Journal of Umm Al-Qura University for Applied Science 6 (2020) 48-50

Journal of Umm Al-Qura University for Applied Science

journal homepage: https://uqu.edu.sa/en/jas/87823

Indoor Radon Concentration in Some Villages of Al-Lieth Province in Saudi Arabia

Amal Mohamed [a,b], H. T. Mahdy [c,*].

[a] *Physics Department. Faculty of Science, Umm Al-Qura University, Makkah, Saudi Arabia.*
[b] *Physics Deprt. Faculty of Science, Zagazig University, Zagazig, Egypt.*
[c] *Physics Department, College of Applied Sciences, Umm Al-Qura University, Makkah, Saudi Arabia*

ARTICLE INFO

Article History:
Submission date: 24/12/2019
Accepted date: 22/6/2020

Keywords:
Radon, solid state nuclear track detector, effective dose, sealed can technique

ABSTRACT

Building composites are a main source of radioactive radon gas. Determination of such a gas and its descendants are usually performed by passive detection technique using 105 radon detectors C-39. One hundred and five sealed were used in houses of villages in Al- Lieth Province. The radon concentration was determined using the "sealed can technique" and CR-39 solid state nuclear track detectors (SSNTDs) which were installed in different locations in every building (Kitchens, bed rooms and bathrooms). The results of the measured radon concentrations in the selected houses were analyzed and found to be in the range of 7.39 Bq/m^3 to 9.11 Bq/m^{3}in studied buildings. From the measured radon concentrations, the effective dose rate was calculated and found to be in the range from 0.17 mSv/y, to 0.21 mSv/y. The results were discussed in the light of the geographic peculiarity of the studied area.

1. Introduction

Radioactive Radon gas is created during the decay of U-238. There are many natural and industrial sources of radiation to which humans are exposed to, such as cosmic rays, terrestrial radionuclides, radon and its daughters. The highest rate of 60% comes from natural sources of radiation. Natural radiation that penetrates us from the Earth's crust varies from place to place on the Earth's surface, depending on geology, and topography [1].

Being odorless and tasteless besides being invisible, Radon is a radioactive gas formed by the disintegration of radium, in a decay chain of uranium. It emits α particles and produces many solid radioactive products called radon daughters or "progeny. Inhalation of radon gas or its progeny exposes the lung tissue to short-lived alpha emitting radionuclides that increases the risk of lung cancer. It is also suspected that Radon is a major factor of increasing skin cancer, where alpha particles induce some damages to epithelial cells due to deposition of such gas on the skin. Kidney related diseases have also been observed. This is because it receives the highest dose, amongst the body organs, after radon being transferred from the lungs to it by blood. Radon and its descendants may constitute a significant health hazard, especially if present with relatively high concentrations in poorly ventilated areas such as underground mines or caves; or badly designed houses. Radon concentration in such enclosed areas is important due to its side effects on health [2]. In closed rooms for a long duration and in air - conditioned rooms, the radiation levels may be raised due to the accumulation of radon gas [3].

Radiation exposure due to natural radionuclide's as well as high radon concentrations has been recognized in early seventies of the 20th century in building's closed spaces [4]. Due to the above consideration, measurement of radon concentration and calculating the effective dose in commonly used building construction materials in the selected area was the aim of this study.

2. Methodology

2.1. Peculiarity of Studied area

Al-Lieth region is one of the governorates of Makkah Province, located at the confluence of the Hijaz mountains on the Tihama plains on the western coast of Saudi Arabia 180 km south of Mecca and Jeddah province, see map in Fig (1). It is adjacent to the Red Sea coast. Al-Lieth is a rocky area and its geology can be divided into two main types of rocks. The first type is basically composed of a set of basements which are huge massive bodies of granitic schist complex. The second type is a series of quaternary deposits, that are located mainly close to the shoreline along a northwest-southeast direction. Wadi fills are filling the main valley of Al-Lieth area, uncomfortably overlying the underlying crystalline rocks [5].

2.2. Materials and Methods

In order to conduct the current radon measurement survey, 105 radon CR-39 detectors were installed in the study area. These detectors were distributed and installed at a carefully selected site within Al-Lieth area. Three reagents are installed in each location and distributed in the living room, the kitchen and the bathroom. The detector was put in the houses in some villages of the province Lieth in Saudi Arabia, such as (Rubue Aleayn – Bani Yazid – Tafil – Aduma- Alshiwaq). In each village, a detector was put in different houses in the bedroom, the kitchen and the bathroom. In each Village, 7 houses were considered in this study. Radon gas and its descendants were detected by solid state nuclear track passive technique using the "sealed can technique" [6,7]. A total of 105 sealed were collected from different places. Inside each container, a cylindrical plastic container having CR-39 track is placed in a diffusion chamber, see Fig (2); and is then sealed for a period of four months; during which, α particles emitted by radon and their descendants' bombard the plastic can. After such period, detectors are then developed in Sodium Hydroxide solution at 70°C for 6 hours. After chemical etching, α particle track densities are then determined by an optical microscope as high as 400X. The radon concentration C_{Rn} (measured in Bq/m^3) could be determined by the equation (1) [8].

$$= \rho x / F t \qquad (1)$$

Where ρx is track density (in tracks/mm^2), t is the exposure time in days and F is a calibration factor (0.42 ± 0.02 tracks.m^3.cm^{-2}.Bq^{-1}.h^{-1}). The Radon concentrations (Bq/m^3) and track density for standard samples are represent in Fig (3). The measured results are fitted well to a linear function, with regression factor R^2 = 0.9998.

