Assessment of dose due to natural radio-nuclides in vegetables of high background radiation area in south-eastern part of Bangladesh

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► ***Short report***

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Received: May 2013
Accepted: Aug. 2013

Int. J. Radiat. Res., July 2014; 12(3): 271-275

ABSTRACT

Background: The aims of the study are to determine the radioactivity concentrations of ^{226}Ra, ^{238}U, ^{232}Th and ^{40}K in vegetables of a recently found high background radiation area of south-eastern part of Bangladesh and to detect the radiological risks to human from intake of these vegetables. ***Materials and Method:*** 10 plant samples were collected randomly from different locations of the study area. The radio-nuclides in papaya were measured by direct γ-ray spectrometry using HPGe detector. ***Results:*** The average activity concentrations of ^{226}Ra, ^{238}U, ^{232}Th and ^{40}K in papaya samples were 80.95±13.61, 64.77±38.47, 83.53±20.50 and 1691.45±244.98 Bq kg^{-1} respectively. The annual effective ingestion dose due to intake of papaya was 1.1 mSv Y^{-1}. ***Conclusion:*** The concentrations of radio-nuclides in the papaya samples found in present study were higher than the world average values suggested by the UNSCEAR. The annual effective ingestion dose was found 3.8 times higher than total exposure per person resulting from the ingestion of terrestrial radioisotopes.

Keywords: *Natural radioactivity, vegetables, HPGe detector, effective ingestion dose.*

INTRODUCTION

High level of natural radioactivity has already been found in soil of Tulatoli village of Teknaf upazila at Cox's Bazar District of Bangladesh. It is an old beach zone where high amount of heavy minerals have been found as placer deposits and now become a well populated area (1). Plants are the primary recipients of the radio-nuclides from soil. These radio-nuclides can get transferred into plants along with the nutrients during mineral uptake and accumulate in various parts and even reach edible portions. Studies on the radioactivity of the consumable parts of a vegetable assume importance as it is necessary to estimate the ingestion dose to the public (2).

So, the aim of the present study is to determine the radioactivity concentrations of ^{226}Ra, ^{238}U, ^{232}Th and ^{40}K in vegetables of the area in order to find out the ingestion dose to the public due to intake of the food. This study will provide a baseline data of the natural *radioactivity concentration* in food of the area for further research.

Papaya has chosen as the vegetable for study. Because in the environment of Bangladesh it grows round the year and mass people generally grow it by the yard corner- side of their residences. Thus, round the year it is a widely taken food for mass people.

MATERIALS AND METHODS

Description of the study area

The Tulatoli village of Teknaf upazila at Cox's Bazar district is the study area which is situated at the south-eastern part of Bangladesh. Geologically the area is an old sandy beach zone, characteristically enriched with heavy mineral-sands including good presence of thorium (^{232}Th) bearing monazite. The whole area is covered by a thin layer of top soil. Human habitation in the area is moderate. The activity concentrations of ^{226}Ra, ^{238}U and ^{232}Th in soil of the study area were found 9, 5.5 and 8 times respectively higher than the world average values [(1)].

Sample collection and preparation

The geographic location of the study area is shown in figure 1. Papaya (*Carica papaya*) was selected as the vegetable for study. 10 samples were collected randomly from different locations of the Tulatoli village. Each plant sample was approximately 2 kg of weight (wet weight). All the samples were processed following the standard procedures as per International Atomic Energy Agency (IAEA) guidelines [(3)]. The plant samples were dried at 105°-110° C temperature. Then these samples were smashed with mortar and pestle, homogenized, screened with laboratory test sieve of aperture 425 micrometer and weighted. The weight of the plant samples were in between 35 to 90 gm. Then all samples were packed individually into cylindrical plastic containers (7.3 cm diameter × 8.9 cm height), sealed tightly and were kept at room temperature for about 30 days to ensure that ^{238}U and its daughter products were in secular equilibrium [(3)].

