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Radon Concentration Measurements in Qaysare of Erbil City

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Abstract: In this study the assessment of indoor radon concentration in the air of Qaysare in Erbil city have been studied by using CR-39 Solid–State Nuclear Track Detector Technique. A total of 18 selected zones inside the suq have been selected to place the dosimeters. The average radon concentration was found to be 21.54 ± 8.017 Bq/m^3 which is fortunately lower than the standard international limit. The potential alpha energy concentration and annual effective dose have been calculated. A proportional relationship between the annual effective dose and radon concentration within the studied region has been certified.

Keywords: Radon, CR-39, Natural Radioactivity, Effective Dose.

1. Introduction

International studies of radon indoors and in the workplace have shown that the dose contribution due to the inhalation of ^{220}Rn and its short-lived decay products have been detected as a significant component of the total radon contribution. To measure both ^{222}Rn and ^{220}Rn gas concentrations in the environment, solid state nuclear track dosimeters are commonly used in dual chambered passive diffusion monitors. It is possible to differentiate between ^{222}Rn and ^{220}Rn gas due to the relative differences in their half-lives which are 3.82 days and 55.6 s respectively [1]. Radon which is a topic of public health concern has been found to be a ubiquitous indoor air pollutant in homes to which all persons are exposed [2]. Radon has no colour, odour or taste and is chemically inert. Its source is from uranium. As the uranium molecule decays to form stable lead, a process taking many, many years, it changes from one radioactive element to another in a sequence known as the Uranium Decay Cycle [3]. Radon is the largest and most variable contributor of public exposure to radiation. It is estimated that the annual effective dose by radon and its progeny from the inhalation of air is about 50% of natural public exposure to high levels of radon can cause lung cancer [4]. Radon can enter buildings through the floor, and in cases where ventilation is poor, the radon concentration can build up to high levels, exposing the occupants via inhalation.[5].

Radon is responsible for the majority of the public exposure to naturally occurring radiation. The United Nation Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) reported that radon and its progenies cause on average a radiation dose of 1.3 mSv per year and 79% of the radiation dose is due to the indoor radon inhalation. Therefore, each country makes national surveys of the actual radon concentration and implements radon management measures to protect its citizens [6].The main source of radon in the air of a dwelling is the ground under buildings, which is responsible for 80% of the whole radon concentration inside a typical house [7]. Radon concentration in a dwelling mainly depends on the concentration of this gas in ground air, permeability of soil on which the building is erected and tightness of a house construction. Radon concentration in the air of dwellings is subject to seasonal and twenty-four hour variations. Moreover, radon contributes most to the effective annual dose received by people living in the area of normal gamma radiation background [8]. In Erbil city (the Capital of Iraqi Kurdistan Region), and despite of its historical background as the oldest city still being populated, there is a few number of works concerning the radon concentration measurements in closed areas [9]. For this the idea of radon concentration measurements in the semi-closed and ancient bazar (Qaisare) has been adopted to assess the radon levels inside and making comparison with the standard permissible values.

2. Measurement Methods

Diffusive chambers with CR-39 type track detectors with 500 µm thickness and dimensions of 1.5 cm x 1.5 cm were used in the present study. Dosimeters, such as shown in Figure 1, containing the prepared nuclear track detectors were designed and distributed (hanged) in 18 different zones in the ancient Erbil Qaysary, Figure2. After an exposure time of 60 days, the dosimeters were collected and chemically etched (6N NaOH at 70C^o over 6 hour period) [10]. To account the number of tracks per cm^2 occurred in each detector an optical microscope with a magnification of 150X was used.

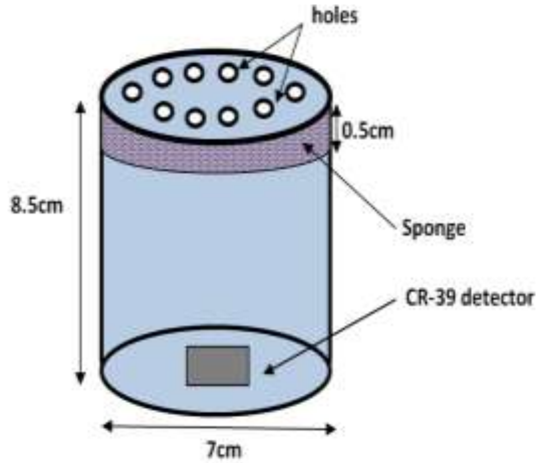

Fig. 1: Schematic diagram showing the geometry of radon dosimeter used in the study (reverse)

Fig. 2: Dosimeters in Qaisare.

