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Assessment of the Concentrations of ^{226} Ra, ^{228} Th, and ^{40} K in the Foods Stuff by Residents of Agona East District in the Central Region.

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ABSTRACT

In order to assess potential radiological dangers to human health, it is especially important to assess the levels of radioactivity in human nutrition. At the Ghana Atomic Energy Commission's Gamma Laboratory, studies of radioactivity concentrations in foods like cowpea, yam, millet, plantain, rice, cocoyam, potatoes, and cassava have been conducted. Gamma spectrometry systems have been used to quantify radionuclides of interest like Radium-226, Thorium-228, and Potassium-40. The average concentration values of 226Ra, 228Th, and 40K were found to vary between 276.88, 597.75 and 15564Bqkg-1 in all the food items that were recorded. The potassium levels in all food samples were found to be high, ranging from 217 -56342BqKg-1. Thorium-228 and Potassium-40 were discovered in the highest concentrations in cassava (2282 and 56342 BqKg-1, respectively). 4.05 mSv was found to be the total annual committed effective dosage after investigation. Plantains and cassava are the biggest donors to daily radionuclides from food consumption, whereas millet is the lowest. The concentrations of radionuclides were similar to those documented in other nations.

Keywords: Radionuclide, Agona East, Effective dose, Foodstuff, Internal dose.

INTRODUCTION

Radionuclide concentrations and distributions are of interest because they provide useful information for tracking environmental radioactivity. Food crops may be at risk from both direct and indirect radioactive contamination with uranium series radionuclides. Fertilizer application promotes the advancement of uranium series nuclides in food crops. [1].Phosphates are used in agriculture, which causes contamination of the land during cultivation. Phosphates are chemically harmful, but they may also pose a risk to radiological health. Phosphate rock has uranium concentrations ranging from 30 to 260 ppm. [2]

Phosphate fertilizers and by-products have the ability to increase and redistribute potassium-40 and radium-226 concentrations in soil. Foods are known to include both naturally occurring and man-made radionuclides, which when consumed, add to an internal dose that is effective. Radionuclide occurrences, particularly those of potassium-40, thorium-232, and uranium-238, are the main cause of man's natural radiation exposure. Food consumption has been found to be responsible for at least one-eighth of the mean yearly effective dosage resulting from natural sources [3].

Man-made radionuclides, such as Ceasium-137, are a source of environmental concern since they are produced by human activity and add to environmental radioactivity [4]. It is essential to establish a baseline value for the contamination assessment of the foods consumed by the populace. Naturally, occurring radionuclides of uranium and thorium are found in the biotic system of the soil, plants, animals, air, and water. They are important contributors of the ingested dosage. Studies have been conducted in a number of nations to determine the concentration of radionuclides in different food samples and to estimate the dose that the public consumes [5].

Numerous scientists have investigated the presence of radioactivity in plant organs. [6, 7].In Ghana, the most widely available and often consumed foods include millet, beans, cassava, rice, potatoes, yam, and cocoyam. A radiometric baseline value would be established by this study for future research in the Greater Accra Region and other areas.

2. STUDY AREA

Agona East District is one of the twenty-two districts in Eastern Region, Ghana. It is situated in the eastern corner of the Central Region and has Nsaba as its capital town The District has one constituency and five Town/Area. Agona East District has coordinates: 5°38′35.88″N 0°45′2.88″W/ 5.6433000°N

