

Measurement of primordial radionuclides in soils and building materials from Mizoram, India

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Humans are constantly exposed to radiations, of which majority (87%) is from natural sources and a fraction (13%) is from man-made. Construction materials can contribute to natural background radiation in two ways, namely emission of gamma radiation, from primordial radionuclides like uranium, thorium and potassium and their decay products (external dose); and exhalation of radon (internal dose). The nature of soil largely determines the degree of gamma radiation. Measurement of natural radioactivity in soil and building materials from Siaha and Lawngtlai districts in Mizoram was carried out using 5"X 4" NaI (TI) detector. Soil samples were collected from 25 different sites and five different commonly used building materials in the study area are also analysed. The activity concentrations were measured for three principal primordial radionuclides namely, ²³⁸U, ²³²Th and ⁴⁰K. The average activity concentration of soil samples was found to be 33.47 Bq/kg for ²³⁸U, 67.00 Bq/kg for ²³²Th nuclides and 942.25 Bq/kg for ⁴⁰K nuclides. The average activity concentration of ²³⁸U & ²³²Th are found to be highest in Glazed tiles and that of ⁴⁰K is found to be highest in bamboo.

Keywords: Radionuclides, activity concentration, NaI (TI) detector, soil, gamma energy.

INTRODUCTION

Of all the radiation dose received by human being, about 87% is due to natural radiation sources and the remaining 13% by anthropogenic radiation (Kannan *et al.*, 2002). The global average natural radiation dose to humans is about 0.3-1.0 mSv/ year which is four times higher than the global average of artificial radiation exposure (UNSCEAR, 2008). Since most of the residents use to spend most of the time indoors, the knowledge of the radioactivity in soil and building materials is important and helps to the study of population exposure to radiations. The building materials may contribute to exposure of human beings to natural background radiation in two ways – emission of gamma radiation, from primordial radionuclides like uranium, thorium and potassium and their decay products (external dose); exhalation of radon (internal dose). The intensity of gamma-radiation de-

pends on soil radioactivity and physical features of the surface soil and their relationship to the geological structure of the study area (Karahan and Bayulken, 2000; De-gerlier *et al.*, 2008). Since the distribution of the said primordial radionuclides is not uniform, the knowledge of their concentration in soil, rocks and building materials play an important role in radiation protection and measurement (Rani and Singh, 2005).

In this work the estimation of ²³⁸U, ²³²Th and ⁴⁰K contents in the soil and commonly used building materials in the study area were therefore carried out using a low-level gamma ray spectrometer using NaI (TI) detector. The geographical locations of the study area are Siaha and Lawngtlai districts of Mizoram, India within Latitude – 22°29'28.3" to 22°36'59.4" and Longitude 92°59'14.3" to 92°52'22.0" with altitude 1866 ± 10 ft to 3807 ± 10 ft from the sea level.

MATERIALS AND METHODS

Sampling

25 soil samples and 5 commonly used building materials (2 each from the two districts) were collected from the study area. Since the density of sample matrix and its geometry affects the attenuation factor for gamma rays, the samples were crushed to powder and then sieved to minimum size as possible. In order to achieved secular equilibrium between primordial radionuclides and their daughter products, the samples were kept sealed and undisturbed for one month, in a plastic container having the same geometry as the standard sources.

Measurement of radioactivity

Measurement of radioactive contents of the samples were carried out using 5"×4" NaI (TI) detector coupled with a GSPEC-SA (version 2.5 X), which is a PC-based multi-channel analyzer. The concentration of ²³⁸U were determined using a photo peak of 295 keV (19%) from ²¹⁴Pb. ²³²Th concentration were determined using a photo peak of 167 keV (0.1%) from ²²⁸Th. ⁴⁰K concentration were determined from its 1460 keV (11%) photo peak.

For efficiency calibration, the IAEA standard samples with known activity were counted for 10,800 seconds. The efficiency was obtained from the particular gamma energy peak of the above radionuclides using the following formula:

$$\eta(\%) = \frac{\text{Area} / s}{dps} \times \frac{100}{A\%} \times 100 \quad (1)$$

where $\eta\%$ = Percentage efficiency

Area/s = Net peak area (background subtracted) per second

dps = Source strength in disintegration per second

A%= Gamma ray abundance factor.

Energy calibration was performed before measurement of radioactive content of the samples. A three-point energy calibration is carried out using two standard sources, ¹³⁷Cs (661.62 keV) and ⁶⁰Co (1173.24 keV and 1332.46 keV) (ISO 18589-3:2007(E)).

