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Natural Radioactivity Contents in Concretes of Some Buildings and Associated Radiation Exposure Values for Building Occupants

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INTRODUCTION & AIM

Building materials are typically sourced from raw materials like rocks, fly ash, and soil, which naturally contain radioactive elements such as ^{226}Ra, ^{232}Th, and ^{40}K. Since most people spend around 80% of their time indoors, managing indoor radiation exposure is essential to minimize health risks. This requires monitoring of radioactivity concentrations in materials used in building construction and in concrete. In this study for this purpose, the background levels of some natural radioisotopes (^{226}Ra, ^{232}Th and ^{40}K) in some chestnut samples were determined before the operation of the nuclear power plant to be established in Sinop province, and the determined levels were compared with the limit values recommended by international organizations. Additionally, the radium equivalent activity (Ra_{eq}), internal hazard index (H_{in}), representative level index (I_g), absorbed dose rate (D), annual effective dose (AED) and excess lifetime cancer risk (LCR) values as radiological risk parameters were calculated.

METHOD

The concrete samples were taken from 14 different buildings in 12 different provinces of Türkiye and the radioactivity contents of these concrete samples were measured using a high purity germanium detector (HPGe). The photograph of the detector system where the samples were measured is given below.

Each concrete sample was counted in the detector for 86,400 s (one day), and the resulting spectra were analysed using the Gamma Vision program. An empty plastic measuring cup, under the same measurement conditions as the samples, was also counted in the detector to determine background concentrations. These background contributions were subtracted when evaluating the sample spectra.

RESULTS & DISCUSSION

The minimum detectable activity (MDA) values for the detector used in the study were determined to be 0.39, 0.40, and 3.29 Bq/kg for radioisotopes ^{226}Ra, ^{232}Th, and ^{40}K, respectively. All radioactivity concentrations determined in the samples were above the MDA values. The radioactivity concentrations and associated radiological risk parameters determined in 14 different concrete samples are listed in the tables below. Additionally, a comparison with different studies in the literature is also presented in a separate table.

Country	Activity Concentration (Bq/kg)			Referans
	^{226}Ra	^{232}Th	^{40}K	
Türkiye	7.34	10.44	57.70	This study
Türkiye (Eskişehir)	13.23	15.41	212.63	Temelli, 2018
Greece	40.00	6.00	101.00	Travisi et al, 2012
Spain	30.00	32.00	204.00	Travisi et al, 2012
Italy	19.00	18.00	329.00	Travisi et al, 2012

The average radioactivity concentrations from this study are lower than all other values in the table (except for the ^{232}Th concentration of the sample from Greece).

Sample Code	Collection Province	Radioactivity Concentration (Bq/kg)		
		^{226}Ra	^{232}Th	^{40}K
C1	Gaziantep	2.34 ± 0.63	4.51 ± 0.72	28.38 ± 4.37
C2	Antalya	4.83 ± 1.63	26.75 ± 1.92	35.54 ± 3.61
C3	Çorum	1.32 ± 0.24	3.27 ± 0.58	30.33 ± 3.68
C4	Gaziantep	1.99 ± 0.33	13.92 ± 0.98	46.78 ± 5.06
C5	İstanbul	5.84 ± 0.46	15.69 ± 1.01	151.49 ± 8.95
C6	Çorum	1.94 ± 0.31	6.18 ± 0.90	32.20 ± 4.55
C7	Hatay	2.29 ± 0.27	7.96 ± 0.85	23.88 ± 3.37
C8	İzmir	5.27 ± 0.40	17.40 ± 0.99	43.50 ± 5.66
C9	Samsun	7.73 ± 0.87	9.08 ± 1.00	171.73 ± 8.87
C10	Zonguldak	5.75 ± 0.80	8.99 ± 0.94	118.13 ± 7.56
C11	Bartın	2.46 ± 0.71	10.73 ± 1.06	17.74 ± 3.21
C12	Ankara	2.54 ± 0.30	11.65 ± 0.68	28.16 ± 5.51
C13	Manisa	47.44 ± 1.55	5.97 ± 1.27	45.53 ± 5.12
C14	Kilis	11.06 ± 0.68	3.99 ± 1.80	34.37 ± 3.44

The averages of activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K radionuclides in 14 concrete samples investigated were found to be 7.34±0.66, 10.44±1.05 and 57.70±5.21 Bq/kg, respectively. It is advised to use 50, 50 and 500 Bq/kg for the global average specific radioactivity values of ^{226}Ra, ^{232}Th, and ^{40}K in construction materials, respectively (UNSCEAR,1993). The radioactivity values obtained for the concrete samples in the current study are less than the world mean values.

Sample Code	Ra_{eq} (Bq/kg)	I_g	H_{in}	D (nGy/h)	AED (μSv/y)	LCR ($x10^{-5}$)
C1	10.97	0.08	0.04	5.00	24.51	9.57
C2	45.82	0.32	0.14	19.88	97.53	38.09
C3	8.33	0.06	0.03	3.86	18.93	7.39
C4	25.50	0.18	0.07	11.29	55.39	21.63
C5	39.94	0.30	0.12	18.54	90.94	35.51
C6	13.26	0.10	0.04	5.98	29.34	11.46
C7	15.51	0.11	0.05	6.87	33.70	13.16
C8	33.50	0.24	0.10	14.77	72.46	28.30
C9	33.94	0.26	0.11	16.27	79.81	31.16
C10	27.70	0.21	0.09	13.05	64.01	25.00
C11	19.17	0.14	0.06	8.36	41.02	16.02
C12	21.37	0.15	0.06	9.39	46.08	17.99
C13	59.48	0.41	0.29	27.44	134.59	52.56
C14	19.41	0.14	0.08	8.96	43.97	17.17

CONCLUSION

The concentrations of ^{226}Ra, ^{232}Th and ^{40}K radioisotopes in the 14 concrete samples taken from different provinces in Türkiye were determined using the gamma spectrometer system (HPGe) and radiological hazards caused by natural radiation were calculated. The radioactivity values obtained in the current study were found to be lower than the world's means. Consequently, this study demonstrates that the concrete samples under investigation are safe to use in constructions and do not present a substantial radioactive risk. The results of this study have the potential to guide future studies.

FUTURE WORK / REFERENCES

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