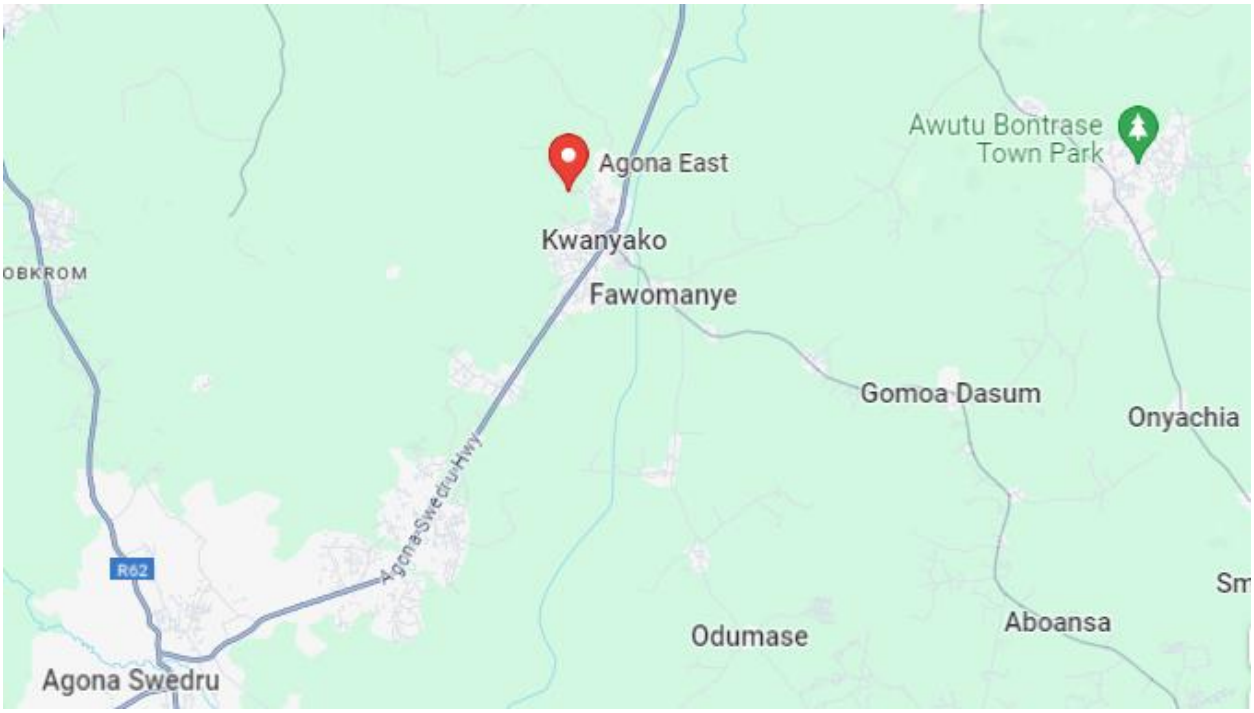

Fig 1: Map of Study Area

METHODOLOGY

Farmers have been using artificial fertilizers, such as phosphate, to grow land in the region for the past 30 years. This process involves sampling and measuring the fertilizer. In order to assess the effective dosage equal to human intake, it is necessary to analyze the amounts of radionuclides in food items. Eight different markets were randomly chosen for this purpose. We sampled and analyzed eight distinct food samples from eight distinct markets. Samples of food were cleaned, dried in the air, and peeled as needed. After drying for roughly 15 hours at 800C, they were ground into a powder for examination [9]. Each sample was weighed, then carefully sealed and placed into a 1000 ml Marineth beaker [10]. The RPI laboratory uses a high-efficiency sodium iodide detector to measure the amount of radionuclides that release gamma rays in the samples. The gamma spectrum was assessed using the PC-based 1024 multichannel analyzer and MAESTRO-32 software. Physikatlisch Technische Bundesanstalt PTB, Germany supplied a 1L Marineth beaker with a mixed gamma standard inside for the purpose of calibrating the detector's efficiency and energy. A cylindrical Lead castle with an inside copper well of 3 mm in thickness was used to shield the detector.

3.1 ACTIVITY CONCENTRATIONS CALCULATIONS

The identified phosphates in the spectra were used to compute the activity concentration for ^{226}Ra, ^{228}Th, and ^{40}K. Two weeks before to gamma counting, the samples were kept in storage for a minimum of one month. 609 keV from 214Bi, 911 keV from ^{228}Ac, and the 2614 keV peak from ^{208}Ti were used to gather the data for investigations ^{226}Ra and ^{228}Th. From 661.7 KeV, the activity concentration of Cesium-137 was studied [11]. Using 1460KeV gamma live, the activity concentration of potassium-40 was studied [12].We calculated the activity concentration A_ρR in BqKg-1 using the following equation.

$$A_{\epsilon R} = \frac{N_{\epsilon R}}{\epsilon_E \times t \times \gamma d \times m}$$

γd is the gamma-ray yield per nuclide disintegration, and t is the counting live time in seconds. R is the energy transition. The sample's mass, expressed in kilograms, is E. m. The detector's energy-dependent efficiency at energy E is denoted by ϵE. The net peak - area of radionuclide R at energy E is denoted by NρR. AρR represents the concentration of activity, R denotes a radionuclide, and E is derived from the equation.

