



Estimate Level of Radon Concentration for Drinking Water in Some Regions of Baghdad City

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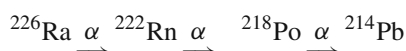
Abstract

In this study, the assessment of radon concentration in drinking water in some regions of Baghdad city in Iraq has been studied using CR-39 solid-state nuclear track detector technique. A total of 18 samples selected from 6 region (5 samples from each region) in Baghdad city have been placed in the dosimeters for 50 day. The average radon concentration was found to be 516.1 Bq/m³ which is greater than the standard international limit (300 Bq/m³). 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 gas · CR-39 detector · Drinking water · Annual effective dose

1 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 and tasteless and odorless, and this component is generated within the intermediate stage of decomposition uranium-238 which includes the addition of radon generating several other radioactive elements, ending a series decays this element lead [1], where α is the gross alpha:



Is an inert gas with an atomic number of 86, the most stable mass number is 222, its density is 9.7 kg/m³, its boiling point is – 61.8 °C, the melting point is – 71 °C [2]. It is seven times heavier than air, and is continuously present in all places [3].

The radon-222 natural nuclear radiation is mainly generated by the natural decay of a series of uranium sources ²³⁸U, thorium ²³²Th and uranium ²³⁵U. ²²²Rn is the only metal which is in a gaseous state [4]. Radon have three radioactive isotopes: radon ²²²Rn, thoron ²²⁰Rn and actinon ²¹⁹Rn. In geological and environmental studies, the counter-

part ²²²Rn was recognized relatively long for the half-life 3.82 day while can neglect the other isotopes ²²⁰Rn and ²¹⁹Rn due to the short half-life 5.66 and 3.92 s respectively [4]. The US Environmental Protection Agency EPA has proposed the maximum concentration of radon in drinking water in 1100 Bq/m³ [5].

The radon leads to health risks via two paths that 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; the radon gas was not linked to any other more disease of cancer, and the risk of inhalation may exceed far beyond the ingestion [6].

The collision of alpha particles that emits from the radon decay with the atoms and molecules that make up the tissues and organs of the body, produces chemical effects and major disturbances. The average length of the path of alpha particles in soft tissue is about 40 μm. The capacity of ionizing increases by more than 1000 times the energy beta particles and thus be more destructive to human tissue, hence the exposure to radon decay products of ²²²Rn and risks [7,8]. In addition to what the offer is part of the annual effective equivalent dose to people in WHO's (The World Health Organization) estimated up to 2 mSv/year with radioactive background unusual environment comes from human inhalation of radon ²²²Rn at a rate of 0.8 mSv/year [9].

The current research aims to measure and study the radon concentration in the drinking water for drinking in differ-

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ent regions of the city of Baghdad: Amil district, Aljamaa district, Almwasalat district, Palestine street, Alkharijeaa district and Shuhada district (as shown in the following table) to be noticed to radon as a source of danger to people's health because of the breadth it spreads in the soil, building materials and groundwater, as well as not without water removing water networks in some areas of this gas.

Coordinates of sampling sites (GPS).

Site	N	E	Height above sea level (m)
Amil district	33°33'38"	44°27'39"	36
Aljamaa district	33°46'01"	44°13'05"	38
Alkharijeaa district	33°37'32"	44°15'26"	37
Almwasalat district	33°23'44"	44°91'20"	37
Shuhada district	33°11'52"	44°63'32"	33
Palestine street district	33°03'47"	44°53'52"	38

2 Measurement Methods

Five bottles of half a liter of water were taken from the water distribution system in the studied area. The samples were placed in can technique with CR-39-type track detectors with 200 μm thickness and dimensions of 1 cm \times 1 cm. Dosimeters are shown in Fig. 1 after an exposure time of 50 days; the dosimeters were collected and chemically etched (6.25N NaOH at 80 $^{\circ}\text{C}$ over 4 h period) [10]. To account the number of tracks/cm² occurred in each detector, an optical microscope with a magnification of 40 \times was used with CCD camera (charge coupled device) Fig. 2.