From the measured data, the annual effective dose E (mSvy^{-1}) indoor closed room was determined by the following relation [9].

$$= C \times F \times H \times T \times D \qquad (2)$$

Where, C is the radon concentration (Bq/m^3), F *is* the equilibrium factor (0.4), H is the occupancy factor (0.8), T is hours in a year (7000 hy^{-1}) and D *is* the dose conversion factor: 9×10^{-6} m Sv (Bq/m^3 h^{-1}).

* **Corresponding Author**
Physics Department, College of Applied Sciences, Umm Al-Qura University, Makkah, Saudi Arabia.
E-mail address: **eemohammad@uqu.edu.sa** (H. T. Mahdy).

Figure 1 Al – Lieth Governorate

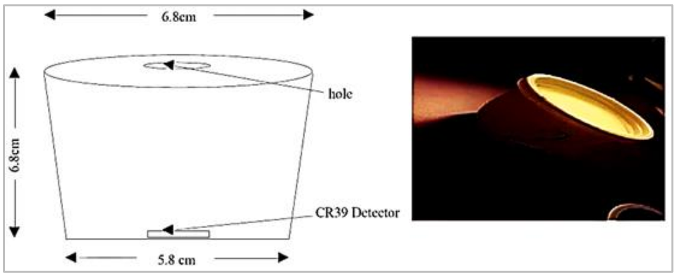

Figure 2 Sealed Can Technique.

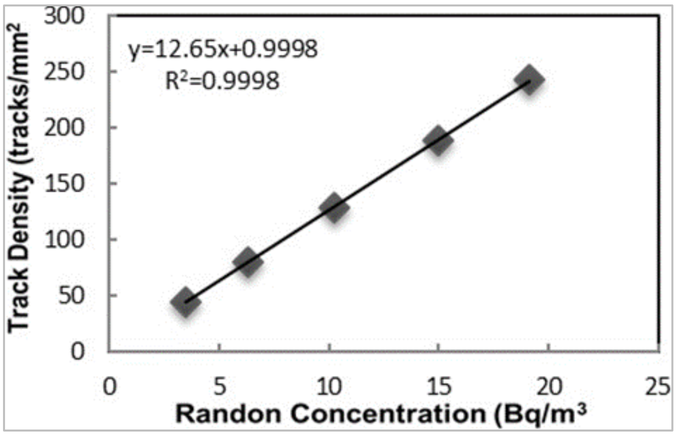

Figure 3 Radon concentration (Bq/m^3) and track density for standard samples

3. Results and discussion

Concentrations of such radon nuclides in houses reported in many publications whose indoor intensity varies according to the houses geometry, villages, and the geography of study area. The radon concentration and the annual effective dose rate were calculated according to Equations 1 and 2 respectively. The results, also, are tabulated in Table 1. It can be seen that the radon concentration varies from 7.39 Bqm-3 to 9.11 Bqm-3 with a mean value of 8.3 Bqm-.3 in the study area of Saudi Arabia. From the measured data given in table 1 the radon one can notice that alpha-activities per unit volume of the buildings were different from one place to another (Kitchens, bed rooms and bathroom) and from one building to another. The effective dose rate was found to vary from 0.17 mSv/y to 0.21 mSv/y respectively. Concentrations of such samples were found to be under the global acceptability limit which has been observed all over the world [10-15].

Table 1, lists the minimum, maximum, and average radon concentration in different types of house rooms in Al-Lieth Governorate. From the measured data, it can be seen radon concentration have their highest mean values in the kitchens compared with the other rooms. These results are consistent with early results of [16,17]. The difference in densities is because of convection current and circulation of the air inside the rooms. In other words, radon concentration could be reduced by the air exchange near windows and in kitchens. From the above remakes, one can conclude that the concentrations of the remaining samples were found to be below the global permissibility limit which is well observed all over the world. Moreover, the high concentrations of Radon in kitchens are due to the bad ventilation present in such a place, more than in bedrooms and bathrooms, which results in more accumulation of Radon. This can be attributed to the peculiarity of kitchen design in the studied area houses, where the buildings are ground floor only, and the kitchens have narrow windows and are ventilated naturally only. This means that the room usage is the main key affecting radon concentration in connection with ventilation. Therefore, rooms having continuous ventilation exhibit smaller concentration.

Table 1: The radon concentration measured the studied places in Al-Lieth Province.

