Radon level in dwellings basement of Yazd-Iran

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Background: Indoor radon gas (^{222}Rn) has been recognized as one of the health hazards for human. Air radon comes mainly from basement soil and construction materials. Saghand region with rich uranium mines lies 180 km from Yazd, so the indoor radon concentration can be high. Yazd, with population of about 457000, is the biggest city near Saghand, thus, indoor gamma background radiation of Yazd could be more than the other cities of Yazd province. *Materials and Methods:* In this study the air radon level of 84 dwellings basement from various regions of Yazd were measured during the year 2007. To do so, a portable radon gas surveyor was used which is an active measurement method. Using this device, α radiation of each basement was measured by a solid state detector for 24 hours. *Results:* Radon concentrations of the basements were between 5.55 to 747.4 Bq/m^3 with mean of 137.36 Bq/m^3. The mean radon concentration wasn't significantly different from the EPA guide line that is mitigation recommendations level (148 Bq/m^3). However, more than 30% of the basements had radon concentration more than EPA guide line. *Conclusion:* Using good air conditioning system in the dwelling basements is suggested. **Iran. J. Radiat. Res., 2008; 6 (3): 141-144**

Keywords: *Radon, dosimetery, active measurement, dwelling basement.*

INTRODUCTION

Radon radioactive gas is arising from the (^{238}U) uranium decay chain, and it is the largest source of radiation exposure to population [(1)]. High radon exposures have been shown to cause lung cancer [(2, 3)]. Radon is the second leading cause of lung cancer in the United States, next to smoking [(4)]. Radon gases can attach themselves to tiny dust particles in indoor air. These dust particles can easily be inhaled and the deposited atoms by emitting alpha cause radiation damage to lung cells [(4)].

In Europe, the annual effective dose from all sources of radiation in the environment is estimated to 3.3 mSv, while the effective dose of radon is 1.6 mSv [(5)]. Radon surveys have been carried out in Europe more than the third world countries. However, the study of radon has been steadily expanding throughout the world [(6- 10)].

Radon monitoring has been achieved in many Iranian cities such as Tehran, Mashhad, Ramsar, Ardabil, Lahijan, and Hamadan [(11)], so radon survey in Yazd can help to supply the radon map of Iran. Yazd with about half a million population is one of the Iranian historic cities which is famous for its adobe buildings in the world. Due to dry and hot weather in Yazd almost all dwellings have basement.

Therefore, the main issue has been about the monitoring of radon gas in the air inside the dwellings, since most of radon in the dwellings comes from the basement soil [(12)]. The air radon comes mainly from the basement soil and construction materials. In general, ^{222}Rn has the highest level in basements spaces that are in contact with the soil [(5)].

The Saghand uranium mines are sited at 185 km north-east of Yazd, covering an area of 20 hectares. This area reserves 1.58 million tones of uranium ore, at an average grade of 533 ppm (0.05% U) [(13)]. In the latest study the gamma background radiation of the province was measured and indoor gamma radiation of Yazd city was more than the average. Due to the fact that Yazd is the most populated city in the province, it's radon monitoring may be valuable [(14)].

