ACTIVITY CONCENTRATIONS AND ABSORBED DOSE EQUIVALENT OF COMMONLY CONSUMED VEGETABLES IN ONDO STATE, NIGERIA .

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Abstract

The activity concentrations of ^{40}K, ^{238}U and ^{232}Th in some vegetables commonly consumed in Akure, Idanre and Agbabu have been measured using the gamma ray spectrometer consisting of a lead shielded 76mm by 76mm NaI (Tl) detector crystal coupled to a Canberra series 10 plus multichannel analyzer. With particular focus on Agbabu to serve as reference for future radioactivity monitoring after the schedule exploitation of the bitumen in the town. The highest concentration of ^{40}K was obtained in Talium Triangulare with value 2459.73Bqkg^{-1}, Talium Triangulare was found also to contain highest concentration ^{238}U with value 97.57Bqkg^{-1} and African Spinach was found to contain the highest level of ^{232}Th with value 18.44Bqkg^{-1}. All these highest concentrations were obtained in vegetables from Idanre. The lowest concentration of ^{40}K was obtained in Telfairia Occidentalis with mean value of 721.86Bqkg^{-1}, Solanium Macncarpon was found to contain the lowest concentration value 2.36Bqkg^{-1}and Corchorous Olitorious contained lowest concentration of ^{232}Th with value 6.23Bqkg^{-1} in Akure and Agbabu. The equivalent dose rates due to intake of the vegetables were determined. The mean effective dose equivalent for Akure, Idanre and Agbabu were 0.59mSvyr^{-1}, 0.73mSvyr^{-1} and 0.64mSvyr^{-1}. These translate to collective doses of 2.95x10^{2}manSvyr^{-1}, 1.46x10^{1}manSvyr^{-1} and 1.28x10^{1}manSvyr^{-1} for Akure, Idanre and Agbabu respectively. All these values are lower than the recommended 2.4mSvyr^{-1} (UNCEAR, 1993) for normal background.

Keywords: *Activity concentrations, vegetables, NaI (Tl) detector, bitumen, equivalent dose rates.*

Introduction

Our world is radioactive. This has been the case since it was created. Over 60 radionuclides (radioactive elements) can be found in nature, and they can be placed in three general categories: Primordial - from before the creation of the earth. Cosmogenic - formed as a result of cosmic ray interactions. Artificial Radionuclides - enhanced or formed due to human actions (minor amounts compared to natural radio nuclides). Radionuclides are found naturally in air, water and soil. They are even found in human being, being that we are the products of our environment. Everyday, we ingest and inhale radionuclides in air, food and water (Olomo, 1990). Natural radioactivity is common in the rocks and soil that make up the planet, in water and oceans, and in building materials. Vegetables are vital in our diet and presence of natural radionuclides

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^{40}K, ^{238}U and ^{232}Th in them have certain radiological implications not only in the food but also on the populace consuming these vegetables (Fortunati et al. 2004). This study investigated the activity concentrations of ^{40}K, ^{238}U and ^{232}Th in some vegetables commonly consumed in Akure, Idanre and Agbabu, with particular focus on Agbabu – a bitumen rich area – serve as reference for future radioactivity monitoring after the schedule exploitation of the bitumen in the town.

Materials and Methods

The criteria for selection of the vegetables were to represent different vegetable types that are commonly consumed by the people in the selected locations. The selection of sites was such that: Agbabu was selected to represent a bitumen-rich area; Idanre, being a rocky area, is selected for the high radioactivity associated with such landscape; while Jegele, a small settlement near Akure, is picked to serve as a control experiment. Seven commonly consumed vegetables were collected from Jegele village near Akure; five same vegetable types were collected from Idanre and six same vegetable types available during this investigation were collected from Agbabu. The vegetables were collected from local farmers from each location. The whole plant was not used in the measurement but only the edible portions were used (IAEA, 1989). The vegetables were hand cleaned to remove soil particles so as not to contaminate them and then washed with tap water. These are then oven-dried at 80^0C until constant weight was attained and ground to powder with electrical blender. These were packed in 50g lots by weight and sealed in airtight plastic container. They were thereafter left for 28 days in order for the gaseous daughters of U and Th series to reach secular equilibrium before counting.
Radioactivity counting in this work was carried out using a lead shielded 76mm x 76mm NaI (Tl) detector crystal (Model No 802 Series) by Canberra Inc., which is coupled to a Canberra series plus 10 Multi channel analyzer (MCA) (Model No 1104) through a preamplifier base. The detector used has a resolution of about 8% at 0.662MeV line of ^{137}Cs for the measurement of ^{40}K, ^{238}U and ^{232}Th. Photo peaks region of (1.460MeV) ^{40}K, (1.76MeV) ^{214}Bi and (2.615MeV) ^{208}Tl were used respectively. Each sample was counted for 36,000s (10 hours).

