Turk J Phy
25 (2001) , 153 – 158.

Factors Affecting Radon Concentration in Houses

A. AL-SHARIF*
Department of Physics, University of Qatar,
Doha-QATAR
Y. S. ABDELRAHMAN*
Ministry of High Education, Education College,
Nazwa-Sultanate of Oman

Received 04.07.2000

Abstract

The dangers to the human health upon exposure to radon and its daughter products is the main motivation behind the vast number of studies performed to find the concentration of radon in our living environment, including our houses. The presence of radon and its daughter products in houses are due to various sources including building materials and the soil under the houses. Many factors affect radon concentration in our houses, the elevation above ground level, ventilation, building materials and room usage being among these factors. In our paper, we discuss the effect of elevation above ground level, room usage and ventilation on the Radon concentration in houses. The faculty residences of the Mu'tah University (Jordan) were chosen in our study. Our results showed that the concentration of radon decreases with elevation. Ventilation rate was also found to affect radon concentration, where low concentrations observed for areas with good ventilation.

1. Introduction

Radon is known to be a radioactive gas, which is created during the radioactive decay of U-238. Several studies indicated the dangers to human health upon exposure to radon and its daughters [1-5]. Inhalation of radon gas and its daughters will expose the lung tissue to short-lived alpha emitting radionuclides, which will increase the risk of lung cancer. Radon is also suspected to be a major factor increasing skin cancer, where alpha particles are suspected to induce damage to epithelial cells due to deposition of radon on the skin. Kidney related diseases have also been observed in some people exposed to radon and this is due to the fact that kidney receives the highest dose, among the body

*on sabbatical from Mu'tah University-Jordan organs, after radon being transferred from the lung to the kidney by blood.

The dangers that arise due to human exposure to radon was the motivation behind all the research carried out to study the concentration of radon in our living environment, including our houses. Presence of radon and its daughters in houses are due to different sources. Radon escaping from soil into houses is one of the major sources of contamination. Radon can flow from underground to the surface through cracks in walls, floors, joints or pipe holes and lines, and finally enters houses. Building materials are also considered as another major source of radon gas. Radon in water is yet another important source, where radon-rich water used inside the houses will increase human exposure to radon gas.

There are many factors affecting the concentration of radon and its daughters inside our houses. The purpose of this work is to investigate some of these factors. To minimize the effects of building design and building materials on our results, we conducted our surveying on the faculty residences of the Mu'tah University (east complex), where the design and building materials of all units are the same.

2. Experimental Procedure and Sampling Strategy

The measurement technique used in this work was the passive radon dosimeter [6-7]. This technique is usually used for long-term measurements inside houses, where solid-state nuclear track detectors (CR-39) were used. The detectors were fixed at the bottom of a plastic cup using double-sided tape (see Figure 1). On the cover of the cup there is a hole sealed by a 5-mm thickness sponge. This set-up allows radon to diffuse inside the cup. The track density of alpha particles in the detectors provides information about the relative concentration of radon in the apartments surveyed.

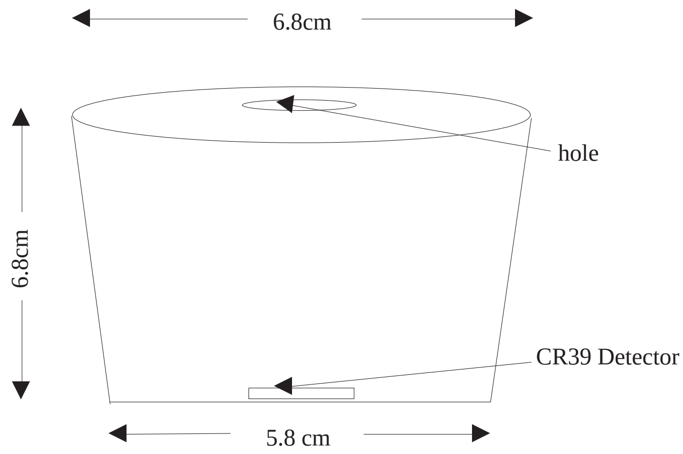

Figure 1. A cross section of the passive dosimeter used for measuring radon concentration.

