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/m³ ,which is fortunately lower than the standard international limit from 200-600 Bq/m³ as recommended by ICRP, IAEA. 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.

قياس تركيز غاز الرادون في قيصرية مدينة اربيل

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الملخص

في هذه الدراسة استخدمت تقنية كواشف الأثر النووي البلاستيكية (CR – 39) لحساب تركيز غاز الرادون في الهواء في الاماكن المغلقة داخل السوق القيصري في مدينة اربيل. تم اختيار ما مجموعه 18 منطقة مختارة داخل سوق لوضع مقاييس الجرعات . تم العثور على متوسط تركيز الرادون Bq/m³ (21.54 ± 8.017) وهو أقل من الحد المسموح بها في المعايير الدولية وهي بحدود (200–600 Bq/m³) التي يوصي به الوكالتين IAEA, ICRP. تم حساب تركيز طاقة جسيمات ألفا والجرعة الفعالة السنوية. وجدت أن هناك علاقة طردية بين الجرعة الفعالة السنوية و تركيز الرادون في المنطقة التي شملتها الدراسة.

الكلمات الدالة: رادون، كواشف CR–39، الجرعة الفعالة، نشاط الإشعاع الطبيعي.

1.INTRODUCTION

Solid State Nuclear Track Detectors (SSNTDs) are insulating solids both naturally occurring and man-made. There are several types of these detectors including inorganic crystals, glasses and plastics. International studies of radon indoors and in the workplace have shown that the dose contribution due to the inhalation of 220Rn and its short-lived decay products have been detected as a significant component of the total radon contribution. To measure both 222Rn and 220Rn 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 222Rn and 220Rn 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].
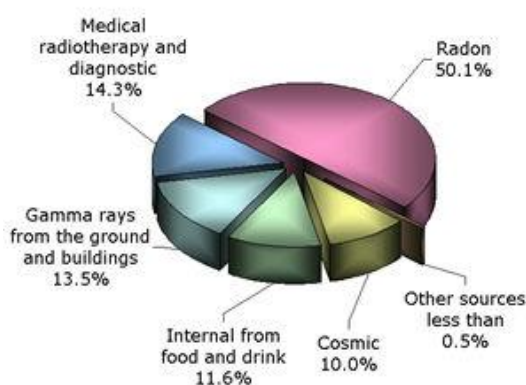

Figure (1-1): Sources of Radiation Exposure; from NCRP Report [5].

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.[6].

Alpha particles are high linear energy transfer (LET) radiation and carry sufficient energy to cause permanent dames to DNA [7]. In addition, a number of in vitro studies using radon gas were defined for understanding the early changes induced at cellular and molecular level and DNA repair of these events. The studies proved that radon is capable of inducing significant chromosome damage event at very low doses and low dose-rate [8]. The studies proved that radon is capable of inducing significant chromosome even at very low doses and low dose- rate [9]. As well as, high ratio of indoor radon has impact of the male fertility [10], this more effects on the infertility of the male children.

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 [11].

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 [12].

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 [13]. 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 [14]. 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.

In solid state track detectors as CR-39 and other polycarbonate compounds, the path of an ionizing particle along the damaged trail is revealed by a conical pitch which is visible to microscopic analysis after a chemical etching. The pitch characteristics depend on properties of the etching solution and on travelling ion, so to allow determination of ion properties. So nuclear track detectors (NTDs) register alpha particles emitted by radon gas and its progeny in the form of tracks, which will become visible under the optical microscope upon suitable chemical etching of the NTDs [15]. Interesting of radon dosimeters depended on the calibration factor, this factor has a wide range depends not only on the geometry of the used configuration but also on many parameters such as; type of the sued detector via their etching conditions, detector efficiency and the dosimeter dimensions [16-17].

