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A Study of Distribution of Gross Alpha Activity and Environmental Gamma Radiation and Dose Estimation

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Abstract

Radioactive elements are ubiquitous in nature. We live in an environment filled with radiation from these elements. Soil, rock, water, air, etc. contain radionuclides of varying concentrations. The concentration also depends on the position of place on Earth. The presence radioactive materials occurring naturally in nature is responsible for radiation dose to the people even in indoors and outdoor. The exposure to radiation is inevitable to human beings. Some region has high amount of radiation and some low. As a result, population experience varying amount of radiation dose from these materials. An estimation of radiation dose due to ambient gamma radiation and gross alpha activity from soil sample were studied. In this research work, the gamma radiation and alpha activity were measured using Scintillation counter and Alpha counting system respectively. Tumakuru is the present study area, which is located in southern India, in the state of Karnataka. The study revealed that, the gamma absorbed dose due to outdoor changed from 44 nGyh^{-1} to 191 nGyh-1 with a mean of 101 nGyh^{-1}. The average of effective dose from gamma outdoor was 124 μSv/year. The indoor absorbed dose varied from 113 nGyh^{-1} to 218 nGyh^{-1} with an average of 124 nGyh^{-1}. The mean effective dose was 742 μSv/year. The indoor gamma radiation level was higher than that of outdoor as expected due to poor ventilation and for the fact that, the average indoor occupancy is higher than that of outdoor. The correlation between gamma radiation level and alpha activity was moderate and the correlation coefficient was 0.4881.

Keywords: *CVD, FPGA, GSM, GPS, SMS, Telecardiac System, Telemedicine*

1.0 Introduction

All organisms on earth have evolved with the omnipresent background radiation[1]. The background radiation is due to terrestrial and cosmic origin. The former is due to the presence of radionuclides present in the earth crust. The rock, soil, water, air, plants and trees and living organisms contain radionuclides in varying quantities. The presence of radionuclides in trees and plants are due to the transfer of former from rock to soil and soil to living organisms and trees via food chain, particularly through water[2]. The concentration of radionuclides in rocks and soil may be quite higher than that in plants and trees. The consumption of food from these sources by human beings

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can make way for the transfer of radionuclides to humans. This produces radiation dose to the human beings. There are more than 340 nuclides exist in earth, of which nearly 70 are radioactive. Natural background radiation arises from the radionuclides uranium, thorium, radium, ^{40}K etc. Some radionuclides have lower atomic weights. Major part of radiation dose arises due to the radionuclides of terrestrial origin[3]. One of the decay products of radium, radon, a noble gas, which is also radioactive, is one of the main radiation dose imparting to human beings. Around 96% of total radiation dose are due to the natural radionuclides present in soil, rocks, water, plants and trees, the remaining 4% is due to the artificial manmade sources[4].

More than 50% of radiation dose to human beings is due to the inhalation of radon gas. As the origin for these gases and corresponding radiation dose is due to the concentration of radionuclides in soil and rocks. The estimation of concentration is tedious and costly process. But there is a simple way by which one can estimate the gross effect of radiation and its dose. This is the estimation of gross alpha activity from the soil. This is a time-saving and cost-effective process, by way of measuring the gross alpha activity by an alpha counter5. The concentration of radionuclides varies from place to place on the earth[6,7]. The present area of research is Tumakuru, Karnataka, India. A total of nineteen geographically different sites were identified which are shown in the geographical map of Tumakuru in Figure 1. Ambient gamma radiation level and its dose estimations were also made in the study area.