The prepared cups were distributed to representative identical buildings of choice. Each building consists of three floors. Two apartments in each building were chosen (one in the ground floor and the other on the second floor). Ten apartments in five different buildings were selected for the present survey. The cups were distributed in the living rooms and kitchens of each apartment. Two cups were placed in the living rooms, one near the window and the other away from the window. The period of exposure were 83 days, from 28/4/97 to 20/7/97.

The sampling methodology described above enabled investigation of the effect of elevation above ground on radon concentration, investigation of whether the usage of the room has any effect on radon concentration, and investigation of whether or not radon concentration depends on the location inside the same room, near or away from window (ventilation source).

At the end of the exposed period, all detectors were collected and etched using 6.25 M NaOH at 70 C for 6 hours. Detectors were left overnight to dry in a clean room. An Autoscan 60 system was used to analyze the data in the detectors, in order to determine the track densities.

3. Experimental Results and Discussion

A summary of the results obtained from the above analyses are shown in Table 1 and Table 2. Table 1a and Table 1b show the net maximum, minimum and average track densities for the rooms studied on ground-floor and second-floor levels respectively. The block diagrams shown in Figures 2, 3 and 4, show a general trend toward higher densities for the rooms located at the ground level than the densities observed in the rooms located at the second floor. Since all the apartments were built using the same materials, it can be assumed that the contribution of building materials to the radon concentration is the same, and the difference in the observed densities is due to the radon gas coming from the soil below the buildings, as well as the surrounding atmosphere.

Table 1. (a) Results obtained for rooms in ground floor. (b) Results obtained for rooms in second floor

(a)

Room	Lowest density (tracks/cm^2)	Highest density (tracks/cm^2)	Mean density (tracks/cm^2)	Standard Deviation
Kitchen	2040	3060	2516	402
Living room	2980	4080	3520	461

(b)

Room	Lowest density (tracks/cm^2)	Highest density (tracks/cm^2)	Mean density (tracks/cm^2)	Standard Deviation
Kitchen	1720	2560	2040	362
Living room	2211	3220	2685	441

Table 2. (a) The results obtained for detectors placed near and away from the window of the living rooms of ground floor. (b) The results obtained for detectors placed near and away from the window of the living rooms of second floor.

(a)

Room	Lowest density (tracks/cm^2)	Highest density (tracks/cm^2)	Mean density (tracks/cm^2)	Standard Deviation
Near window	2980	4080	3520	461
Away from window	11870	15672	13620	1619

(b)

Room	Lowest density (tracks/cm^2)	Highest density (tracks/cm^2)	Mean density (tracks/cm^2)	Standard Deviation
Near window	2211	3220	2685	197
Away from window	7990	12850	10840	903

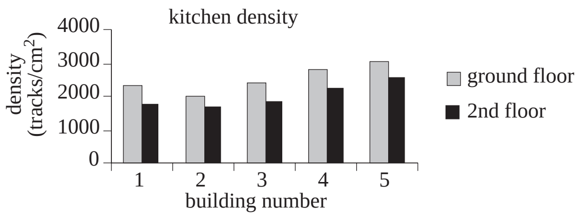

Figure 2. Track density in kitchens of ground and second floors.

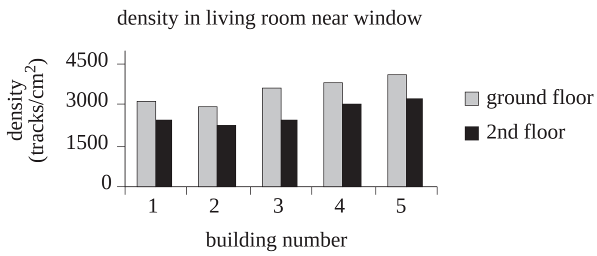

Figure 3. Track density in living rooms near window in ground and second Floors.

