

HETEROGENEITY OF RADIOACTIVITY IN SOIL FROM VARKALA, KERALA

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Abstract

There exist monazite sand-bearing placer deposits causing high background radiation along its long coastline of Kerala and Tamil Nadu in India. The extent and effects of the radioactivity in this region is well studied and are available in literature. Other regions along the coast are assumed to have normal radiation levels. Still, it has been observed that certain regions along the coast have regions of high radioactivity with a highly heterogeneous nature of distribution. We have made a brief investigation to study the extend and diversity of levels in one of the coastal thaluk, which is otherwise known as normal background region. The gamma spectrometric measurement was used for the estimation of natural radioactivity in soil samples collected in a systematic way from Varkala, which is an important tourist destination in Kerala. Radium equivalent activity (Ra_{eq}) and the radiological parameters such as internal and external hazard indices, absorbed dose rate, indoor and outdoor annual effective dose, Representative Level index were also determined from the estimated value of the specific activity of ^{226}Ra , ^{232}Th and ^{40}K . The

measured specific activity in soil samples show a wide range of activity with certain radioactive pockets in the region. The results indicate the necessity of an in depth study in the region.

Keywords: Gamma ray spectrometer, Specific Activity, Radium equivalent activity, Gamma absorbed dose rate.

INTRODUCTION

Radionuclides occurring naturally in building materials are sources of external and internal radiation exposure in dwellings, besides gamma radiation and cosmic radiation. External radiation exposure is caused by the gamma radiation originating from members of the uranium and thorium decay chain and from ^{40}K . Internal radiation exposure, mainly affecting the respiratory tract, is due to the short lived products of radon which are exhaled from building materials in room air [1]. The content of the natural radionuclides in building materials is caused by the factors such as geological origin, composition of soil, density, porosity, content of water in soil, diffusion rate, rate of emanation

and exhalation etc.[2]. Radon can move freely from the place of its origin through cracks in walls. Radon transportation is mainly due to diffusion and forced flow [3]. This transportation of radon resulted in radiological risk to human health, which mainly depends on the factors such as the level of radon and duration of exposure. The worldwide average annual effective dose for natural sources is 2.4mSv of which 1.1mSv is due to basic background radiation and 1.3 mSv is due to exposure to radon [4]. This makes the importance of investigating natural radiation from building materials.

The present studies give an insight of the activity concentration of the natural radioactive nuclides namely, ^{226}Ra , ^{232}Th and ^{40}K of brick and granite, each of five samples. The material, brick is of great interest in construction industry since the raw material is easily available. The granite is not only used as a basic construction material but also as a decoration material. The wide use of these materials paves the way for testing the NORM levels. The gamma spectroscopic measurement technique is adopted for the measurement.

METHODOLOGY

A total of 12 samples of soils are collected from Varkala Taluk for the measurement of natural radiation. These samples were crushed to get fine powder and moisture content is completely removed by heating at 110°C in an oven. The sample is then homogenized and sealed in radon

impermeable airtight can with capacity of 305cm³ for more than 30 days to reach secular equilibrium were the rate of decay of the daughter becomes equal to that of the parent. All samples were analyzed using a gamma spectrometer with NaI(Tl) based detector. The samples were counted for 10000seconds. The spectrum was stored in a PC based multichannel analyzer. Radiometric measurements were carried out for the determination of radionuclides present in the samples of building materials.

1. Determination of natural radioactivity

The activity concentrations of the radionuclides ^{226}Ra , ^{232}Th and ^{40}K for the samples were determined using the equation.

$$\text{Activity}(Bq) = \frac{\text{cps} \times 100 \times 100}{BI \times E_{ff}}$$

Where **cps** is the net count per second; **BI** is the branching intensity and **E_{ff}** is the efficiency of the detector.

