Indoor risk assessment of radon gas in the science college buildings-University of Mustansiriyah using RAD-7 detector

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Abstract

In the present work, a set of indoor Radon concentration measurements was carried out in a number of rooms and buildings of Science College in the University of Mustansiriyah for the first time in Iraq using RAD-7 detector which is an active method for short time measuring compared with the passive method in solid state nuclear track detectors (SSNTD's). The results show that, the Radon concentrations values vary from 9.85±1.7 $Bq.m^{-3}$ to 94.21±34.7 $Bq.m^{-3}$ with an average value 53.64±26 $Bq.m^{-3}$ which is lower than the recommended action level 200-300 Bq/m^3 [ICRP, 2009].

The values of the annual effective dose (A.E.D) vary from 0.25 mSv/y to 2.38 mSv/y, with an average value 1.46±0.67 mSv/y which is lower than the recommended the range 3-10 mSv/y [ICRP, 1993]. While the values of lung cancer cases per year per million person vary from 4.50 per million person to 42.84 per million person with an average value 24.35±12 per million person which is lower than the recommended range 170-230 per million person [ICRP, 1993].

The values of the potential alpha energy concentration were found to vary from 10.18 mWL to 1.06 mWL, with an average value 5.79±2.8 mWL which is lower than the recommended value of 53.33 mWL given by [UNSCEAR, 1993].

Key words

Radon concentration, RAD-7 Detector, annual effective dose, cancer.

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تقييم المخاطر الداخلية لغاز الرادون في أبنية كلية العلوم - الجامعة المستنصرية باستخدام كاشف RAD-7

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الخلاصة

تم في هذا العمل قياس تراكيز غاز الرادون داخل عدد من بنايات وغرف كلية العلوم في الجامعة المستنصرية ولاول مرة في العراق باستخدام كاشف RAD-7 والذي يعتبر من الكواشف الفعالة لزمن قياس قصير مقارنة بالكواشف الاخرى ككواشف الاثر النووي للحالة الصلبة، وقد تراوحت تراكيز غاز الرادون بين (9.85±1.7 $Bq.m^{-3}$) الى (94.21±34.7 $Bq.m^{-3}$) وبمعدل (53.64±26 $Bq.m^{-3}$) حيث كانت اقل من المستوى الموصى به من قبل الوكالة الدولية للطاقة الذرية [ICRP,2009] والذي هو (200-300 $Bq.m^{-3}$).

في حين تراوحت القيمة الفعالة للجرع السنوية بين (0.25 mSv/y) و (2.38 mSv/y) وبمعدل (1.46±0.67 mSv /y) وهو أيضا اقل من المستوى الموصى به من قبل الوكالة الدولية للطاقة الذرية [ICRP,1993] و الذي هو (3-10 mSv/y). في حين تراوحت القيم النظرية لحالات الإصابة بسرطان الرئة في السنة لكل مليون شخص بين (4.50 الى 42.84 إصابة لكل مليون نسمة) وبمعدل 12±24.35 اصابة لكل مليون نسمة وهو اقل بكثيرمن المستوى الموصى به من قبل الوكالة الدولية [ICRP,1993] والذي هو 170-230اصابة لكل مليون نسمة.

اما عن قيم تراكيز طاقة ألفا فقد تراوحت بين (1.06 mWL) و (10.18mWL) وبمعدل 2.8±5.79 (mWL) وهي اقل من القيمة الموصي بها من قبل [UNSCEAR ,1993] والذي هو (53.33 mWL).

Introduction

Although there are several different isotopes of Radon, the one that is of greatest concern as a potential human health threat is Radon (Rn-222), where Rn-222 gas is formed naturally during a chain of radioactive disintegration reactions. The decay series begins when uranium-238 decays; uranium is widely distributed in rocks and soils throughout the earth's crust with half-life of 4.5 billion years, which means a very slow breakdown [1].

Workplaces may differ from homes in terms of building structure, microclimatic conditions and occupancy factors. Some of the peculiarities of workplaces are: (a) multistoried buildings with large entrance hall; (b) presence of air conditioning or forced ventilation; (c) widespread use of ground floor or basements; (d) high probability of finding elevated temperatures and high levels of humidity, dust and aerosols. Such workplace characteristics might result in large spatial and time variations of Radon, thus requiring an appropriate monitoring strategy [2].

Some amounts of Radon can enter the buildings from the construction materials itself and some can also be carried in by the water supply. It does not find easy to escape back to the outside because of restricted ventilation. Restriction of ventilation is exacerbated in the modern homes and buildings. As far as human dwellings are concerned the possible enhanced risk could be expected only in a rather small faction of homes depending essentially on the building materials ventilation features and soil characteristics. These factors are directly responsible for enhanced input and subsequent stagnation of Rn-222 in indoor air [3].

The aim of the present work is to measure the concentration of Radon and Thoron gas in science college buildings-University of Mustansiriyah using RAD-7 detector and determine the risk of these gases.