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) [18]. To account the number of tracks per cm^2 occurred in each detector an optical microscope with a magnification of 150X was used.
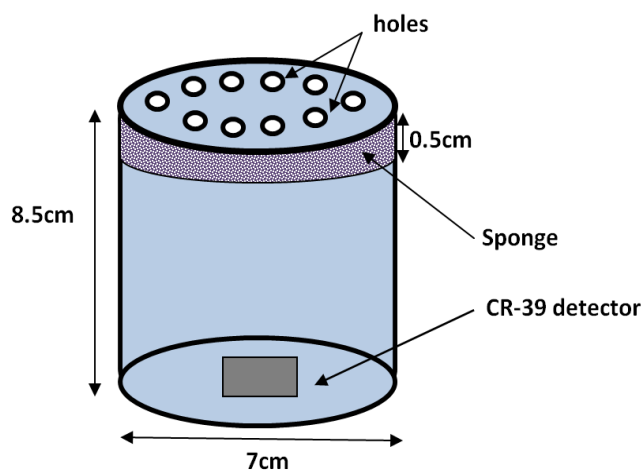

Figure (1): Schematic diagram showing the geometry of radon dosimeter used in the study.(reverse) [14].

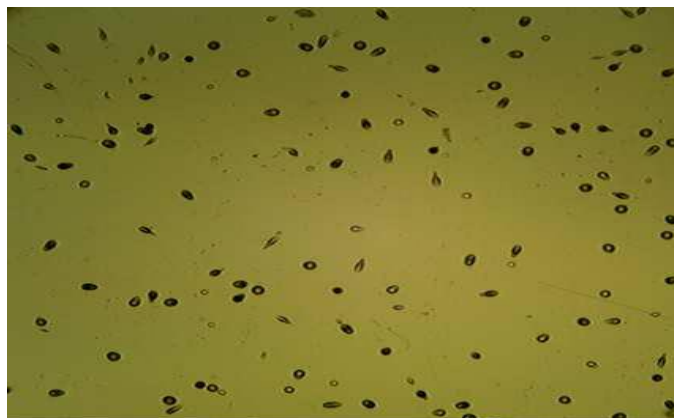**Figure (2):** Dosimeters in Qaisare.

Figure (3): Track occurred in each detector

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 [19]:

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

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 [19]. The value of the constant x is the sum of separate constants calculated for all isotopes (^{222}Rn, ^{213} 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: [20,21]:

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

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[22]:

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

where: *F* is the equilibrium factor and recommended as $F_{Rn} = 0.4$ [23]. Furthermore Qureshi. A et.al. [24] proposed a method to calculate the annual effective dose using the Working Level Month (WLM) units, and is given by Eq. (4):

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

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

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

where: G is constant.

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/m3. This value is lower than the radon references level

which ranges from 200-600 Bqm-3 as recommended by ICRP, IAEA.[25,26] . 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 Figure (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 $G = 6 \ \mu Sv \cdot aY^{-1}$[18].
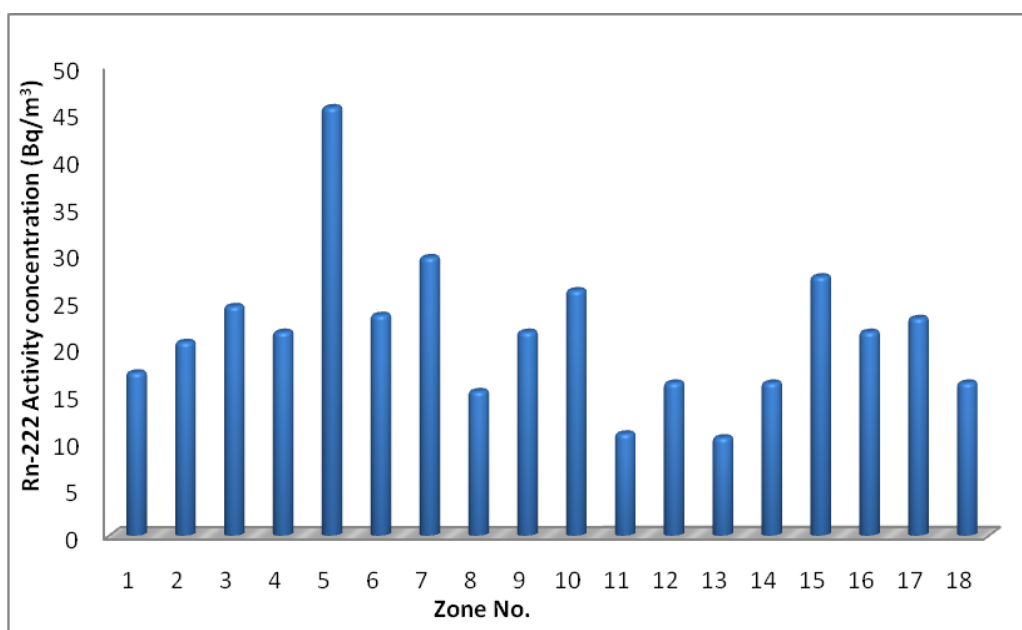