3. Calculations and Evaluations

The CR-39 detectors exposed to the air inside the shops will be affected by radon and its daughters in the volume of air around them. In relating the observed track densities to the radon and its daughter activities per unit volume of air, the following equation has been used [11]:

$$\rho = x\,A \quad \ldots\ldots\ldots\ldots (1)$$

Where ρ : is the number of tracks per cm^3 per unit volume.

x: is a constant with dimension of length (cm)

A: is the alpha activity per unit volume (disintegrations per unit time per cm^3)

The detailed calculation related to the equation has been published earlier [11]. The value of the constant x is the sum of separate constants calculated for all isotopes (^{222}Rn, ^{218}Po, ^{214}Po). In order to estimate the radon concentration, experimental method for radon detection and measurement are based on alpha-counting of radon and its daughters. The track density was calculated in terms of number of tracks per mm^2, the average number of tracks was determined by processing an unexposed films CR-39 detector under identical etching condition. The signal measured by etched track detectors is integrated track density, ρ(track. mm^{-2}) recorded on the detector, (K) the average value of the calibration factor of ^{222}Rn in [(Bq. daym^{-3}) per (tracks. mm^{-2})] and (T) exposure time (day) has been applied to determine the activity of ^{222}Rn concentration (C_{Rn}) in (Bq/m^3) using the following equation: [12,13]:

$$CRn = \rho / T\,Ki \quad \ldots\ldots\ldots (2)$$

Where, T is the exposure time, K_i is the calibration factor with the dimension of length or equivalent to (tracks.m^{-2}.d^{-1} per Bq.m^{-3}). ρ is the Track Density.
Almost all measurements of radon levels in the home or outdoors are expressed as the concentration of radon in units of picocuries per liter of air (pCi/liter), or in SI units as Becquerel per cubic meter (Bq/m^3), or radon daughters are expressed in working levels (WL), which is given by[14]:

$$C_p(WL) = \frac{F\ C_{Rn}}{3700} \quad \ldots\ldots\ldots\ldots\ldots (3)$$

where: F is the equilibrium factor and recommended as F_{Rn} = 0.4 [15]. Furthermore Qureshi. A et.al. [16] proposed a method to calculate the annual effective dose using the Working Level Month (WLM) units, and is given by Eq. (4):

$$(WLM) = \frac{F \times t \times C_{Rn}}{170 \times 3700} \quad \ldots\ldots\ldots\ldots\ldots (4)$$

Therefore, the relation between the effective dose and Radon concentration is given by:

$$H_E = G\ C_{Rn} \quad \ldots\ldots\ldots\ldots\ldots (5)$$

where: G is a constant (conversion factor)

In this study measurement of indoor radon concentration (C_{Rn}), potential alpha energy concentration (PAEC) and annual effective dose (H_E) have been performed. The potential alpha energy concentration (WL) was calculated using Eq. (3), annual effective dose equivalent (WLM/year) and effective dose also has been calculated using Eqs. (4) and (5), respectively.

4. Results and Discussion

The recorded values of radon concentration (Bq/m^3) in different zones inside Erbil-Qaysare, Annual effective dose using the Working Level Month (WLM) units are presented in Table (1). The histogram schemes of these data are then shown in Figures (3 through 5) in which the results of different zones were declared obviously. The calculated average Radon concentration was (21.54 ± 8.017) Bq/m^3. The value is smaller than the recommended limit (50-150) Bq/m^3 sets by ICRP [17]. On the other hand, radon concentration was varying from region to another, for example the activity of radon concentration in (Gold Smith) zone (5, 7, 10, and 15) is more than the other zones, while the minimum value was in (Shops selling textiles and clothing) Zone (11 and 13).The comparison between the maximum and minimum values of radon activity concentration obtained at the different zones is given in Table 2. It found that in the Gold smith zones, the maximum radon concentration ranged between 26.05 - 45.55 Bq/m^3, while the minimum value ranged between 10.41-10.82 Bq/m^3 in shops selling textiles and cloths, respectively.

