ASSESSMENT OF NATURAL RADIATION EXPOSURE RATE IN KOREA +

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INTRODUCTION

The measurement of natural environmental radiation exposure rate in Korea was initiated in 1961, and has been routinely carried out since then over twenty years in the present Korea Advanced Energy Research Institute (KAERI) as a part of environmental radiation monitoring program for north-eastern part of Seoul area where the institute is located. Similar surveys were also made around Kori nuclear power plant on south-eastern coast of Korea in two separate years, 1978 and 1982, respectively, by the same group. Major part of the measurement was made using portable G-M counting system.

Very recently another type of measurement of natural radiation exposure rate was carried out by a group of the Department of Physics, Chungnam National University(CNU) for Daejeon area, which is a city in mid-western part of south Korea, by means of gamma-ray scintillation spectrometry. The areas mentioned are shown in Fig. 1.

In this study a series of assessment is made to figure out the absorbed dose rate in air, corresponding organ dose, and collective dose due mainly to the external exposure of terrestrial component of natural environmental radiation based on the analysis of KAERI and CNU data obtained for those three areas.

THE MEASURED EXPOSURE RATE

1. Measured by KAERI group

For the assessment of exposure rate measured in Seoul area, the data obtained off site of KAERI for recent five years from 1977 to 1981 were statistically analyzed, for which the influence of fission products originated from atmospheric nuclear explosions conducted early 1960s are negligible. The measurement in this area has been carried out at 5 sampling sites distributed in the region of 1 to 12 km in radius from the KAERI reactor building.[1,2] The measurement was done on monthly basis using unshielded end-window type portable G-M counting system calibrated periodically with a reference source of ^{226}Ra of known activity encapsulated in 0.5 mm platinum capsule for converting count rate into exposure rate. Thus determined latest conversion factor is 0.512 uR/h.cpm.

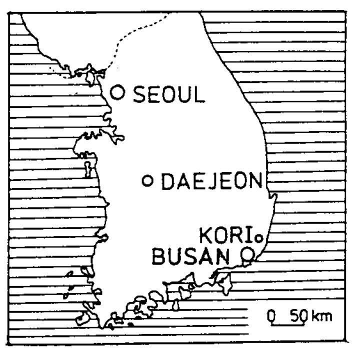

Fig. 1. Areas where Natural Radiation Exposure Rates were Measured

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The exposure rate at each point was measured at a height of 1 m from the earth with the detector window facing the ground surface. The results[1-4] were summarized in Fig. 2 as a variation of monthly average of the given period of time, with yearly average of 16.1 ± 0.8 uR/h. The pattern of the monthly variation of natural radiation exposure rate shown in the figure is quite similar with that observed by Minato[5] in Nagoya, Japan, for four years from 1977 to 1980, which shows strong dependence of terrestrial radiation exposure on the dryness of surface soil.

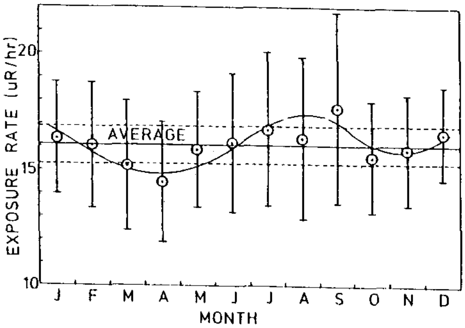

Fig. 2. Monthly Variation of Natural Radiation Exposure Rate in Seoul Area (1977 - 1981) measured by G-M counting system

In the same way the natural radiation exposure rate in Kori area were measured in the region covering 1 to 30 km in radius from Kori unit 1 nuclear power reactor. In 1978 the measurement was made at 12 different points distributed in the region[2], while it was done at 23 points in 1982[6]. The measurement was made quarterly at each point, and the results[2,6] obtained are summarized in Fig. 3, with yearly average of 16,3 ± 0.8 uR/h.

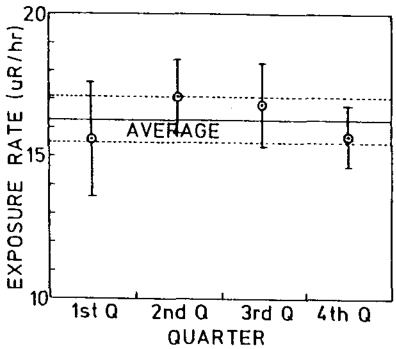

Fig.3. Quarterly Variation of Natural Radiation Exposure Rate in Kori Area (1978 and 1982) measured by G-M counting system

2. Measured by CNU group

A series of in-situ gamma-ray spectrometric investigation on the natural radiation exposure has been carried out in Daejeon area using 3"∅ x 3" cylindrical NaI(Tl) scintillation detector in association with a 400 channel pulse height analyzer. It was carried out at 8 different points distributed in an area of about 200 km^2. During the coarse of the measurement the detector was kept at a height of 1 m from the ground with the detector axis vertical to the earth surface.

The measured gamma-ray spectra were directly converted into exposure rate by using Moriuchi's spectrum-exposure rate conversion operator, G(E),[7,8] which was derived from the assumption of linear proportionality between the output pulse height of the detector and the energy of secondary electrons generated by incident photons in the detector, and the existence of an integral equation

$$D(E_0) = \int_0^\infty f(E,E_0)\, G(E)\, dE \qquad (1)$$

where $f(E,E_0)$ is pulse height distribution of the secondary electron of energy E due to the incident photon of energy E_0 of unit flux density, and $D(E_0)$ is the exposure rate in the identical gamma-ray field. The conversion operator, G(E), is a function of incident photon energy and the size of scintillation crystal, and the numerical vulues for commonly used crystals are readily available.

