Assessment of Individual External Doses of Inhabitants in Ramsar, Iran

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Individual external doses of inhabitants were examined in high levels of natural radiation areas (HLNRAs) in Ramsar. Each of 15 inhabitants in HLNRAs and 10 inhabitants in a control area carried an electronic personal dosimeter (EPD) for one day in April and in December 2005. In addition, their individual doses were estimated from indoor and outdoor radiation dose rates determined with a NaI (Tl) survey meter. A good correlation existed between the dose rate values obtained through estimation and personal measurement, and estimated annual doses ranged from 0.5 to 32 mGy/y. Each of the dosimetric subjects carried also an optically stimulated luminescence dosimeter (OSLD) for about one month in September 2005, but a few values obtained by these measurements deviated widely from those obtained by one-day measurements with EPDs and those estimated by environmental dosimetry. This deviation might have been due to the fact that these OSLDs were left behind somewhere in houses. Hence, the observed dose values depended heavily on the place where dosimeters had been left, because of the non-uniform distribution of Ra-226 contained in building materials as well as the structure of the house and the existence of shields.

KEY WORDS: external dose, individual dosimetry, environmental dosimetry, high levels of natural radiation area, Ramsar, Iran, electronic personal dosimeter, optically stimulated luminescence dosimeter, NaI (Tl) survey meter.

INTRODUCTION

Some epidemiological and cytogenetic studies on inhabitants living in high levels of natural radiation areas (HLNRAs) have been performed to examine the health effects of exposure to low dose radiation.1, 2) Ramsar, Iran is 160 km northwest of Tehran and on the coast of the Caspian Sea. While Ramsar is known as the city where the convention on wetlands was adopted, it contains some HLNRAs of a few square kilometers, caused by Radium-226 deposited from water rising from hot springs.3, 4) The population of exposed residents is about 2000.1, 3)

As a part of international collaborative studies, we carried out radiological surveys at locations around several hot springs, and inside about 20 dwellings of inhabitants living in HLNRAs in Ramsar, in 1999, 2000 and 2005.2, 4~6) Some spots with high levels of natural radiation were scattered around springs. At a spot near a spring, outdoor radiation dose rates were found to reach levels of 32 μGy/h at 1m height, and 97 μGy/h on the surface of the ground.6) These results are consistent with those reported by Sohrabi et al.3, 5) Although hot water from some springs is used for spas, most springs are located far from dwellings. Particular attention should be given to internal exposure from the ingestion of food crops gathered from farms located near springs, since the spring water flowing into a stream is used for irrigation together with river water.

The present report deals with the results of estimating individual external doses of inhabitants in the HLNRAs.

MATERIALS AND METHODS

1. Environmental dosimetry

Measurement of indoor and outdoor radiation dose rates was made at one meter above the ground and at the earth’s surface using an Aloka TCS-166 NaI (Tl) scintillation survey meter. Indoor measurement was made also with Luxel optically stimulated luminescence dosimeters (OSLDs).

2. Individual dosimetry

2.1 Direct method

Individual external doses of inhabitants in HLNRAs were determined with Aloka PDM-111 electronic personal dosimeters (EPDs) and OSLDs worn by subjects.

Values indicated with EPDs were divided by the conversion coefficient (1.213 Sv/Gy) for 0.66-MeV gamma ray from air kerma to personal dose equivalent,9) since the PDM-111 model was calibrated with cesium-137. This is because effective dose is intended for use as a protection quantity, while it should be...
used neither for epidemiological evaluations nor for detailed specific retrospective investigations of individual exposure and risk.10)

### 2.2 Indirect method

Individual external doses were also estimated from indoor and outdoor radiation dose rates determined by environmental dosimetry, and occupancy factors (OFs) obtained by personal interviews, which were fractions of time spent in a certain place. To be concrete, the dose rate for each individual was calculated using the following equation.

\[
[\text{Individual dose rate} (\mu\text{Gy/d})] = [\text{Dose rate}]_{\text{outdoor}} \times [\text{OF}]_{\text{outdoor}} + [\text{Dose rate}]_{\text{bedroom}} \times [\text{OF}]_{\text{bedroom}} + [\text{Dose rate}]_{\text{the other rooms}} \times [\text{OF}]_{\text{the other rooms}}
\]

### 2.3 Dosimetric subjects

In a cytogenetic study conducted in Ramsar, Iran,11) 15 and 10 elderly housewives were selected respectively from inhabitants living in HLNRAs in Talesh Mahalleh and the control area (CA) in Katalom. The two villages, whose distance is about 3 km, have similar lifestyles, living circumstances and culture to each other. The range and average of subjects’ ages were 50 – 63 and 55.6 ± 4.4 years old for the HLNRAs, while they were 50 – 62 and 53.3 ± 4.9 years old for the CA. Every subject carried an EPD for one day in April and December 2005.

