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Natural Background Radiation in Saudi Arabia

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Abstract: *Natural background radiation measurements have been made at numerous locations throughout the world. Little work in this field has been done in developing countries. In this study, the external exposure rates due to natural background radiation sources have been measured for different Saudi Arabian cities. Thermoluminescence dosimeters, CaF_2:Dy (TLD-200), has been used for field measurements. Exposure to TLD's response correlations were obtained for each TLD using a ^{137}Cs source. A correlation of TLD's response fading at a continuous radiation exposure environment was obtained and applied to correct field measurements. The measurements were taken every two months for a total of six intervals during the whole year. The average measurements of outdoor external exposure rates was found to vary between a minimum of 5.29 μR h^{-1} in Dammam city and a maximum of 11.59 μR h^{-1} in Al-Khamis city.*

Introduction

Man-kind is exposed to ionizing radiation all the time, either externally or internally. Exposure to ionizing radiation may come from man-made radiation sources and/or natural background radiation sources. However, natural background sources remain the greatest contributor to radiation exposure. Natural background radiation may be divided into three components; cosmic radiation, terrestrial radiation and radiation due to cosmogenic radionuclides.

The greater part of the external natural radiation comes from the radioactivity of naturally occurring materials. The primordial series of radionuclides and potassium-40 contribute significantly to external exposure. The progeny which contribute most of the absorbed dose are thallium-208 and actinium-228 in the thorium-232 series, while in the uranium-238 series the dose is due to almost completely to lead-214 and bismuth-214, which are short-lived decay products of radon-222. The significant exposure received by humans from external terrestrial radiation comes mainly from two gamma-radiation sources. These are the natural radionuclides present in the soil, and atmospheric radon progeny.

External exposure due to cosmic radiations comes primarily from the ionizing component and the neutron component. Variations in the external exposure at different locations are due to the magnetic latitude and the location altitude.

The objective of this work is the measurement of natural background radiation in Saudi Arabia. The importance of determining the levels of the natural background radiation lies in the fact that it represents the largest source of radiation dose to the population. In addition, it can serve as a standard and a reference with which additional incremental levels, due to man made radiation sources, can be determined. This study is believed to be the first nation-wide survey and estimate of external exposure components of natural background radiations.

Natural background radiation measurements have been made at different locations throughout the world. There have been limited and small scale studies of the natural background radiation levels in different locations in Saudi Arabia. The estimated annual effective dose equivalent due to external exposure to natural background radiation at the campus of King Fahad University in Dahran city was found to be in the range of 0.4 - 0.8 mSv y^{-1} [1]; while it was determined to be 0.73 mSv y^{-1} at the campus of King Saud University in Riyadh city, and 0.65 mSv y^{-1} at Al-Kharj City (80 Km south of Riyadh)[2]. A study to determine the radionuclides of terrestrial origin in some locations in Riyadh city was conducted and found that the annual effective dose equivalent, including cosmic ray contribution, was 0.57 mSv y^{-1} [3]. Another study of the natural background radiation, performed for a one year period, in the Riyadh area estimated the average annual effective dose equivalent to be 0.6 mSv y^{-1} [4].

Instrumentation

In order to perform a large scale survey of the external exposure due to natural background radiation various parameters should be considered when selecting the proper dosimetry detectors. The dosimetry detectors should be practical, easy to handle, low in cost, and have high sensitivity and wide dynamic response range. In this study the integrated Thermoluminescent Dosimeters (TLDs) were used for measurements.

The thermoluminescent dosimeters employed in this study were Harshaw model 2040 bulb CaF_2:Dy dosimeters (TLD-200). These dosimeters consist of two solid chips of CaF_2:Dy crystals (Harshaw TLD-200) firmly mounted on either side of an electric filament and encapsulated in a sealed free potassium glass bulb to eliminate contribution of ^{40}K to the measurements. Two wires protruding from the glass permit the crystals to be heated by electric current for analysis. An aluminum-tin-lead shield was used to flatten the over response of the dosimeters for low energy gamma photons. The shield cap in which the glass bulb dosimeter is placed is black, to reduce the color effect on the dosimeters stability.