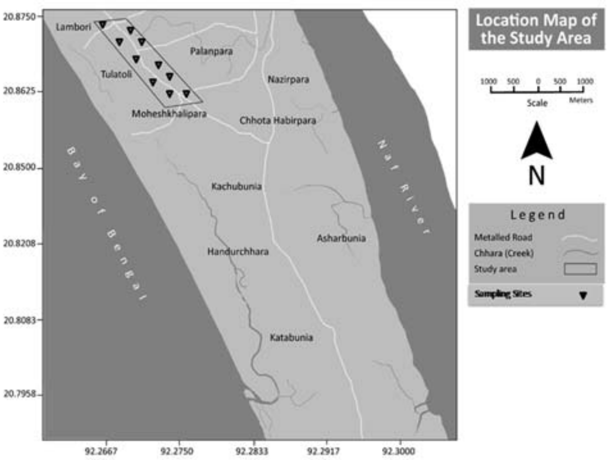

Figure 1. Geographic location of the study area.

Radioactivity measurement

The activity concentration of gamma ray emitting radioisotopes in the samples were measured by using a gamma ray spectrometer with a high-resolution HPGe coaxial detector coupled with a Silena Emcaplus multichannel analyzer (MCA). The effective volume of the detector was 83.469 cm^3 and energy resolution of the 1.33 MeV energy peak for ^{60}Co was found as 1.69 keV at full width half maximum (FWHM) with a relative efficiency of 19.6%. All samples were counted for 5000s. The activity concentration of ^{226}Ra was calculated through 609.3 keV of ^{214}Bi. ^{238}U was calculated through 351.92 keV of ^{214}Pb and 1120.3 keV, 1764.5 keV of ^{214}Bi. ^{232}Th activity was calculated through and 238.63 keV of ^{212}Pb, 583.14 keV ^{208}Tl, 911.07 keV, 969.11 keV of ^{228}Ac respectively. The ^{40}K activity was calculated through 1460.75 keV. The radioactivity concentration of each radionuclide was calculated using the equation (i) [(3)].

$$A_i \text{ (Bq kg}^{-1}) = N/ (W \times \varepsilon \times P_\gamma) \qquad \text{(i)}$$

Where A_i is the activity concentration of each radionuclide in the sample, N is the net count of each radionuclide which is found by subtracting the sample radionuclide activity counting from background activity counting, ε is the detector efficiency of the specific γ ray, P_γ is the transition probability of the specific γ ray and W is the weight of the sample (kg).

Calculation of annual effective dose of radio-nuclides from ingested vegetables

Radiation doses to population from intake of radio nuclides in foods can be calculated from the formula (ii) reported in UNSCEAR 2000 [(4)].

$$D = C\,A\,R \qquad \text{(ii)}$$

Where D is the effective dose by ingestion of the radionuclide (Sv Y^{-1}), A is the activity concentration of the radio-nuclides in the sample (Bq kg^{-1}), C is the internal dose conversion coefficient by ingestion of the radio-nuclides (Sv Bq^{-1}) and R is the annual intake of papaya (kg Y^{-1}) which depends on a given age [(5)].

RESULTS

Activity concentrations (Bq kg^{-1}) of radio-nuclides

Activity concentrations of radio-nuclides in papaya samples have shown in table 1. The concentrations of ^{226}Ra in papaya samples ranged from 41.82 to 120.08 Bq kg^{-1} with an average of 80.95±13.61 Bq kg^{-1}. The concentrations of ^{238}U ranged from 18.57 to 110.98 Bq kg^{-1} with an average of 64.77±38.47 Bq kg^{-1}. The concentrations of ^{232}Th ranged from 39.58 to 127.48 Bq kg^{-1} with an average of 83.53±20.50 Bq kg^{-1} and the concentrations ^{40}K ranged from 1030.88 to 2352.02 Bq kg^{-1} with an average of 1691.45±244.98 Bq kg^{-1}. The concentration of ^{40}K was found very high.

Annual effective dose of radio-nuclides from ingested vegetables

Annual effective ingestion dose due to vegetables consumption strongly depends on the vegetables consumption. The consumption rate was defined using FAO definition [6]. In this study the annual consumption rate of papaya consumed by the adults was 20 kg Y^{-1}.

The annual effective ingestion dose due to intake of radio-nuclides is shown in table 2. Results show that the total average effective ingestion dose due to annual intake of ^{226}Ra, ^{238}U, ^{232}Th and ^{40}K from papaya was 1.1 mSv Y^{-1} of which 0.21 mSv was from ^{40}K and 0.89 mSv was from ^{226}Ra, ^{238}U and ^{232}Th.

Table 1. Activity concentrations (Bq kg^{-1}) of radio-nuclides in papaya samples.