Types of rooms	No. of Samples	Rn. Concentration (Bq/m^3)		Average (Bq/m^3)	Effective dose (mSv/y)
		Minim.	Maximum		
Kitchens	35	3.56	19.26	9.11	0.21
Bed rooms	35	3.56	16.18	8.4	0.19
bathroom	35	3.38	12.02	7.39	0.17
Average				8.3	0.19

4. Conclusion

The highest average radon concentration in houses and buildings have been observed mostly in kitchens and guest rooms while measured with minimum concentrations in bed rooms and living rooms. This can be due to the use of narrow windows in kitchens that lead to natural ventilation. Obtained results range from 12.02 Bq/m^3 to 19.26 Bq/m^3 with a value of 8.3 Bq/m^3 as an average, which is the less than the UNSCEAR limits. Annual effective dose from indoor air is 0.19 mSv/y in average. So although the geology of the province of Al-Lieth is a rocky region consisting of granite and sedimentary rocks, the radon concentration is permissibly distributed as follows. The high concentrations of Radon in kitchens are due to the bad ventilation present in such a place, more than in bedrooms and bathrooms, which results in more accumulation of Radon. This can be attributed to the peculiarity of kitchen design in the studied area houses, where the buildings are ground floor only, the kitchens have narrow windows, and are ventilated naturally only. This means that the room usage is related to radon concentrations, which reduces with ventilation. Rooms with good ventilation show lower concentration.

References

[1] UNSCEAR ; United Nations Scientific Committee on the Effect of Atomic Radiation. Sources and Effects of Ionizing Radiation. Report to the General Assembly, **2000**.

[2] A.K. Singh, K. Ashavani, P. Rajendra, Distribution of Radon Levels in Udaipur. *Asian J. Chem.*, **2006**, *18*, 3408-3411.

[3] UNSCEAR; Report, United Nations Scientific Committee on Effects of Atomic Radiation, UN, New York. **2017**, 12,No. E 11.

[4] D. Popovic, D. Todorovic, Radon Indoor Concentrations and Activity of Radionuclide's in Building Materials in Serbia. *Physics, Chemistry and Technology*, **2006**, *4*, 11- 20.

[5] A. A. Arafat, M. S. El-Tahwaya, H. Samrab. Comparison of Radon Concentrations In Three Types of Egyptian Houses. *J. Nucl. Radiat. Phys.*, **2018**, *13*, 147-156.

[6] A. J. Khan, R. Prasad, R. K. Tyagi, Measurement of Radon Exhalation Rate From Some Building Materials. *Nucl. Tracks Radiat. Meas*, **1992**, *20*, 609-610.

[7] J. Chen, N. M. Rahman, I. A. Itiya, Radon Exhalation from Building Materials for Decorative Use. *J. of Environ. Radioactivity*, **2010**, *101*, 317-322. https://doi.org/10.1016/j.jenvrad.2010.01.005

[8] A. Mohamed, T. H. Alsheddi, S. Almansour. Study of Radium and Radon Exhalation Rate in Some Sand Samples Using Solid State. N*uclear Track Detectors*, **2015**, *48*, 100-104.

[9] UNSCEAR Report, Exposure from Natural Sources. United Nations, New York. **2010**, 12,No. B 12.

[10] M. Al-Jarallah. Radon Exhalation from Granites used in Saudi Arabia. *J. Envir. Radioact*, **2001**, *53*, 91-98. https://doi.org/10.1016/S0265-931X(00)00110-7

[11] M. A. Misdaq, A. Amghar. Radon and Thoron Emanation from Various Marble Materials: Impact on the Workers. *Radiation Measurements*, **2005**, *39*, 421-430. https://doi.org/10.1016/j.radmeas.2004.06.011

[12] A.O. Ferreira, B. R. Pecequilo, R. R. Aquino, Application of Sealed Can Technique and CR-39 Detector For Measuring Radon Emanation From undamaged Granitic Ornamental building materials. *Radioprotection*, **2011**, *46*, 49-54. DOI: 10.1051/radiopro/20116557s

[13] M. A. Misdaq, H. Moustaaidine. A New Method for Determining Radon Emanation Coefficients and Radon Production Rates in Different Building Materials Using Solid State Nuclear Track Detectors. *J. Radioanal. Nucl. Chem.*, **1997**, *218*, 9- 12. https://doi.org/10.1007/BF02033966

[14] M. A. Kobeissi, O. EL Salmad, K. Zahraman, S. Milky., F. A. Bahson, K. M. Abumurad, Natural Radioactivity Measurements in Building Material in Southern Lebanon. *J. Environ. Radioactivity*, **2000**, *99*, 1279-1288. https://doi.org/10.1016/j.jenvrad.2008.03.007

[15] B. M. Moharram, M. N. Suliman, N. F. Zahran, S. E. Shennawy, A. R. El Sayed. 238U, 232Th Content and Radon Exhalation Rate in Some Egyptian Building Materials. *Ann. Nucl. Energy*, **2012**, *45*, 138-143. https://doi.org/10.1016/j.anucene.2012.03.008

[16] M. A. Rafat, Evaluation of radon gas concentration in the drinking water and dwellings of south-west Libya, using CR-39 detector. *Intr. J. Environ. Sci.*, **2013**, *4*, 484-490.

[17] A. Lashin et. al. Geophysical Exploration of the Western Saudi Arabian Geothermal Province: First Results from the Al-Lieth Area. Proceedings World Geothermal Congress, **2015**.