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Gross alpha and beta activity concentrations in soil and some selected Nigerian food crops

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Gross alpha and beta activity concentrations in soil, cassava and fluted pumpkin (leaf and stem) were investigated using a gas flow proportional counter. The gross alpha activity concentrations for the fluted pumpkin were between 3.55 and 13.95 Bq/Kg and 3.53 and 3.61 Bq/Kg for the leaves and stems, respectively. The gross alpha activity concentrations for cassava and soil samples ranged from 0.07 to 0.60 Bq/Kg and 0.35 to 0.53 Bq/Kg, respectively while the gross beta activity concentrations ranged from 0.43 to 0.89 Bq/Kg and 0.46 to 1.04 Bq/Kg for the cassava and soil samples, respectively. The gross alpha and beta activity concentrations in cassava, fluted pumpkin and soils samples have been determined using alpha/beta spectroscopy. The result of thestudy showed that the Iva-valley coal mine area has lower gross alpha and beta activity concentrations compared to other areas of the country. This shows that the coal mining activities in the area may not have increased the radiation burden of the area.

Key words: Gross, alpha, beta, concentration, activity, food, crop.

INTRODUCTION

Geographical location upon the earth surface influences the level of terrestrial radiation as a result of the radionuclides concentration in soil which largely depend on the local geology (Farai and Jibiri, 2000; Jibiri and Bankole, 2006). So, as plant uptake of radionuclides varies from species to species and also from place to place, the intake of different food products forms a secondary source of exposure to radionuclides (Addo et al., 2013).

The quality of foodstuffs produced is to a large extent dependent on the nutritional status of the soil on which they are grown (Jibiri, 2001), likewise the distribution of radionuclides in the different segments of a plant is dependent on the chemical characteristics and several other parameters contributing to the soil-plant interactions (Shanthi et al.,2009).

There are two mechanisms for the contamination of vegetation, that is, by root uptake or directly by aerial

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deposition of fallout radionuclides on plants. It is necessary to carry out an accurate assessment of these radionuclides in the daily used food materials in order to ascertain the degree of risk and deleterious effects to the public health. Fluted pumpkin and cassava are food sources largely consumed daily in Nigeria, this make them potential radioactive contamination pathway for the local population. Fluted pumpkin which is a leafy vegetable is found in most delicacies consumed in Nigeria, whereas cassava (a tuber) constitutes one of the major food sources for carbohydrates. The analysis of these radionuclides in soil and food stuffs is an important part of the environmental monitoring program. These natural radioactive sources are the largest contributor of the radiation dose received by mankind. This researched is aimed at estimating the level of radionuclide concentrations found in these staple food sources.

MATERIALS AND METHODS

Study area

The study area is the old coal mining area of Enugu Urban area, located approximately at Latitude 06° 301°N and Longitude 07° 301°E in the Southern part of Nigeria. The study area is bounded in the Iva Valley Coal Mine Settlement area of Enugu, South- Eastern Nigeria, Located within the Coordinates of 6° 27’0”N and 7° 27’0”E. The area is famous for its coal mining activities (Amakom et al., 2015). There are road networks that connects or link to each of the urban areas in the state.

Sample collection

The cassava and fluted pumpkin (leaf and stem) samples were collected in four different farms within the old coal mine area.

Four different samples of cassava specimens were collected from the selected farms while fluted pumpkins were collected in two farms along the bank of the Ekulu River that snakes from the Iva-valley into the main urban areas of Enugu. At the point of collection of the individual cassava and fluted pumpkin samples, soil samples were also collected at a depth of 10 cm, which is assumed to be the rooting zone of the plants. About 1 kg of soil samples were collected at each sample point using a hand trowel and black polythene bags. All the collected samples were labeled accordingly and transported to the laboratory for further analysis.

Sample preparation

The crops (fluted pumpkin and cassava) were thoroughly washed with tap water and then rinsed with distilled water to remove surface sand and other forms of contamination. In the laboratory, the cuticles of the cassava were removed with a stainless steel knife (previously rinsed with distilled water) and the edible parts were cut into pieces of about 10 mm^2 and put together in polyethylene materials for refrigeration. The samples were freeze-dried for three days after which they were grinded by means of a cleaned industrial blender and kept separately in their respective containers (which were previously washed and rinsed with distilled water and dried). The samples were then oven dried at a constant temperature of 100°C until a constant mass was achieved.

For the fluted pumpkin, the leaf was separated from the stem and both the leaf and stem were sun-dried for three days, and then oven dried at a temperature of 100°C until a constant weight was attained. The soil samples were also sun-dried for 3 days, after which they were oven dried to attain a constant mass.

Each sample was further crushed and sieved using a 60 µm mesh sieve to obtain smaller grain-sized particle. The individual samples were weighted and sealed-packed in 500 ml plastic containers and was ready for alpha/beta spectroscopy.

Instrumentation

The equipment used for the gross alpha and gross beta counting is a gas flow proportional counter with 450 mg/cm^3 thick window of diameter 0.06 m. It is a EURISYS MEASURE IN20 low background multiple (eight) channel alpha and beta counter. The counting system incorporates an anti-coincident guard counter used to eliminate interference from high-energy cosmic radiation into the measuring environment. The chambers are covered with 0.1 m lead and the inside dimensions are 0.48 × 0.28 × 0.10 m^3 with stainless steel linings to prevent part of ambient gamma rays from entering the measuring environment. Thus the only contribution to the counting would be from impurities in the chamber constructing materials. The counting gas is an argon-methane mixture in the ratio of 90 to 10%. For signal processing purpose, the system is connected to a microprocessor IN – SYST, a spreadsheet programme, QUARTTRO – PRO and a graphic programme MULTIPLAN (Akpa et al., 2004).