Results and Discussion

The value and the associated errors ($\pm\sigma$) in the concentration of ^{40}K, ^{238}U and ^{232}Th measured in vegetable samples in Jegele Akure are presented in Table 1. Fig 1 is a bar chart representing the measured values in Jegele Akure. The activity of ^{40}K range from 721.60 ± 36.44Bqkg^{-1} to 2376.91 ± 120.23Bqkg^{-1} with highest concentration in Gbure (*TaliumTriagulare*) and lowest in Ugwu (*Telfairia Occidentalis*). The activity of ^{238}U found in vegetable samples ranged from 2.38 ± 0.14Bqkg^{-1} to 51.94 ± 39.40Bqkg^{-1} with highest in Igbo (*Solanium macncarpon*) and lowest concentration in Ewedu(*Corchorous Olitorious*). The activity of ^{232}Th ranged from ND to 14.43 ± 2.99Bqkg^{-1}with highest concentration in Ewuro (*Vernonia Amygdalina*) obtained from Jegele in Akure. Concentrations of ^{40}K, ^{238}U and ^{232}Th measured in samples in Idanre are presented in Table 2. Fig 2 is the bar chart representing the measured values. The activity of ^{40}K range from ND to 2459.73 ± 62.52Bqkg^{-1} with highest concentration in Gbure (*TaliumTriagulare*) and lowest in Ugwu (*Telfairia Occidentalis*). The activity of ^{238}U in the vegetable samples ranged from ND to 97.57 ± 5.28Bqkg^{-1} with highest concentration in Gbure (*TaliumTriagulare*). The concentration of ^{232}Th range from ND to 18.44 ± 1.78Bqkg^{-1} with highest concentration in Rorowo (*African spinach*).
Concentrations of ^{40}K, ^{238}U and ^{232}Th measured in vegetable samples collected in Agbabu are presented in Table 3. Fig 3 is the bar chart representing the measured values. The activity of ^{40}K range from 986.32 ± 50.73Bqkg^{-1} to 2208.69 ± 65.60Bqkg^{-1} with highest concentration in Gbure (*TaliumTriagulare*) and lowest in Ugwu (*Telfairia Occidentalis*). The activity of ^{238}U in the vegetable samples ranged from 2.36 ± 0.34Bqkg^{-1} to 56.65 ± 2.83Bqkg^{-1} with highest concentration in Gbure (*TaliumTriagulare*) and lowest in Igbo (*Solanium macncarpon*). The activity of ^{232}Th range from 6.23 ± 0.76Bqkg^{-1} to 15.99 ± 3.32Bqkg^{-1}with highest concentration in Ugwu (*Telfairia Occidentalis*) and lowest in Ewedu(*Corchorous Olitorious*).

Table 1: Radioactivity concentrations of vegetables in Jegele, Akure

Sample	^{40}K (Bqkg^{-1})	^{238}U(Bqkg^{-1})	^{232}Th (Bqkg^{-1})
C_1	1725.28 ± 85.44	27.96 ± 5.26	12.34 ± 1.83
C_2	721.60 ± 36.44	28.94 ± 5.26	8.54 ± 1.71
C_3	2376.91 ± 120.23	32.93 ± 4.60	11.71 ± 2.06
C_4	893.75 ± 44.19	8.56 ± 1.20	14.48 ± 2.99
C_5	779.54 ± 50.61	51.94 ± 39.40	ND
C_6	1613 ± 88.8	47.66 ± 17.16	ND
C_7	1287.00 ± 32.17	2.38 ± 0.14	12.83 ± 1.66
Weighted mean	1342 ± 30.63	28.62 ± 12.89	11.98 ± 0.79