2. Radium equivalent activity (Ra_{eq})

Radium equivalent activity is an index that has been introduced to evaluate the specific activities of ^{226}Ra , ^{232}Th and ^{40}K by a single quantity [6]. It is generally defined as

$$Ra_{eq} = C_{Ra} + 1.43 C_{Th} + 0.077 C_k$$

Where C_{Ra} , C_{Th} and C_k are activities of ^{226}Ra , ^{232}Th and ^{40}K respectively in Bq/Kg. The radium equivalent activity is defined on the assumption that 10Bq/Kg of ^{226}Ra , 7 Bq/kg of ^{232}Th and 130 Bq/kg of ^{40}K

produce the same gamma ray dose rates [7].
 The maximum value of radium equivalent must be less than 370Bq/Kg for the safe limit [8].

3. Estimation of absorbed dose rate

The absorbed dose rates (D) in air at above the ground surface for the uniform distribution of radionuclides (^{226}Ra , ^{232}Th and ^{40}K) was calculated using the following equation [9],

$$D(\text{nGyh}^{-1}) = (0.462 C_{Ra} + 0.621 C_{Th} + 0.0417 C_K)$$

Where the numerical values 0.462, 0.621 and 0.417 are the dose conversion factors for converting activity concentrations of ^{226}Ra , ^{232}Th and ^{40}K into doses.

4. External and internal hazard index

The value of external hazard index should be less than or equal to unity for the safe use of building materials, which corresponds to the upper limit of Ra_{eq} 370Bq/Kg for limiting the dose from building materials to 1.5mGy^{-1} . External hazard index can be calculated using the equation [6],

$$H_{ex} = \frac{C_{Ra}}{370} + \frac{C_{Th}}{259} + \frac{C_K}{4810} \leq 1$$

Internal exposure to ^{222}Rn and its radioactive progeny is controlled by the internal hazard index (H_{in}) and is obtained by the equation [10], for the safe use of a material in the construction of dwellings internal hazard index should be less than unity.

$$H_{in} = \frac{C_{Ra}}{185} + \frac{C_{Th}}{259} + \frac{C_K}{4810} \leq 1$$

5. Annual effective dose rate

The annual effective dose rate is determined by considering the conversion coefficient from absorbed dose in air to effective dose 0.7 SvGy^{-1} and the indoor occupancy factor of 0.8 and the outdoor occupancy factor of 0.2 proposed by UNSCEAR 2000. The annual effective dose was calculated from the equation,

$$\begin{aligned} \text{Indoor}(\text{mSvy}^{-1}) &= D(\text{nGyh}^{-1}) \times 8766 \text{ hy}^{-1} \\ &\times 0.8 \times 0.7(\text{SvGy}^{-1}) \\ &\times 10^{-6} \end{aligned}$$

$$\begin{aligned} \text{Outdoor}(\text{mSvy}^{-1}) &= D(\text{nGyh}^{-1}) \times 8766 \text{ hy}^{-1} \\ &\times 0.2 \times 0.7(\text{SvGy}^{-1}) \\ &\times 10^{-6} \end{aligned}$$

Where D is the Absorbed dose rate in nGyh^{-1} .

6. Radioactivity level index

The radioactivity level index is used to represent the γ radiation hazards associated with the natural radio nuclide. The representative level of I_γ was obtained by the equation [11],

$$I_\gamma = \frac{C_{Ra}}{150} + \frac{C_{Th}}{100} + \frac{C_K}{1500}$$

7. Alpha index

The index is used for the assessment of internal hazard due to the radon inhalation originating from building materials and is defined by the equation [12],

$$I_\alpha = \frac{C_{Ra}}{200}$$

Where C_{Ra} is the activity concentration of radium in and its recommended limit is 200Bq/Kg. Hence for the safe use of building materials the value of I_α chosen to be less than unity.

