ISSN: 1813 – 1662 (Print)
E-ISSN: 2415 – 1726 (On Line)

Indoor radon levels in apartments of Erbil city by using long and short term techniques

Zakariya A. Hussein[1], Asaad H. Ismail[2], Ammar A. Battawy[3], Hawbash Hamadamin Karim[1], Jahfer Majeed Ismail[1]

[1]*Department of Physics , Faculty of Sciences and Health , Koya University, Erbil, Iraq*
[2]*Department of Physics , Education College, University of Salahaddin , Erbil , Iraq*
[3]*Department of Physics , College of Education for pure Science, University of Tikrit, Iraq*

Abstract

Inhalation of radon (^{222}Rn) and daughter products are a major source of natural radiation exposure. Measurement of indoor radon concentrations were performed in the two hundred rooms for the 25 apartments in Erbil city by using long term technique (CR-39 SSNTDs) for 90 days exposure time and short term technique (radon monitor) for 2 hours exposure time. The higher value of average indoor radon concentration for long and short term techniques was found in Office rooms 56.72±14.72 Bq/m^3 and 48.64±12.52 Bq/m^3, respectively and lower value was found in Drawing rooms 42.11±10.82 Bq/m^3 and 34.45±8.66 Bq/m^3, respectively. The mean annual estimated effective dose was received by the residents of the studied area was 1.14 mSv. The highest indoor radon concentrations was found in ground floor for all apartment comport with the first, second and third floors. The rate indoor radon concentration in different type rooms depended of the ventilation rate and the age of the building.

Key words: CR-39 detectors, Indoor radon. Radon monitor, nuclear track detectors

1. Introduction

Radon (^{222}Rn) is a naturally occurring radioactive gas generated by the decay of the naturally occurring ^{238}U series [1,2]. Radon is one of the most important natural contributors to the radiation dose received by humans [3,4]. ^{222}Rn is emanated from soil and rock, which is the main source of it to the atmosphere. Atmospheric ^{222}Rn concentration depends on the emanation power on the ground and advection/ diffusion in the air [1,5]. Radon decays with a half-life of 3.82 days into a series of short-lived daughter products out of which ^{218}Po and ^{214}Po emit high-energy alpha particles which are highly effective in damaging tissues. Measurement of the indoor radon is highly desirable because the radiation dose received by the human population due to the inhalation of radon and its progeny contribute more than 50% of the total dose from natural sources [6,7]. Recent experimental and epidemiological studies suggest that inhalation of radon progeny, which are the most important source of irradiation of the human respiratory track in the workplace and domestic environment could be a cause of lung cancer [8,9]. Indoor radon measurements are generally associated with dwellings. However, a typical person spends more than eight hours a day in their workplace, so that it is recognized as essential to monitor workers' exposure to radon to control their health risks [6].

In this study the indoor radon concentrations in two hundred rooms for different locations in Erbil city, using long and short term techniques and over a period 90 days. These concentrations were then used to calculate the dose from radon and its progenies.

2. Materials and methods

2.1 Long term technique

The long term technique (can technique) using the CR-39 SSNTDs has been utilised for the comparative study of the indoor radon (^{222} Rn) level in the apartment of Erbil city. Radon activity concentrations were measured mainly using the long term closed-and-open can techniques (cylindrical can made of high grade plastic having diameter of 6cm and height of 7cm). Each can was equipped with a polymeric solid state nuclear track detector CR-39 SSNTDs each with size (1.5 × 1.5 × 0.05) cm^3 fixed at its bottom [10].

2.2 Short term technique

The short term technique using continuous radon monitor (CRM) is a technologically advanced real time, portable, radon monitor, designed for multiple applications in radon studies is a patented detection device to measure the concentration of radon gas. The wide measurement range of 5 Bqm^{-3} to 50 MBqm^{-3}. Average radon concentration was measured in four hundred rooms for the four levels ground, first, second and third levels. The counting time was 2 hours for each room [11].