The TLD reader (Harshaw model 2000 P) settings were established by careful observations of the glow curve. The total TL (in terms of electrical charge) is obtained by integrating the glow curve in the specified region of interest. The integration range of the glow curve was determined in such a way that the unstable part of the glow curve is excluded (the low temperature TL peaks). The high temperature part of the glow curve was also excluded to eliminate any possible interference of infrared light that may come from the heating system. In order to allow the TLD reader to attain stable and consistent conditions during each TLD reading, a time schedule was established. This timing schedule was used in order to minimize any differences in the readout of a series of TLDs. For the same reason, the room temperature and humidity of the TLD reader were maintained constant.

To assure the stability of the reader, the light emitted from the reference light, which is installed within the reader, was recorded at the beginning of the first cycle and after the reading

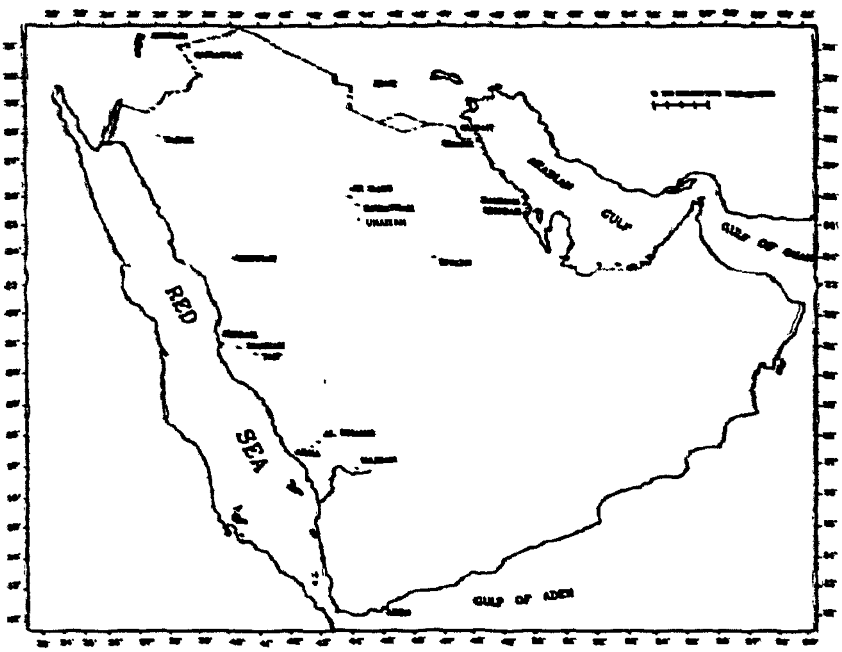

Figure (2): Country map indicating the cities under study.

above the ground was one meter. A tag was fixed on each dosimeter assembly indicating the city, site number, and other necessary information.

Forty one outdoor assemblies were distributed in the selected cities. The sites were selected to represent the normal outdoor environment. In order to secure the stations and avoid any human interference the assemblies were placed at housing properties belonging to Civil Defence Department in each city.

Three to four TLDs of the same production batch were assigned to each measurement site. This provided assurance that if one TLD was lost during measurement or if it had a misleading reading, the other TLDs would be sufficient to represent the site exposure level during the specified time interval. The measurement at each site was taken to be the average reading of the TLDs in that site.

The measurements were taken every two months for a total of six intervals during the whole year. The spread of the intervals allowed for monitoring of seasonal variation of the external exposure. A measurement cycle was established to assure consistency in the measurements conditions and to reduce any possible human errors. The dosimeters for each city were annealed and placed in a box with the city name labeled on it. Another set of dosimeters, assigned as control set dosimeters, were also annealed since the city's dosimeters and the control dosimeters are exposed to different radiation levels after annealing and during the trips to and from the sites. The purpose for using the control set dosimeters was to record the dose received by the dosimeters after their annealing and during their forward and backward trips and prior to reading.