C_1 = Amaranthus spp

C_2 = Telfairia Occidentalis

C_3 = Talium Triangulare

C_4 = Venonia amygdalina

C_5 = Solanium macncarpon

C_6 = African Spinach

C_7 = Corchorous Olitorius

Table 2: Radioactivity concentrations of the radionuclide in Idanre

Sample	^{40}K (Bqkg^{-1})	^{238}U(Bqkg^{-1})	^{232}Th(Bqkg^{-1})
C_1	1075.67 ± 52.52	42.46 ± 3.80	14.34 ± 2.95
C_2	ND	ND	ND
C_3	2459.73 ± 62.52	97.57 ± 5.28	9.85 ± 0.94
C_4	1169.16 ± 30.31	25.01 ± 2.13	8.38 ± 1.11
C_6	1209.28 ± 90.52	26.75 ± 3.06	18.44 ± 1.78
Weighted mean	1478.31 ± 21.63	47.95 ± 1.15	12.75 ± 0.79

C_1 = Amaranthus spp

C_2 = Telfairia Occidentalis

C_3 = Talium Triangulare

C_4 = Venonia amygdalina

C_6 =African Spinach

ND = Not Detected

Table 3 Radioactivity concentrations of vegetables in Agbabu

Sample	^{40}K (Bqkg^{-1})	^{238}U(Bqkg^{-1})	^{232}Th (Bqkg^{-1})
C_1	1764.79 ±113.54	26.09 ± 4.41	8.23 ± 2.18
C_2	986.32 ± 50.73	9.88 ± 1.97	15.99 ± 3.32
C_3	2208.69 ± 65.60	56.65 ± 2.83	12.04 ± 1.27
C_4	1153.14 ± 56.57	17.99 ± 3.04	10.32 ± 1.36
C_5	1278.90 ± 68.34	2.36 ± 0.34	13.06 ± 2.73
C_7	1286.49 ± 38.81	7.06 ± 1.31	6.23 ± 0.76
Weighted mean	1446.39 ± 23.54	20.01 ± 1.30	10.98 ± 0.91