### III RESULTS AND DISCUSSION

#### 1. Environmental dosimetry

Among all the houses where we surveyed, the highest dose rates detected were 22 μGy/h at 1 m height and 110 μGy/h on one wall of a room5,6) inside a house in Talesh Mahalleh. **Figure 1** shows the radiation dose rates inside and around the house. These high dose rates arose as a result of the use of travertine - the Ra-226 content of which was very high - as a building material in the wall.4) This maximum value for the radiation dose rate on the wall’s surface was nearly equal to the value 105 μGy/h reported by SOHRABI et al.8) Twenty-three OSLDs were placed at various points in this house for one month, where we measured indoor dose rates with a survey meter. **Figure 2** shows the relationship between the dose rate values obtained using OSLDs and those obtained using a survey meter. From this figure, it is clear that the dose rate values obtained with the two kinds of devices had a positive correlation.

Outdoor dose rates varied largely and irregularly even within a narrow area. This variation was significant in the vicinity of hot springs. As shown in **Fig. 1**, there were also large differences of indoor dose rates among rooms, because of the non-uniform distribution of travertine contained in building materials as well as the structure of the house and

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**Fig. 1** Radiation dose rates at 1 m height, inside and around the house in Talesh Mahalleh, Ramsar where the highest indoor dose rate was detected. Values for “wall” indicate the dose rate on the surface of the indicated wall. (unit of measurement: μGy/h)

- The size of each bedroom was approximately 3 m × 4 m, the thickness of the wall was about 20 cm and the whole house covered an area of about 150 m².
the existence of shields. These findings imply that not only environmental dosimetry but individual dosimetry is necessary for studying the health effects of low dose radiation on inhabitants living in HLNRAs.

2. Individual dosimetry

Figure 3 shows the correlation between the dose rate values obtained with EPDs worn by subjects in April 2005 and those similarly obtained in December 2005. This figure demonstrates that results of personal measurement carried out twice were essentially similar. Figure 4 shows the relationship between the dose rate values obtained by the direct method and those obtained by the indirect method. The results indicated a definite correlation between the dose rate values obtained through personal measurement and estimation by environmental dosimetry.

Estimated annual doses based on these results ranged from 0.5 to 32 mGy/y for the HLNRAs and from 0.5 to 0.6 mGy/y for the CA in Ramsar. The woman whose dose value was the highest recently moved to a new house from that which was surveyed here in detail. If her value was disregarded, the estimated annual dose for the HLNRAs mentioned above came to range from 0.5 to 4.9 mGy/y. Her present dose would need to be examined to estimate her cumulative dose. Even if inhabitants do not move their domicile, their doses can be influenced by development and urbanization as well as lifestyle. Changes in the environment of HLNRAs therefore always need to be observed.

In the above cytogenetic study, each of the dosimetric subjects also carried an OSLD for about one month in September 2005. Figure 5 shows the relationship between the dose rate values obtained by one-day measurement with an
EPD and those obtained by one-month measurement with an OSLD. Figures 4 and 5 show that a few values obtained by one-month measurement deviated widely from those obtained by one-day measurement and those estimated by the indirect one-month measurement. This deviation might have been due to the fact that these OSLDs were left behind somewhere in houses, since it was too troublesome for a few inhabitants to always wear dosimeters for a month. As a result, the observed dose values depended heavily on the place where dosimeters had been left, mainly because of the non-uniform distribution of Ra-226 contained in materials of the houses built in the HLNRAs. These findings imply that it is in all cases necessary to confirm whether each dosimetric subject had constantly been wearing the dosimeter during the measurement period and whether he had his usual pattern of movement, in order to exclude non-representative individual dose values.

REFERENCES


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