2.3 Building characteristics

The dwellings in the studied areas are concrete apartments, which are different ventilated. These apartments were built from the same materials that are using cement, sand, bricks, limestone, iron, marble, and concrete. The walls of the dwelling were covered with gypsum and the floor material was covered with ceramic tile. These building materials contribute to the increase indoor radon concentration.

2.4 Distribution of radon dosimeters

A total of 800 radon dosimeters distribution in the two hundred rooms for the 25 apartments. All the dosimeters were suspended in the office rooms, laboratory, kitchens, store rooms and drawing rooms of the dwellings of interest at a height of more than 2 m above the level of the floor. The detectors were exposed for 90 days. After the exposure time, the detectors from all cans were retrieved. For the revelation of tracks, the detectors were chemically etched in 6N NaOH at temperature 70 ± 1 °C for ten hours. The etched tracks were counted using an optical microscope at × 400 magnification [12].

3. The Measurements

3.1 Indoor Radon Concentration ($Bq.m^{-3}$)

The average radon concentration (C_{Rn}) in air measured by CR-39 NTDs was calculated using the following formula [13].

$$C_{Rn} = \frac{\rho}{k \times t}$$

Where ρ is the track density (track/cm^2), k is the calibration factor = 0.23 track/cm^2.d per Bq/m^3, and t is the exposure time in air (90 days).

3.2 Annual Effective Dose

The annual effective dose (H in units mSv/y) of radon and its progeny, can be calculate from the following relation [6].

$H = C_{Rn} \times F \times O \times T \times D$

Where C_{Rn} the average radon concentration (Bq/m^3), F is an equilibrium factor, O for occupancy factor (0.8 as taken in UNSCEAR 2000 report), T for time (1800 h.y^{-1}) and D for dose conversion factor (9×10^{-6} mSv.h^{-1}(Bq.m^{-3})$^{-1}$).

3.3 Potential Alpha Energy Concentration (PAEC)

The measurements of potential alpha energy concentration (PAEC) are necessary to estimate effective dose from ^{222}Rn progeny and its concentration in the present locations. PAEC be measure in terms of working level (WL) unit. The potential alpha energy concentration (PAEC) was calculated as equation [14].

$$WL = \frac{F\, C_{Rn}}{3700}$$

4. Results and Discussion

The average indoor radon (^{222}Rn) concentration levels have been measured in 25 apartments for different locations in Erbil city. The results obtained are summarised in Table 1. The higher value of average indoor radon concentration for long and short term techniques was found in Office rooms 56.72±14.72 Bq/m^3 and 48.64±12.52 Bq/m^3, respectively and lower value was found in Drawing rooms 42.11±10.82 Bq/m^3 and 34.45±8.66 Bq/m^3, respectively, as shown in Figure 1. This may be due to the difference in the ventilation rate and building material of the study area. The rates of indoor radon gas in studied areas are less than the accepted level approved by IAEA 148 Bq/m^3 [15]. The average effective dose, potential alpha energy concentration (PAEC) and type of ventilation rate summarised in Table 2.

The results show that the indoor radon concentration for the ground level is much higher than the first, second and third levels, as shown in Figure 2. This is due to the low ventilation rate of ground floor, and its close proximity to the soil. Thus, emanation rate of radon gas from the soil (ground) also contributes to increased rate of indoor radon gas [16]. Average annual dose equivalent to the bronchial epithelium varies from 0.98 to 1.86 mSv.

The indoor radon concentrations dependence on the year of apartment construction interest in many investigations [17,18,19]. The radon concentration increase considerably only for the buildings older than 60 years, as shown in Figure 3.

