y** in zone B to **65.00 mSv/y** in

zone C (Mean : **34.24 mSv/y**) as presented in Table 2b.

Table 2a. Gamma activity concentration for Yam (*Discorea* spp) in Ogbomoso, South western, Nigeria.

Site/location	^{40}K (Bq/kg)	^{238}U (Bq/kg)	^{232}Th (Bq/kg)
A	1227.11 ± 67.49	42.16 ± 7.24	9.97 ± 1.29
B	285.75 ± 16.63	BDL	BDL
C	1240.38 ± 68.34	76.13 ± 2.96	28.99 ± 1.87
D	362.96 ± 20.98	43.67 ± 7.35	2.91 ± 0.19
Mean	779.05 ± 43.36	40.49 ± 6.89	10.47 ± 0.84

BDL means below detection level.

Table 2b. Absorbed Dose Rate (ADR), Radium equivalent activity (Ra_{eq}), External Hazard index (H_{ex}), Activity Concentration Index (ACI) and effective dose rate (D_E) for Yam (*Discorea* spp) in Ogbomoso Southwestern, Nigeria.

Site/location	ADR (nGy/h)	REA (Bq/kg)	Hex	ACI	EDR (mSv/y)
A	69.05	150.90	0.41	0.60	41.43
B	11.03	22.00	0.06	0.10	7.72
C	92.83	213.09	0.58	0.68	65.00
D	32.55	75.77	0.20	0.28	22.79
Mean	51.37	115.45	0.31	0.42	34.24

Radioactivity Concentration in Potato (*Ipomoea batatas*)

The Specific Activity for ^{40}K ranged from **568.58 ± 32.25 BqKg⁻¹** in zone B to **1674.71 ± 92.33 BqKg⁻¹** in zone A (Mean : **1282.83 ± 71.33 BqKg⁻¹**), ^{238}U ranged from BDL (Below Detection Level (0) **BqKg⁻¹** in zone B to **59.23 ± 10.15 BqKg⁻¹** in zone D (Mean : **37.80 ± 6.51 BqKg⁻¹**) and ^{232}Th ranged from **16.18 ± 1.07 BqKg⁻¹** in zone B to **27.91 ± 1.79 BqKg⁻¹** in zone A (Mean :

21.13 ± 1.37 BqKg⁻¹) as presented in Table 2a. Absorbed Dose Rate (ADR) (Beck and Planque, 1968, Beck et al, 1972), ranged from **30.50 nGy/h** in zone B to **93.93 nGy/h** in zone C (Mean : **75.39 nGy/h**). The Radium equivalent (Ra_{eq}) (UNCEAR, 1982), ranged from **22.00 BqKg⁻¹** in zone B to **213.09 BqKg⁻¹** in zone C (Mean :

115.45 Bq/kg) as presented in Table 2b. The External Hazard Index (H_{ex}) (NEA, 1979, Shunga, 1988), ranged from 0.06 in zone B to 0.58 in zone C (Mean : 0.31) as presented in Table 2b. The Activity Concentration Index (ACI) (ECR, 1999), ranged from 0.10 in zone B

to 0.68 in zone C (Mean : 0.42) as presented in Table 2b. The Effective Dose Rate (D_E), ranged from 7.72 mSv/y in zone B to 65.00 mSv/y in zone C (Mean : 34.24 mSv/y) as presented in Table 2b.

Table 3a. Gamma activity concentration for Potato (*Ipomoea batatas*)

Site/location	^{40}K (Bq/kg)	^{238}U (Bq/kg)	^{232}Th (Bq/kg)
A	1674.71 ± 92.33	33.71 ± 5.81	27.91 ± 1.79
B	568.58 ± 32.25	BDL	16.18 ± 1.07
C	1521.62 ± 84.38	58.25 ± 10.06	23.68 ± 1.53
D	1366.40 ± 76.34	59.23 ± 10.15	16.68 ± 1.09
Mean	1282.83 ± 71.33	37.80 ± 6.51	21.13 ± 1.37

BDL means below detection level.

Table 3b. Absorbed Dose Rate (ADR), Radium equivalent activity (Ra_{eq}), External Hazard index (H_{ex}), Activity Concentration Index (ACI) and effective dose rate (D_E) for Potato (*Ipomoea batatas*) in Ogbomoso Southwestern, Nigeria.

	ADR (nGy/h)	REA (Bq/kg)	Hex	ACI	EDR (mSv/y)
A	92.52	202.57	0.55	0.81	64.76
B	30.50	66.92	0.18	0.27	21.35
C	93.93	209.28	0.57	0.82	65.75
D	84.62	188.30	0.51	0.74	59.23
Mean	75.39	166.77	0.45	0.66	52.77

Conclusion.

The results showed that all tubers majorly absorbed ^{40}K more than ^{238}U and ^{232}Th . This is due to the fact that potassium is an essential element and tubers do not have the ability of differentiating each element, thus ^{40}K is preferred above the two other radionuclides. Cassava from Surulere local government (C) absorbed the highest amount of ^{40}K concentration of $1630 \pm 89.49 \text{ Bq/kg}$ through root and leaves uptake as a result of atmospheric

deposit. The activity concentration of the natural radionuclides in the food crops ranged from $(285.75 \pm 16.63 \text{ and } 1674.71 \pm 92.33) \text{ Bq/kg}$ for ^{40}K , $(2.49 \pm 0.54 \text{ and } 15.18 \pm 1.34) \text{ Bq/kg}$ for ^{238}U , $(2.91 \pm 0.19 \text{ and } 28.99 \pm 1.87) \text{ Bq/kg}$ for ^{232}Th . However, the results of the study indicate that the dose taken from ^{238}U and ^{232}Th intake are low and are not harmful, while that of ^{40}K is a little bit higher against the recommended limit of 100 Bq/kg (WHO, 2012), this can cause high level of potassium in the blood (Ozanne, 2015).

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