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Annual background radiation in Chaharmahal and Bakhtiari province

D. Shahbazi-Gahrouei*

Dept. of Medical Physics, Shahrekord University of Medical Sciences, Shahrekord, Iran

ABSTRACT

Background: Measurement of background radiation is very important from different points of view especially for human health. The aim of this survey was focused on determining the current background radiation in one of the highest altitude regions (Zagros Mountains), Chaharmahal and Bakhtiari province, in the south west of Iran.

Materials and Methods: The outdoors-environmental monitoring exposure rate of radiation was measured in 200 randomly chosen regions using portable Geiger-Muller and Scintillation detectors. Eight measurements were made for each region and an average value was used to calculate the exposure rate from natural background radiation.

Results: The exposure dose rate was found to be 28.4 μRh^{-1} and the annual average effective equivalent dose was found to be 0.49 mSv. An overall population weighted average outdoor dose rate was calculated to be 49 $nGyh^{-1}$, which is higher than the world-wide mean value of 44 $nGyh^{-1}$ and is comparable to the annual effective equivalent dose of 0.38 mSv.

Conclusion: A good correlation between the altitude and the exposure rate was observed, as the higher altitude regions have higher natural background radiation levels. *Iran. J. Radiat. Res.; 2003; 1(2): 87 – 91.*

Keywords: *Background radiation, annual effective dose, Geiger-Muller and scintillation detectors, altitude.*

INTRODUCTION

Investigations and measurements of natural environmental radiation (i.e. background radiation) and radioactivity are of great importance and interest in health physics not only for many practical reasons, but also for more fundamental scientific reasons (Quindos *et al.* 1994). The main sources of background radiation are cosmic, cosmogenic and terrestrial radiations. Cosmic radiation originates from the action of stars, which are vast nuclear reactors. It is the direct result of the action of the Sun (such as neutrino, Pion, Meson,….). Cosmogenic radionuclides arise from the collision of highly energetic cosmic ray particles with stable elements in the atmosphere and on the ground.

The major production of cosmogenic radionuclides is resulted from the interaction of cosmic rays with atmospheric gases. There are many naturally occurring radionuclides that have half-lives of at least the same order of magnitude as the estimated age of the earth and that have been present since its formation. They are included uranium and thorium series and single occurring radionuclides such as ^{40}K. Natural background radiation varies over a range of concentration and exposure rate for a variety of causes.

Generally, the background dose rates from cosmic rays depend slightly on the latitude and strongly on the altitude (Hollins 1990). The latitude effect is due to the charged particle nature of the primary cosmic rays, and the effect

* **Corresponding author:**
Dr. D. Shahbazi-Gahrouei; Dept. of Medical Physics, Sharekord University of Medical Sciences, Sharekord, Iran.
Fax: +98-381-3334911
E-mail: shahbazi24@yahoo.com

of the Earth's magnetic field, which tends to direct ions away from the equator and toward the poles.

Since natural radiation is the main source of human exposure, studies of the dose from this source and its effects on health can improve the understanding of radiation damage and are of great value as a reference when standard and regulatory control actions on radiation protection are established. Interest in this kind of study has led to many national surveys on natural radiation in the last decade (Quindos *et al.* 1994, Butt *et al.* 1998, Jagger 1998, Karunakara *et al.* 2001). There are considerable variations in background radiation, as shown in table 1. The maximum value occurs for the population in part of the Indian states of Kerala and Madras. As a result of the underlying rock they receive an average annual dose of 5-10 mSv which is four to eight times greater than the worldwide average dose (Cember 1983, Hollins 1990).

In developing countries such as Iran, the main source of human exposure (94%) is natural radiation (UNSCEAR, 1988). Thus, the Atomic Energy Organization of Iran (AEOI) organized some survey programs concerning natural radiation. To complete this program, the Medical Physics Department of Shahrekord University of Medical Sciences carried out a survey of natural background radiation in the highest altitude region of Iran. These regions may have an increase in background radiation because they have less protection from cosmic radiation by the atmosphere. For this reason, the aim of this survey was focused on determining the current background radiation in the one of the highest altitude regions of Iran, Chaharmahal and Bakhtiari province.

