International Journal
of
Integrated Sciences & Technology (IJIST)
http://www.cuet.ac.bd/IJIST/index.html

International Journal of Integrated Sciences & Technology 3 (2018) 24-29

Measurement of ^{226}Ra, ^{232}Th and ^{40}K in Papaya Grown on the Bank of Rupsha River, Khulna, Bangladesh and its Impact on Human Health

J. Sultana[1*], N. Nahar[1], D. Paul[2] and I. Ali[2]

[1] *Department of Physics, Kkulna University of Engineering and Technology, Khulna, Bangladesh*
[2] *Health Physics and Radioactive Waste Management Unit, Bangladesh*
Atomic Energy Commission, Saver, Dhaka, Bangladesh

Abstract:

Environmental pollutions are increasingly becoming great concerns for human beings. In order to determine the presence of natural and probable artificial radioactivity in the human food-chain, papaya samples have been collected from different parts on the Bank of Rupsha River at Rupsha Upazilla in Khulna. All samples have been analyzed by gamma-ray spectrometry system using a 'Hyper -Pure Germanium' (HPGe) detector of 20% relative efficiency. A total of 7 Papaya samples have been collected from 7 locations of the area under investigation to identify the probable radionuclides, activity concentrations and the radiological risks to human from intake of papaya vegetables. Natural radionuclides such as ^{226}Ra, ^{232}Th and ^{40}K have been found in the samples and no artificial radionuclide has been detected in any of the sample. The activity concentrations in papaya samples have been found to be varied from 13.295±9.64 to 77.96±22.01, average 43.31±15.28 Bq/Kg, BDL to 26.2±17.27, average 15.44±11.28Bq/Kg and 1112.65±202.33 to 1712.47±221.96, average 1490.27±226.27 Bq/Kg, respectively. The effective dose of ^{226}Ra (0.39mSv) is slightly high than world safe value (0.29 mSv) in papaya. However, these values of doses are much below the permissible level set by ICRP and, therefore, there is no immediate health risk on workers and public due to natural radioactivity present in the papaya samples of the study area.

Keywords**:** *Natural radionuclides, Papaya, Activity concentrations, HPGe, Harmful.*

1. Introduction

Radiation is a part and parcel of our environment. The distribution of the radionuclides in nature, contribution and movements can seriously be affected by the activity population. Sometimes this can result in deleterious effect such as harmful consequence on environment and health hazards to human being, entering into the body through different metabolic pathway. For the assessment of effective dose equivalent to the population of Bangladesh, It is necessary to estimate the concentration of various radionuclides in the environment, entering the various organs of the body as a function of time.The present study has been designed to determine the level of natural ^{226}Ra, ^{232}Th and ^{40}K radioactivity in the papaya samples.Radioactivity are not uniformly distributed and vary from region to region[1]. Therefore, the knowledge of their distribution in crops and vegetables play an important role in radiation protection activities. The radioactivity concentration of these nuclides above permissible level is very harmful to the human body. Therefore, measurement of natural radioactivity in these elements and the radiation doses arising from these radionuclides are of great interest to the researchers which have led the nationwide surveys throughout the world[2, 3]. Since natural radiation is the largest contributor of external dose to the world-population, assessment of gamma radiation dose from natural sources is of particular importance. Rupsha is one of the agricultural zones located at the bank of

Corresponding Author: jsa_kuet@yahoo.com

Rupsha river near the Khulna city. Large number of populations, some brick field, various shops and ship-industries in Khulna are near the agricultural zones. Industrial activities discharge untreated or poorly treated industrial wastewater, effluent and even sludge into the surrounding environment which may contain elevated level of radioactivity. Besides, the farmers in that area are randomly using fertilizers and pesticides in agricultural lands out of their ignorance. A very little work has been done and almost no significant data are available on the radioactivity contents in the crops of the agricultural zones in Khulna, Bangladesh. Moreover, probable radiological impact on the people and environment due to the radioactivity content in these environmental elements needs to be determined for the radiation protection purpose. That's why we like to study in the present work to determine the probable radionuclides, radioactivity concentration and annual effective dose in the agricultural crops papay. The present work helps the determination of radiation dose received by the people from the papaya to human food-chain.

