Journal of Scientific & Industrial Research
Vol. 70, March 2011, pp. 230-231

# Evaluation of radon exhalation rate from granite stone

P Nassiri[1], H Ebrahimi[1] and P Jafari Shalkouhi[2]
[1]Department of Occupational Health, School of Public Health, Tehran University of Medical Sciences, PO Box 6446-14155, Tehran, Iran
[2]Department of Environmental Engineering, Graduate School of the Environment and Energy, Science and Research Branch, Islamic Azad University, Tehran, Iran

*Received 14 June 2010; revised 08 February 2011; accepted 10 February 2011*

This study evaluates radon exhalation rate from 10 different granite stones, used for building construction in Iran. Radon exhalation rate ranged from non-detectable to 0.6 Bq $m^{-2} h^{-1}$. Six samples had exhalation rate above detectable level. A significant statistical relationship between radon exhalation rate with $^{226}Ra$ and $^{232}Th$ indicated that $^{226}Ra$ and $^{232}Th$ were responsible for radon exhalation from granite stones.

**Keywords**: Alpha GURD, Granite stone, Iran, Radon

## Introduction

Existences of three primordial radio nuclides ($^{40}K$, $^{238}U$ and $^{232}Th$) in building materials cause internal and external exposures to residents. External exposure is caused by gamma radiation emitted from $^{40}K$ and daughter products of $^{238}U$ and $^{232}Th$. It is well known that as a result of inhalation of $^{222}Rn$, a daughter product of decay chain of $^{238}U$ and its daughter products, equivalent dose to entire lung is higher than the equivalent dose in other tissues[1]. Granite stones emit more radon (Rn) compared to other types of construction materials because of the existence of relatively high uranium content[2]. Granite samples are reported[3,4] main source of Rn emanations. Chen *et al*[5] observed that slate tiles and granite slabs had relatively higher Rn exhalation rates than other decorative materials. Al-Jarallah *et al*[6] observed that exhalation rate of granite samples was higher than marble and ceramic. Ur-Rehman *et al*[7] and Sakoda *et al*[8] reported Rn exhalation from granite samples. This study evaluates Rn gas exhalation rate from local made granite stone, which have been used for building construction in Iran.

## Experimental Section

Gamma spectrophotometer determined $^{226}Ra$ and $^{232}Th$ concentration in granite samples. To measure Rn gas, an Alpha GURD model PQ 2000 pro (GENITRON Co.) was used. This device works based on the passing of Rn gas from a filter to ionization chamber. Measurement lasted 60 min such that every 10 min a number was registered. Also, Alpha GURD has Alpha View/Expert software to analyze and store measurements. For Rn gas exhalation, a 50 l steel emanation container (GENITRON Co.) was used. To measure Rn exhalation rate, 10 varieties of local granite stones (25 cm × 25 cm × 25 cm) from different parts of Iran were randomly selected. Each sample was put near Alpha GURD inside Rn gas emanation container for 120 min so that every 1 h Rn gas concentration was measured. By Alpha View/Expert software, final activity of Rn gas ($A_0$) was computed. Rn gas exhalation rate was computed as[9]

$$E = A_0 \lambda \left( \frac{V}{F} \right) \qquad \ldots(1)$$

where E, Rn gas exhalation rate (Bq $m^{-2} h^{-1}$); $A_0$, final activity of Rn gas (Bq/$m^3$); ë, Rn decay constant (7.567. $10^{-3}$); V, emanation container volume ($m^3$); and F, area of each sample ($m^2$).

## Results and Discussion

Rn exhalation rate of 10 granite stones (Table 1) ranged from non- detectable up to 0.6 Bq $m^{-2} h^{-1}$.

*Author for correspondence
Tel / Fax: +982188951390
E-mail: nassiri@sina.tums.ac.ir

Table 1—Radon exhalation rate from granite stones

| Radon exhalation rate Bq $m^{-2} h^{-1}$ | N | % |
|---|---|---|
| Non- detectable | 4 | 40 |
| Non-detectable-0.2 | 2 | 20 |
| 0.2-0.4` | 3 | 30 |
| 0.4-0.6 | 1 | 10 |

Table 2—Activity concentrations of $^{226}$Ra and $^{232}$Th of granite stones

| Element | Min. concentration Bq $kg^{-1}$ | Max. concentration Bq $kg^{-1}$ | Mean concentration Bq $kg^{-1}$ | SD |
|---|---|---|---|---|
| $^{226}$Ra | Non- detectable | 114 | 54 | 4.14 |
| $^{232}$Th | Non- detectable | 203 | 89 | 7.24 |

Six samples had Rn exhalation rate above detectable level. Rn exhalation rate of granite stones in this study are minimal compared to reported (Al-Jarallah *et al*[3], up to 13.1 Bq $m^{-2} h^{-1}$; and Al-Jarallah[4], 10.6 Bq $m^{-2} h^{-1}$) results.