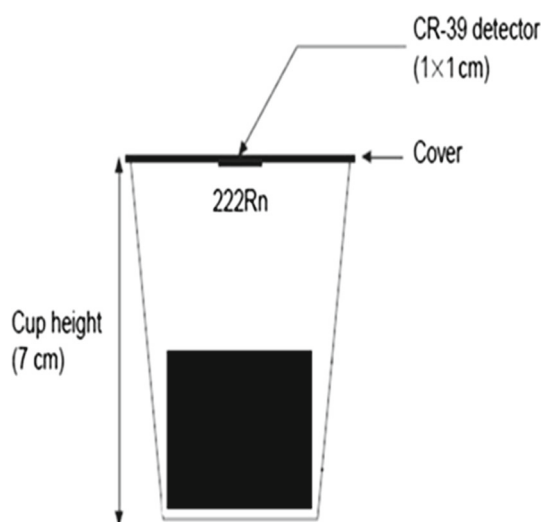


Fig. 1 Schematic diagram showing the geometry of radon dosimeter used in the study

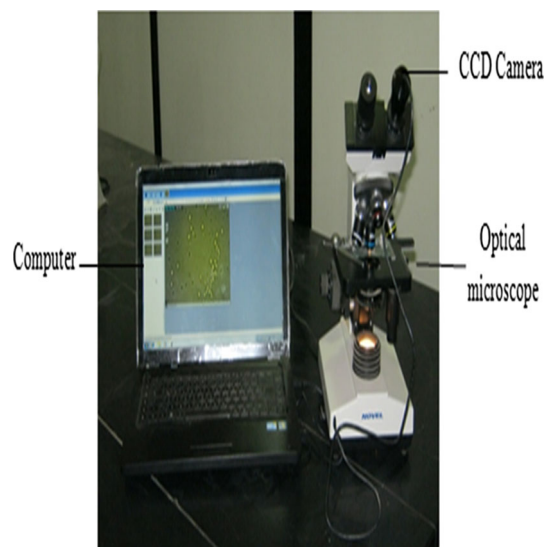


Fig. 2 The track counting system

3 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].

$$\rho = xA \quad (1)$$

where ρ is the number of tracks per cm², x is a constant with dimension of length (cm/Bq), A is the alpha activity per unit volume (disintegrations per unit time per cm³).

The value of the constant x is the sum of separate constants calculated for all isotopes (²²²Rn, ²¹⁸Po and ²¹⁴Po). 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/mm²; 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/mm²) recorded on the detector, K_i (0.004) the average value of the calibration factor of ²²²Rn in (Bq day m⁻³) per (tracks/mm²) and T exposure time (50 day) has been applied to determine the activity of ²²²Rn concentration (C_{Rn}) in Bq/m³ using the following equation [12]:

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



Table 1 Radon concentration, CEEC, WL, Eff, ECR, excess lung cancer per million person per year and E_x rate for water samples

Sample	Track average	Density (track/cm ²)	C_{Rn} (Bq/m ³)	F	CEEC (Bq/m ³)	WL	Eff. (mSv/year)	ECR	Excess lung cancer per million persons per year	E_x rate (Bq/m ² h)
Amil district	122	67.8	336	0.4	134.4	0.036	8.48	0.005	5000	0.038
Aljamaa district	260	144.4	716.3	0.4	286.5	0.077	18.07	0.01	10,000	0.08
Almwasalat district	112	62.2	308.5	0.4	123.4	0.033	7.78	0.0047	4700	0.035
Palestine street	130	72.2	358.1	0.4	143.3	0.039	9.035	0.0054	5400	0.04
AlKharijeaa district	180	100	495.9	0.4	198.4	0.054	12.51	0.0075	7500	0.06
Shuhada district	320	178	881.6	0.4	352.6	0.095	22.24	0.0133	13,300	0.1
Average	187.3	104.1	516.1		206.4	0.056	13.02	0.008	7650	0.058

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/m³), 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].

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

$$Eff. = GC_{Rn} \quad (4)$$

where G is a constant 0.4 (conversion factor).

In this study measurement of indoor radon concentration (C_{Rn}), potential alpha energy concentration (PAEC) and annual effective dose (Eff.) has been taken. The potential alpha energy concentration (WL) was calculated using Eq. (3); annual effective dose equivalent has been calculated using Eq. (4). Exhalation rate was also calculated using the following equation [11]:

$$E_x = \frac{C_t \lambda V}{S [t - 1/\lambda (1 - e^{-\lambda t})]} \quad (5)$$

where E_x is radon exhalation rate (mBq/m² h), C_t is mean radon concentration as measured by CR-39 detector (Bq/m³), V is volume of the can (m³), t is the exposure time, λ is the radon decay constant and S is the surface area from which radon is exhaled into the closed can.

4 Results and Discussion

The overall results for radon concentrations in Bq/m³, radon exhalation rates in Bq/m² h, the equilibrium equivalent ²²²Rn concentration (CEEC in Bq/m³), and the annual effective dose E_{ff} (in mSv/year) for six drinking water samples from six region in Baghdad city are given in Table 1. The water samples were taken from the water pipes that reach the houses. 100ml from each type of water was taken was put in a plastic cup, and then the plastic detector (CR-39) was fixed in the bottom of the cover 5cm above the surface of the sample as shown in Fig. 1; three samples for each type of water were used, and the average was taken.