Sample ID	^{226}Ra	^{238}U	^{232}Th	^{40}K
P1	41.82	18.57	57.43	1259
P2	111.5	68.86	127.5	1088
P3	63.57	25.37	123.76	1632
P4	92.80	38.72	108	1892
P5	120	111	107.9	1907
P6	86.03	35.73	89.15	1951
P7	47.79	28.59	58.18	1642
P8	49.10	41.40	39.58	1030
P9	76.81	76.50	84.57	1470
P10	66.64	61.07	80.51	2352
Range	**41.82-120**	**18.57-111**	**39.58-127.5**	**1030-2352**
Mean	**80.95±13.61**	**64.77±38.47**	**83.53±20.50**	**1691±245**

Table 2. Annual effective ingestion dose due to intake of radio-nuclides from papaya.

Radio-nuclides		Annual effective ingestion dose (mSv Y^{-1})	Dose conversion coefficient (Sv/Bq) (Adults)
^{226}Ra	Maximum	0.67	2.8×10^{-7}
	Minimum	0.23	
	Average	0.45	
^{238}U	Maximum	0.10	4.5×10^{-8}
	Minimum	0.02	
	Average	0.06	
^{232}Th	Maximum	0.59	2.3×10^{-7}
	Minimum	0.18	
	Average	0.38	
^{40}K	Maximum	0.13	6.2×10^{-9}
	Minimum	0.29	
	Average	0.21	
Total ingestion dose from papaya		**1.1 mSv Y^{-1}**	

DISCUSSION

The average activity concentration of ^{226}Ra, ^{238}U, ^{232}Th and ^{40}K in papaya samples were 80.95±13.61, 64.77±38.47, 83.53±20.50 and 1691.45±244.98 Bq kg^{-1} respectively. A comparison of the obtained value has done with the activity concentration (Bq kg^{-1}) of the natural radio-nuclides in plants of different districts of Bangladesh which is given in table 3. It shows that papaya of the study area has higher radioactivity concentration than the other parts of Bangladesh as well as than world average value for root vegetables and fruits suggested by UNSCEAR. Potassium is a macronutrient, so the concentration can be high in vegetables (8). Beside this, beach soil contains high amount of salts due to regression of sea water, which may also cause high concentration of ^{40}K in papaya of this area.

According to a report by UNSCER (4), the total exposure per person resulting from ingestion of terrestrial radioisotopes should be 0.29 mSv, of which 0.17 mSv is from ^{40}K and 0.12 mSv is from thorium and uranium series. The annual effective ingestion dose due to intake of papaya was 1.1 mSv Y^{-1} which was found 3.8 times higher than world safe value of total exposure per person resulting from the ingestion of terrestrial radioisotopes (table 4).

CONCLUSION

A radiological study was performed to obtain the annual effective dose of natural radio-nuclides (^{226}Ra, ^{238}U and ^{232}Th) into human body due to intake of vegetables from a high background radiation area in south-eastern part of Bangladesh. The radioactivity concentrations in papaya samples were higher than the world average value. The annual effective ingestion dose to human body due to intake of papaya was also found 3.8 times higher than the world safe value of total exposure per person resulting from the ingestion of terrestrial radioisotopes. The data derived from this study represent a baseline database of dose levels that can serve as a reference point for future studies.

ACKNOWLEDGEMENT

The author would like to thank the Health Physics Division of Bangladesh Atomic Energy Centre, Dhaka, Bangladesh for allowing the experiment to be conducted in their laboratories.

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Table 3. Comparison of activity concentration (Bq kg^{-1}) of natural radio-nuclides in root vegetables/fruits with different districts of Bangladesh.

Region	Vegetables	^{226}Ra	^{238}U	^{232}Th	^{40}K	Reference
Jamalpur	Ladies finger	-	5.5-74	8-248	1274-4860	(7)
Kustia	Red amaranth	-	4.22-20	5.5-23	870-2531	”
Tangail	Red amaranth	-	9.4-18.3	9-23.6	1109-1383	”
Jessor	Red amaranth	-	9-36	4-19	204-366	”
Tulatoli village,Teknaf	Papaya	**80.95**	**64.77**	**83.53**	**1691**	Present study
World average value	Root vegetables/ fruits	0.03	0.003	0.0005	-	UNSCEAR (4)

Table 4. Comparison of annual effective ingestion dose with world safe value.

Obtained value	1.1 mSv Y^{-1}
World safe value (4)	0.29 mSv Y^{-1}

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