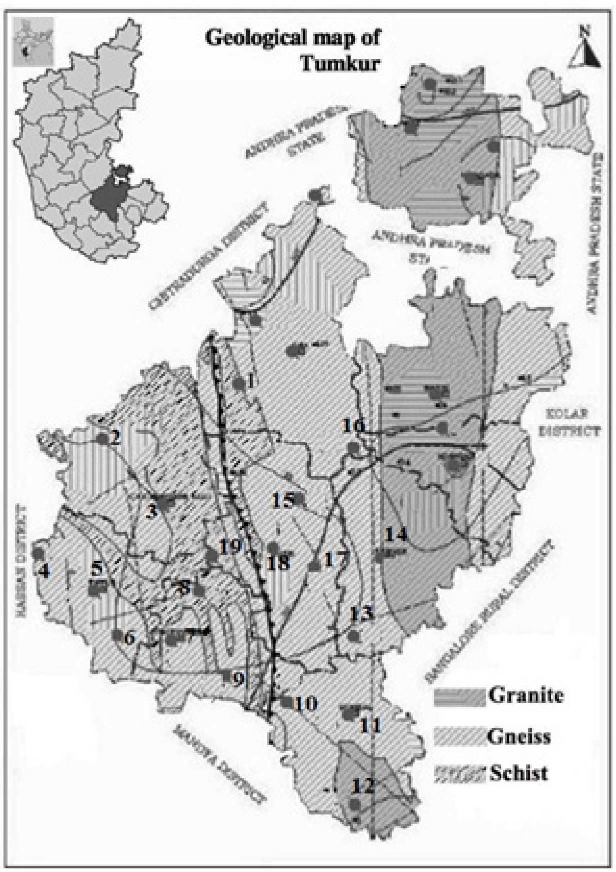

Figure 1. Geological map of sampling sites.

2.0 Materials and Methods

2.1 Estimation of Gamma Radiation Level

The gamma radiation levels in outdoors and in indoor in Tumakuru were determined by ECIL make Scintillation (Section 3.1) that was calibrated using standard sources (^{60}Co ^{137}Cs and ^{55}Mn) at the Rare Material Project (RMP), a unit of Bhaba Atomic Research Center (BARC), Department of Atomic Energy (DAE) at Mysore.

The soil samples for gamma radiation were made by following the standard measurement procedures. During measurement, undisturbed soil samples in an open area which is free from or minimum human intervention was chosen. The sampling locations were free from construction materials and debris. Agricultural lands were excluded to avoid the intervention of fertilizers, as they also contain radionuclides[8]. All the measurements were done from a height of 1 meter above the ground. The average of several readings was taken which act as a representative sample of that location. The radiation dose through the dosimeter data was recorded at all the selected locations. The gamma exposure rate (μRh^{-1}) was converted into dose rate ($nGyh^{-1}$) using the formula given in Equation 1, $\mu Rh^{-1} = 8.7\ nGyh^{-1}$[9]. Indoor/outdoor annual effective dose (*d*) in μSv was calculated using Equation 1.

$$d(\mu Sv) = D(nGyh^{-1}) \times 24 \times 365 \times 0.7 \times F \times 10^{6} \tag{1}$$

Where, *d* = Effective dose per annum in μSv

D = rate of exposure in $nGyh^{-1}$

F = Occupancy factor

UNSCEAR 2000 recommended 0.7 $SvGy^{-1}$ as conversion factor from absorbed dose in air to effective dose experienced by an average adult and F = 0.8 for the indoor and 0.2 for the outdoors.

2.2 Estimation of Concentration of Gross Alpha

The range of alpha particle is short, hence, for accurate measurements the thickness of soil sample layer was made as thin as possible. This also ensures that, there is minimum self absorption of alpha rays by soil samples. Around 10 gram of ashed soil samples was taken in the powdered form. A thin uniform layer was made on aluminium planchet. The sampled planchet was dried and weighed and evaporated to complete dryness. The alpha counts were measured by an alpha counter shown in Figure 2. The gross α activity was calculated using the equation 2[10].

Figure 2. Portable Radiation Dosimeter.

Figure 3. Alpha counting system.

$$Activity(Bqkg^{-1}) = \left\{\left(\frac{C_s}{t_s} - \frac{C_b}{t_b}\right) \pm {}_{s}\right\} \times \frac{100 \times 1000 \times (100 - A)}{E \times W \times 100 \times 100}$$

$$\sigma_s = \sqrt{\frac{\mathbf{C_s}}{\mathbf{t_s^2}} + \frac{\mathbf{C_b}}{\mathbf{t_b^2}}} \qquad (2)$$

Where, C_S & C_b = Gross sample and gross background counts, t_S & t_b = Sample and background counting time, σ_S = Standard deviation, W = Dry weight of ash (g), E = Alpha counting system efficiency (%), A = Percentage of ash obtained with respect to dry weight.

3.0 Results

The measurements made were tabulated. The outdoor and indoor gamma absorbed doses were tabulated in Tables

Table 1. Radiation due to gamma (outdoor)

No	Sampling spot	γ Level exposure (µRh^{-1})		γ Absorbed Dose (nGyh^{-1})	γ Effective Dose (µSvy^{-1})
		No. of Readings	Average		
1	Bukkapattana	12	10.1	87	107
2	Huliyaar	12	17.2	148	182
3	Chiknayakanahalli	12	5.2	44	53
4	Honnavali	12	13.2	113	139
5	Tipatur	12	7.3	61	75
6	Nonavinkere	12	9.1	78	96
7	Turvekere	12	21.9	191	235
8	Dandinshivara	12	8.8	78	96
9	Maayasandra	12	9.3	78	96