4. 0 RESULTS AND DISCUSSION

Investigations were conducted on the activity concentration of ^{226}Ra, , ^{228}Th, and ^{40}K in eight distinct food items from eight distinct markets at Agona east in the Central region. The food items had concentration amounts of ^{226}Ra, ^{228}Th, and ^{40}K ranging from 4 - 914 ,7 - 911 and 217 -56342 Bqkg-1. correspondingly. The samples of cassava for 226Ra in plantain for 228Th and 40K had the highest concentration value ever measured. The local rice, potato, and yam had the lowest recorded values for ^{226}Ra, ^{228}Th, and ^{40}K. In every meal sample, ^{40}K was found at a level of reasonable concentration.

This result is not consistent with the global range for potassium-40 content, which is 40–260 Bqkg-1, as reported by Maul and O'Hara [13]. Since potassium is a micronutrient, it stands to reason that certain aspects of the soil will encourage the plant to mobilize potassium [14]. The study's findings that the content of potassium was significantly higher than that of radium may have contributed to the radium's poor environmental migration characteristics from the substrate to the plant. The results of this study were compared to the activity concentration of the same foods and the average daily intake in other nations [24, 25, and 19].

Table 1: The Central Region's Agona East District's mean concentrations of radionuclide consumption from various foods.

Foodstuff	Consumption rate[a] (kg/year)	Mean annual radionuclide intake (Bq)			
		^{226}Ra	^{228}Th	^{40}K	Dose (mSv)
Cassava	151.89	586.0	2282.0	56342.0	1.32
Cocoyam	56.10	244.0	723.0	17731.0	0.54
Cowpea (Local)	5.00	25.0	25.0	1719.0	0.05
Millet	2.00	4.0	7.0	217.0	0.02
Plantain	83.81	914.0	911.0	23701.0	1.18
Potato	53.00	180.0	409.0	10032.0	0.37
Rice (Local)	25.00	112.0	102.0	2507.0	0.19
Yam	40.90	150.0	323.0	12263.0	0.36
Total		2215.0	4789.0	124512.0	4.05

Table 2: Mean Concentrations of Radionuclide intake of Foodstuffs in different countries

Country	Sample	^{226}Ra	^{228}Ra	^{228}Th	^{40}K	References
Brazil	Plantain	1.43	-	-	434.0	[4]
Brazil	Rice	0.04	-	-	14.7	[4]
USA	Rice	0.042	-	-	49.6	[9]
India	Cassava	3.07 ± 0.02	-	34 ± 11.3	120 ± 2.1	[7]
Turkey	Corn	25.82	-	-	491.62	[1]
Brazil	Potatoes	30 ± 0.3	-	-	-	[4]
Iran	Cocoyam	0.104	<0.023	-	-	[5]
Poland	yam	57.7±6.21	-	22.2±1.03	40.9±1.21	[14]

INTERNAL DOSAGE FROM FOOD CONSUMPTION

According to the Ministry of Food and Agriculture [15], the mean annual food consumption rate (f) by the Ghanaian population and the activity concentration levels (c) in foods were used to explore the yearly intake for ^{226}Ra, ^{228}Th, and ^{40}K in foodstuffs. According to the Ministry of Food and Agriculture, activity concentration levels (b) and the mean annual food consumption rate (J) in all foods consumed annually were (A) studied for ^{226}Ra, ^{228}Th, and ^{40}K utilizing the Ghanaian population. [15].The committed effective dosage was computed using the following formula [16].

IDC = A ×IDCF (2)

A Equivalent to b ×J

where A = annual intake, J = mean annual food consumption rates, c = parameter for biological effect, b = activity concentration levels, and IDCF = internal dose conversion factors.

Higher concentrations of the annual effective dose were found in plantain and cassava. Furthermore, it was shown that plantains and cassava had the greatest consumption rates among the foods mentioned. 4.05 mSv was the total yearly effective dosage obtained from consumed meals. The highest value was 27 - 56342 BqKg-1 for potassium-40. The figure of thorium, which ranged from 7 - 911BqKg-1, was the second highest. The food with the largest intake was cassava.

5. CONCLUSION

In all the meals consumed by residents of Ghana's Ayawaso Municipal Assembly, estimates of ^{226}Ra, ^{228}Th, and ^{40}K were examined in this study. Cassava was found to have a high radioactivity concentration of ^{228}Th and ^{40}K. With an average value of 0.51mSv, the total eaten food had a yearly effective dose of 4.05mSv. From the research:

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