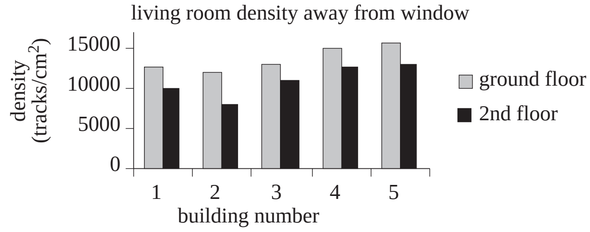

Figure 4. Track density in living rooms away from window in ground and Second floor.

The variation of concentration at different locations in the same room was also evaluated. With this intention, two sets of detectors were placed at two different positions in the living rooms of each apartment. Table 2 shows the densities obtained from these detectors. Figures 5 and 6, show the block diagrams for the obtained results. The results showed that the track densities observed in detectors placed near the windows were less than those observed for the detectors put away from the windows. The difference in density is probably due to the convection currents inside the rooms. In other words, the air exchange near the windows reduces the radon concentration near them.

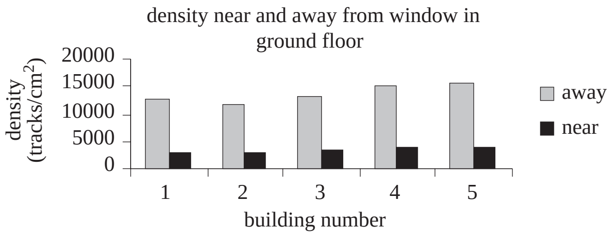

Figure 5. Track density in living rooms near and away from window in ground Floor.

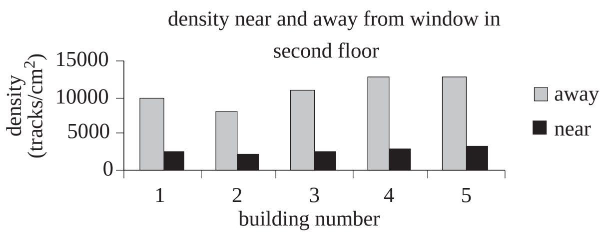

Figure 6. Track density in living rooms near and away from window in second Floor.

Regarding room usage, it was found out that radon concentration values for the kitchens were less than those for the living rooms. It is believed that this difference is due to the frequent ventilation of the kitchens, mostly to get rid of cooking vapor and fumes.

4. Conclusions

We have studied some factors affecting the radon concentration in houses. Our results showed that the concentration of radon gas is decreased with the elevation above the ground level. Similarly, ventilation rate showed an effect on the observed concentrations. In this regard, locations near the windows showed smaller values than those far away from the windows. Room usage also affected radon concentration in connection with ventilation. In this context, rooms having continuous ventilation exhibited smaller concentration.

References

[1] C. Bowie and S. H. Bowie; *Radon and health. Lancet* **337**, 409 (1991)

[2] J. Fabrikant; Radon and lung cancer. *Health Phys.***59**, 89 (1990).

[3] S. P. Wolf; *Leukaemia risk and radon. Nature* **352**, 288 (1991).

[4] B. K. Butland, C.R. Muirhead and G.J. Draper; *Radon and Leukaemia. Lancet* **335**, 1138 (1990).

[5] D. L. Henshaw, J.P. Eatough and R.B. Richardson; Radon as a causative factor in induction of myeloid leukaemia and other cancers. Lancet **335**, 1008 (1990).

[6] D. A-Garakani; Performance characteristics of different passive detectors in radon chamber. *Indoor environment*, **1(6)** 358 (1992).

[7] F. Abu Jarad and M. Al-Jarrakllah; *Rad. Prot. Dos.* **14**, 243 (1986)