Experimental details

A- Locations of the study area

Some locations in the following science college Buildings; (Deanery, physics, chemistry, mathematic and biology) had been chosen in our study because these buildings are distinguished by low ventilation and tight place comparing with the large number of students, teaching staff and officers.

B- RAD-7 detector

RAD-7 is a highly versatile instrument that can form the basis of a comprehensive Radon measurement system. It may be used in many different modes for different purposes continuous monitoring of Radon in air, sniffing for Radon and/or Thoron, testing air grab samples, measuring Radon in water, testing soil gas, and measuring Radon and Thoron emission from objects and surfaces. Fig. 1 shows RAD-7 Professional Electronic Radon Detector. Detector Passivity, Implanted, Planar Silicon detector, insensitive to vibrations and noise that plague many other detectors [4].

Fig. 1: The RAD-7 detector [4].

The air flow rate was 0.7 L/min. Room air was drawn from the inlet and Radon/Thoron generated in the air flow system was measured with the

RAD-7. The measurement interval was 1 h. The sample weight was different from sample to sample, Fig. 2 shows the schematic diagram for the measurement of Radon gas concentration in indoor air [5].

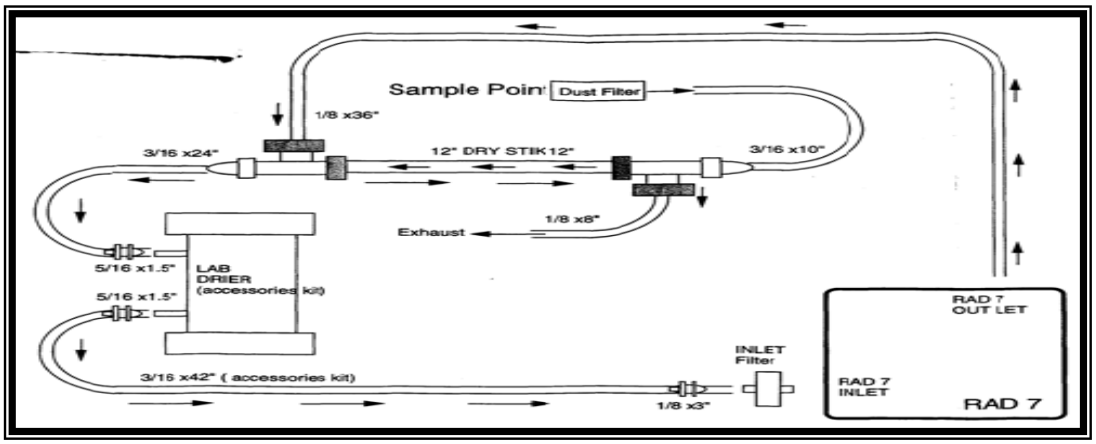

Fig.2: Schematic diagram for the Radon measurement in indoor air [5].

C- Measurements of indoor radon gas

The average indoor Radon gas concentration (C_R) inside the rooms in science college buildings in the University of Mustansiriyah and indices, have been calculated as follows:

1- The annual effective dose (A.E.D) in terms of (mSv/y) units was obtained using the relation [6]:

$$A.E.D\ (m\ Sv/y) = C_{Rn}\ A\ F\ Dc \qquad (1)$$

where C_{Rn} is the concentration of ^{222}Rn (Bq/m^3), A is the occupancy factor (7008 hours indoor), F is the equilibrium factor 0.4 and Dc is the dose coefficient which is equal to 9×10^{-6} $(mSv)/(Bq.h.m^{-3})$.

2- The lung cancer cases per year per million (CPPP) it should be noted that different baseline cancer rates are used to convert the results from relative risk to absolute risk; ICRP report. The conversion factor for cancer cases per year per million per person (CPPP) is given by [7]:

$$(CPPP) = A.E.D \times (18\times10^{-6}\ mSv/y),$$

3- The Potential Alpha Energy Concentration (PAEC) in terms of worker levels (WL) units was obtained using the relation [8]:

$$PAEC\ (WL) = F \times C_{Rn} / 3700 \qquad (2)$$

Where F is the equilibrium factor 0.4 and C_{Rn} is the activity concentration of Radon in Bq/m^3.

Results and discussion

The calculated results are listed in Table 1 and drawing in Fig. 3 can be listed the following remarkable points:

1. Indoor radon concentration

The highest value was found in the storage room presented in the ground floor of the physics department which was equal to 94.21±34.7 Bq/m^3, while the lowest value was found in reporter room presented in the third floor of the biology department which was equal to 9.85±1.7 Bq/m^3, with an average value of 53.64±26 Bq/m^3, which is less than the lower limit of the recommended action level of ICRP, 2009 (200- 300 Bq/m^3) [9].

2. Annual effective dose

The highest value again found in the storage room presented in the ground floor of the physics department which was equal to 2.38 mSv/y, while the lowest value was found in reporter room presented in the third floor of the biology department which was equal to 0.25 mSv/y, with an average value of 1.46±0.67 mSv/y. In the all rooms surveyed the indoor annual effective dose is less than the lower limit of the

recommended action level of ICRP, 1993 (3-10 mSv/y) [10].

