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Evaluation of ^{226}Radium, ^{228}Radium, ^{228}Thorium and ^{40}Potassium Concentrations in Foodstuffs Consume by Dwellers of Ayawaso North Municipal Assembly.

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ABSTRACT

Assessment of radioactivity levels in human diet is of particular concern for the evaluation of potential radiological hazards to human health. Studies of radioactivity concentrations in foodstuffs such as cassava, cocoyam, maize, plantain, potatoes, yam and rice have been investigated at Gamma laboratory under Ghana Atomic Energy Commission using gamma spectrometry system to quantify the radionuclides of interest such as Radium -226, Radium-228, Thorium-228 and Potassium-40. The recorded mean average concentration values of ^{226}Ra, ^{228}Ra, ^{228}Th and ^{40}K in all the foodstuffs varied from 5.96 ± 2.34, 7.38 ±3.35 ,5.98 ±2.52,253.59 ± 15.39 Bqkg^{-1} respectively. All food samples were found to contain high potassium level, which ranged from 41.71- 367.51 ± 19.21BqKg^{-1}. The highest concentration of Thorium-228 and Potassium-40 was found in cassava with recorded values of 8.70-28.90 and 367.51 ± 19.21 BqKg^{-1} respectively. The total annual committed effective dose was investigated to be 4.33 mSv. The daily radionuclides from food consumption indicate that plantain and cassava are the highest contributors while maize is the lowest. The radionuclide concentrations were comparable with those reported from other countries.

Keywords: Radionuclide, Effective dose, Foodstuff, Internal dose, Dome – Kwabenya Municipality

1. INTRODUCTION

Concentrations and distributions of radionuclides are of interest with regards to it expedient information in the monitoring of environmental radioactivity. Direct and indirect contamination of uranium – series radionuclides may be imperiled to food crops. Advancement of uranium series nuclide in food crops is enhance by the use of fertilizer. [1].Contamination of agricultural land during cultivation is cause by the use of phosphates. Phosphates have possible radiological health concern in addition to their chemical toxicity. Concentration of uranium in phosphate rock range between 30 and 260ppm. [2]

Applications of phosphate fertilizers and by-products can redistribute and elevate Radium -226 and potassium-40 concentration in soils. Foodstuffs are known to contain man -made and natural radionuclides, which after ingestion contribute to an effective internal dose. Occurrence of radionuclides especially Potassium-40, Thorium-232 and Uranium-238 are the major source of natural radiation exposure to man. It has been evaluated that at least one-eighth of the mean annual effective dose due to natural sources is cause by consumption of foodstuffs [3].

Human activities leads to man -made radionuclides, which contribute to environmental radioactivity of which Ceasium-137 radionuclide is an environmental concern [4]. A baseline value for the contamination assessment for foodstuff consume by the population is vital. Naturally, occurring radionuclides of Uranium and Thorium are essential contributors of ingestion dose and are present in the biotic system of the soil, plants, animals, air and water. Determination of radionuclides concentration in various food samples and dose assessment from consumption of foodstuff by the population have been study in diverse countries [5]. Several workers have studied occurrence of radioactivity in plant organs. [6, 7].The most available and consumed foodstuff in Ghana are maize, yam, cocoyam, rice, potato, millet, beans and cassava. This study would create a radiometric baseline value for further study in Greater Accra Region and other regions.

2. Background of Study Area

Ayawaso, Accra Ghana is located at in the cities place category with GPS coordinates of 5^0 36’51.2028’’N and 0^0 11’46.8096’’W. The latitude and longitude of Ayawaso is 5.614223 and -0.196336.

