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Radon Gas Concentration Measurement in Air of Al - Haswaa City in Province of Baghdad

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Abstract

In this study the radon gas concentration in air in Al - Haswaa city in province of Baghdad in Iraq have been calculated using CR-39 solid–state nuclear track detector technique. A total of 8 samples selected from 8 region in Al – Haswaa city in province of Baghdad have been placed in the dosimeters for 30 day. The average radon gas concentration was found to be 486.26 Bq/m^3 which is lower than the standard international limit (1100 Bq/m^3). The potential alpha energy concentration and annual effective dose have been calculated. A proportional relationship between the annual effective dose and radon gas concentration within the studied region has been certified.

Keywords; Radon gas; CR-39 detector; Air; Annual effective dose; Dosimeter; Can technique.

قياس تركيز غاز الرادون في هواء مدينة الحصوة في محافظة بغداد

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الخلاصة

في هذه الدراسة تم حساب تركيز غاز الرادون في هواء مدينة الحصوة في محافظة بغداد باستخدام تقنية كاشف تعقب الاثر النووي في الحالة الصلبة CR-39. تم اختيار ثمان عينات في ثمان مناطق في مدينة الحصوة في محافظة بغداد ووضعت فيها مقاييس الجرعة لمدة 30 يوم. معدل تركيز غاز الرادون كان 486.26 بيكريل / متر مكعب وهو اقل من المدى المسموح به عالميا (1100 بيكريل / متر مكعب). وتم حساب تركيز طاقة ألفا المحتمل والجرعة الفعالة السنوية. وكذلك تم تحديد العلاقة التناسبية بين الجرعة المكافئة السنوية وتركيز غاز الرادون للمنطقة تحت الدراسة.

Introduction

Radon 222 is one of the periodic table elements located within the range noble elements (Noble gases) (helium-neon-xenon, etc.), a gas is invisible, tasteless and odorless, this component is generated within the intermediate stage of decomposition uranium- 238 which includes several other radioactive elements, ending a series decays is lead [1], where α is the gross alpha:

$$^{226}Ra \xrightarrow{a} {}^{226}Rn \xrightarrow{a} {}^{218}Po \xrightarrow{a} {}^{214}Pb$$

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Radon gas is one of the inert gases chemically, atomic number 86, mass number of his most stable is 222, density 9.7 kg.m^{-3}, its boiling point -61.8 ^{o}C and degree of freezing -71 ^{o}C [2], which is heavier than air seven times and available is in all places at all times [3].

The radon -222 natural nuclear radiation, which is mainly generated by the natural decay of a series of uranium sources ^{238}U, thorium ^{232}Th and uranium ^{235}U, is the only metal which is in a gaseous state, there are two another isotopes; thoron ^{220}Rn and actinon ^{219}Rn it is recognized in geological and environmental studies is the counterpart ^{222}Rn relatively long for the half-life 3.82 day while can neglect the role of other isotopes ^{220}Rn and ^{219}Rn due to the short half-life 5.66 and 3.92 second respectively [4]. The US Environmental Protection Agency EPA has proposed the maximum concentration of radon in air is 1100 Bq/m^3 [5].

Radon leads to health risks via two paths are inhaled radon and products decay after liberation from the water to the air of homes and direct ingestion of radon in drinking water, the risk of lung cancer resulting from inhalation of decay products of radon [6].

The fact that the alpha particles emitted by radon decay products of heavy charged particles, they occur when colliding with atoms making up the tissues and organs of the body cells and the effects of large disturbances which, as well as the chemical effects at the molecular level. The average length of the path of alpha particles in soft tissue about 40µm. The capacity of ionizing increase by more than 1,000 times the energy beta particles and thus be more destructive to human tissue, hence the exposure to radon decay products of ^{222}Rn and risks [7, 8]. In addition what the offer is part of the annual effective equivalent dose to people in Who's estimated up to 2mSv.y^{-1} with radioactive background unusual environment comes from human inhalation of radon ^{222}Rn at a rate of 0.8 mSv. y^{-1} [9].

The current research aims to measure and study the radon concentration of Radioactive gas radon in air in different regions of Al-Haswaa region in Baghdad city: Al Maraj secondary school, residential complex, 4000 region, 7000 region, 6000 region, the first intersection, Al olaa and near the electricity dept. to be noticed to radon as a source of danger to people's health because of the breadth of its spread in the soil, building materials and groundwater.