MATERIALS AND METHODS

Radon concentration was measured in 84 dwellings basement in Yazd during 2006-

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2007 to improve the radiation background information. A calibrated active radon device (RAD7, Durridge Company, USA) was used for fast measurement of indoor radon activity levels on sites. RAD7 is a portable Radon gas surveyor (PRS) which is suitable for radon gas continuous or grab sampling measurements by solid state detector. Three types of alpha particle detectors are presently used in electronic radon monitors: Scintillation cells, ion chambers and solid state alpha detectors. RAD7 uses a semiconductor material (silicon) that converts alpha radiation directly to an electrical signal. One important advantage of solid state devices is the ability to electronically determine the energy of alpha particle. Every nucleus of ^{222}Rn decays through the sequence Polonium-218, Lead-214, Bismuth-214, Polonium-214 and Lead-210. With each transformation the nuclei emits alpha, beta or gamma radiation. The RAD7 was designed to detect alpha radiation only. A group of commands configured the RAD7 to perform tests according to the study's requirements. The user protocols consisted of 1.5 hours cycle, 16 recycles, auto mode thoron off, and auto pump. The total duration of run was determined by multiplication of cycle time by recycle number; so each location was automatically measured for 24 hours. In auto pump setting, the pump was switched on for 4 minutes and the air containing radon gas was pumped to the detector through drying tube (figure 1). The radon survey was carried out based on Environmental Protection Agency (EPA) protocol, denoted that the house basement should be fully closed from 24 hours before the beginning and during the test. So, all doors and windows should have been closed tightly, and no air conditioning system or ventilation fans run. The sampling points were at a height of 1 m above the floor with a distance longer than 1 m from the walls. The site samples were randomly selected in Yazd including old and new houses as shown in figure 4, and walls construction materials.

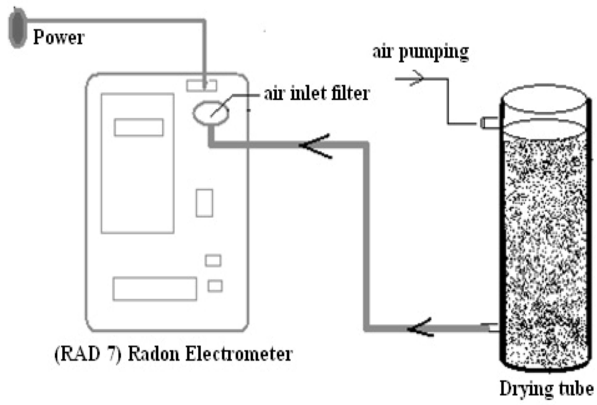

Figure 1. The scheme of drying tube, electrometer connections and air flow way.

RESULTS

Data obtained for radon concentrations in the 84 dwellings basement of the Yazd's various zones are summarized in table 1. Figure 2 shows the city map and the location of each sample measurement. The sampling distribution was almost homogenous. The radon concentrations of 56 dwelling basements were lower than 148 Bq/m^3 and 28 others were higher than the guide level. As the results show in table 1, the all radon concentrations range from 5.55 to 747.4 Bq/m^3 and the average ± SD has been 137.36 ± 149.48 Bq/m^3.

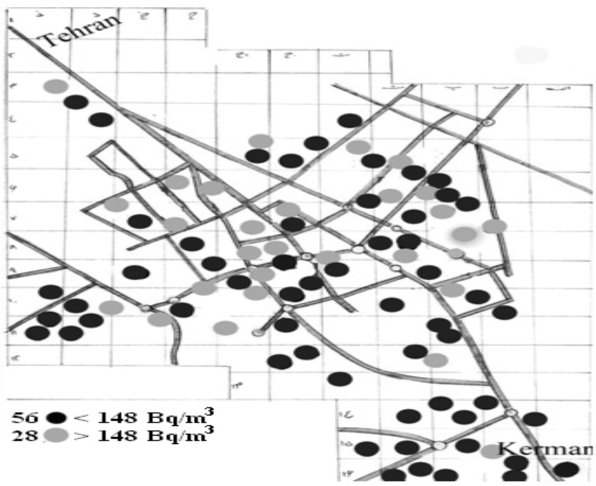

Figure2. The Yazd city map and the locals of radon concentration measuring, these locals are shown by black color circles (radon concentration <148 Bq/m^3) and gray color circles (radon concentration >148 Bq/m^3)

Table1. The statistical information of the radon concentrations (Bq/m^3) of the Yazd city dwellings underground.

n	Mean	SD	Med	Min	Max	quar.1	quar.2	quar.3	quar.4
84	137.36	149.48	78.65	5.55	747.4	44.49	78.65	192.67	747.4

Frequency distribution of the radon concentrations is shown in figure 3. Based on this figure, more than half of the radon concentrations were lower than the guide level of EPA (148 Bq/m^3). Figure 4 shows the mean radon concentrations based on the construction materials of the basements' wall. The mean radon concentrations of adobe, concrete, brick and plaster walls were 250.27, 126.1, 131.9 and 47.1 Bq/m^3 respectively. The adobe walls had the radon concentration more than the others ($p<0.05$).