2. Methodology

A total of 7 papaya samples have been collected from in and around the Rupsha river located at Rupsha sites, Khulna, Bangladesh during the period of 30/04/2015 to 02/05/2015. Using a GPS device geographical coordinates of sampling sites have been recorded. Samples have been collected from equidistant locations with a distance of about 1 km from each other. The radionuclide contents and their activity levels of the each sample haven been measured using a calibrated HPGe detector of energy resolution of 2.0 KeV at 1.33 MeV of Cobalt-60 for a period of 10,000s, at Health Physics, Atomic Energy Commission, Saver, Dhaka. An error analysis of the data has also been performed. Moreover, based on the activity level and the annual intake of radionuclides through the consumption of these samples, the annual effective doses due to these radionuclides has also been estimated.The activity concentrations of each radionuclide in the sample has been determined by using the count per second (cps) after subtracting the background counts from the gross counts for the same counting time under the selected photo peaks, weight of the sample, the photo-peak efficiency and the gamma intensity at a specific energy as [4] : $A = \frac{cps}{E \times I \times W}$ .....(1)

Where, A = Activity concentrations of the sample in $Bqkg^{-1}$, Cps = The net counts per second = (cps for the sample - cps for the background value). E = The counting efficiency of the gamma energy. I = Absolute intensity of the gamma ray and W = Net weight of the sample (in kilogram).

The errors in the measurements were expressed in terms of standard deviation (±σ), where σ is expressed as [5] : $\sigma = \left[\frac{N_s}{T_s^2} + \frac{N_b}{T_b^2} \right]^{1/2}$ .....(2)

Where, N_s is the sample counts measured in time T_s, and N_b is the background counts measured in time T_b. The standard deviation ±2σ in cps was converted into activity in $Bqkg^{-1}$ according to equation (1).

Annual Effective Dose (AED): The annual effective dose due to the intake of radionuclides from food and vegetables samples were calculated using the following equation [6] :

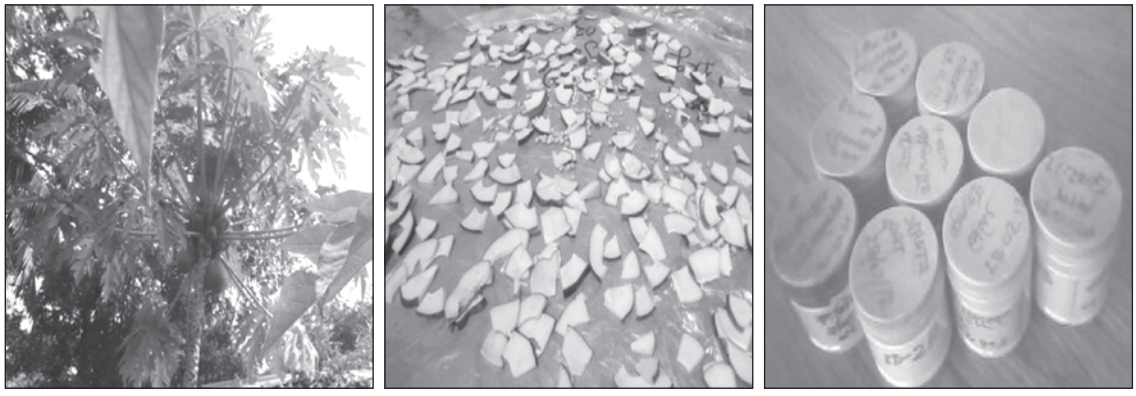
$AED\ (\mu Sv) = C \times I \times E \times 10^6$ .....(3)

Where, C is the activity concentration of radionuclides in the collected samples (Bq/kg), I is the annual intake of food and vegetables, E is the ingested dose conversion factor for radionuclides (Sv/Bq) [7].