Table 1: Radon concentration in different zones in Qaysare of Erbil city

Zone No.	C(Rn-222)	PAEC(mWL)	WLM/yr.	He(mSv.yr-1)
1(Cutlery shops)	17.32 ± 3.78	1.87	0.021	0.107
2(house wares)	20.56 ± 3.23	2.22	0.025	0.127
3(perform shops)	24.39 ± 2.13	2.63	0.030	0.150
4(house wares)	21.65 ± 3.03	2.34	0.026	0.133
5(Gold smith)	45.55 ± 3.65	4.92	0.056	0.281
6(perform shops)	23.45 ± 1.35	2.53	0.028	0.144
7(Gold smith)	29.59 ± 3.18	3.19	0.036	0.182
8(Cutlery shops)	15.33 ± 3.57	1.65	0.018	0.094
9(house wares)	21.65 ± 2.17	2.34	0.026	0.133
10(Gold smith)	26.07 ± 3.97	2.81	0.032	0.161
11(Shops selling textiles and clothing)	10.82 ± 0.99	1.17	0.013	0.066
12(Cutlery shops)	16.23 ± 1.61	1.75	0.020	0.100
13 (Shops selling textiles and clothing)	10.41 ± 1.99	1.12	0.012	0.064
14(Cutlery shops)	16.23 ± 1.37	1.75	0.020	0.100
15(Gold smith)	27.55 ± 3.56	2.97	0.034	0.170
16(house wares)	21.64 ± 4.82	2.34	0.026	0.133
17(perform shops)	23.12 ± 2.96	2.49	0.028	0.142
18(Cutlery shops)	16.23 ± 3.83	1.75	0.020	0.100
Average	21.54 ± 8.017	2.32 ± 0.86	0.0266 ± 0.009	0.133 ± 0.049

Table 2: Minimum, maximum and average values of radon concentration (Bq/m^3) at different studied zones

Zone	Radon Concentration (Bq/m3)		
	Min	Max.	Average ± S.D
Cutlery Shops	15.33	17.32	16.325 ± 0.148
house wares	20.56	21.65	21.105 ±0.141
perform shops	23.12	24.39	23.755 ± 0.587
Gold smith	26.07	45.55	35.81 ±0.226
Shops selling textiles and cloths	10.41	10.82	10.615 ±0.707

From Fig.6 one can observe the linearity of relation between radon concentration and effective dose as a consequence of Eq. (4). The slope of the straight line gives the value of constant (G) which was determined as $G = 5\ \mu SvY^{-1}$ [18].