RESULT AND DISCUSSION

The concentrations of the radionuclides present in the collected samples are summarized in the table 1. In the selected soil sample, the activity concentrations for ^{226}Ra varies up to 20.19

Bq/Kg from the below detectable level, ^{232}Th varies from 13.34 Bq/Kg to a maximum of 30.27 Bq/kg and ^{40}K varies from 65.99 Bq/Kg to a maximum level of 81.64 Bq/Kg. In the case granite, the detectable level of radium is noticed only in black with red coloured granite from the selected samples. The concentration of ^{232}Th and ^{40}K samples varies from 4.82 to 8.75Bq/Kg and 119.18 to 147.92Bq/Kg respectively. From the table it is clear that Ra_{eq} values of the soil samples ranges from 31.16Bq/Kg to 68.30Bq/Kg is less than the maximum admissible value of 370Bq/Kg.

Soil	$^{226}\text{Ra}(\text{Bq/Kg})$	$^{232}\text{Th}(\text{Bq/Kg})$	$^{40}\text{K}(\text{Bq/Kg})$	$Ra_{eq}(\text{Bq/Kg})$
Sample 1	18.51	28.15	83.52	65.19
Sample 2	7.03	14.84	66.82	33.39
Sample 3	4.80	14.34	76.06	31.16
Sample 4	BDL	30.27	78.38	49.32
Sample 5	13.98	22.20	65.99	50.80
Sample 6	BDL	26.11	76.98	43.26
Sample 7	20.19	29.12	84.07	68.30
Sample 8	9.22	22.58	71.06	46.98
Sample 9	5.00	19	119.18	41.34
Sample 10	6.8	17.35	78.34	37.64
Sample 11	7.9	15.91	73.55	36.31
Sample 12	BDL	24.58	81.92	41.45

Table 1: Activity concentrations of ^{226}Ra , ^{232}Th , ^{40}K and Radium equivalent activity

Table 2 presents the radiological risk factors such as absorbed dose rate, indoor and outdoor annual effective dose rate, internal and external hazard index, radioactivity level

index, alpha index. The value of hazard indices and radioactivity level index are less than unity and indicates that selected samples are within the safe limit.

Soil	D(nGyh ⁻¹)	H _{ex}	H _{in}	I _γ	I _α	Annual Effective Dose Rate(mSvy ⁻¹)	
						Indoor	Outdoor
Sample 1	51.08	0.302	0.478	0.772	0.326	0.251	0.063
Sample 2	27.43	0.161	0.252	0.416	0.167	0.135	0.034
Sample 3	26.47	0.155	0.240	0.402	0.156	0.130	0.032
Sample 4	44.85	0.266	0.400	0.684	0.247	0.220	0.055
Sample 5	40.01	0.237	0.374	0.605	0.254	0.196	0.049
Sample 6	39.41	0.234	0.351	0.601	0.216	0.193	0.048
Sample 7	53.15	0.315	0.499	0.803	0.342	0.261	0.065
Sample 8	38.69	0.229	0.356	0.586	0.235	0.190	0.047
Sample 9	35.87	0.210	0.322	0.545	0.207	0.176	0.044
Sample 10	31.43	0.185	0.287	0.477	0.188	0.154	0.039
Sample 11	29.72	0.175	0.273	0.450	0.182	0.146	0.036
Sample 12	37.83	0.224	0.336	0.577	0.207	0.186	0.046

Table 2 : Absorbed dose rate, External and internal hazard index, Representative level index, alpha index and annual effective dose rate.

CONCLUSION

In this study, the analysis of radioactivity was carried out for the samples collected from the coastal taluk, Varkala of Thiruvananthapuram district. The gamma spectrometric measurement technique is used to analyze the activity concentrations of ²²⁶Ra, ²³²Th and ⁴⁰K. The risk factors such as Radium equivalent activity (R_{eq}), internal and external hazard index, absorbed dose rate, indoor and outdoor annual effective dose and Radioactive Level index were also calculated from the estimated value of the specific activity of ²²⁶Ra, ²³²Th and ⁴⁰K. The values obtained in the study are within the safe limits and does not

pose any significant health hazard to human beings.

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