10	Yediyur	12	8.1	70	85
11	Kunigallu	12	16.4	140	171
12	Huliyuradurga	12	21.3	183	224
13	Hebburu	12	8.2	70	85
14	Tumakuru city	12	9.2	78	96
15	Cheluru	12	10.8	96	117
16	Sheebi	12	9.2	78	96
17	Gubbi	12	13.2	113	139
18	Nitturu	12	7.2	61	75
19	Kibbanahallicross	12	14.2	122	149
Min			5.2	44	53
Max			21.9	191	235
Mean			12	101	124
STDEV			5	45	55

Table 2. Radiation due to gamma (indoor)

No	**Sampling spot**	**γ Level exposure (μRh^{-1})**		**γ Absorbed Dose (nGyh^{-1})**	**γ Effective Dose (μSvy^{-1})**
		No. of Readings	**Average**		
1	Bukkapattana	12	16	139	683
2	Huliyaar	12	21	183	896
3	Chiknayakanahalli	12	13	113	555
4	Honnavali	12	14	122	598
5	Tipatur	12	18	157	768
6	Nonavinkere	12	16	140	683
7	Turvekere	12	20	174	854
8	Dandinshivara	12	18	157	768
9	Maayasandra	12	17	148	726
10	Yediyur	12	16	139	683
11	Kunigallu	12	20	174	854
12	Huliyuradurga	12	25	218	1067
13	Hebburu	12	16	139	683
14	Tumakuru city	12	17	148	725
15	Cheluru	12	18	157	768
16	Sheebi	12	15	131	640
17	Gubbi	12	13	113	555
18	Nitturu	12	15	131	640
19	Kibbanahallicross	12	19	165	811
Min			13	113	555
Max			25	218	1067
Mean			17	151	742
STDEV			3	26	127

Table 3. Effective and absorbed dose in different places (comparison)

Region	Absorbed dose ($nGyh^{-1}$)		Effective dose ($mSvy^{-1}$)		Reference
	Indoor	Outdoor	Indoor	Outdoor	
Tumakuru	151	101	0.742	0.124	Present work
Bengalooru	384	411	0.8790	0.5	[11]
Mysore	76	41	0.370	0.070	[12]
Indian average	----	56	----	0.090	[3]
Global mean	**83**	**56**	**0.4510**	**0.090**	[13]

Table 4. Gross α activities in Soil, in Tumakuru district

No.	Sampling spot	Gross alpha activity ($Bqkg^{-1}$)
1	Bukkapattana	195
2	Huliyaar	232
3	Chiknayakanahalli	147
4	Honnavali	428
5	Tipatur	513
6	Nonavinkere	194
7	Turvekere	533
8	Dandinshivara	333
9	Maayasandra	179
10	Yediyur	157
11	Kunigallu	373
12	Huliyuradurga	563
13	Hebburu	441
14	Tumakuru city	384
15	Cheluru	190
16	Sheebi	254
17	Gubbi	458
18	Nitturu	422
19	Kibbanahallicross	360
Min		147
Max		563
Mean		336
STDEV		148

1 and 2 respectively. The gamma absorbed dose from outdoor varied from 44 to 191 $nGyh^{-1}$ with an average of 101 $nGyh^{-1}$. The average of effective dose from gamma was 124 µSv per year. The indoor gamma absorbed dose varied form113 to 218 $nGyh^{-1}$ with an average of 151 $nGyh^{-1}$. The average value of effective gamma dose was 1067 µSv per year. The lowest outdoor and indoor gamma levels were found at the same place, Chiknayakanahalli with a value 17μRh^{-1} and 12 μRh^{-1} respectively. The highest outdoor and indoor gamma levels were found at Turvekere and Huliyuradurga with a value of 21.9 μRh^{-1} and 25μRh^{-1} respectively. The study shows that, the minimum value gross alpha activity was observed in Chiknayakanahalli, 147 $Bqkg^{-1}$, and maximum value was observed in Huliyuradurga, 563 $Bqkg^{-1}$. The average value of gross alpha activity was 336 $Bqkg^{-1}$.