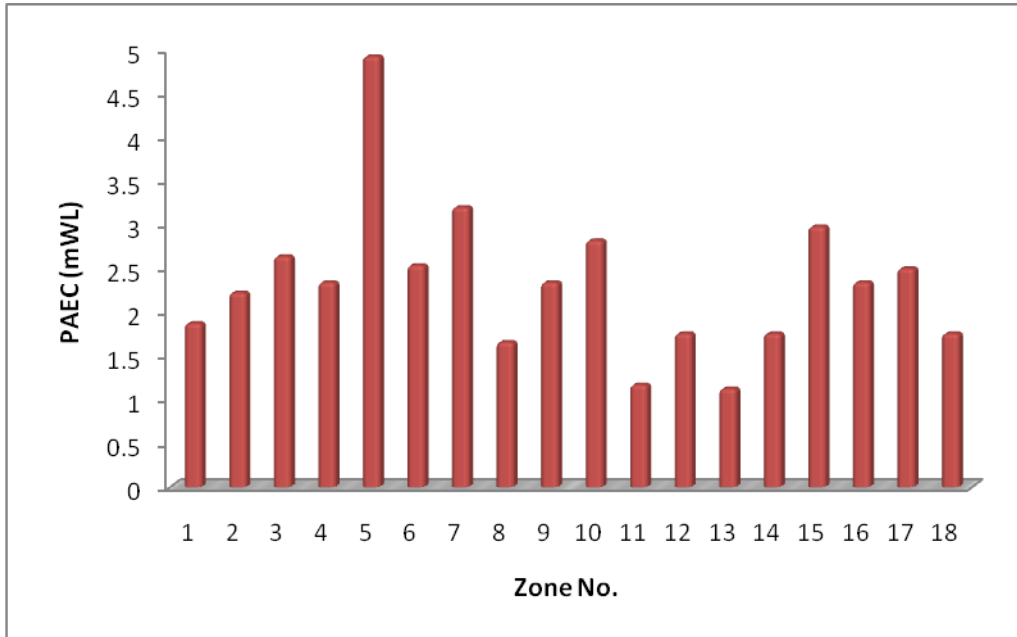**Figure (3):** Radon activity concentrations versus Zone numbers