Table 1: Average Indoor Radon Concentrations in different type rooms for both techniques

Type rooms	No. of Rooms	Average Indoor Radon Concentrations Bq/m^3	
		CR-39	Radon Monitor
Office rooms	46	56.72±14.72	48.64±12.52
Laboratory	44	80.42±16.86	72.92±14.77
Kitchens	43	78.92±12.85	68.22±11.56
Store rooms	42	98.84±16.45	92.84±12.85
Drawing rooms	25	42.11±10.82	34.45±8.66

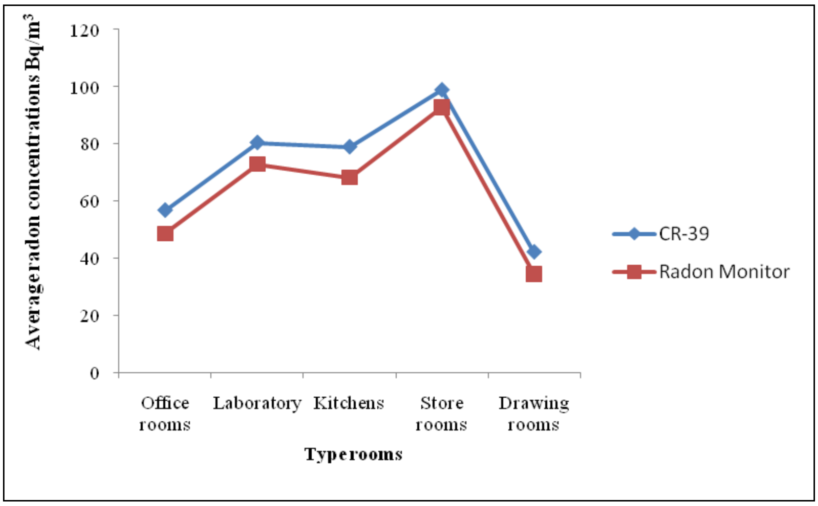

Figure 1: Average radon concentration in different type rooms for both techniques

Table 2: Type of ventilation rate [a], average effective dose and potential alpha energy concentration (PAEC) in different type rooms

Type Rooms	Type of Ventilation Rate	Average Effective Dose mSv/y	PAEC (mWL)
Office rooms	Partial	1.02±0.01	6.31±1.34
Laboratory	Poor	1.56±0.09	8.69±1.22
Kitchens	Poor	1.62±0.07	8.53±1.86
Store rooms	Poor	1.86±0.08	10.68±2.08
Drawing rooms	Good	0.98±0.02	4.55±1.04

a- Poor ventilation: doors and windows are open <8 h; Partial ventilation: doors and windows are open >8 h; but<16 h; Good ventilation: doors and windows are open>16 h

