Iran. J. Radiat. Res., 2005; 3 (1): 17-20

# Gamma background radiation in Yazd province; A preliminary report

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***Background:*** There are relatively rich uranium mines in regions of Saghand and Bafgh in Yazd province. This survey was carried out to provide a map of ambient gamma radiation of Yazd province and the probable effects of the existence of these mines on background radiation dose rates. ***Materials and Methods:*** The measurements of the outdoor and indoor–environmental exposures (including cosmic and terrestrial components) were accomplished by a portable Geiger Muller detector in the five areas in each of eight big cities of Yazd province. ***Results:*** The average exposure rates of indoor and outdoor ambient of Yazd province were 13.9 ± 0.7 μRh$^{-1}$ and 11.6 ± 0.8 μRh$^{-1}$ respectively. The average dose rates in air, resulting from gamma background radiation of indoor and outdoor were 122 ± 6.8 nSvh$^{-1}$ and 101.4 ± 7.4 nSvh$^{-1}$ respectively. The annual average of equivalent dose in air was found to be 1.03 ± 0.05 mSv, and the annual average of effective dose was 0.72 mSv. ***Conclusion:*** The results of this study in comparison with the same measurements in some other cities in Iran such as Isfahan and Tabriz, proves that the existence of uranium mines doesn't affect gamma background radiation of Yazd province. **Iran. J. Radiat. Res., 2005; 3 (1): 17-20**

***Keywords:*** *Background radiation, annual effective dose, cosmic rays, terrestrial Radiation.*

## INTRODUCTION

The great interest expressed worldwide for the study of naturally occurring radiation and environmental radioactivity has led to the performance of extensive surveys in many countries. Such investigations can be useful for both assessment of public dose rates and the performance of epidemiological studies, as well as keeping reference–data records to ascertain possible changes in the environmental radioactivity due to nuclear, industrial, and other human activities[1].

The natural background ionization radiation is due to ambient radioactivity and cosmic rays. Terrestrial background radiation primarily results from gamma emitting primordial radionuclide such as uranium and thorium (and their decay products), and $^{40}K$, which are naturally occurring in geologic material and associated soils. Primary cosmic radiation (mostly protons) impinging on the upper atmosphere from space interacts with atmospheric nuclei to produce secondary radiation reaching the earth's surface in the form of mesons, electrons, and other particles. Dose rate from this secondary cosmic radiation at the earth's surface increases with both elevation and latitude[2].

The variability of natural background in time and space, both cosmic and terrestrial gamma has been reviewed in some detail in the reports of[3, 4] and in NCRP report 94[5]. The major variation in cosmic-ray intensity is with altitude, which approximately doubles for every 2000-meter increase in elevation. The variation in cosmic-ray intensity from 30$^o$ N to 60$^o$ N latitude is only about 10% at sea level[5]. In the United States, the average cosmic-ray dose rate in air about 31nGyh$^{-1}$, is at sea level, but in Denver (at 1600 m), for example, the cosmic-ray dose rate is about 55 nGyh$^{-1}$[6].

The variability in external terrestrial radiation is typically larger than that of cosmic sources. Activity concentrations of primordial radionuclides in rocks are usually higher in igneous than in sedimentary types. There are, however, exceptions as certain sedimentary rocks, notably some shale and phosphate rocks, are highly radioactive[7]. The activity concentrations in soil, which are directly relevant to external exposure, are largely determined by the activity concentrations in the source rock.

Large-scale surveys, using different methods and types of instrumentation, have been carried out in a number of countries in order to estimate average nation wide exposures to outdoor external gamma-radiation. Absorbed dose rates in air from 23 countries ranged between 24 and 85 nGyh$^{-1}$[3].

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The overall objective of this study was to measure background radiation using a Geiger Muller (GM) counter at populated area of Yazd province in order to estimate the magnitudes of external dose rates (cosmic plus terrestrial). The ambient exposures are measured in some provinces such as Mazandaran, Isfahan, Kordestan, Chaharmahal Bakhtiary, Azarbaeijan, Khorasan and Hormozgan[8-11]. Yazd province is located in the center of Iran with an area of about 73600 km$^2$ consists of 9 big cities. There are two uranium minerals in this region of Iran; therefore, monitoring natural external radiation in this province may be of great importance.

## MATERIALS AND METHODS

The environmental dose rate is determined by two methods, one of them is count rate measurement of terrestrial material ($^{235}$U, $^{232}$Th and $^{40}$K) by gamma ray spectrometry and calculating its dose rate, and the other one is direct measurement. In this study, the later method was used. The measurements were accomplished by a G.M. detector (Wictoreen-190), during daylight since Oct. to Dec. 2004. The G.M. was calibrated by Iran Secondary Standard Dosimetry Libratory (ISSDL), and the determined calibration factor was +0.86. The measured exposure rates (μRh$^{-1}$) were converted to absorbed dose rates in air, using a multiplication factor of 0.873[5]; finally, this data were converted to nGh-1 for further analysis. The gamma background radiation measurements were performed in indoor and outdoor places of five areas (in north, south, west and east) in eight cities of Yazd province (Yazd, Taft, Meibod, Ardakan, Mehriz, Abarkoh, Bafgh and Ashkezar). In each area one building was selected randomly for indoor measurement. The outdoor measurements were accomplished at least 6 m far from those buildings and 1 m above the ground.