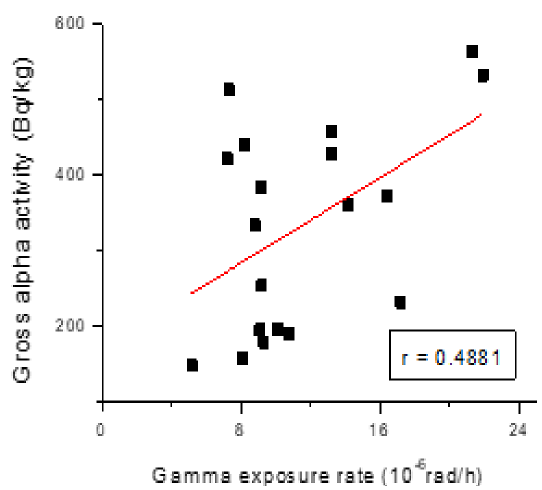

Figure 4. Correlation of Gamma exposure level with Gross alpha activity.

4.0 Discussion

The lowest indoor and outdoor gamma levels were found at the same place, Chiknayakanahalli with a value 13 μRh^{-1} and 5.2 μRh^{-1}. The nature of soil and the rock underneath plays a major role in the degree of gamma radiation dose. The nature of soil in this region is schist. The rock under the soil in most of the places of Chiknayakanahalli is quartzite. The presence of quartzite schist in the underground produces very less radiation, because the concentration of radionuclides in schist rocks is less compared to that of granitic rocks. The highest outdoor and indoor gamma levels were found at Turvekere and Huliyuradurga with a value of 21.9 μRh^{-1} and 25 μRh^{-1} respectively. The nature of soil in Turvekere is quartzite schist-granite gniess and in Huliyuradurga it is granite gneiss and Red loamy soil. The presence of granitic geography in these areas' region showed elevated amount of gamma radiation due to the presence of radionuclides in higher concentrations.

The indoor annual effective gamma doses were 555 and 1067µSv in Chiknayakanahalli and Huliyuradurga respectively. The nature of soil in Chiknayakanahalli is mixed red and black soil. These soils usually show lesser radiation due to the presence of lower concentration of radionuclides. The higher activity and dose in Huliyuradurga may be due to the presence of granitic formations in this area. The ambient gamma levels in all the sites under study showed activities less than the normal range[9,14].

The gamma radiation levels in indoor is higher than that of outdoor environment, this is due to the lack of ventilation in indoor as compared to outdoor. The effective gamma indoor dose was 1067μSvy^{-1}but that of outdoor was 124 μSvy^{-1}. The indoor dose is nearly eight times that of outdoor, even though the absorbed doses were 151 $nGyh^{-1}$and 101 $nGyh^{-1}$respectively. This is due to the fact that, the occupancy factor is 80% for indoor. Most of our time is spent in indoor than outdoor. The values of absorbed and effective dose of gamma radiation in different places were given in Tables number 1 and 2.

The gross alpha activities in the soil samples of Tumakuru region was determined using an alpha counting system and the readings were tabulated in Table 4. The study shows that, lowest value of alpha activity was observed in Chiknayakanahalli,147 $Bqkg^{-1}$, and highest was observed in Huliyuradurga, 563 $Bqkg^{-1}$. The mean value from the study was 336 $Bqkg^{-1}$. The increased value alpha activity may be due to the presence of granitic formations in Huliyuradurga and the presence of granites under the ground. The geographical map in Figure 1 does not show any such geographical features in Chiknayakanahalli, this is the reason for the decreased alpha activity value in this area. A correlation graph for gross alpha activity and the gamma radiation level was plotted and shown in Figure 4. The graph reveals that, the correlation was moderate and the correlation coefficient was 0.4881. The study can be further extended for the concentration of gross beta activity. Also the concentrations of radon in the atmosphere and seasonal variations can also be studied.

5.0 Conclusion

The measured gamma absorbed doses due to outdoor were in the range of 44 $nGyh^{-1}$ to 191$nGyh^{-1}$ with a mean of 101 $nGyh^{-1}$. The mean annual effective dose due to outdoor gamma radiation alone was 124 µSv. The average of effective dose from gamma indoor conditions was 742 µSv per year. The highest outdoor and indoor gamma levels were 21.9μRh^{-1} and 25μRh^{-1}, found at Turvekere and Huliyuradurga respectively. The indoor gamma radiation levels are quite higher than that of outdoor, this is due to the lack of ventilation and the corresponding increase in dose due to the higher occupancy factor in indoor. The study showed that, lowest value alpha activity was observed in Chiknayakanahalli, 147 $Bqkg^{-1}$, and highest was observed in Huliyuradurga, 563 $Bqkg^{-1}$. The mean value from the study was 336 $Bqkg^{-1}$. The correlations between ambient gamma radiation level and gross alpha activity was moderate and the correlation coefficient was 0.4881.

6.0 Acknowledgements

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