3. Results and Discussion

Picture 1 (a) shows Papaya samples grown on the Bank of Rupsha River, (b) Drying process of papaya sample in sun shine and (c) Prepared samples. Activity Concentrations of radioactive daughter elements of ^{226}Ra & ^{232}Th radioactive series in papaya samples has been given in Table 1. It has been seen that the concentration of ^{214}Pb, ^{214}Bi, ^{212}Pb, ^{208}Tl and ^{228}Ac are found to be varied between 19.7±4.12 $Bqkg^{-1}$to 61.07±6.82 $Bqkg^{-1}$,6.89±15.15 Bqkg,$^{-1}$to 97.13±34.82 Bqkg,$^{-1}$ BDL, BDL to 12.38±6.73 $Bqkg^{-1}$ and BDL to 26.2±17.27 Bqkg,$^{-1}$ The activity concentration of ^{226}Ra, ^{232}Th and ^{40}K in Papaya samples have been found to be varied between 13.295±9.64 Bq kg^{-1} to 77.96±22.01$Bqkg^{-1}$, BDL to 26.2±17.27 $Bqkg^{-1}$ and 1112.65±202.33 $Bqkg^{-1}$ to 1712.47±221.96 $Bqkg^{-1}$ respectively, with an average of 43.31±15.28 $Bqkg^{-1}$ of ^{226}Ra, 15.44±11.28 $Bqkg^{-1}$of ^{232}Th and 1490.27±226.27 $Bqkg^{-1}$ of ^{40}K (Table 2). The highest activity concentration of 1712.47±221.96 $Bqkg^{-1}$ for ^{40}K has been found in Papaya sample (sample ID Papaya 3) collected from Aichgati. Figure 1 shows (a) Activity concentrations of daughters (^{214}Pb; ^{214}Bi) of ^{226}Ra, (b) Activity concentrations of daughters (^{212}Pb.^{208}Ti, ^{228}Ac) of ^{232}Th, (c) Activity concentrations of parents' nuclei ^{226}Ra, ^{232}Th and ^{40}K,(d) Variation of estimated annual effective dose respectively. Comparison of the present study with different parts of Bangladesh and the world for radionuclides in vegetables samples ($BqKg^{-1}$) have also been given in Table 3. Annual intake of radionuclides in the papaya samples and estimated annual effective dose has also been calculated (Table 4).

It shows that papaya of the study sites has higher radioactivity concentration than the other parts of Bangladesh as wellas than world average value for root vegetables and fruits suggested by UNSCEAR [8]. According to a report by (UNSCER, 2000) 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 0.12mSv is from Thorium and Uranium series. In the present study the effective dose of ^{226}Ra (0.349 mSv) is slightly high than world safe value (0.29 mSv) in Papaya. So further study should be needed with more samples as well as radioactivity in soil and water of this sites should be analyzed. The current result was slightly higher compared with the results of similar studies undertaken in other countries and in different places in Bangladesh. However, these values of doses are much below the permissible level set by International Commission on Radiological Protection [7], and, therefore, there is no immediate health risk on workers and public due to natural radioactivity present in the samples of the study area.



(a) (b) (c)

Fig. 1: (a) Papaya samplegrown on the Bank of Rupsha River, (b) Papaya sample dry in sun shine, (c) Prepared samples.

Table-1: Activity concentrations of radioactive daughter elements of ^{226}Ra &^{232}Th radioactive series in papaya samples. BDL: Below Detection Level.