To arrive at the net radioactivity (Bq) of a particular radionuclide in the samples, counting was done for 50,000 seconds. The activity of particular radionuclides was calculated using the formula

$$\text{Activity(Bq / kg)} = \frac{N}{T} \times \frac{100}{\gamma\%} \times \frac{100}{\eta\%} \times \frac{1}{W} \quad (2)$$

where W = Weight of the sample.

N = Background subtracted net peak area counted in T second.

$\gamma\%$ = Abundance of gamma ray under consideration.

$\eta\%$ = Previously obtained percentage efficiency of the standard source.

RESULTS

Table 1 and Figure 1 shows the result of measurement of natural radioactivity concentration of principal primordial radionuclides of the soil samples. The activity concentration of ²³⁸U range from 19.32 Bq/kg to 47.70 Bq/kg with the average value of 33.47 Bq/kg, GM of 32.11 Bq/kg, SD of 9.54 and GSD of 1.34. The activity concentration of ²³²Th range from 43.63 Bq/kg to 85.61 Bq/kg with the average value of 67.00 Bq/kg, GM of 66.32 Bq/kg, SD of 9.62 and GSD of 1.16. The activity concentration of ⁴⁰K range from 686.58 Bq/kg to 1150.81 Bq/kg with the average value of 942.25 Bq/kg, GM of 932.29 Bq/kg, SD of 135.74 and GSD of 1.15.

The radioactive content of some commonly used building materials, namely, asbestos, glazed tiles, bricks, bamboo and wood are also analysed. Table 2 and Figure 2 show the radioactivity content in different types of building materials in Bq/kg. Asbestos, glazed tiles and bricks contain regular level of the primordial radionuclides, some other materials like bamboo and wood contain only ⁴⁰K. Thus, the average activity of ²³⁸U, ²³²Th and ⁴⁰K in commonly used building material in the study area range from 22.22-29.1 Bq/kg, 59.23-144.95 Bq/kg and 436.82-814.18 Bq/kg respectively.

DISCUSSION

The global average value of activity of ²³⁸U range from 16-110 Bq/kg with the average value of 35 Bq/kg, global average value of activity of ²³²Th range from 11-64 Bq/kg with the average value of 30 Bq/kg and global average value of activity of ⁴⁰K range from 140 – 850 Bq/kg with the average value of 400 Bq/kg (UNSCEAR, 2000). Our result of the average activity of ²³⁸U is lower than that of global average and while the activity of ²³²Th is a higher than that of the global average. But our result of the average ⁴⁰K activity is way above the global average.

Authors like Haquin (2008) and SC Lee *et al.*, (2001) report presence of small amount of ²²⁶Ra/²³⁸U and absence of ²³²Th in wood samples. However, the presence or absence of primordial radionuclides in the bamboo samples has not been recorded to compare with our result.

The average value of activity of ²³⁸U is found to be comparable to the global average while the activity of ²³²Th and ⁴⁰K is found to be much more than the global average. The natural radioactivity content of some of the building materials like asbestos, glazed tiles, bricks, bam-

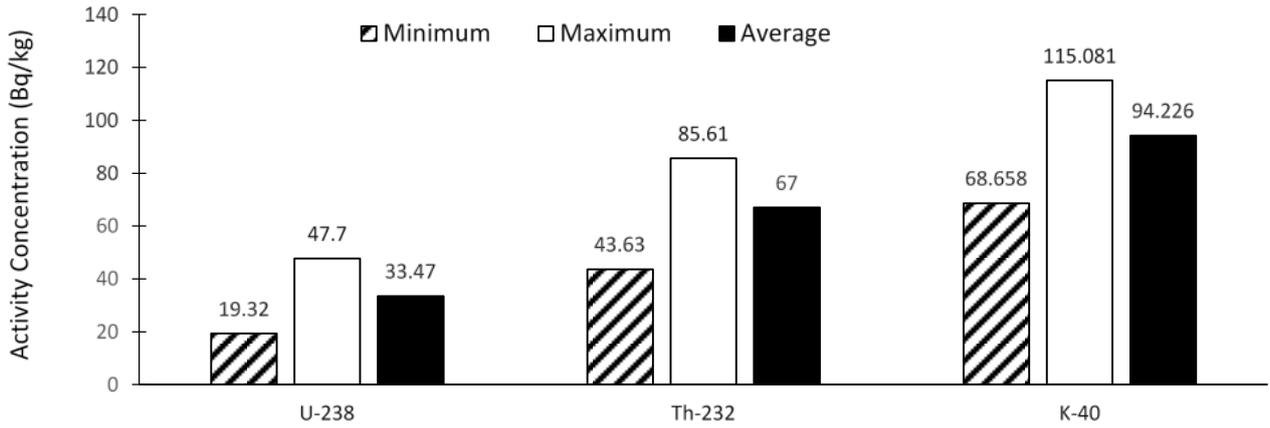


Figure 1: Activity concentration of ^{238}U , ^{232}Th & ^{40}K in soil samples. (The activity concentration of ^{40}K is diminished ten times for the sake of convenience for viewing.)