C_1 = Amaranthus spp

C_2 = Telfairia Occidentalis

C_3 = Talium Triangulare

C_4 = Venonia amygdahna

C_5 = Solanium macncarpon

C_7= Corchorous Olitorius

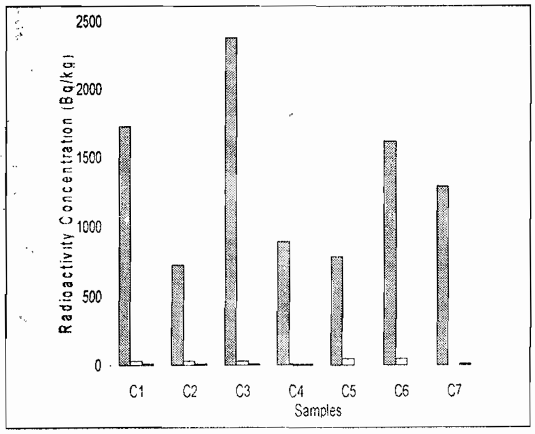

Fig. 1. Bar chart representing measured values in Jegele-Akure

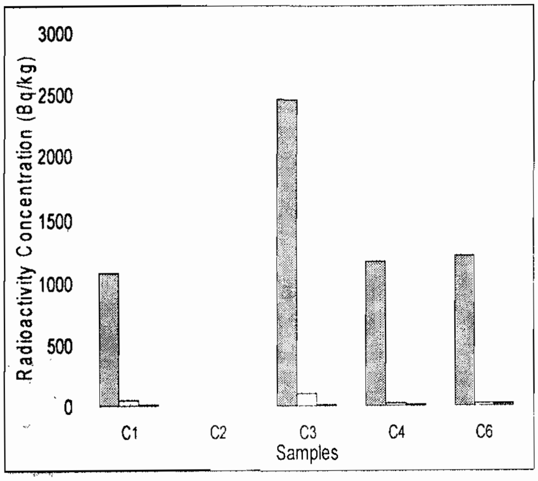

Fig. 2: Bar chart representing measured values in Idanre

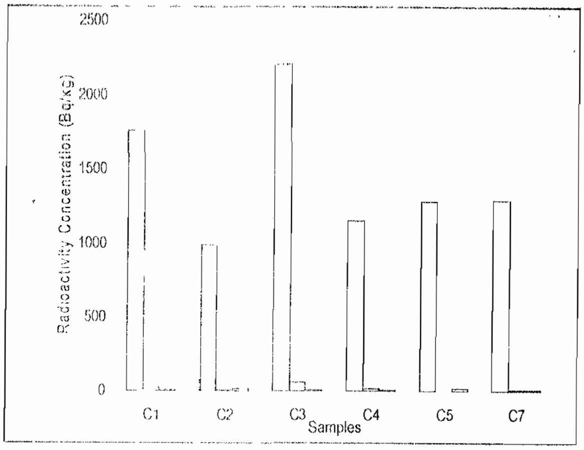

Fig. 3: Bar chart representing measured values in Agbabu

The doses received by a person consuming aquatic foodstuffs were reported by (Farai and Oni, 2002; Jibri and Farai, 1998) which they found to be dependent on the radionuclides concentration of the food and the quantity taken. The effective dose incurred from a single radionuclide by an individual consuming a foodstuff is given as (Badran, et al. 2003)

$$H_{rf} = G_{rf}\, C_{rf}\, U_r$$

where,

H_{rf} = effective dose equivalent by ingestion of nuclide (Sv/y)

G_{rf} = dose conversion factor by ingestion of nuclide (Sv/Bq)

C_{rf} = activity concentration of nuclide in ingested food (Bq/kg)

U_r = consumption of vegetable (kg/y)

The dose calculations were based on the assumptions that each person obtained food according to the consumption defined by in the food balance sheet (FAO,2000) and radionuclide dose conversion factors for ^{40}K, ^{238}U and ^{232}Th are 5 X 10^{-9} Sv/Bq, 4.6 X10^{-8} Sv/Bq and 2.3 X 10^{-7} Sv/Bq respectively for adults (ICRP, 1994). The mean effective dose for Jegele Akure was 0.59mSvyr^{-1}, 0.73mSvyr^{-1} for Idanre and 0.64mSvyr^{-1} for Agbabu. The annual collective effective dose equivalents in the towns were obtained using ICRP expression.

$$S_e = H_i\, N\,(H)_i$$

S_e = collective effective dose equivalent

H_i = Average annual effective dose equivalent

$N\,(H)_i$ = number of individuals in the population sub group in the area.

This translates to a collective dose equivalent of 2.95x10^{2}manSvyr^{-1} for Jegele Akure, 1.46x10^{1}manSvyr^{-1} for Idanre and 1.28x10^{1}manSvyr^{-1} for Agbabu when population values of 499,999, 19,999 and 19,999 (Encarta, 2000) was used for Jegele, Idanre and Agbabu respectively.

Conclusion

The method of gamma spectrometry has been used to determine the radioactivity concentrations of vegetable samples in Jegele, Idanre and Agbabu. The three natural radionuclides were unevenly distributed in all the samples. Concentration of ^{40}K is high in the tested vegetable samples because potassium concentrates in leaves, the edible parts more than any other parts of the plant (Arogunjo, 2003). Another reason is traceable to increased use of potassium rich fertilizer. The concentrations in Agbabu was in between that of Jegele and Idanre, which does not pose any risk level for problems associated with radioactivity The effective dose equivalent may increase with the exploitation of the bitumen due to the disturbance of the natural equilibrium. The concentration in Idanre was high because the land is rocky which confirms the statement that igneous rocks are source of the primordial radionuclides. The mean effective dose equivalent for consumption of these vegetables are below 2.4mSvyr^{-1} recommended for the normal background (UNSCEAR, 1993) which shows that the consumption of the investigated vegetables does not convey any risk to the health of population in the towns considered.

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