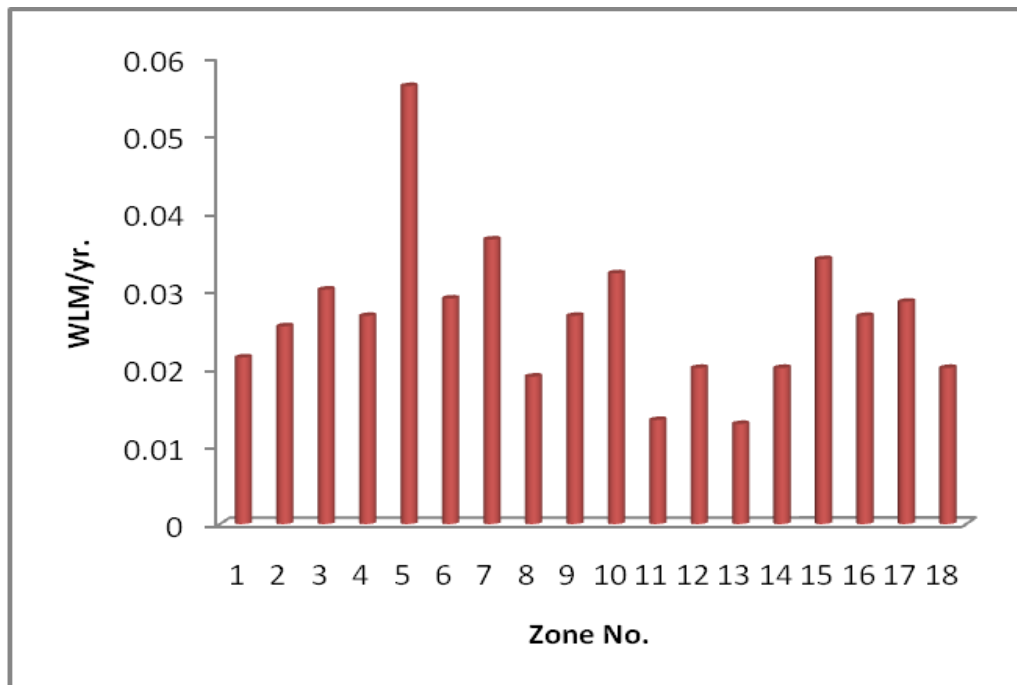**Figure (4):** Potential alpha energy concentration (PAEC) versus Zone number.

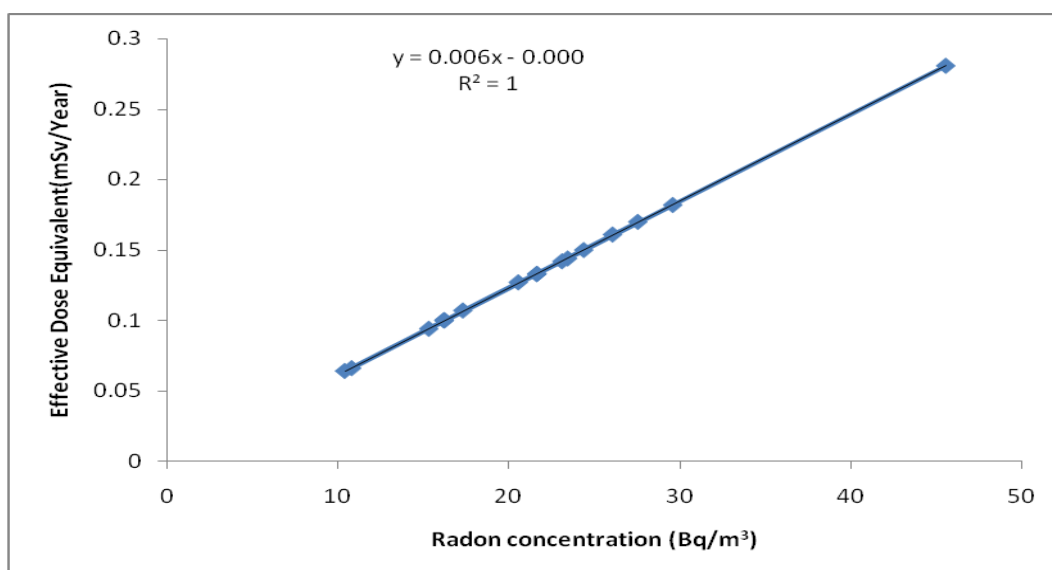**Figure (5):** Working Level Month (WLM) versus Zone number.

Figure (6): Relationship between effective dose equivalent and radon concentration.

5.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.

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