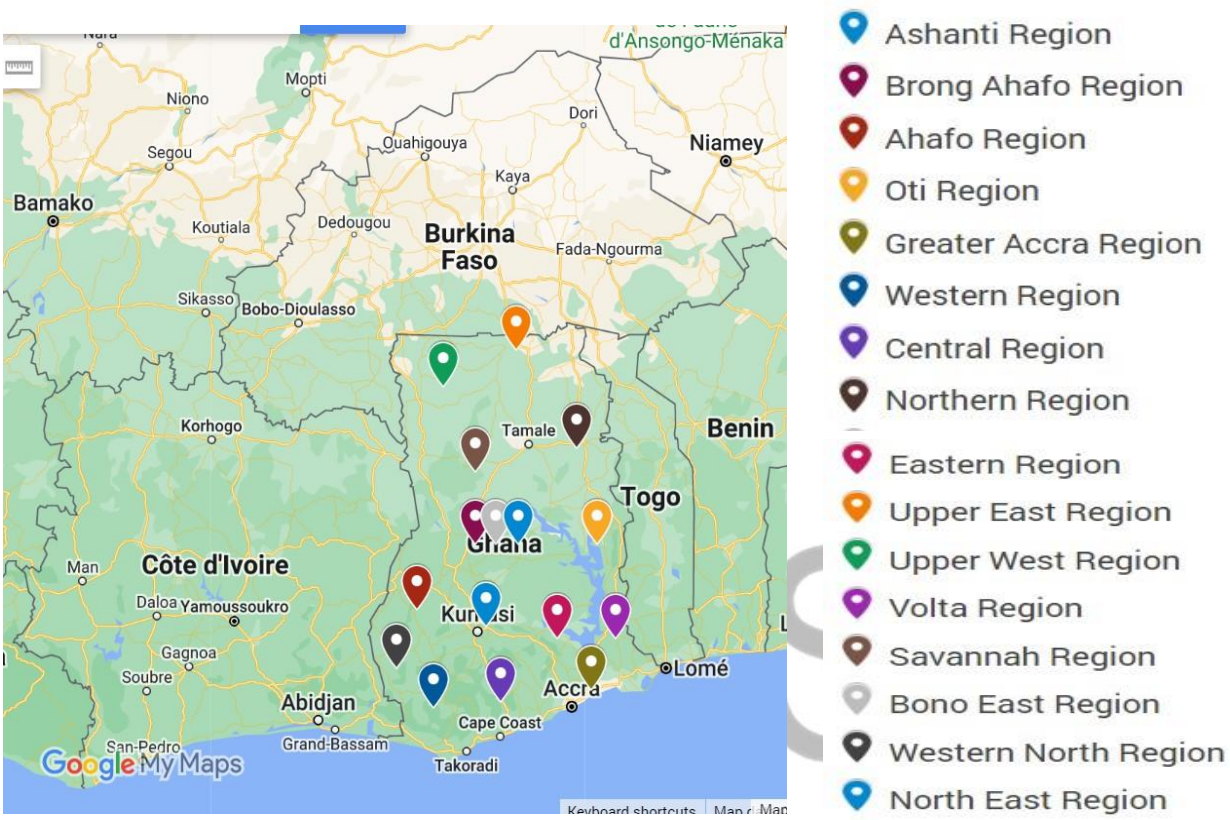

Fig 1: Map of Ghana

Fig 2: Map of Study Area

3. METHODOLOGY

Sample collection and measurement of Phosphate fertilizers, which is an example of artificial fertilizers; have been used for the past 30yrs by farmers to cultivate lands in the regions. It is essential to analyze radionuclide concentrations in foodstuffs so that their effective dose equivalent to human consumption can be estimated from eight different market were randomly selected. Seven different food samples from five different markets were sampled and analyze. Food samples were washed, peeled when necessary and dried in air.

They were then dried at 80^0C for about 15hrs and grinded into powder for analysis [9]. Each samples were weighed and transferred to 1000ml of Marineth beakers [10] and tightly sealed. High efficiency Sodium Iodide detector at the laboratory of RPI used to measure the concentration of gamma ray emitting radionuclides in the samples. MAESTRO-32 software and PC based 1024 multichannel analyzer was used to evaluate the gamma spectrum.

Efficiency and energy calibration was acquired by using a mixed gamma standard enclosed in 1L Marineth beaker provided by Physikatlisch Technische Bundesanstalt PTB, Germany to calibrate the detector. The detector was shielded using a cylindrical Lead castle of 20mm thickness with an internal well made of copper of 3mm thick.

3.1 Calculations of Activity Concentrations

Activity Concentration for ^{226}Ra, ^{228}Th, and ^{40}K were calculated using the detected phosphates in the spectra. The samples were stored for at least one month two weeks prior to gamma counting. Investigations ^{226}Ra and ^{228}Th were acquired using the peaks 2614KeV peak from ^{208}Ti, 609KeV from ^{214}Bi and 911KeV from ^{228}Ac. Activity concentration of Cesium-137 was investigated from 661.7KeV [11]. The activity concentration of Potassium-40 was investigated using 1460KeV gamma live [12].The equation below was used to determine the activity concentration $A_{\epsilon R}$ in BqKg^{-1}.

$$A_{\epsilon R} = \frac{N_{\epsilon R}}{\epsilon_E \times t \times \gamma d \times m} \quad (1)$$

t is the counting live time in sec, γd is the gamma-ray ray yield per disintegration of the nuclide R is transition at the energy E. m is the mass of the sample measured in kg. $^{\epsilon}$E is the detector energy – dependent efficiency at energy E. $N_{\epsilon R}$ is the net peak – area of radionuclide R at energy E. $A_{\epsilon R}$ is the Activity concentration, R is a radionuclide, Energy, E is obtained from the equation.