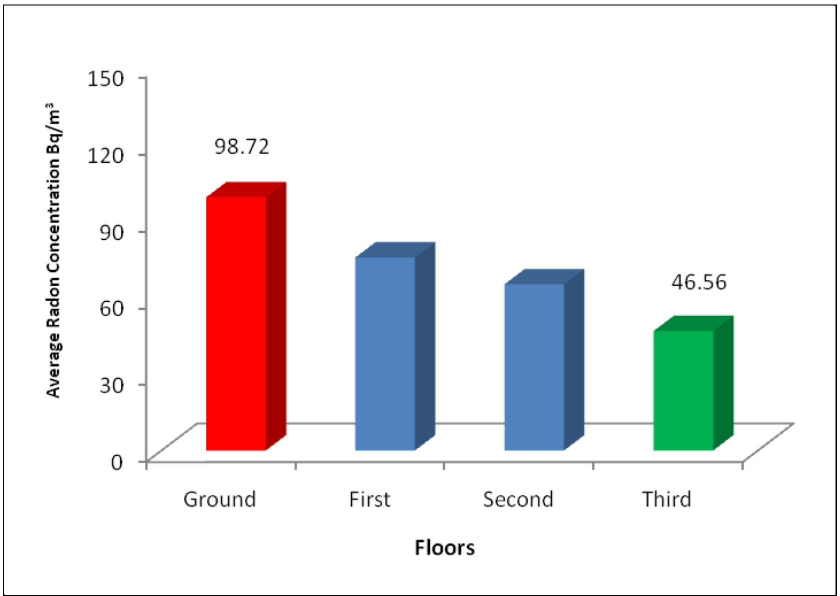

Figure 2: Average radon concentrations for different floor

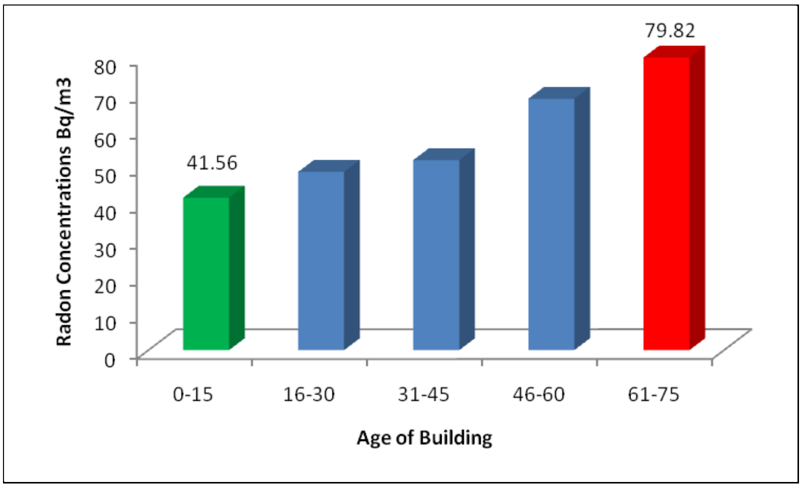

Figure 3: Relation between radon concentration and age of building [17, 18, and 19]

5. Conclusions

The radon concentrations were measured in the two hundred rooms for the 25 apartments in Erbil city using long and short term techniques. For both techniques, the low value was found in Drawing rooms and highest was found in store rooms. Therefore, the results showed that the average radon concentration decreases gradually as the floor level increases. The low and high value of indoor radon concentration dependence on the age of building and ventilation rate.

References

[1] Espinosa, G., Golzarri, J. and Chavarria, A. (2013). A study of indoor radon in greenhouses in Mexico City, Mexico. Journal of Radioanalytical and Nuclear Chemistry. Volume 296, Pages 37-41.

[2] Al-Khateeb, H. M., Al-Qudah, A. A., Alzoubi, F. Y., Alqadi, M. K. and Aljarrah, K. M. (2012). Radon concentration and radon effective dose rate in dwellings of some villages. Applied Radiation and Isotopes 70 , 1579-1582.

[3] ICRP (International Commission on Radiological Protection). (2000), Lung cancer risk from indoor exposure to radon daughters, Publication 66.

[4] Friend and Gooding, 2002 Variations in the concentration of radon in parts of the Ogof Ffynnon Ddu system, Penwyllt, South Wales and estimates of doses to recreational cavers. J. Environ Radioact, 58 (2002), pp. 45–58.

[5] International Commission on Radiological Protection ICRP, (1984). Non-stochastic Effects of Irradiation. ICRP Publication 41. Ann. ICRP. 14.

[6] UNSCEAR. (2000). Sources and effects of ionizing radiation. ANNEX A. Dose assessment methodologies. Report I p.18-82.

[7] EPA (Environmental Protection Agency). (2010). Consumer's guide to radon reduction; How to fix your home. EPA. 402/K-10/005.

[8] Kavasi, N., Somlai, J., Vigh, T., Tokonami, S., Ishikawa, T., Sorimachi, A. and Kova, C. S. (2009). Difficulties in the dose estimate of workers originated from radon and radon progeny in manganese mine. Radiation Measurements, 44, 300-305.

[9] Khan, M. S., Naqvi, A. H., Azam, A. and Srivastava, D. S. (2011). Radium and radon exhalation studies of soil, Iran. J. Radiat. Res., 8, (4), 207-210.

[10] Ismail A H and Jaafar M S.(2010). Relationship between radon concentration, ventilation rate and male infertility: A Case study in Iraqi Kurdistan. International Journal of Low Radiation 7(3) p.175-187.