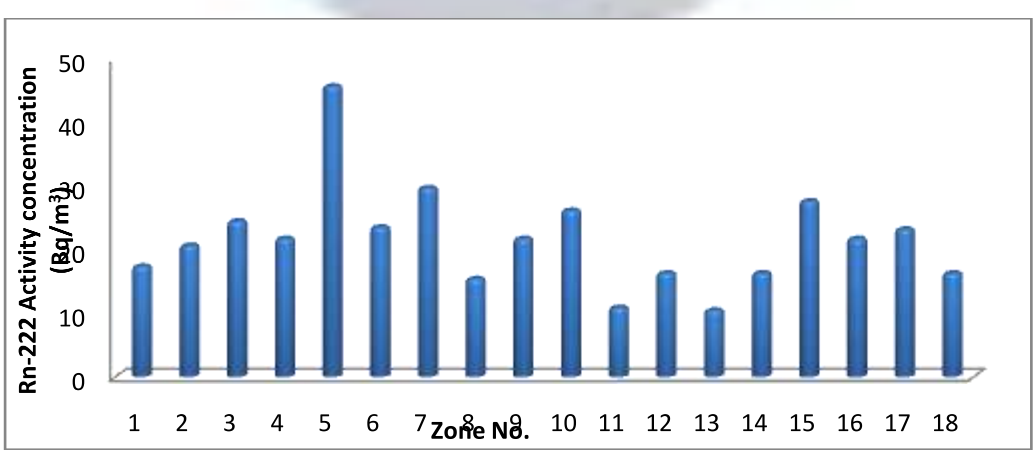

Fig. (3): Radon activity concentrations versus Zone numbers

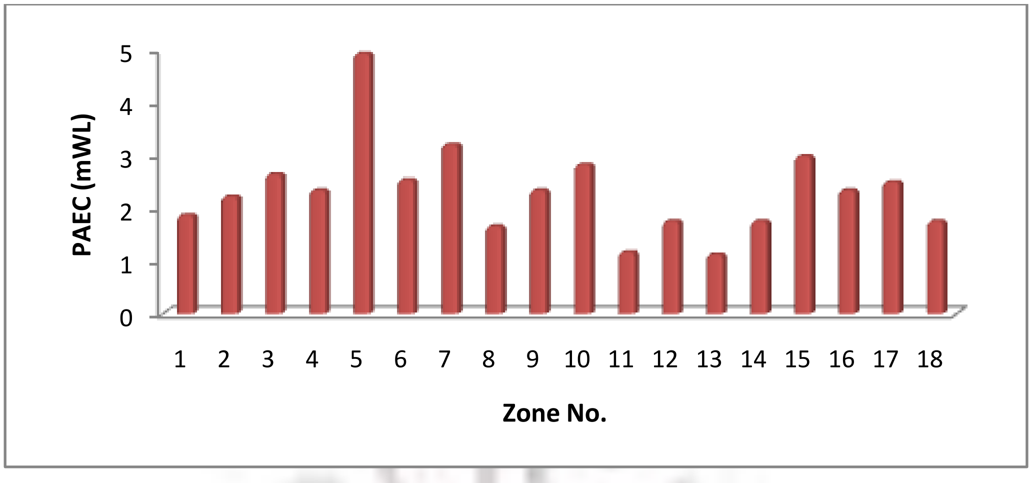

Fig.(4): Potential alpha energy concentration (PAEC) versus Zone number.

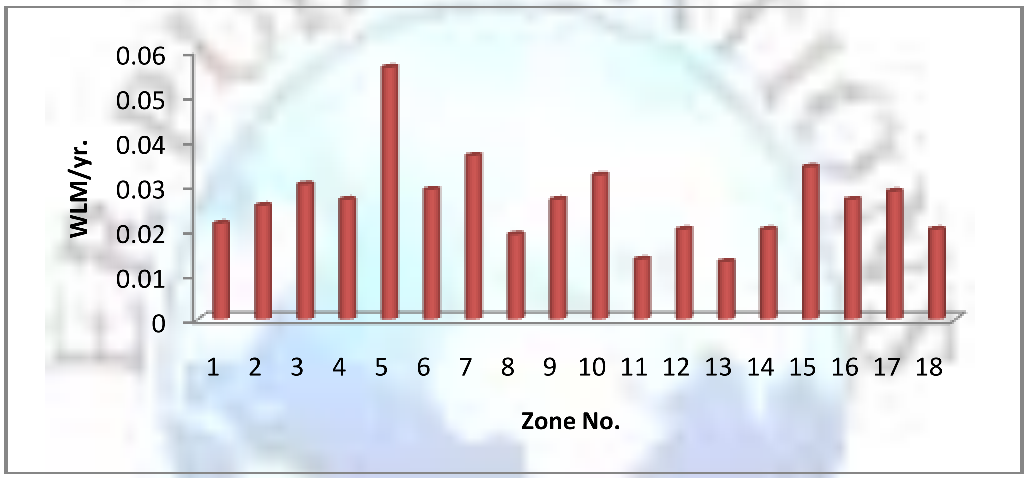

Fig.(5): Working Level Month (WLM) versus Zone number.

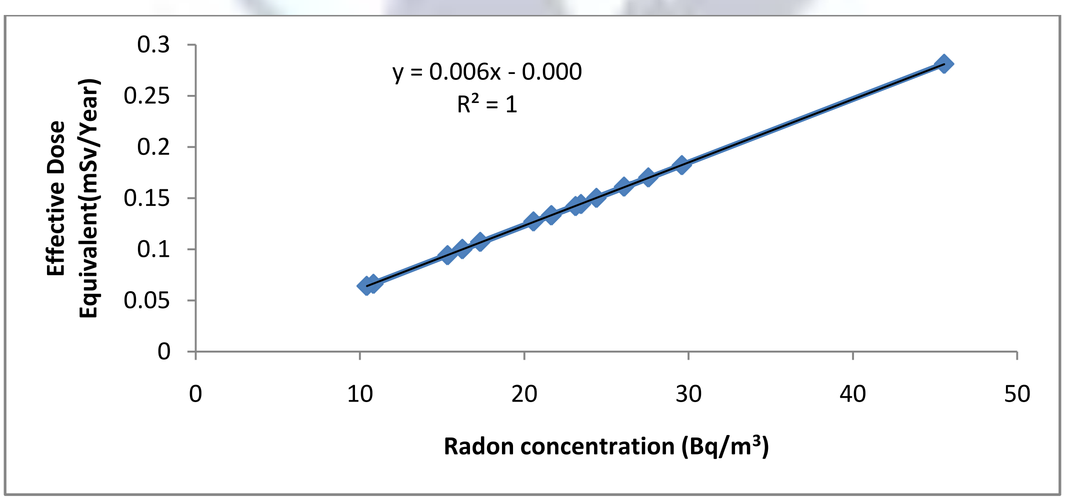

Fig. 6: Relationship between effective dose equivalent and radon concentration.