Sl NO	Sampling Location	Sample ID	Activity concentration (Bq/kg)				
			Pb-214	Bi-214	Pb-12	Tl-208	Ac-228
1	Deara	papaya 1	23.82±5.59	11.96±21.89	BDL	BDL	BDL
2	Khand.pur	papaya 2	58.79±9.19	97.13±34.82	BDL	BDL	BDL
3	Aichgati	papaya 3	51.46±6.47	33.9±20.79	BDL	BDL	26.2±17.27
4	Jabusa	papaya 4	47.74±5.83	41.77±7.58	BDL	BDL	9.54±14.73
5	Elahipur	papaya 5	38.79±5.7	27.29±19.46	BDL	12.38±6.73	8.75±19.52
6	Noeihati	papaya 6	61.07±6.82	86±23.04	BDL	BDL	BDL
7	Kharabad	papaya 7	19.7±4.12	6.89±15.15	BDL	BDL	BDL
Maximum			**61.07±6.82**	**97.13±34.82**	**BDL**	**BDL**	**BDL**
Minimum			**19.7±4.12**	**6.89±15.15**	**BDL**	**12.38±6.73**	**26.2±17.27**
Average			**43.05±6.25**	**43.56±20.39**			**14.83±17.17**

Table-2: Activity concentration of radio nuclei Ra-226 &Th-232 and K-40 in Papaya

Sl NO.	Sampling Location	Sample ID	Activity concentration (Bq/kg)		
			Ra-226	Th-232	K-40
1	Deara	papaya 1	17.89±27.48	BDL	1455.38±238.57
2	Khan md.pur	papaya 2	77.96±22.01	BDL	1698.34±333.51
3	Aichgati	papaya 3	42.68±13.63	26.2±17.27	1712.47±221.96
4	Jabusa	papaya 4	44.76±6.71	9.54±14.73	1587.93±19.78
5	Elahipur	papaya 5	33.04±12.58	10.565±13.13	1112.65±202.33
6	Noeihati	papaya 6	73.535±14.93	BDL	1643.56±220.26
7	Kharabad	papaya 7	13.295±9.64	BDL	1221.53±169.49
Maximum.			**77.96±22.01**	**26.2±17.27**	**1712.47±221.96**
Minimum			**13.295±9.64**	**BDL**	**1112.65±202.33**
Average			**43.31±15.28**	**15.44±11.28**	**1490.27±226.27**

Table-3: Comparison of the present study with different parts of Bangladesh and the world for radio nuclides in vegetables and rice samples ($BqKg^{-1}$).

Region	Samples name	Radio-nuclides ($BqKg^{-1}$)			Reference
		^{226}Ra	^{232}Th	^{40}K	
Jamalpur Bangladesh	Ladies finger	_	8 - 248	1274 - 4860	[9]
Kustia Bangladesh	Redamaranth	_	5.5 - 23	870 - 1231	
Tangail Bangladesh	Redamaranth	_	9 – 23.6	1109 – 1383	
Jessore Bangladesh	Redamaranth	_	4 - 19	204 – 366	
Savar Bangladesh	Rice	2.86 – 26.61	1.93 – 42.63	307 - 498	[10]
Bangladesh Cox's Bazar	vegetables	80.95	83.53	1691.45	[11]
Malaysia	vegetables	17.5	65.2	446	[12]
Nigeria	vegetables	83.5	-	684.5	[13]
Iran	vegetables	67	0.5	91.73	[14]
China	vegetables	0.32	-	111	[15]
World average value	Vegetables/Fruits	0.03	0.0005	-	[08]
Khulna Bangladesh	Paddy	17.59 – 42.33	0 – 3.75	35.9– 170.12	[16]
Khulna Bangladesh	Leafy vegetables	25.97-49.11	0- 17.08	625.88-1378.25	[16]
Khulna Bangladesh	Arum	O – 8.78	0 – 2.53	426.91-1280.71	[16]
Khulna Bangladesh	Papaya	13.29-77.96	0 -26.2	1112.65-1712.47	Present study

Table-4: Annual intake of radionuclides in the Papaya samples and estimated annual effective dose