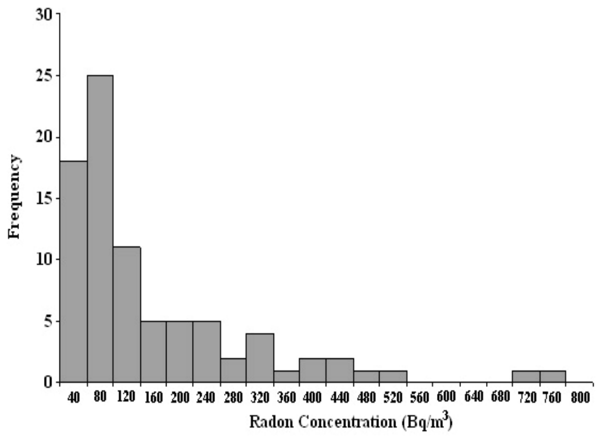

Figure 3. Frequency distribution of ^{222}Rn concentration (Bq/m^3) in the dwellings underground of Yazd city.

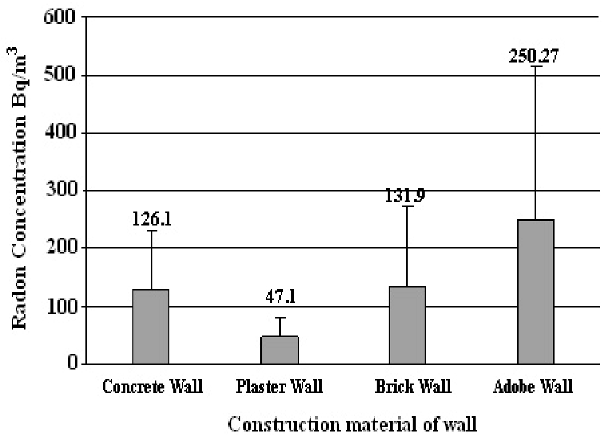

Figure4. The wall construction materials of building undergrounds.

DISCUSSION

Radioactive radon gas was produced by uranium and thorium chains decay. Radon gas is mobile and can diffuse from the site of production into the open air. Inhalation of the radioactive ^{222}Rn increases lung cancer risk (15). Radon distribution has been found to be related with the tectonic lines and high heat flow zones in the region (16). The average radon level in Yazd dwellings basement was found to be 137.36 ± 149 Bq/m^3 which isn't significantly different ($p<0.48$) from the EPA guide line (148 Bq/m^3), of course more than 30% of the undergrounds had radon concentration more than this guide line, so for these dwellings underground ventilation conditions has been recommended (17). As the results show, construction materials affect indoor radon concentration, namely, the adobe walls. Adobe walls basements had the highest radon concentration (250.27 ± 263.1 Bq/m^3) while the plaster walls had the lowest (47.1 ± 35 Bq/m^3) ($P<0.01$). It is reported by other researchers that the adobe structures could raise radon concentration due to higher porosity for radon emission (16).

The average radon concentrations of 11 Iranian cities are compared in figure 5 (18). Though, radon concentration of building basement is higher than the upper stage, but the average radon concentrations of current study which has been related to buildings basement (137.36 bq/m^3) has been lower than the results reported for Ramsar (560 Bq/m^3) and Ardabil (238 Bq/m^3) ($p<0.05$) and was not significantly different from the results reported for Sar-ein, Namin and Lahijan cities (11).