Since radionuclide decay and cosmic radiation fluency varies slightly in time, the measurements were accomplished by the integrate mode of detector. In this mode, total counting times and integrated exposure were recorded. The total exposure time of 2000 seconds was considered in each measurement. For calculation of effective dose, the absorbed doses of outdoor and indoor exposure were multiplied by the occupancy factors of 20% and 80% respectively.

## RESULTS

The exposure and dose rates measurements due to the outdoor gamma background radiation in 8 cities of Yazd province are shown in table 1. Each of the values is mean plus standard error of the five measurement areas of these cities. As seen the standard error of the measurements is quite low. The measurements' results of indoor background radiation are shown in table 2. The indoor exposure rates are almost 15% more than the outdoor measurements. The annual effective doses of each of the cities are calculated from equivalent dose rates multiplied to time and the occupancy factors of 0.2 and 0.8 for outdoor and indoor respectively. These results are shown in table 3. The average annual equivalent dose of Yazd province due to gamma background radiation is:

Table 1. The values of exposure rates and dose rates due to gamma background radiation of outdoor in the cities of Yazd province.

| City | Exposure Rate (μRh$^{-1}$) | Range of Expo. Rate (μRh$^{-1}$) | Equivalent Dose Rate (nSvh$^{-1}$) |
|---|---|---|---|
| **Abarkoh** | 10.75 ± 1.08 | 9.8-12.5 | 93.8 ± 9.4 |
| **Ardakan** | 10.98 ± 0.38 | 10.45-11.5 | 95.8 ± 3.3 |
| **Ashkezar** | 12.6 ± 0.43 | 12.02-13.05 | 110 ± 3.8 |
| **Bafgh** | 10.92 ± 0.16 | 10.7-11.07 | 95 ± 1.4 |
| **Maibod** | 11.95 ± 1.14 | 10.76-14.08 | 104.3 ± 9.9 |
| **Mehriz** | 11.18 ± 0.45 | 10.67-11.76 | 97.6 ± 3.9 |
| **Taft** | 13.28 ± 0.79 | 11.84-14.3 | 115.9 ± 6.9 |
| **Yazd** | 11.38 ± 0.34 | 10.8-11.75 | 99.3 ± 2.9 |
| **Average** | 11.63 ± 0.84 | 9.8-14.3 | 101.42 ± 7.4 |

Table 2. The values of exposure rates and dose rates due to gamma background radiation of indoor in the cities of Yazd province.

| City | Exposure Rate (μRh$^{-1}$) | Range of Expo. Rate (μRh$^{-1}$) | Equivalent Dose Rate (nSvh$^{-1}$) |
|---|---|---|---|
| **Abarkoh** | 12.87 ± 0.55 | 12.2-13.75 | 112.3 ± 4.8 |
| **Ardakan** | 13.18 ± 1.37 | 11.8-15.4 | 115 ± 11.9 |
| **Ashkezar** | 14.69 ± 1.15 | 13.04-16.25 | 128.2 ± 10 |
| **Bafgh** | 12.98 ± 0.58 | 12.28-13.7 | 113 ± 5 |
| **Maibod** | 14.2 ± 1.28 | 12.5-15.5 | 123.9 ± 11 |
| **Mehriz** | 14.7 ± 1.01 | 12.94-15.5 | 128 ± 8.8 |
| **Taft** | 14.59 ± 1.03 | 13.45-16.2 | 127.3 ± 9 |
| **Yazd** | 14.7 ± 0.82 | 13.19-15.3 | 128.3 ± 7.1 |
| **Average** | 13.98 ± 0.78 | 11.8-16.25 | 122 ± 6.8 |

Table 3. The annual effective doses of gamma background radiation in the cities of Yazd province.

| City | Yazd | Mehriz | Taft | Abarkoh | Ardakan | Maibod | Ashkezar | Bafgh |
|---|---|---|---|---|---|---|---|---|
| Altitude (m) | 1200 | 1366 | 1560 | 1505 | 1234 | 1234 | 1170 | 995 |
| Effective dose $mSvy^{-1}$ | 0.75 | 0.74 | 0.77 | 0.66 | 0.68 | 0.73 | 0.76 | 0.66 |

$101.42 \times 0.2 + 122 \times 0.8 = 117.88\ nSvh^{-1}$, and annual equivalent dose is:

$117.88 \times 24 \times 365 \times 10^{-6} = 1.03\ mSvy^{-1}$.

To estimate annual effective dose, the conversion coefficient must be taken into account from the absorbed dose in air to the effective dose. Gamma radiation is less absorbed in children and infants resulting in a higher dose conversion coefficient (adults: 0.7, children: 0.8 and infants: 0.9). Then the annual average effective dose for adults would be: $1.03 \times 0.7 = 0.72\ mSvy^{-1}$ [12, 13].