Sl NO	Sampling Location	Sample ID	Annual Intake (Bq)			Annual effective dose (uSv)		
			^{226}Ra	^{232}Th	^{40}K	^{226}Ra	^{232}Th	^{40}K
1	Deara	Papaya 1	515.23	0.00	41914.94	144.26	0.00	209.57
2	Khan md.pur	Papaya 2	2245.25	0.00	48912.19	628.67	0.00	244.56
3	Aichgati	Papaya 3	1229.18	754.56	49319.14	344.17	558.37	246.60
4	Jabusa	Papaya 4	1288.94	274.75	45732.38	360.90	203.32	228.66
5	Elahipur	Papaya 5	951.55	304.27	32044.32	266.43	225.16	160.22
6	Noeihati	Papaya 6	2117.81	0.00	47334.53	592.99	0.00	236.67
7	Kharabad	Papaya 7	382.90	0.00	35180.06	107.21	0.00	175.90
Average			**1247.26**	**190.51**	**42919.65**	**349.23**	**140.97**	**214.59**

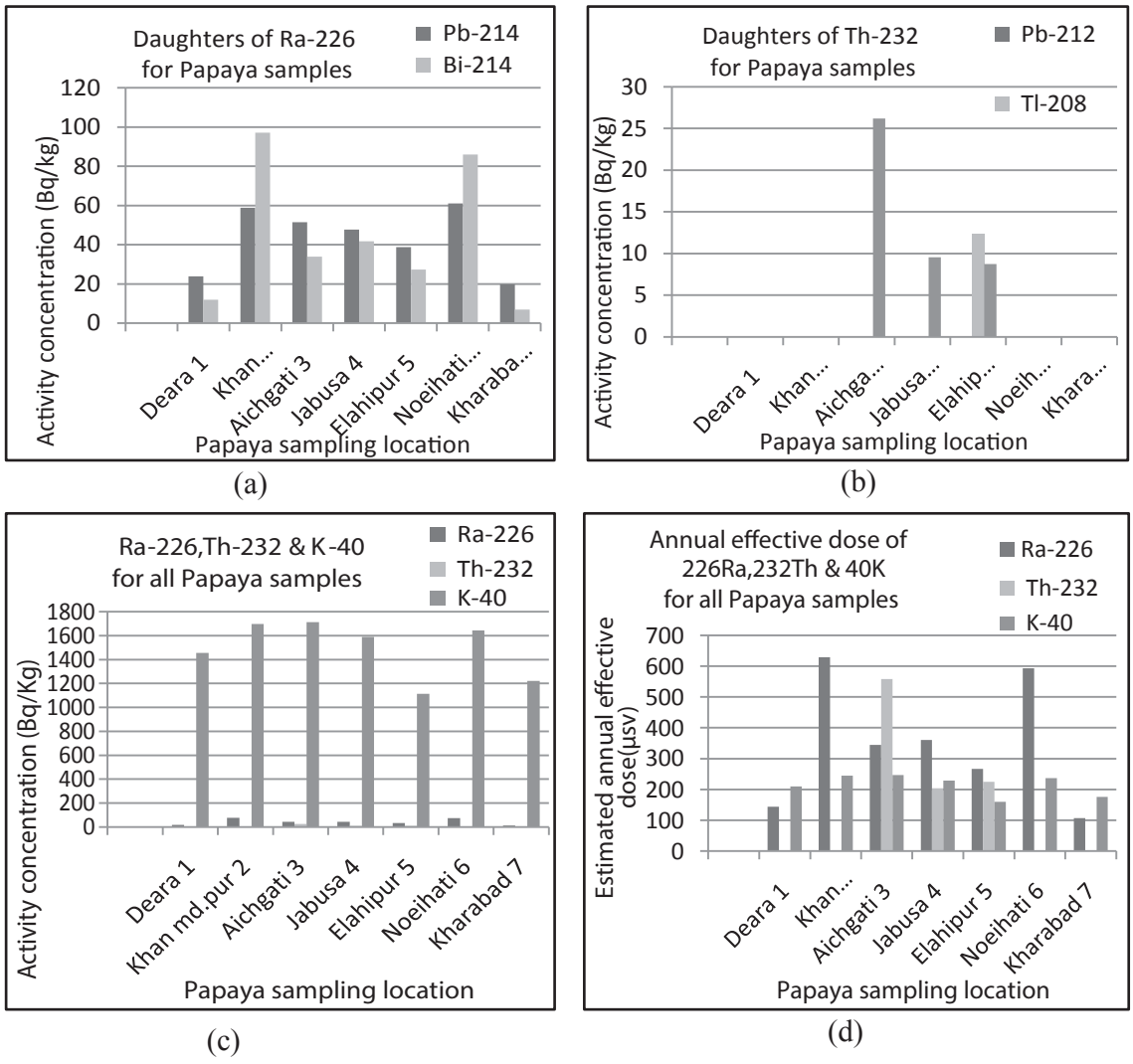


Fig. 2: (a) Activity concentrations of daughters (^{214}Pb, ^{214}Bi) of ^{226}Ra (b) Activity concentrations of daughters (^{212}Pb, ^{208}Ti, ^{228}Ac) of ^{232}Th (c) Activity concentrations of parents' nuclei ^{226}Ra, ^{232}Th and ^{40}K (d) Variation of estimated annual effective dose

4. Conclusions

The results have been indicated that only the natural radionuclides (^{226}Ra, ^{232}Th and ^{40}K) are present in the samples and no artificial radionuclide has been detected in the samples. The natural radioactivity concentrations and annul effective dose of ^{226}Ra, ^{232}Th and ^{40}K for all samples are higher than the worldwide average values. The estimated annual effective dose found in this study for an adult individual in Bangladesh is relatively higher than that of the world average value. However, these values of doses are much below the permissible level set by ICRP, and, therefore, there