$^{226}$Ra concentration of granite stones ranged from non- detectable to 114 Bq $kg^{-1}$ and $^{232}$Th concentration varied from non-detectable to 203 Bq $kg^{-1}$ (Table 2). Sakoda *et al*[8] found that $^{226}$Ra concentration of two different granite samples were 895±50 Bq $kg^{-1}$ and 7064±325 Bq $kg^{-1}$ respectively, and that of $^{232}$Th concentration were 21±2 and 64±15 Bq $kg^{-1}$ respectively. El-Dine *et al*[10] showed that $^{226}$Ra concentration of granite samples ranged from 30.23 to 121.75 Bq $kg^{-1}$.

Statistical relationships between Rn exhalation rate with $^{226}$Ra and $^{232}$Th, respectively, are as follows: $P_{value}$, 0.002, 0.012; and $R^2$, 0.9, 0.8. There are significant statistical relationships between Rn exhalation rate with $^{226}$Ra and $^{232}$Th. On the other hand, Rn gas exhalation rate from granite stones is related to $^{226}$Ra and $^{232}$Th concentration. In contrast, Al-Jarallah *et al*[3] reported $R^2$=0.9 between emanated Rn per unit mass (Bq $kg^{-1}$) and total Ra content (Bq $kg^{-1}$) of granite sample. Also, Al-Jarallah[4] reported strong correlation ($R^2$=0.92) between emanated Rn and Ra content of granite samples. ICRP[11] proposed action level of 500-1500 Bq $m^{-3}$ for Rn gas at workplaces. Atomic Energy Organization (AEO) of Iran proposed action level of 1000 Bq $m^{-3}$ for dwellings. Therefore, for a hall (6 m × 9 m × 3 m) and with walls covering with granite stones, which emit Rn (rate, 0.5 Bq $m^{-2} h^{-1}$), action level obtained (1080 Bq $m^{-3}$) for 24 h is higher than 1000 Bq $m^{-3}$ proposed by AEO of Iran. Hence, it is better not to use granite stones in dwellings.

## Conclusions

Concentration of $^{226}$Ra and $^{232}$Th were responsible for Rn exhalation from granite stones. Hence, granite stones must be mined with low concentration of $^{226}$Ra and $^{232}$Th or uranium.

## Acknowledgment

Authors thank Atomic Energy Organization of Iran for assistance.

## References

1 Sundar S B, Ajoy K C, Dhanasekaran A, Gajendiran V & Santhanam R, Measurement of radon exhalation rate from Indian granite tiles, in *Proc Int Radon Symp,* **vol II** (Amer Assoc of Radon Sci and Technol, USA) 2003.

2 Durrani SA & Ilic R, *Radon Measurements by Etched Track Detectors: Applications to Radiation Protection, Earth Sciences and the Environment* (World Scientific, Singapore) 1997.

3 Al-Jarallah M I, ur-Rehman F, Musazay M S & Aksoy A, Correlation between radon exhalation and radium content in granite samples used as construction material in Saudi Arabia, *Rad Measure*, **40** (2005) 625-629.

4 Al-Jarallah M I, Radon exhalation from granites used in Saudi Arabia, *J Environ Radioactivity*, **53** (2001) 91-98.

5 Chen J, Rahman N M & Abu Atiya I, Radon exhalation from building materials for decorative use, *J Environ Radioactivity*, **101** (2010) 317–322.

6 Al-Jarallah M I, Abu-Jarad F & ur-Rehman, F, Determination of radon exhalation rates from tiles using active and passive techniques, *Rad Measure*, **34** (2001) 491-495.

7 ur-Rehman F, Al-Jarallah M I, Musazay M S & Abu-Jarad F, Application of the can technique and radon gas analyzer for radon exhalation measurements, *Appl Radiation & Isot*, **59** (2003) 353-358.

8 Sakoda A, Hanamoto K, Ishimori Y, Nagamatsu T & Yamaoka K, Radioactivity and radon emanation fraction of the granites sampled at Misasa and Badgastein, *Appl Radiation & Isot*, **66** (2008) 648-652.

9 Mustonen R, Natural radioactivity in and radon exhalation from Finnish building materials, *Health Phys*, **46** (1984) 1195-1203.

10 El-Dine N W, El-Shershaby A, Ahmed F & Abdel-Haleem A S, Measurement of radioactivity and radon exhalation rate in different kinds of marbles and granites, *Appl Radiation & Isot*, **55** (2001) 853-860.

11 ICRP- Inter Comm on Radiol Protect, Draft recommendations of the International Commission on Radiological Protection, 2006.