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Research Article

Heterogeneity of Radioactivity In Soil From Karunagapally, Kerala

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Abstract: 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 Karunagapally. Radium equivalent activity (Raeq) 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 226Ra, 232Th and40K.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.

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Introduction: External radiation exposure is caused by the gamma radiation originating from members of the uranium and thorium decay chain and from 40k. 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 2.4 mSv of which 1.1 mSv 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, 226Ra, 232Th and 40K 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 Karunagapally Taluk for the measurement of natural radiation. These samples were crushed to get fine powder and moisture content is completely removed by heating at 110oC in an oven. The sample

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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 226Ra, 232Th and 40K for the samples were determined using the equation.

$$Act(Bq)=cps\times 100\times 100/(BI\times Eff)$$

Where cps is the net count per second; BI is the branching intensity and Eff is the efficiency of the detector.

2. Radium equivalent activity (Raeq)

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

$R= a + 1.43\, CTh + 0.077Ck$ Where CRa, CTh and Ck are activities of 226Ra, 232Th and 40K respectively in Bq/Kg. The radium equivalent activity is defined on the assumption that 10Bq/Kg of 226Ra, 7 Bq/kg of 232Th and 130 Bq/kg of 40K

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(226Ra, 232Th and 40K) was calculated using the following equation [9],

$$(\mathrm{D\ nGyh}-1) = (0.462\, CRa + 0.621\, CTh + 0.0417\, CK$$

Where the numerical values 0.462, 0.621 and 0.417 are the dose conversion factors for converting activity concentrations of 226Ra, 232Th and 40K 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 Raeq 370Bq/Kg for limiting the dose from building materials to 1.5mGyy-1. External hazard index can be calculated using the equation [6],

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

Internal exposure to 222Rn and its radioactive progeny is controlled by the internal hazard index (Hin) 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.

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

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,

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

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

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 Iγ was obtained by the equation

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

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],

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

Where CRa is the activity concentration of radium in and its recommended limit is 200 Bq/Kg. Hence for the safe use of building materials the value of Iα 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 226Ra varies up to 20.19 Bq/Kg from the below detectable level, 232Th varies from 13.34 Bq/Kg to a maximum of 30.27 Bq/kg and 40K 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 232Th and 40K samples varies from 4.82 to 8.75 Bq/Kg and 119.18 to 147.92 Bq/Kg respectively. From the table it is clear that Raeq values of the soil samples ranges from 31.16 Bq/Kg to 68.30 Bq/Kg is less than the maximum admissible value of 370 Bq/Kg.

Table 1

Soil	^{226}Ra(Bq/Kg)	^{232}Th(Bq/Kg)	^{40}K(Bq/Kg)	Ra_{eq}(Bq/Kg)
Sample 1	17.51	27.15	84.52	64.19
Sample 2	8.03	13.84	67.82	34.39
Sample 3	3.80	15.34	77.06	32.16
Sample 4	BDL	31.27	79.38	50.32
Sample 5	14.98	23.20	66.99	51.80
Sample 6	BDL	27.11	77.98	44.26
Sample 7	19.19	28.12	85.07	69.30
Sample 8	10.22	23.58	72.06	47.98
Sample 9	4.00	18	118.18	42.34
Sample 10	7.8	18.35	79.34	38.64
Sample 11	7.9	16.91	74.55	37.31
Sample 12	BDL	24.58	82.92	42.45

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.

Table 2

Soil	D($nGyh^{-1}$)	H_{ex}	H_{in}	I_{γ}	I_{α}	Annual Effective Dose Rate($mSvy^{-1}$)	
						Indoor	Outdoor
Sample 1	52.08	0.302	0.478	0.772	0.326	0.251	0.063
Sample 2	28.43	0.161	0.252	0.416	0.167	0.135	0.034
Sample 3	27.47	0.155	0.240	0.402	0.156	0.130	0.032
Sample 4	43.85	0.266	0.400	0.684	0.247	0.220	0.055
Sample 5	41.01	0.237	0.374	0.605	0.254	0.196	0.049
Sample 6	38.41	0.234	0.351	0.601	0.216	0.193	0.048
Sample 7	54.15	0.315	0.499	0.803	0.342	0.261	0.065
Sample 8	39.69	0.229	0.356	0.586	0.235	0.190	0.047
Sample 9	36.87	0.210	0.322	0.545	0.207	0.176	0.044
Sample 10	32.43	0.185	0.287	0.477	0.188	0.154	0.039
Sample 111	30.72	0.175	0.273	0.450	0.182	0.146	0.036
Sample 12	36.83	0.224	0.336	0.577	0.207	0.186	0.046

Conclusion

In this study, the analysis of radioactivity was carried out for the samples collected from the coastal taluk, Karunagapally of Kollam 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 (Raeq), 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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