[11] Shapiro, J. 2002. Radiation Protection, A Guide for Scientists, Regulators and Physician. 4thEdition. Harvard University Press: Cambridge, p219 and 444.

[12] Mansour H. H., Khdar S. per, Abdulla H. Y., Muhamad N. Q., Othman M. M. and Qader S., (2005), Measurement of indoor radon levels in Erbil capital by using solid state nuclear track detector, *Radiation Measurement*, 40, 544-547.

[13] Amin, R. M., Mansy, M., Eissa, M. F., Eissa, H. M. and Shahin, F. M. (2008). Assessment of natural radioactivity and radon exhalation rate in Sannur cave, eastern desert of Egypt. J. Radiol. Prot. 28, 213–222.

[14] Khan, A. J. (2000). A study of indoor radon levels in Indian dwellings, influencing factors and lung cancer risks. Radiation Measurements, 32, 87–92.

[15] IAEA (International Atomic Energy Agency). (1997). Sources and Measurements of Radon and Radon Progeny Applied to Climate and Air Quality Studies: A survey, TECDOC-934.

[16] Rahmana, S.U., Matiullah, B.F., Nasir, T. and Anwar, J. (2011). Monitoring of indoor radon levels around an oil refinery using CR-39 based radon detectors. Islamabad, Pakistan. Original Paper. Indoor and Built Environment, 1-6.

[17] Obed, R.I., Ademola, A.K. and Ogundare, F.O. (2011). Radon measurements by nuclear track detectors in dwelling Oke-Ogun area, South-Western, Nigeria. Radiation Protection Dosimetry, 1–7.

[18] Nsiah - Akoto, I., Fletcher, J.J., Oppon, O.C., Andam, A.B. (2011). Indoor radon levels and the associated effective dose rate determination at Dome in the Great.

[19] Yong-Jin, J., Young, H. R., Kyung, R. D., Jae, H. C., Hae, K. L. and Woon, K. C. (2012). Study on measurement and quantitative analysis of Radon-222 emitted from construction materials. Annals of Nuclear Energy, 49(4), 88-95.

مستويات غاز الرادون في عمارات مدينة اربيل باستخدام التقنيتين الطويلة والقصيرة الأمد

زكريا عادل حسين[1] ، اسعد حميد اسماعيل[2] ، عمار عبد عبدالله البطاوي[3] ، هاويش حمد امين كريم[1] ، جعفر مجيد اسماعيل[1]

[1]قسم الفيزياء ، كلية العلوم والصحة ، جامعة كويه ، اربيل ، العراق

[2]قسم الفيزياء ، كلية التربية ، جامعة صلاح الدين ، اربيل ، العراق

[3]قسم الفيزياء ، كلية التربية للعلوم الصرفة ، جامعة تكريت ، تكريت ، العراق

الملخص

تم حساب وقياس تركيز غاز الرادون في مائتي غرفة لخمسة وعشرين عمارة في محافظة اربيل باستعمال طريقتين الاولى تقنية كاشف الاثر النووي في الحالة الصلبة لمدة تسعين يوماً والثانية عداد الرادون لمدة ساعتين. وتم القياس ادنى مستوى لمعدل تركيز غاز الرادون في غرفة المرسم $42.11\pm10.82\ Bq/m^3$ و $34.45\pm8.66\ Bq/m^3$ على الترتيب. وتم القياس اعلى مستوى لمعدل تركيز غاز الرادون في غرفة المخزن $56.72\pm14.72\ Bq/m^3$ و $48.64\pm12.52\ Bq/m^3$ على الترتيب. معدل الجرعة السنوي للمناطق المختارة هو 1.14 mSv. وكان اعلى مستوى لمعدل تركيزغاز الرادون هو في الطابق الارضي مقارنة مع الطوابق الاول الثاني الثالث. و تعتمد نسبة التغير في التركيز غاز الرادون في كل الغرف على نسبة التهوية لهذا الغرف وعلى عمر انشاء البناية.