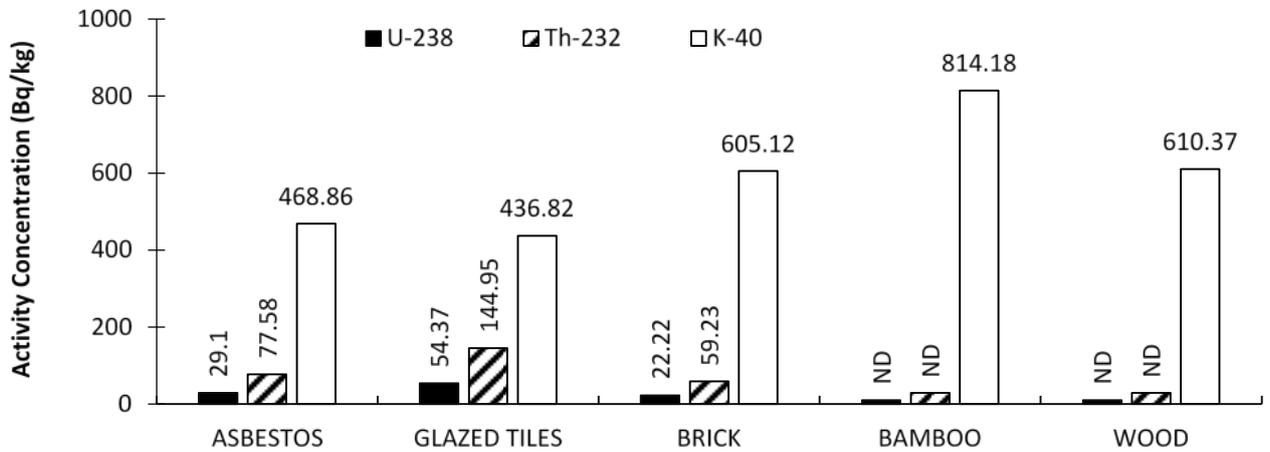


Figure 2: Activity concentration of ^{238}U , ^{232}Th & ^{40}K in building materials.

Table 1: Activity concentration of ^{238}U , ^{232}Th & ^{40}K radionuclides in soil samples.

Sample No	^{238}U	^{232}Th	^{40}K	Sample No	^{238}U	^{232}Th	^{40}K
1	39.91	73.65	861.24	14	37.06	71.16	987.29
2	19.32	57.71	1008.37	15	29.68	68.69	706.92
3	22.76	43.63	742.04	16	22.07	60.37	1062.73
4	43.68	79.57	686.58	17	47.69	68.57	1119.82
5	21.39	73.85	1150.81	18	22.63	58.34	940.74
6	28.03	58.25	964.17	19	44.65	75.45	975.75
7	24.50	58.12	1020.85	20	41.79	65.34	1068.25
8	47.69	68.57	1119.82	21	31.76	61.58	863.02
9	22.63	58.34	940.74	22	41.22	85.61	836.68
10	44.65	75.45	975.75	23	37.06	71.16	987.29
11	41.79	65.34	1068.25	24	29.68	68.69	706.92
12	31.76	61.58	863.02	25	22.07	60.37	1062.73
13	41.22	85.61	836.68				

Table 2: Activity concentration of ^{238}U , ^{232}Th & ^{40}K radionuclides in building materials.

	Asbestos	Glazed Tile	Brick	Bamboo	Wood
^{238}U	29.1	54.37	22.22	ND ⁺	ND ⁺
^{232}Th	77.58	144.95	59.23	ND ⁺	ND ⁺
^{40}K	468.86	436.82	605.12	814.18	610.37

boo and wood lies in a range to other data as mentioned earlier. From the result of analysis of building materials (Table 2), we can find that bamboo have the highest activity concentration of ^{40}K and glazed tiles have highest activity concentration of ^{238}U and ^{232}Th . The natural sources like wood and bamboo are expected to have more concentration of ^{40}K . The activity concentration of primordial radionuclides in all the samples are lower than the critical value describes by the International Atomic Energy Agency (IAEA) which is 10,000 Bq/kg for ^{40}K , 1000 Bq/kg for all other natural radionuclides (IAEA, 2004).

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