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Measurement of Natural Radioactivity in Brick Samples Using Gamma-Ray Spectrometry

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The activity concentrations of primordial radio nuclides (226Ra, 232Th and 40K)have been determined for the brick samples of Jalandhar city of Punjab using HPGe detector based on high resolution gamma spectrometry system. The average activity concentration values of 226Ra, 232Th and 40K from the studied samples are 21.38 Bq kg-1, 25.03 Bq kg-1 and 333.08 Bq kg-1 respectively. The average value of radium equivalent activity (Raeq) for studied brick samples is 80.48 Bq kg-1 which is less than the safe limit 370 Bq kg-1 recommended by Organization for Economic Cooperation and Development (OECD) equivalent to external gamma dose of 1.5 mSvyr-1.

Key Words: Natural Radioactivity, Gamma-ray Spectrometry, Radium-equivalent activity

INTRODUCTION

Environment contains some naturally occurring radioactive materials (NORM) which are found in soils, rocks, vegetation, air, water and also in building materials. Bricks are used as one of the main building materials so the knowledge of content of natural radioactivity in bricks becomes an important aspect. The natural radionuclides of concern are mainly ^{238}U (^{226}Ra)-series, ^{232}Th-series and non-series ^{40}K isotope. These radionuclides constitute natural sources of indoor and outdoor radiation exposure as well as internal and external radiation exposure. The main objective of the present study is to determine the level of radioactive elements viz. radium (^{226}Ra), thorium (^{232}Th) and potassium

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(^{40}K) in brick samples for the assessment of radiological risks in this area of Punjab.

EXPERIMENTAL

Sample collection and preparation: The collected samples of bricks are crushed, sieved and then sealed in an airtight PVC container and kept for about 4 week's period to allow radioactive equilibrium among the daughter products of radon (^{222}Rn), thoron (^{220}Rn) and their short lived decay products. An average 0.25 kg of soil is used per sample.

Experimental Method: Radioactivity measurements are performed by using HPGe detector based on gamma-ray spectrometry. The secondary standard was calibrated with the primary standard (RGU-1) obtained from the International Atomic Energy Agency. Gamma transitions of 1461 keV for ^{40}K, 186 keV and 609 keV of ^{214}Bi for ^{226}Ra, 338, 463, 911, 968 keV for ^{228}Ac, 727 keV for ^{212}Bi, 238 keV for ^{212}Pb were used for the laboratory measurement of activity concentration potassium, radium and thorium. The samples were counted for a period of 72,000 seconds, and the spectra of the photo peak of radium (^{226}Ra), thorium (^{232}Th) daughter products and Potassium (^{40}K) is obtained and analyzed. The activity of the radionuclide was calculated using the following equation:

$$Activity\,(Bq) = \frac{CPS \times 100 \times 100}{B.I. \times Eff} \pm \frac{CPS_{error} \times 100 \times 100}{B.I. \times Eff} \qquad (1)$$

where, *CPS* = Net count rate per second; *B.I.* = Branching Intensity, and E*ff* = Efficiency of the detector.

Table1: Activity concentration values for ^{226}Ra, ^{232}Th and ^{40}K using gamma ray spectrometry and Ra_{eq} activity values in brick samples

Sr. No.	Radium Concentration A_{Ra} (Bq kg^{-1})	Thorium Concentration A_{Th} (Bq kg^{-1})	Potassium Concentration A_K (Bq kg^{-1})	Radium equivalent activity (Bqkg^{-1})
1	20.59	26.61	347.56	82.97
2	18.36	23.14	342.12	75.4
3	25.12	20.45	335.14	77.82
4	22.49	28.63	320.31	85.85
5	23.65	31.12	318.33	90.43
6	19.01	22.09	334.21	73.99
7	20.42	23.14	333.89	76.88

Table 2: Air absorbed dose rates, External hazards and annual effective dose values for brick samples

Sr. No.	Absorbed dose ($nGyh^{-1}$)				External Hazard Index H_{ex}	Annual effective dose(mSv)	
	^{226}Ra	^{232}Th	^{40}K	Total		Indoor	Outdoor
1	9.49	16.58	14.39	40.46	0.23	0.20	0.05
2	8.46	14.42	14.16	37.04	0.21	0.18	0.05
3	11.58	12.74	13.87	38.20	0.22	0.19	0.05
4	10.37	17.84	13.26	41.47	0.24	0.20	0.05
5	10.90	19.39	13.18	43.47	0.25	0.21	0.05
6	8.76	13.76	13.84	36.36	0.21	0.18	0.04
7	9.41	14.42	13.82	37.65	0.21	0.18	0.05

RESULTS AND DISCUSSION

Table 1 shows that the specific activity concentration values for the radionuclides viz. ^{226}Ra, ^{232}Th and ^{40}K range from 18.36 Bq kg^{-1} to 25.12 Bq kg^{-1}, 20.45 Bq kg^{-1} to 31.12 Bq kg^{-1} and 318.33 Bq kg^{-1} to 347.56 Bq kg^{-1} with mean values of 21.38 Bq kg^{-1}, 25.03 Bq kg^{-1}, 333.08 Bq kg^{-1} for ^{226}Ra, ^{232}Th and ^{40}K respectively which are less in comparison to the world average concentration values for these natural radionuclides viz. ^{226}Ra, ^{232}Th and ^{40}K. The mean value of Raeq for the present study of brick samples is 80.48 Bq kg^{-1} which is lower than the safe limit(370 $Bqkg^{-1}$) recommended by OECD[1]. Table 2 presents that absorbed dose rates ranges from 8.46 $nGyh^{-1}$ to 11.58 $nGyh^{-1}$, 12.74 $nGyh^{-1}$ to 19.39 $nGyh^{-1}$ and 13.18 $nGyh^{-1}$ to 14.39 $nGyh^{-1}$ for ^{226}Ra, ^{232}Th and ^{40}K respectively for the present study. The total absorbed dose rate varies from 36.36 $nGyh^{-1}$ to 43.47 $nGyh^{-1}$. The calculated average values of annual indoor and outdoor effective dose are 0.19 mSv and 0.05 mSv respectively which are less than the annual effective dose equivalent limit of $1mSvY^{-1}$ recommended by International Commission on Radiological Protection ICRP[2]. Further detailed investigation tells that there is a negative correlation (R= -0.58) between activity concentration values for ^{232}Th and ^{40}K.The activity concentration values for ^{226}Ra and ^{40}K for the present study are more but the activity concentration values for ^{232}Th for the present study are less as compared to the activity concentration values for ^{226}Ra, ^{232}Th and ^{40}K in the samples of bricks from Amritsar and Batala

districts of Punjab reported by Kumar *et al.*[3].

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