All dosimeters were transported to their

INTERVAL

City	1	2	3	4	5	6	Average
Abha	10.65(0.82)	13.05(1.05)	9.30(0.62)	9.69(0.88)	7.60(0.46)	11.27(0.98)	10.26(1.88)
Al-Khamis	12.55(2.40)	13.36(2.04)	11.32(1.79)	10.30(1.70)	9.25(1.39)	12.78(1.33)	11.59(1.59)
Burraidah	9.06(0.28)	10.48(0.13)	6.95(0.26)	9.63(0.08)	4.73(0.03)	8.99(0.56)	8.31(2.10)
Unaizah	10.97(2.60)	11.11(2.48)	8.27(1.87)	10.42(1.83)	5.73(1.66)	10.33(2.18)	9.48(2.10)
Ar-Rass.	13.76(3.71)	13.17(3.63)	10.20(3.18)	11.55(3.40)	6.24(2.50)	11.24(3.36)	11.03(2.68)
Jeddah	7.70(0.89)	7.44(0.44)	6.32(0.58)	7.52(0.50)	4.52(0.61)	5.90(0.25)	6.57(1.24)
Makkah	7.19(0.67)	7.38(0.10)	5.57(0.30)	7.33(0.30)	4.30(0.27)	6.11(0.18)	6.31(1.24)
Najran	11.79(2.87)	12.07(2.11)	9.86(1.90)	11.49(2.40)	8.08(1.89)	11.21(1.97)	10.74(1.52)
Tabuk	10.23(0.82)	10.78(0.27)	7.44(0.56)	8.70(0.15)	5.61(0.42)	8.51(0.39)	8.55(1.88)
Taif	10.64(0.43)	10.95(0.40)	8.15(0.28)	9.63(0.40)	6.98(0.26)	8.64(0.36)	9.10(1.65)
Dammam	5.08(0.45)	6.74(0.34)	4.00(0.23)	7.43(0.13)	2.81(0.03)	5.69(0.43)	5.29(1.70)
Khafji	7.34(0.30)	7.50(1.07)	6.55(0.48)	7.77(1.70)	5.00(0.06)	6.97(0.32)	6.86(1.00)
Khobar	7.51(2.74)	6.57(2.56)	5.06(2.25)	6.95(2.64)	4.49(2.12)	5.78(2.40)	6.06(1.18)
Qurayyat	8.67(1.36)	8.91(0.98)	7.26(1.73)	7.00(0.85)	7.59(0.45)	7.92(0.81)	7.89(0.75)
Madinah	9.38(0.99)	10.39(0.56)	6.67(1.09)	7.76(0.19)	4.78(0.72)	7.53(0.76)	7.75(1.98)

Table-1 Measured exposure rate in each city for in μR/hr (+/- σ) for each measurement interval.

assigned sites by air planes. The reading of the control set dosimeters for each city was deducted from the reading of the city sites dosimeters. The readings for all dosimeters sets (both control and sites) were evaluated immediately after arrival at the TLD laboratory.

Results

All results of the measurements are presented in table-1 . The first interval was started late November 1992, and each interval was two months long. The gross TLD readings were corrected for TLD reader background, transient exposure and TLD time-fading. Afterward, the calibration correlation of each TLD was applied to convert the TLD response (nC) to radiation exposure rate (μR h^{-1}).

The minimum average exposure rate was reported in Dammam city, it was 5.29 μR h^{-1}. On other hand, the maximum value was in Al-Khamis city and it was 11.59 μR h^{-1}. Damma is a port city on the Arabian Gulf and consists of sedimentary geological formation. While the geological formation of Al-Khamis consists of metamorphic rocks and its altitude is 2055 meters above see level. General speaking, the lowest exposure rates in all cities was found in the fifth interval (July-August).

References

1. *Martin. P.H.. Estimate of Gamma-ray dose equivalent rates due to natural radioactivity sources in Saudi Arabia. Procc Intern Sym Appl Technol. Ion. Rad., Vol. 3., 1982*

2. *Owain, R.S., Environmental radiation monitoring, M.S. thesis. King Saud University. Riyadh, 1984.*

3. *Al-Haj. A. Noaman. Measurement of natural radiation background level of Riyadh city. M.S. thesis. King Saud University. Riyadh, 1987.*

4. *AL-Hussan. Khalid A. and Wafa. Nizar. Environmental radiation background level in Riyadh city. Rad. Prot. Dos., Vol 40. No. 1, 1992.*