MATERIALS AND METHODS

The outdoor exposure rate of radiation was measured in 200 randomly selected regions using portable Geiger-Muller (SUM-AD8, Ricken Fine, Japan) and Scintillation (Fuji Electric Co. Ltd., Japan) detectors. The detectors were calibrated using standard sources of ^{226}Ra and ^{60}Co (Ginjaume *et al.* 2001). Eight measurements were done for each region and an average of those was used to calculate the exposure rate of the natural background radiation.

To estimate the exposure, the regions were divided into two groups. One group was the lower altitude regions (raging from 1650 to 2100 meters above sea level) and the other was the higher altitude regions (ranging from 2100 to 2600 meters above sea level). A topographic map of the studied regions was obtained from Civic Engineering Organization of the state.

Table 1. Worldwide examples of annual doses from natural sources (Mc Ainsh, 1986 and Hollins, 1990).

Region/City	Population (millions)	Dose (μSv)
London, UK	11.0	1×10^4
New York, USA	17.0	1×10^4
Paris, France	10.0	1.2×10^4
Kerala and Madras, India	0.1	$5\text{-}10 \times 10^4$
La Paz, Bolivia	0.3	1.7×10^3
Nairobi, Kenya	1.2	5.8×10^3
Denver, USA	1.6	5.7×10^3
Tehran, Iran	7.5	4.4×10^3

The outdoor radiation measurements were performed by placing the detectors at least six meters away from any building or wall and one meter higher than the ground, to reduce their effects on the radiation field. The values of the out door absorbed dose were calculated using an occupancy factor (representing the weighted average for the population of this region) of 20% (Butt *et al.* 1998). The values of annual effective dose were determined based on the equivalent dose.

RESULTS

Comparison of detector results

The results of measurements of the natural background radiation exposure rate in 200 randomly selected regions using portable Geiger-Muller and Scintillation detectors are shown in table 2. As can be seen from this table, there was no significant difference among the results by the detectors used. The results reported here are the average of the measured exposure rate and the dose rate using both detectors.

The exposure rate measurements

As previously mentioned, the regions were divided into two groups. One group was the lower altitude regions (raging from 1650 to 2100 meters above sea level) and the other was the higher altitude region (ranging from 2100 to 2600 meters above sea level). The t-student analysis showed a significant difference ($P<0.05$) between the lower altitude regions and the higher altitude regions. The exposure rate was found to be 27.9 ± 1.1 μRh^{-1} and 28.9 ± 0.9 μRh^{-1} for lower and higher altitude regions, respectively. The correlation between the altitude and the exposure rate for different regions is shown in figure 1. As can be seen from this figure, there is a correlation between the altitude and exposure rate ($r^2 = 0.83$).

The relationship between the absorbed dose rate and the exposure rate is given by the following equation (Cember 1983):

$D_{air} = 8.69 \times 10^{-3}$ X (Gy)

where 8.69×10^{-3} is a conversion factor obtained using the 34 eV ionization energy required to produce an ion pair, multiplied by 1.6×10^{12} ions produced for each Roentgen.

The overall population-weighted mean outdoor dose rate is 49 $nGyh^{-1}$, which is slightly higher than the worldwide mean value of 44 $nGyh^{-1}$. Using the dose rate obtained from different regions of natural background radiation, and the conversion occupancy factor of 0.2, as recommended by UNSCEAR in 1988 and 2000, the average of exposure rate was found to be 28.4 ± 1.4 μRh^{-1} and the annual average effective dose was found to be 0.49 mSv.

DISCUSSION

The presence of natural background radiation and environmental radioactivity is due to the distribution of radionuclides on the earth and causes exposure to all living organisms. The main source of this radioactivity is radionuclide elements of earth and cosmic rays. The contents of natural radionuclides (uranium, actinium, and thorium) as well as the thin layer of atmosphere in the higher altitude regions (mountains) are reasons why they have high levels of human exposure. The highest gamma radiation is associated with areas comprising metamorphic rocks heavily intruded by granites and granitic pegmatites.

Table 2. Exposure rate measurements of the natural background radiation using Geiger-Muller and scintillation detectors for selected regions.