The measurements methods

Can technique with CR-39 type track detectors with 200µm thickness and dimensions of 1cm×1cm were used in the present study. Dosimeters، was shown in Figure- 1 after an exposure time of 30 days, the dosimeters were collected and chemically etched (6.25N NaOH at 70 ^{o}C 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 40X was used with CCD camera Figure- 2. As it has been taking 20 pictures of each detector.

Calculations and evaluations

The CR-39 detectors exposed to the samples 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].

$$\rho = x\,A \qquad (1)$$

where ρ: is the number of tracks per cm^2.

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

A: is the alpha activity per unit volume (disintegrations per unit time per cm^2).

The value of the constant x is the sum of separate constants calculated for all isotopes (^{222}Rn, ^{218}Po and ^{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_i the average value of the calibration factor of ^{222}Rn in (Bq. day m^{-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]:

$$C_{Rn} = \frac{\rho}{TK_i} \qquad (2)$$

where, K_i is the calibration factor with the dimension of length or equivalent to (tracks.m^{-2}.d^{-1} per Bq.m^{-3}) and 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 [13]:

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

where: F is the equilibrium factor and recommended as FC_{Rn} = 0.4 [14].

Furthermore Qureshi. [15], proposed a method to calculate the annual effective dose using the Working Level Month (WLM) units, and is given by Eq 4:

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

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

$$E_{ff} = G\ C_{Rn} \quad (5)$$

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 (HE) 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.

Results and Discussion

The overall results for radon concentrations in Bq/m^3, the equilibrium equivalent ^{222}Rn concentration (CEEC in Bq/m^3), and the Annual Effective Dose Eff (in mSv/y) for eight air samples from eight region in Al-Haswaa region in Baghdad city were given in Table- 1. Radon concentrations were measured by closed can technique dosimeter, as shown in Figure- 1, which means that the air at the whole exposure time was confined within the container.

The overall average value of the activity concentrations of ^{222}Rn for air samples was 486.26 Bq/m^3. The maximum concentration of ^{222}Rn was 871.1 Bq/m^3 appeared in Residential complex sample and the minimum concentration was 90.58 Bq/m^3 in the first intersection sample. The calculated CEEC values showed that the maximum value was 348.4 Bq/m^3 in residential complex sample, and the minimum value was 36.2 Bq/m^3 in The first intersection sample. The average value of CEEC for ^{222}Rn was 194.5 Bq/m^3, and this shows that the concentration of radon emitted from the samples does not depend on ^{226}Ra concentration only. The overall average value of the representative (WLM) of ^{222}Rn concentrations for the full air samples set were determined to be 2.7. The highest value was 4.8 in residential complex sample and the minimum value was 0.5 in the first intersection sample.

Figure- 3 shows the relationships between (WLM) and radon concentration Bq/kg. From this figure, one can note that the relationships are linear increasing, and useful fitting equations can be deduced؛

$$WLM = 0.0056 * C_{Rn}\ (Bq/m^3) \quad (7)$$

The average value of annual effective dose E obtained for drinking water samples set was 12.2 mSv/y, while the maximum value was 22 mSv/y in residential complex sample, and the minimum value was 2.3 mSv/y in The first intersection sample.

Figure 4 shows the relationships between $E_{ff.}$ in mSv/y and radon concentration Bq/kg. From this figure, one can note that the relationships are linear increasing, and useful fitting equations can be deduced;

$$E_{ff.} = 0.0252 * C_{Rn}\ (Bq/m^3) \quad (8)$$

The average value of Excess Lung Cancer per Million Persons per Year (ELC) for the full air samples set was 7300. The highest value was 13100 in residential complex sample and the minimum value was 1300 in the first intersection sample. Additionally, this disparity in the values is due to differences of the nature of air samples. Figure 5 shows the relationship between ECL and radon concentration Bq/m^3. From this figure, the fallowing equation is good fitting equation;