The overall average value of the activity concentrations of ²²²Rn for drinking water samples was 516.1 Bq/m³. The maximum concentration of ²²²Rn was 881.6 Bq/m³ appeared in Shuhada district sample, and the minimum concentration was 308.5 Bq/m³ in Almwasalat district sample. The calculated CEEC values showed that the maximum value was 352.6 Bq/m³ in Shuhada district sample, and the minimum value was 123.4 Bq/m³ in Almwasalat district sample. The overall average value of CEEC for ²²²Rn was 206.4 Bq/m³, and this showed that the concentration of radon emitted from the samples does not depend on ²²⁶Ra concentration only. The overall average value of the annual effective dose E_{ff} obtained for drinking water samples set was 13.02 mSv/year, while the maximum value was 22.24 mSv/year in Shuhada district sample, and the minimum value was 7.78 mSv/year in Almwasalat district sample. Figure 3 shows the relationships between E_{ff} in mSv/year and radon concentration Bq/kg. From this figure, one can note that the relationships are linearly increasing, and useful fitting equations can be deduced;

$$Eff. = 0.0252 * C_{Rn} (Bq/m^3) \quad (6)$$

The overall average value of excess lung cancer per million persons per year (ELC) for the full drinking water samples set



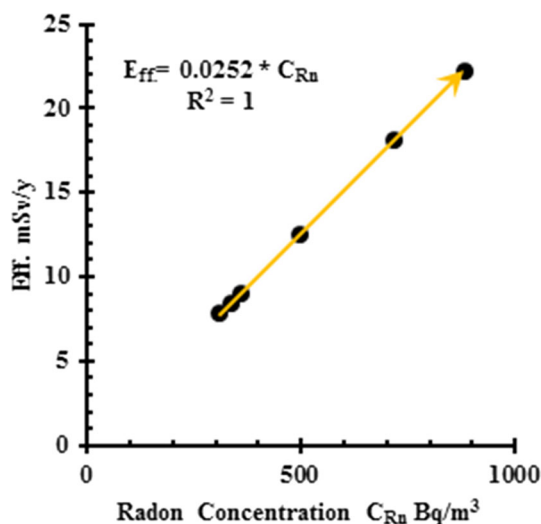


Fig. 3 Eff. as a function of radon concentration Bq/m³

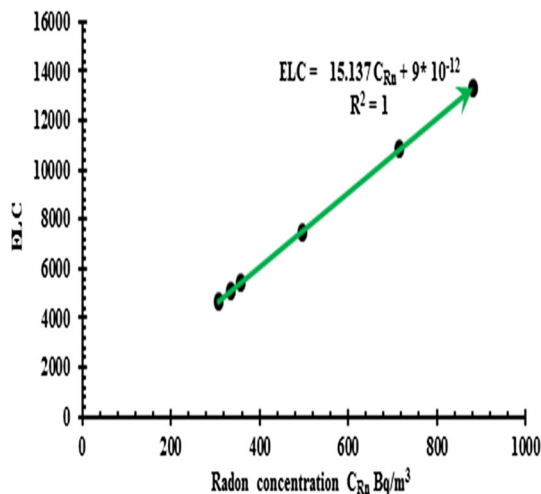


Fig. 4 The relation between ELC and radon concentration C_{Rn} (Bq/m³)

was 7650. The highest value was 13,300 in Shuhada district sample, and the minimum value was 4700 in Almwassalat district sample. Additionally, this disparity in the values is due to differences of the nature of drinking water samples. Figure 4 shows the relationship between ELC and radon concentration Bq/m³. From this figure, the following equation is good fitting equation:

$$ELC = 15.137C_{Rn} \text{ (Bq/m}^3\text{)} + 9 \times 10^{-12} \quad (7)$$

These sites were randomly selected and represent areas with moderate population density. Most of the population receives drinking water at a rate of 2 l per day from the water distribution network in Baghdad governorate.

This study is part of a series of environmental assessment studies in Baghdad Governorate [2,16,17].

5 Conclusions

The radon concentration values obtained was varied within the studied drinking water samples in different region in Baghdad city. The recorded values of radon concentration were greater than these values in Wassit governorate (0.82 Bq/L) [15], greater than their values in the University of Baghdad, Jadiriya site 46.227 Bq/m³ [16] and greater than the standard limits. A linear relationship has been traced between the annual effective dose and the measured radon concentrations.

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