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Radionuclide concentration in cabbage samples due to gamma radiation in Samsun, Turkey

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Abstract. Establishing of radioactivity planes in foodstuff has emphasis because it allows the evaluation of population exposure to radiation by take nourishment. In this paper, the activity concentrations of ^{226}Ra, ^{232}Th, ^{40}K and ^{137}Cs were determined in cabbage samples collected from Samsun city of Turkey using a gamma ray spectrometry method with a HPGe detector. The mean concentration value of ^{226}Ra, ^{232}Th,^{40}K and ^{137}Cs in cabbage samples were 1.11±0.03 Bqkg^{-1}, 1.44±0.04 Bqkg^{-1}, 743.75±21.21 Bqkg^{-1} and 0.18±0.003 Bqkg^{-1}, respectively. The calculated total annual effective dose received from ^{226}Ra, ^{232}Th, ^{40}K and ^{137}Cs due to cabbage samples by population of Samsun province was quite lower than the World average value as suggested by UNSCEAR.

1 Introduction

The sources of radioactivity in the environment have natural, terrestrial and anthropogenic origins which are resulted from nuclear trial and the processing of nuclear power stations. It is known that air residue of artificial radionuclides be formed as a result of the significant series of nuclear gun tests and nuclear disaster such as the Chernobyl disaster in 1986. The primary resource of artificial radionuclides in Turkey is the nuclear contamination from the Chernobyl accidents. During the process of nuclear waste, the airbone particles may be intercepted by plants or return to help soil. Therefore, plants may get radioactivity nuclides by deposition of radioactive waste on the foodstuff directly and by absorption from the soil Measurement of the concentrations of radionuclides present in foodstuffs permits the determine of the dose caused by the intake of foodstuff [1]. Since gamma radiation provides information about excess lifetime cancer risk, determining gamma dose rate has also importance [2]. The aim of this study is to determine the specific activities of radionuclides such as ^{226}Ra, ^{232}Th, ^{40}K and ^{137}Cs in cabbage samples grown in the Samsun city which is so close to the nuclear central that is going to be built in Turkey and calculate the annual effective dose.

2 Materials and methods

The samples were put inside on the detector and take counted for a term of 80.000 s. The net area under the specific peaks in energy spectrum was calculated by taking counts owing to Compton scattering of suitable peaks. From the net area of a clear peak, the activity concentrations in the samples were acquired from the following equation.

$$C\,(Bqkg^{-1}) = \frac{Cn}{\mathcal{E}\ P_{\text{ɣ}}\,Ms} \qquad (1)$$

Where C is the activity concentration of the radionuclide in sample given in Bqkg^{-1}, C_n is the count ratio under the specific peak, $\mathcal{E}$ is the detector efficiency at the certain ɣ-ray energy, $P_{\text{ɣ}}$ is the exact progression probability of the specific ɣ- ray and M_s is the mass of the sample [4]. The energy and efficiency calibration of the detector were performed using photopeaks from radioactive standards IAEA- RGU-1, IAEA-RGTh-1 and IAEA-RGK-1 reference materials [5]. Calibration sources were prepared with the same geometry as the vegetable samples thus didn't need to a geometry correction. The efficiency tables were formed by using known activities of photopeaks of intense gamma emitters from uranium series nuclides, ^{214}Bi and ^{214}Pb, thorium series nuclides ^{228}Ac and ^{208}Tl and gamma transitions of 1461 keV for K were also used [6]. Relative efficiency at 1332 keV ^{60}Co is %35. The ^{226}Ra activity of the samples was detected owing to the density of 351.9 keV and 609.3 keV gamma marks of ^{214}Pb and ^{214}Bi separately.

3 Result and discussion

3.1 Activity concentrations

The activity concentrations in cabbage samples ranged from 0.38±0.01 to 2.7±0.08 with an average 1.11±0.03 Bqkg^{-1} for ^{226}Ra; from 0.5±0.01 to 2.55±0.08 with an average 1.44±0.04 Bqkg^{-1} for ^{232}Th; from 0.1±0.003 to 0.71±0.02 with an average 0.18±0.003 for ^{137}Cs. The activity concentrations of ^{137}Cs are quite low values in many samples. As regarding of ^{40}K, Table.1 presents its measured activity concentrations in cabbage samples. The activity concentrations of ^{40}K varied between 373.37 and 1164.87±36.25 with an average 743.75±21.21. It can be said that the studied radionuclides (^{226}Ra, ^{232}Th, ^{40}K and ^{137}Cs) were defined in all cabbage samples.