3. Lung cancer cases per year per million person

The highest value was found in the storage room presented in the ground floor of the physics department which was equal to 42.84 per million person, while the lowest value was found in reporter room presented in the third floor of the biology department which was equal to 4.50 per million person, with an the average value of 24.35±12 per million person, these values are less than the lower limit of the range (170-230) per million person recommended by the ICRP, 1993 [10].

4.Potential alpha energy concentration

The highest value was found in the storage room presented in the ground floor of the physics department which was equal to 10.18 mWL, while the lowest value was found in reporter room presented in the third floor of the biology department and equal to 1.06 mWL, with an average value of 5.79±2.8 mWL, which is higher than the recommended value of UNSCEAR, 1993 (53.33 mWL) [11].

Conclusions

1. The Radon concentrations in the checked rooms in science college buildings are safe when compare with the recommended action level (ICRP, 2009).
2. This study showed that the concentrations of Radon gas less whenever we are rising to the upper floors.

Table 1: Radon gas concentration, the annual effective dose (A.E.D), lung cancer cases per year per million person (CPPP), the potential alpha energy concentration (PAEC).

No.	Location	Site	Floor	C_R (Bq/m^3)	(AED) (mSv /y)	CPPP	PAEC (m WL)
1	Deanery building	in the middle	Basement	68.04±17.8	1.71	30.78	7.36
		central heatsink	Basement	91.48±15.5	2.31	41.58	9.89
		storeroom	Basement	83.09±11.9	2.10	37.8	8.98
		subjectivity-Archive	Ground	44.68±12.8	1.13	20.34	4.83
		Class room (A101)	Ground	35.36±15.6	0.89	16.02	3.82
2	Physics dept.	Nuclear lab.	Ground	91.40±21.4	2.30	41.40	9.88
		Near storeroom	Ground	94.21±34.7	2.38	42.84	10.18
		Atomic lab.	Ground	64.10±16.5	1.62	29.16	6.93
3	Chemistry dept.	Organic diagnostics lab. (lab.A1)	Ground	56.83±11.9	1.43	25.74	6.14
4	Mathematic dept.	examination committee room	First	22.54±6.9	0.57	10.26	2.43
		Class room (A201)	First	18.13±5.4	0.46	8.28	1.96
5	Biology dept	Class room (A303)	Second	17.66±6.6	0.44	7.92	1.91
		Rrapporteur department room	Third	9.85±1.7	0.25	4.50	1.06
Average				**53.64±26**	**1.46±0.67**	**24.35±12**	**5.79±2.8**
Global limit				**200-300 (Bq/m^3) [9]**	**3-10 (mSv/y) [10]**	**170-230 [10]**	**53.33 (mWL) [11]**

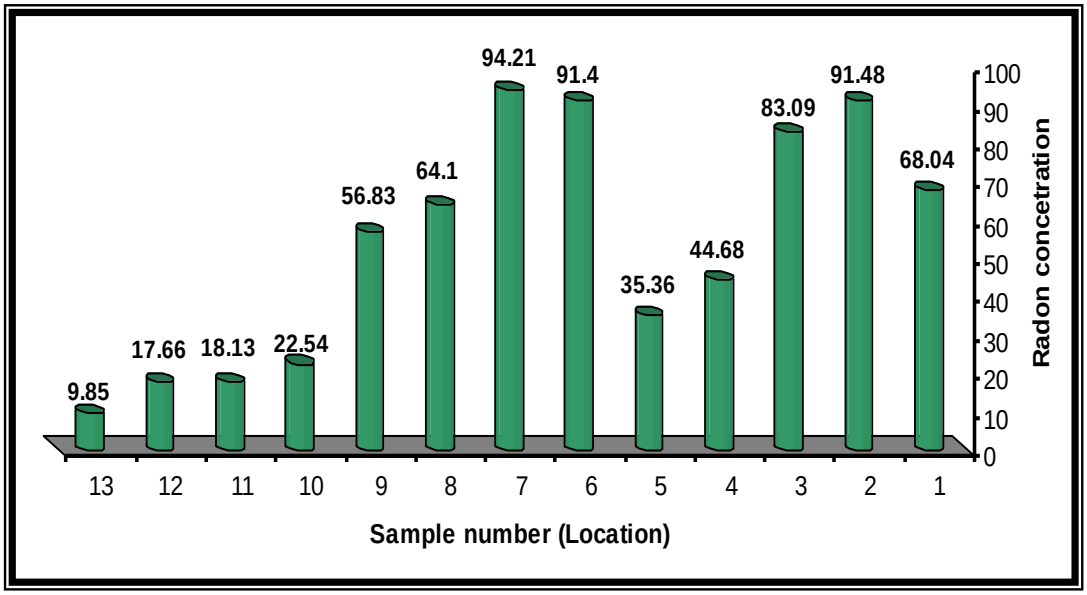

Fig. 3: A histogram illustrating the change in radon gas concentration in indoor rooms in science college buildings in the university of Mustansiriyah.

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