$$ELC = 15.137\ C_{Rn}\ (Bq/m^3) \quad (9)$$

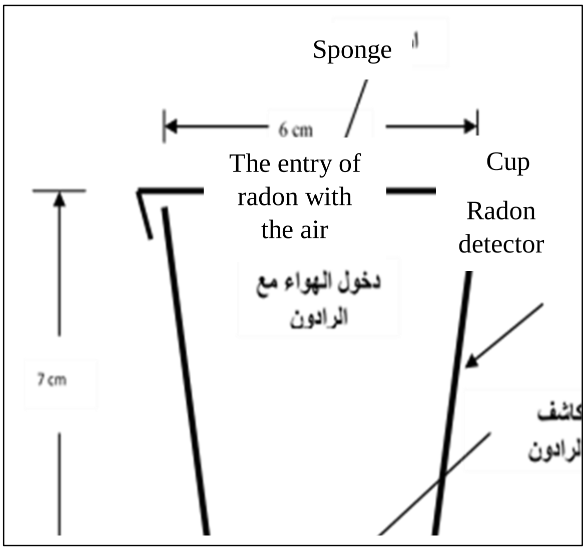


Figure 1- Schematic diagram showing the geometry of radon dosimeter used in the study.

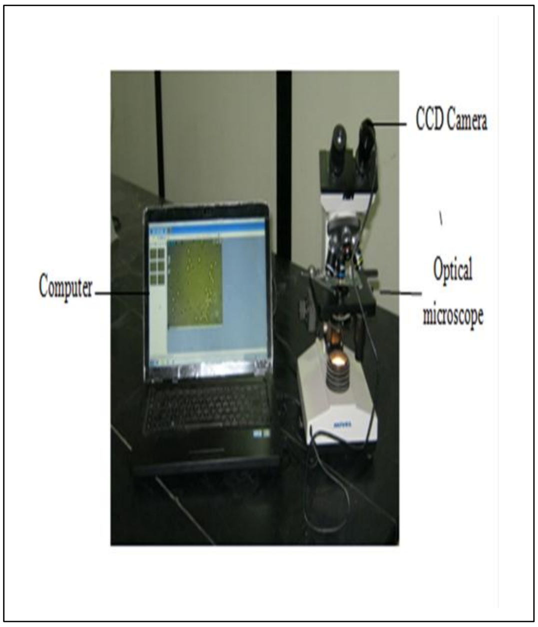


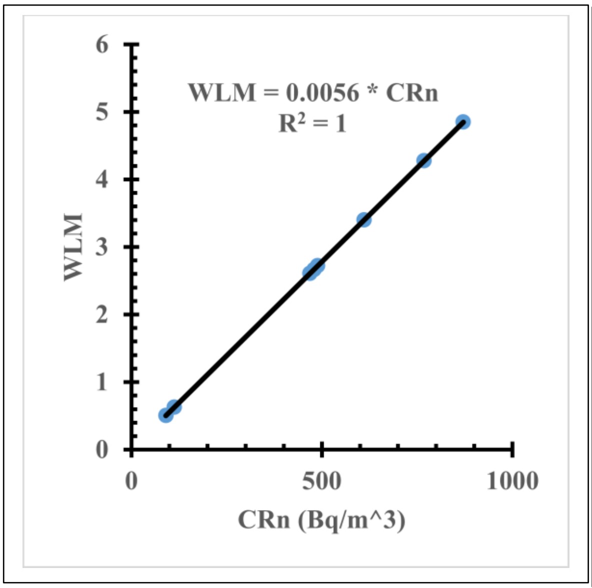
Figure 2- The track counting system.

Table 1- Radon Concentration, CEEC, WL, WLM, E, ECR and ELC for air samples.

Sample	Track average	density	CRn	F	CEEC	WL	WLM	E	ECR	ELC
Al Maraj Secondary	**221.7**	**123.17**	**610.76**	**0.4**	**244.3**	**0.065**	**3.4**	**15.4**	**0.0092**	**9200**
Residential complex	**316.2**	**175.67**	**871.1**	**0.4**	**348.4**	**0.094**	**4.8**	**22**	**0.0131**	**13100**
4000 Region	**174**	**96.67**	**479.4**	**0.4**	**191.7**	**0.051**	**2.7**	**12.1**	**0.0072**	**7200**
7000 Region	**41**	**22.78**	**112.95**	**0.4**	**45.2**	**0.012**	**0.6**	**2.8**	**0.0017**	**1700**
6000 Region	**278.8**	**154.89**	**768.06**	**0.4**	**307.2**	**0.083**	**4.3**	**19.4**	**0.0116**	**11600**
The first intersection	**32.88**	**18.27**	**90.58**	**0.4**	**36.2**	**0.01**	**0.5**	**2.3**	**0.0013**	**1300**
Al Olaa	**38.77**	**98.57**	**488.8**	**0.4**	**195.5**	**0.052**	**2.7**	**12.3**	**0.0074**	**7400**
Near the Electricity Dept.	**69.22**	**94.47**	**468.5**	**0.4**	**187.4**	**0.0506**	**2.6**	**11.8**	**0.007**	**7000**
Average	**146.6**	**98.06**	**486.26**		**194.5**	**0.0525**	**2.7**	**12.2**	**0.0073**	**7300**