4.0 RESULTS AND DISCUSSION

Activity concentration of ^{226}Ra,^{228}Ra,^{228}Th and ^{40}K in seven different foodstuffs from five different market at Dome – Kwabenya constituent were investigated. The recorded average concentrations ^{226}Ra,^{226}Ra,^{228}Th and ^{40}K in the foodstuffs varied from 5.96 ± 2.34 7.38 ±3.35, 5.98 ±2.52, 253.59 ± 15.39 Bqkg^{-1}. Respectively. The highest recorded value for concentration value was found in cassava samples for ^{226}Ra in plantain for ^{228}Th and ^{40}K. The

lowest recorded value for ^{226}Ra, ^{228}Th and ^{40}K were found in local rice, potato and yam. ^{40}K was detected in all food samples with reasonable concentration level.

This result did not agrees with the world range reported by Maul and O' Hara [13] for Potassium-40 concentration from 40 – 260Bqkg^{-1}. Potassium is a micronutrient and it may be expected that soil characteristics favor the mobilization of potassium into the plant [14]. From the study, concentration of potassium was found to be very high compared to the radium, thus may attribute to poor migration characteristic of radium from the substrate to the plant in the environment. Activity concentration of the same foodstuffs and average daily intake in different countries were compared to the result from this study [24, 25, and 19].

Table 1: Mean Concentrations of Radionuclide intake of different Foodstuffs in Ayawaso North Municipal Assembly.

Foodstuff	Number of samples	^{226}Ra min-max avg.	^{228}Ra min-max avg.	^{228}Th min-max avg.	^{40}K min-max avg.	Dose (mSv)
Cassava	7	1.88-7.31 3.54± 1.76	3.30-10.22 5.14± 2.03	8.70-28.90 4.94± 3.21	279.00-446.00 367.51± 19.21	1.34
Cocoyam	7	2.74-5.65 4.43± 2.10	4.37-11.40 8.09± 2.07	6.64-18.82 9.64± 2.19	165.00-403.00 311.50± 16.52	0.54
Maize	7	1.54-10.50 4.96± 2.30	3.04-16.01 7.33± 2.80	5.44-18.27 7.50± 3.14	135.00-376.00 232.83± 16.23	0.37
Plantain	7	2.83-30.50 10.36± 4.56	6.50-17.00 11.21± 3.13	6.40-12.69 9.89± 2.11	174.00-352.00 280.50± 17.82	1.17
Potato	7	1.92-4.61 3.27± 1.74	3.78-7.48 6.21± 2.42	4.99-9.52 4.34± 2.13	124.00-257.00 184.80± 12.63	0.36
Yam	7	1.03-5.34 3.51± 1.80	3.01-7.47 5.41± 2.70	3.79-16.28 5.44± 2.17	239.00-352.00 293.67± 18.11	0.38

Rice (local)	7	2.71-6.82 4.62± 2.15	3.51-9.40 8.27± 2.29	2.30-6.73 3.14± 2.32	41.71-211.80 105.36± 11.22	0.17
		5.96± 2.34	7.38± 3.35	5.98± 2.52	253.59± 15.39	4.33

Internal dose from Ingested foods

Annual intake for ^{226}Ra, ^{228}Th and ^{40}K were investigated in foodstuffs by using the activity concentration levels (c) in foods and mean annual food consumption rate (f) by the Ghanaian population according to the ministry of food and Agriculture [15]. Activity concentration levels (b) and mean annual food consumption rate (J) in all foodstuffs consume annually were (A) were investigated for ^{226}Ra, ^{228}Th and ^{40}K by using the Ghanaian population according to the Ministry of Food and Agriculture. [15].The equation below was used to calculate the committed effective dose [16].

$$C = A \times IDCF \quad (2)$$

$$A = b \times J \quad (3)$$

Where IDCF = internal dose conversion factors

b = activity concentration levels, J = mean annual food consumption rates, c = parameter for biological effect, A = annual intake.

Annual effective dose with higher concentration was forms in plantain and cassava. Moreover, the highest consumption rate among the listed foodstuff was found in plantain and cassava. The total annual effective dose from ingested foods was 4.33 mSv. Potassim-40 recorded the highest value of 367.51± 19.21 BqKg^{-1}. Thorium recorded the second highest value of 8.70-28.90 BqKg^{-1}. Bq. Cassava recorded the highest amount of food intake.

5. CONCLUSION

Estimation of ^{226}Ra,^{228}Ra,^{228}Th and ^{40}K in all the foodstuffs consumed by dwellers of the Ayawaso Municipal Assembly of Ghana were investigated in this study. Radioactivity concentration of ^{228}Th and ^{40}K was recorded to be high in cassava. The annual effective dose from all the ingested food was 4.33mSv with a recorded average value of 0.62mSv. From the study:

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Conflict of Interest: There was no conflict of interest

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APPENDIX

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]
Nigeria	Maize	0.210	-	-	87.0	[6]
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]