Detectors/Results	Average of exposure rate for lower altitude regions (μRh^{-1})	Average of exposure rate for higher altitude regions (μRh^{-1})
Geiger-Muller	27.9 ± 1.1	28.9 ± 0.9
Scintillation	27.3 ± 0.6	29.2 ± 0.5

Since altitude is one of the important factors relevant to the measured dose rate, these results showed that the altitude of the region had a small effect on the level of background radiation. Some areas showed low background radiation in spite of their high altitude, as a result of the low concentrations of radionuclides in their soils. A more detailed analysis of our results from individual measurements shows that there is a correlation between the altitude and exposure rate (figure 1).

The average exposure rate was found to be 28.4 ± 1.4 μRh^{-1}, or 49 $nGyh^{-1}$, and the annual average effective dose was found to be 0.49 ± 0.04 mSv. With regard to altitude, the results also showed that higher altitude regions have higher natural background radiation levels in good agreement with the literature. The dose rate level of 49 $nGyh^{-1}$ and the annual effective dose of 0.49 ± 0.04 mSv are comparable with the dose rate of 55 $nGyh^{-1}$ reported by Butt *et al.* (1998) and the annual effective dose of 0.38 mSv.

It is of interest to note that the average total annual effective dose in the studied region is about 2.4 mSv which is much lower than that of the annual equivalent dose, as reported by NRPB (1981).

The main goal of this paper was to measure natural background radiation for comparison with worldwide data. The results of measurements of the background radiation in the studied regions have been shown to conform well to observations in various other countries. The results reported here provide a valuable and useful reference for the design and development of specific regional surveys related to the measurement of out door natural background radiation in the highest altitude regions of Chaharmahal and Bakhtiari province, in the south west of Iran.

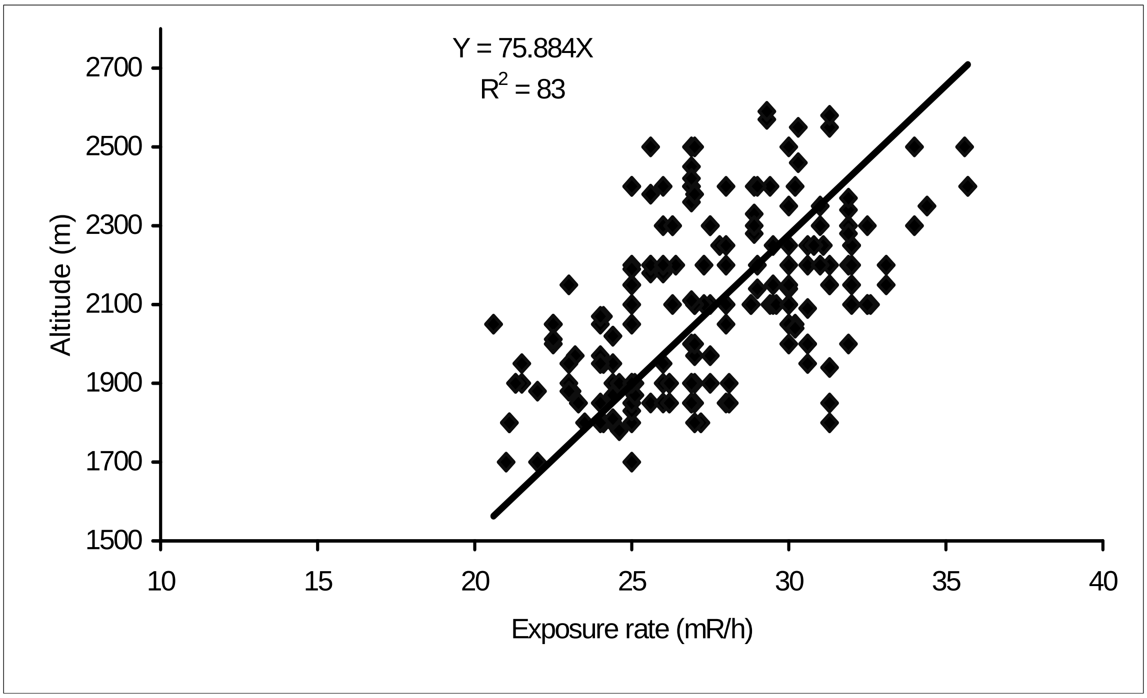

Figure 1. Correlation between the altitude and the exposure rate for selected randomly regions in Chaharmahal and Bakhtiari province.

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