In conclusion, based on the results obtained in this study, using passive methods for annual radon monitoring of

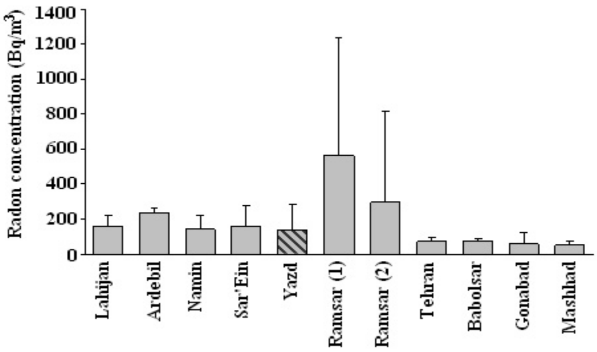

Figure 5. Average radon concentration in 11 cities of Iran. The error bars are 1 SD.

Yazd dwellings is suggested, especially for those dwellings where had radon concentrations more than guide line level. It is also better to use good air condition systems in the dwellings' basement.

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REFRENCES

1. Fovt LL, Baixeras C, Domingo C, Fernandez F (1999) Experimental and theoretical study of radon levels and entry mechanisms in a Mediterranean climate house. *Radiation Measurements, **31:** 277–82.*
2. Miles J (1988) Development of maps of radon-prone areas using radon measurements in houses. *Journal of Hazardous Materials, **61:** 53–8.*
3. Wenjie Y, Yang L, Yufeng L, Hongtao L, Wang S, Weiquan L (1999) Measuring ^{222}Rn level in underground space by SSNTD'S. *Chinese Journal of Health, **3:** 93-115.*
4. BIER VI report (1999) Health effects of exposure to radon. National Academic Press, Washington, DC, USA.
5. Popović D and Todorović D (2006) Radon indoor concentrations and activity of radionuclide in building materials in Serbia, Physics, *Chemistry and Technology, **4:** 11 – 20.*
6. Verdelocco S, Turkowsky P, Walker D, Osimani C (2001) Radon-222 monitoring at the Joint Research Centre, Ispra. *The Science of the Total Environment, **272:** 367-368.*
7. Silva D and Yoshimura EM (2005) Radon and progeny in the city of São Paulo-Brazil. *Radiation Measurements, **40:** 678 – 681.*
8. Kullab M (2005) Assessment of radon-222 concentrations in buildings, building material, water and soil in Jordan. *Applied Radiation and Isotopes, **62:** 765-773.*
9. Mui KW, Wong LT (2004) Evaluation on different sampling schemes for assessing indoor radon level in Hong Kong. *Atmospheric Environment, **38:** 6711–6723.*
10. Nsibande MC, Mahlobo M, Farid SM (1994) Radon levels inside residences in Swaziland. *Sci Total Environ, **151:** 181-5.*
11. Hadad K, Doulatdar R, Mehdizadeh S (2007) Indoor radon monitoring in Northern Iran using passive and active measurements. *J Environ Radioactivity, **95:** 39-52.*
12. Anastasiou T, Tsertosa H, Christofides S, Christodoulides G (2003) Indoor radon (^{222}Rn) concentration measurements in Cyprus using high-sensitivity portable detectors. *Journal of Environmental Radioactivity, **68:** 159–69.*
13. Statistical calendar of Yazd province (2003) The planning and managership organization of Yazd province reports (in Persian).
14. Bouzarjomehri F and Ehramposh MH (2005) Gamma background radiation in Yazd. *Iran J Radiat Res, **3:** 25-28.*
15. Cheng J, Guo Q, Ren T (2002) Radon levels in china. *J Nuclear Science Technology, **39:** 695-699.*
16. Qiuju G, Boa C, Quanfu S (2005) A pilot survey on indoor radon and thoron progeny in Yangjiang. *China International Congress Series, **276:** 313-314.*
17. Belin B, Yalcin T, Suner F, Bozkurtoglu E, Gelir A, Guven H (2002) Earthquake related chemical and radioactivity changes of thermal water in Kuzuluk-Adapazari. *Turkey Journal of Environmental Radioactivity, **63:** 239-249.*
18. Ghiassi-nejad M, Mortazavi J, Camron JR, Niroomand-rad A, Karam PA (2002) Very high background radiation areas of Ramsar. *Health Physics, **82:** 87-93.*