is no immediate health risk on workers and public due to natural radioactivity present in the samples of the study area. The investigation conducted under the current study is very important concerning the radiological safety of the public and the environment in these areas. This study also provides current exposure level and base-line database for the development of future guidelines in the country.

References

[01] S. Yeasmin and A. Begum, Bangladesh J. Phys., 2 (2012).

[02] Asimov and B. Isaac, New York: ACE books. 37 (1976).

[03] S. P. Zhang, Europe Pub Med Central, 44, 815 (2012).

[04] M. A. Usif and A. E. Taher, Radiation Protection Dosimetry, 130, 228 (2008).

[05] G. F. Knoll, John Wiley and Sons, 388 (1989).

[06] O. S. Ajayi and T. P. Owolabi, Radiation Protection Dosimetry, 128, 477 (2008).

[07] ICRP, Publication 26, Published in the Annals of the ICRP, Pergamon Press, Oxford, 1, 3 (1977).

[08] UNSCEAR, United Nations, New York, USA, Annex, (2000).

[09] Y. Selina, Bangladesh J. Phys., 2 (2012).

[10] J. Imrose, M. Sc. Thesis, Jahangirnagar University, Bangladesh, (2015).

[11]. I. Ashna, B. Aleya and Y. Selina, Int. J. Radia. Research, 12, 3 (2014).

[12] M. Hariandra and Y. M. Amin, AIP Conference Proceedings, 1017, 245 (2008).

[13] N.N. Jibiri, I. P. Farai and S. K. Alausa, Radiat Environ Biophys, (2007).

[14] C. Vahid, S. Elham and M. Z. Reza, Iran J Public Health. 42, 903 (2013).

[15] F. Tuo, Q. Zhang, Q. Zhou, C. Xu, J. Zhang, W. Li, J. Zhang and X. Su, 111, 40 (2016).

[16] N. Nahar, M. Sc. Thesis, Khulna University of Engineering and Technology, (2016).