Table 1. Activity concentrations of ^{226}Ra, ^{232}Th, ^{40}K and ^{137}Cs in evaluated in cabbage samples

Sample ID	Activity concentrations of cabbage samples			
	^{226}Ra	^{232}Th	^{40}K	^{137}Cs
1	0.75±0.02	1.98±0.05	753.37±24.87	0.25±0.008
2	0.62±0.02	0.7±0.02	866.75±27.37	0.16±0.005
3	1.6±0.05	1.16±0.03	1035.5±32.12	0.22±0.007
4	0.38±0.01	0.63±0.02	940.12±28.5	0.12±0.003
5	0.47±0.01	1.25±0.03	339.62±11.87	0.11±0.003
6	0.26±0.008	0.57±0.01	399.37±12.5	0.1±0.003
7	1.07±0.03	2.55±0.08	1221.5±39.5	0.27±0.007
8	0.66±0.02	2.05±0.06	1164.87±36.25	0.71±0.02
9	1.52±0.05	6.02±0.19	915.25±29.62	0.22±0.007
10	0.7±0.02	0.5±0.01	373.37±11.72	0.36±0.01
11	2.7±0.08	1.72±0.05	650.25±21.25	0.20±0.007
12	0.71±0.02	1.9±0.06	883±28.12	0.25±0.007
13	1.35±0.04	0.98±0.02	440.5±14.12	0.13±0.003
14	1.48±0.04	0.91±0.02	430.37±14.37	0.21±0.007
Average	1.11±0.03	1.44±0.04	743.75±21.21	0.18±0.003

3.2 Dose Estimation

Annual effective dose from estimated to evaluate the threat of radiation for human fitness. Annual effective dose is calculated by

$$H_{T,r}=\sum(U_{\text{i}}C_r^i)g_{T,r} \quad (2)$$

where i is foodstuff group, U^i and C_r^i are annual consumption ratio (kg) and radionuclide activity concentration (Bqkg^{-1}), respectively for their factor, $g_{T,r}$ is dose transformation factor for r radionuclide (SvBq^{-1}). Dose transformation factor of ^{226}Ra, ^{232}Th, ^{40}K and ^{137}Cs radionuclides for the adult members of society are 4.5x10^{-8}, 2.3x10^{-7}, 6.2x10^{-9} and 1.3x10^{-8} SvBq^{-1}, respectively [7,8,9]. The annual effective dose due to each radionuclide is shown in Table 2. It can be seen from Table 2 that ^{40}K conduced the maximum to the annual dose generated by intake of foodstuff. The sum of ^{40}K doses ensured by foodstuff adds to mean value of 33.66±0.5 μSvy^{-1}, which shows the mean annual effective dose for the Turkish consumer.

Table 2. Dose coefficients and appointed effective dose values

Radioisotopes	Activity intake (Bq)	AED (μSvBq-^{1})	Appointed effective dose (μSvy-^{1})	
			Range	Average
^{226}Ra	8.10±0.21	0.045	0.08±0.01-0.52±0.12	0.36±0.08
^{232}Th	10.51±0.29	0.23	1.02±0.3-12.30±1.14	2.94±0.61
^{40}K	5.429±147.53	6.2 x 10^{-3}	15.37±0.53-55.28±1.78	33.66±0.5
^{137}Cs	1.31±0.02	1.3 x 10^{-2}	0.002±0.01-0.71±0.26	0.01±0.003

The calculated total annual effective dose (AED) received from ^{137}Cs vary from 0.002±0.01 to 0.71±0.26 with a mean of 0.01±0.003 μSvy^{-1}. This paper based on that humans living in Samsun province be exposed radiation dose nearly 38 μSvy^{-1} from cabbage consumption is quite lower than the World average value (290 μSvy^{-1}) that established by UNSCEAR [10].

4 Conclusion

It was observed that the mean annual effective dose due to ^{40}K quite higher than ^{137}Cs. The total annual effective dose due to consumption of foodstuff was less than the average world value that announced as 290 μSvy^{-1} by UNSCEAR. As a result, the study showed that there is no radiological risk for the people living in Samsun province.

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