The standard error involved in the exposure rate evaluated by means of G(E) operation is a function of total counts under the pulse height spectrum. It is estimated to be less than 0.4 % for 3"ϕ x 3" NaI(Tl) detector at 10 uR/h level[9].

In order to figure out the terrestrial component of exposure rate($\dot{X}$), it is necessary to correct the exposure rate calculated from the spectra($\dot{X}_s$) for cosmic ray contribution, the contribution of ^{40}K gamma-rays in PM tube glass, and directional dependence of the detector on the incident photons. This can be made by

Table 1. Terrestrial Radiation Exposure Rate in Daejeon Area+

Location No.	$\dot{X}$ (uR/h)
1	10.30
2	10.34
3	9.00
4	10.25
5	6.38
6	7.25
7	8.42
8	9.90
Average	8.98 ± 1.52

+ Daytime, March 1983

$$\dot{X} = 0.94(\dot{X}_s - 0.25) \quad \text{uR/h} \qquad (2)$$

according to an evaluation for presently available 3"ϕ x 3" NaI(Tl) detector.

The results thus obtained are summarized in Table 1. Reproducibility of this type of measurement was within 0.1 to 1 %.

ASSESSMENT OF THE EXPOSURE RATE AND DOSE

1. Assessment of the Exposure Rate

In order to assure the exposure rate measured by means of gamma-ray spectrometry it was compared with those measured by the Reuter/Stocks' pressurized ionization chamber, which was calibrated with ^{226}Ra and ^{60}Co standard sources, by carrying out a series of simultaneous measurement made at the same place. The terrestrial radiation exposure rates measured by the spectrometry and ion chamber in this series of experiment were 10.61 ± 0.44 uR/h and 9.95 ± 0.19 uR/h, respectively, which are in satisfactory agreement within statistical error considering that the response of this particular ion chamber to the photons of below 50 keV is zero, while that of the NaI(Tl) detector down to photons of 30 keV is still existing. The numerical value of 9.95 uR/h resulted from the elimination of cosmic ray contribution to the ionization chamber which is known to be 3.59 uR/h at normal atmospheric pressure.

For the assessment of exposure rate measured by portable G-M counting system, similar comparative measurement was again made with the gamma-ray spectrometry by carrying out ten times simultaneous measurement at the same place. According to the result of the assessment the exposure rate measured by the G-M system is higher as much as 8.4 ± 0.7 uR/h than those measured by the gamma-ray spectrometry. This discrepancy is understandable in comparison with the value of 6.9 uR/h determined by Moriuchi for a G-M counter as a result of cosmic ray contribution and self contamination due to such materials as ^{40}K and other radioisotopes in the detector tube[9] when we consider the standard deviation in exposure rate measured individually by a G-M survey meter reaching about 30 % at background level[10]. Taking all these factors into account, the yearly average of exposure rates due to the terrestrial component of environmental radiation in Seoul and Kori areas are estimated to be 7.7 ± 0.4 uR/h and 7.9 ± 0.3 uR/h, respectively.

2. Assessment of Dose

On the basis of thus estimated numerical values of the terrestrial radiation exposure rate ($\dot{X}$) the absorbed dose rate in air ($\dot{D}_a$) in "receptor free" condition is easily calculated by applying the conversion factor, 0.869 rad/R.

From $\dot{D}_a$ organ dose rate ($\dot{D}_o$) is calculated by

$$\dot{D}_o = sg\dot{D}_a \qquad (3)$$

where s is the ratio of mass energy absorption coefficient for tissue and air, and g is geometrical factor. sg = 0.82 is used to calculate gonad dose rate for external outdoor exposure ($\dot{D}_g$), and 0.7 is used for average absorbed dose rate in the body ($\dot{D}_b$)(11). $\dot{D}_b$ is also calculated directly from $\dot{X}$ applying conversion factor, 0.6 rad/R(12).

Annual gonad dose (D_g) and annual body dose (D_b) are calculated by time integration of $\dot{D}_g$ and $\dot{D}_b$, respectively. Successive calculation of the annual collective dose (S_y) in the areas of the exposure rate measurement can be carried out using presently available population data. The results of the assessment are summarized in Table 2.

Table 2. Exposure Rate and Dose from Terrestrial Radiation in Korea

Area	$\dot{X}$(uR/h)	$\dot{D}_a$(urad/h)	$\dot{D}_b$(urad/h)	D_g(mrad)	D_b(mrad)	S_y(man-rad)
Seoul	7.7	6.7	4.6	33.1	40.3	3.50×10^5
Kori	7.9	6.9	4.7	33.8	41.2	1.67×10^5
Daejeon	8.98	7.9	5.4	38.9	47.3	3.67×10^4

CONCLUSION

With the results obtained through this study it is concluded that as far as the areas mentioned are concerned, Korea is one of the "normal" areas in the world in radiological point of view suggested by UNSCEAR. According to the 1977 report of the Committee(11) annual gonad dose from external terrestrial radiation in "normal" area is, on average, 32 mrad, and 95% of the world population would receive annual gonad doses in the range of 21 to 43 mrad. Korea belongs to this category.

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