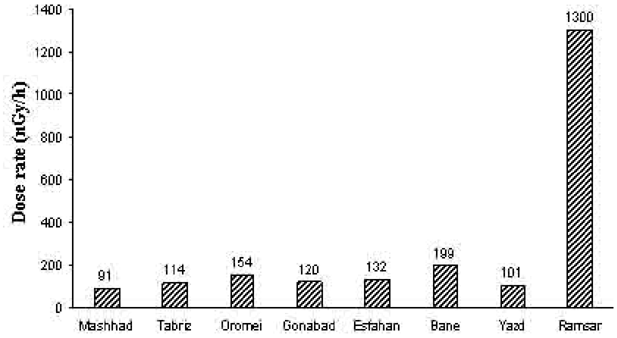


Figure 1. The average dose rates of outdoor background radiation for some Iranian cities in compare to Yazd [8-10].

## DISCUSSION

Studies of background radiation are of great importance which are measured in most of countries[14]. The aim of this study was to measure the external gamma-ray dose rates in the environment of Yazd province in the central part of Iran which is rich in different mines such as: uranium, zinc and lead.

The measured results in air, by a GM counter, showed that the average outdoor dose rate in this province is about 101.4 ± 7.4 $nGyh^{-1}$. This value is due to both, the terrestrial radioactive sources and the cosmic-rays. This result in comparison with the values reported by UNSEAR 2000[13] from different countries (with the mean of 59 $nGyh^{-1}$ in the range of 18–93 $nGyh^{-1}$) is high, but is lower than the values, which are reported from the other cities in Iran such as; Tabriz, Oromeih, Gonabad, Isfahan and Baneh[9, 10]. It is noticeable that the maximum dose rate of Ramsar city located in the northern part of Iran is 13600 $nGyh^{-1}$ [15]. The outdoor background radiation dose rate measurements of some cities of Iran are shown in table 3. This table shows that the dose rates of Yazd, is lower than the data reported for the majority of other cities in Iran (figure 1) and is very lower than the Ramsar city, specifically this is due to high levels of resolved radium in many hot mineral waters springs in this area, this kind of spas in Yazd province. Such a case dose not exists in Yazd.

The mean of indoor dose rate measurements in Yazd province, (122 ± 6.8 $nGyh^{-1}$), is higher than the mean absorbed dose rate that has reported by UNSCEAR 2000; (with the mean of 84 $nGyh^{-1}$ in the range of 20–200 $nGyh^{-1}$), and is almost the same as the average data in some other countries such as: Sri Lanka (102 $nGyh^{-1}$)[16], Italy (with the mean of 105 $nGyh^{-1}$ in the range of 3-228 $nGyh^{-1}$), Spain (with the mean 110 $nGyh^{-1}$ in the range of 40-120 $nGyh^{-1}$) and Sweden (with the mean 110 $nGyh^{-1}$ in the range of 40-500 $nGyh^{-1}$)[13].

The results shown in table 3 indicate that there isn't any correlation between altitudes and the annual effective dose, which means, the cities with the same altitude have different exposure rates. The reason is that this study includes both the cosmic and terrestrial rays. So if the cosmic rays were measured alone, the correlation might be having been found. The dose rate of cosmic rays at sea level is estimated to be about 31 $nGyh^{-1}$[3], and for each 1500 meters, this value must be multiplied by two; therefore in Yazd, with an average altitude of 1283 meters, the dose rate of cosmic rays would be 53 $nGyh^{-1}$, (31 × 1.71 altitude correction). The dose rate of terrestrial sources, in turn, is 48.42 $nGyh^{-1}$ (101.42–53) which is lower than worldwide of this value reported by UNSCEAR, the worldwide mean for this value is 60 $nGyh^{-1}$( which is due to $^{40}K$, $^{226}Ra$, $^{232}Th$, which are 18, 15 and 27 $nGyh^{-1}$ respectively)[13]. The average annual effective dose, for background gamma radiation, due to both cosmic rays and terrestrial sources in

Yazd province is 0.72 mSv. The resulting average of the effective dose for the adult population from gamma radiation of external terrestrial radiation and cosmic rays is 0.48 mSv and 0.22 mSv respectively all around the world and the sum is 0.7 mSv. The altitude correction for cosmic rays in worldwide is considered 1.25 but for Yazd province is 1.7. So, the average annual effective dose of our measurement is normal[13, 17].

The natural radiation exposure level around the globe usually varies by factor of about 3[18], but in some locations, however, typical levels of natural radiation exposure exceed the average levels by factor of 10 and sometimes even by factor of 100. Therefore based on this preliminary study, it might be possible to conclude that the annual effective dose in Yazd province at about 0.72 mSv may not pose a threat to the population in the region.

In conclusion the comparison of the obtained results in this study and comparing them with the ones for other cities in Iran such as Isfahan and Tabriz, shows that presence of the uranium mines in Yazd province dose not lead to high level of gamma background radiation.

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