Conclusions

The radon concentration values obtained was varied within the studied zones depending on the height, wide, and ventilation opportunities of qaysare tracks. The recorded values of radon concentration were lower than the standard limits. A linear relationship has been traced between the annual effective dose and the measured radon concentrations.

References

[1]. Brown J.M.C., Solomon S., Tinker R.A." Development of an energy discriminate CR-39 nuclear track etch dosimeter for Radon-220 gas measurements. Journal of Environmental Radioactivity 102 (2011) 901-905

[2]. Kant K., Upadhyay S.b., Sharma G.S. and Chakarvarti S.K., " Measurement of inhalation dose due to radon and its progeny in an oil refinery and its dwellings.Iran. J. Radiant. Res., 2004; 1(4): 181-186.

[3]. Asaad H. I., "Measurement of Radon Activity concentration in Iraqi Kurdistan Soil by Using CR-39 Nuclear Track Detectors, M.Sc. Thesis, Univ. of Salahaddin, Iraqi Kurdistan (2004).

[4]. Gilhoon Ahn and JAl-Kilee, Construction of an Environmental Radon Monitoring system using CR-39 Nucle Track Detectors. Nuclear Engineering and Technology Vol 37 No. 4, 2005.

[5]. Birchall A., and Marsh J.W. Radon dosimetry and its implication for risk, International Congress Series (2005) 81-84.

[6]. Park .C. H., et al.: Effects of Bed rock Type on the Indoor Radon Concentrations, Nuclear Technology & Radiation Protection: Year 2011, Vol. 26, No. 3, pp. 226-232

[7]. UNSCEAR.2000. Exposures from Natural Radiation Sources. New Yourk, UN.

[8]. Kozak. K, Mazur. J, Kozlowska. B., Karpinska. M. and et al., Correction factors for determination of annual average radon concentration in dwellings of Poland resulting from seasonal variability of indoor radon., Applied Radiation and Isotopes 69(2011)1459-1465.

[9]. Samal. S. F. Khdir, Diffusion Cup Technique for Long term Radon Gas Activity Measurement Using CR-39 Nuclear Track Detector., MSc. Thesis , 2011, Salahaddin University, Iraq.

[10]. Younis M. Atia1 ,Khetam Abd-Aladel1 , Hameed B. Mahood and Muhammed A. Hssoni ج Determination of Radon-222 Concentration in Center of Misan City Using Nuclear Track Detectors CR-39, Journol of Basra Searches , No(36) ,6(15B)2010

[11]. Abu-Jarad, F., Fremlin, J. h. and Bull, R. 1980. A study of Radon Emitted from Building Materials using Plastic α- track detectors, Phys. Med. Biol. 25, 683-694.

[12]. Milad J. Ali " Radon Concentration in Al-Gazalia City, Baghdad, Iraq" Journal of Al-Nahrain University Vol.16 (1), March, 2013, pp.121-128

[13]. Hafez, A.F., Hussein, A.S., Rasheed, N.M., (2001): A study of radon and thoron release from Egyptian building materials using polymeric nuclear track detectors, Applied Radiation and Isotopes, Vol.54, pp. 291-298.

[14]. Khan .A.J., Varhney A.K., Prasad R., Tyagi R.K., T.V. Ramachandran, Calibration of a CR-39 plastic detector for the measurement of radon and its daughters in swellings, Nucl. Tracks. Radiat. Meas. 17 (1990) 497-502.

[15]. UNSCEAR (United National Scientific Committee on the Effects of Atomic Radiation), Report to the General Assembly, United Nations, New York, 2000

[16]. Qureshi A.A., Kakar D.M., Akram M., Khattak N.U., Tufail M., Mehmood K., et al., Radon concentrations in coal mines of Baluchistan, Pakistan, Joural of Environmental Radioactivity 48 (2) (2000) 203-209.

[17]. ICRP (International Commission on Radiological Protection), Protection against Radon-222 at home and at work, in: Annals of ICRP, Pergamon press, Oxford, 1994, pp. 1-45.

[18]. Vaupotic J., Celikovic I., Smrekar N., Zunic Z. S. and Koba I., Concentrations of ^{222}Rn and ^{220}Rn in Indoor Air. Acta Chim. Slov. 2008, 55, 160-165.