Conclusions

The radon concentration values obtained was varied within the studied air samples in different region in Al-Haswaa region in Baghdad city. The recorded values of radon concentration were lower than the standard limits (1100 Bq/m^3).



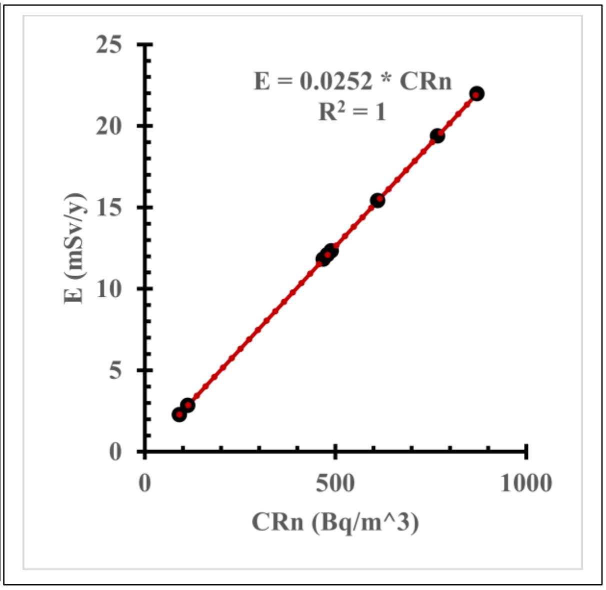


Figure 3- WLM as a function of radon concentration Bq/m^3.

Figure 4- E a function of radon concentration Bq/m^3.

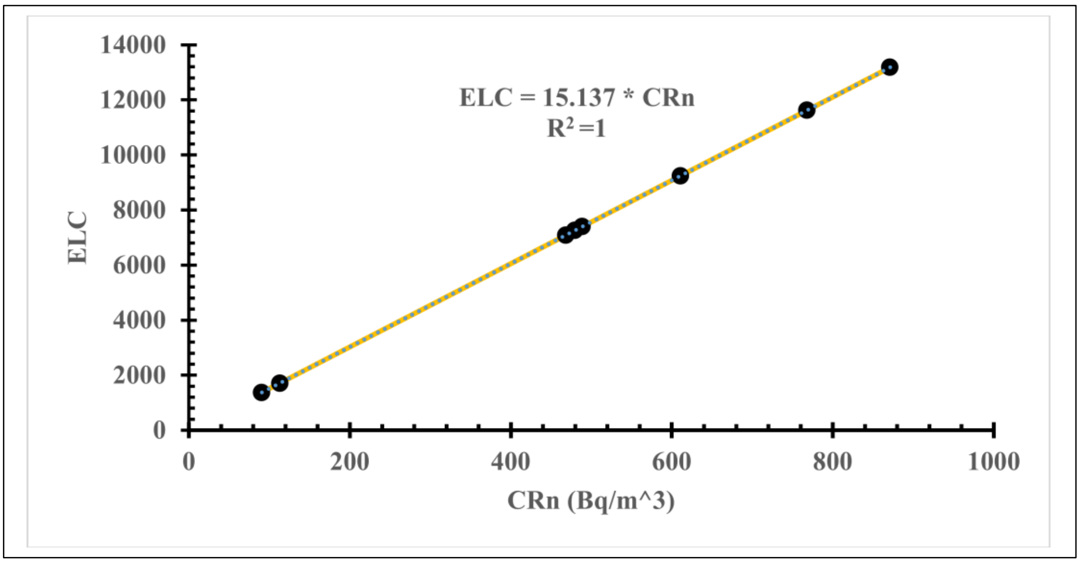


Figure 5- The relation between ELC and radon concentration C_{Rn} Bq/m^3.

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