The beta and alpha specific activities were calculated using the following expression (Jibiri and Fasae, 2012):

$$\text{Specific activity } (\alpha, \beta) = \frac{\text{C.R } (\alpha,\beta) - \text{B.C.R}(\alpha,\beta)}{\text{S.E} \times \text{C.E} \times \text{W}} \quad (1)$$

Where C.R is the counting rate, B.C.R is the background counting rate, S.E is sample efficiency, C. E is channel efficiency and W is weight of sample.

The detector background measurement is aimed at getting the channel efficiency. It was carried out with empty counting planchette, washed with deionized water and dried. The operational high voltages, 1600 V for alpha and 1700 V for beta was set and background radioactivity was measured for thirteen cycles for 900s per cycle for alpha background and twenty-five cycles of 180s per cycle for beta. A histogram and a scatter graph of the counts against channel number were obtained for all the eight channels measured simultaneously. The background count rates were recorded in counts per minute in alpha only and beta only modes.

RESULTS AND DISCUSSION

The results of the gross alpha and beta activity concentrations in the Fluted pumpkin (*Ugu*) leaf, stem and their constituent soils are presented in Table 1. The alpha activity concentrations for the Ugu leaf were 3.55 ± 2.05 and 13.95 ± 4.03 Bq/Kg for the locations 1 and 2 respectively while their corresponding beta activity concentrations were 80.32 ± 2.25 and 12.67 ± 1.82 Bq/Kg. The gross alpha activity concentrations for the Ugu stems were 3.61 ± 2.08 and 3.53 ± 2.04 Bq/Kg for the locations 1 and 2 respectively with a corresponding gross beta activity of 20.04 ± 1.93 and 23.47 ± 1.91 Bq/Kg respectively. The gross alpha activity concentrations for the soils locations were 8.82 ± 3.38

Table 1. Gross alpha and beta activity concentrations in leaf, stem and soil samples.

S/N	Sample ID	Sample type	Alpha activity (Bq/kg)	Beta activity (Bq/kg)
1	UL1	Leaf	3.55±2.05	80.32±2.25
2	UL2	Leaf	13.95±4.03	12.67±1.82
3	US1	Stem	3.61 ± 2.08	20.04±1.93
4	US2	Stem	3.53 ± 2.04	23.47±1.91
5	SOI 1	Soil	8.82 ± 3.38	196.30±2.98
6	SOI 2	Soil	10.15±3.54	87.11 ± 2.04

Table 2. Gross alpha and beta radioactivity concentrations for cassava samples.

S/N	Gross alpha and beta radioactivity concentrations			
	Sample ID	Sample type	Alpha activity (Bq/kg)	Beta activity (Bq/kg)
1	A1F	Cassava	0.39 ± 0.02	0.65 ± 2.66
2	A1S	Soil	0.37 ± 0.01	0.69 ± 2.84
3	A2F	Cassava	0.07 ± 0.02	0.43 ± 2.70
4	A2S	Soil	0.53 ± 0.02	0.46 ± 2.71
5	A3F	Cassava	0.28 ± 0.01	0.63 ± 2.83
6	A3S	Soil	0.45 ± 0.02	0.53 ± 2.54
7	A4F	Cassava	0.60 ± 0.02	0.89 ± 2.60
8	A4S	Soil	0.35 ± 0.02	1.04 ± 2.35

and 10.15 ± 3.54 Bq/Kg for locations 1 and 2 respectively while the gross beta activity concentrations were 196.30 ± 2.98 and 87.11 ± 2.04 Bq/Kg for the locations 1 and 2, respectively.

A higher gross alpha activity concentrations were recorded for the leaves of the fluted pumpkin than the stems, while that of the gross beta activity concentrations varies. The gross alpha activity from the old coal mine area was quite lower than that obtained for vegetables in old Uranium mine site in Udaipur, Rajasthan (Pathak and Pathak, 2012).

The results for the gross alpha and beta activity concentrations in cassava crop and their constituent soils are presented in Table 2. The gross alpha activity concentrations for cassava and soil samples ranged from 0.07 to 0.60 Bq/Kg and 0.35 to 0.53 Bq/Kg, respectively while the gross beta activity concentrations ranged from 0.43 to 0.89 Bq/Kg and 0.46 to 1.04 Bq/Kg for the cassava and soil samples, respectively.

Generally, the ranges of the beta activity concentrations were observed to be higher than that of the alpha activity concentrations. The results obtained in this study were slightly low when compared with the mean gross alpha and beta activity concentration reported by Jibiri and Fasae (2013), which reported that the gross beta activity concentration for farm soils from the northern part of Nigeria varied from 360.0 to 570.0 Bq/kg while for the alpha activities it varied from 8.0 to 40.0 Bq/kg. Also, the results obtained from this work are slightly lower when compared to the work done by Ogundare and Adekoya (2015). They reported that the mean gross alpha and beta activities in soil samples were between 32.0 and 64.0 Bq/kg and 411.5 and 2710.0 Bq/kg, respectively. The mean gross alpha activities is much lower than those of selected oil fields around Imirigin, Bayelsa state and Rivers State (Anekwe et al., 2013; Meindinyo and Agbalagba, 2012).

Conclusion

The gross alpha and beta activity concentrations in cassava, fluted pumpkin and soils samples have been determined using alpha/beta spectroscopy. The result of this study showed that the Iva-valley coal mine area has lower gross alpha and beta activity concentrations compared to other areas of the country. This shows that the coal mining activities in the area may not have increased the radiation burden of the area.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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