Evaluation of environmental radioactive contamination of radon gas in Karrada homes in Baghdad Governorate, Iraq

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Abstract. The analysis addressed the study of radon contamination collection in dwellings located at Karada, Baghdad. The outcomes revealed that the concentration of radon varied from 17.324 to 45.00 Bq/m3 with an average value of 26.8432 ± 2.216 Bq/m3. AED results were observed to vary from 0.001 mSv/year to 0.847 mSv/year having an average value of 0.2352 ± 0.0647 mSv/year, where potential alpha energy concentrations ranged from 0.26 mWL to 0.93 mWL with a mean value of 0.4179 ± 0.057 mWL and radon daughter exposure ranged from 0.13 mWLM/Y to 0.44 mWLM/Y having a mean value of 0.4943 ± 0.111 mWLM/Y.Based on our findings we can conclude that, as anticipated, most indoor values are well below the US EPA limit of 148 Bq/m3

1 Introduction

Radon is a natural radioactive gas that is formed when the element uranium-238 (U-238) decays. It is present in small quantities all around us, but can only be measured using specialized detectors. Uranium-238 is found in low levels in soil and rocks; it decays over time into other elements such as radium and eventually radon. Radium sometimes moves to the earth's surface from where it can enter the air while at other times it remains deep underground and can seep into water bodies [1, 2]. Radon is one of the radioactive isotopes that causes background radiation and is very dangerous to human health. It is the source of approximately 55% of the annual radiation dose received by humans [3]. Alpha particles have a hard time traveling very far because they are so heavy. It cannot pass through our skin, but it can enter our lungs if we inhale it. The accumulation of energy in the lungs is highly focal which can make you more prone to lung cancer: radon comes from rocks and soil [3]. Radon is odorless, colorless, and tasteless: it's a radioactive gas. Unlike other man-made environmental hazards, radon is naturally occurring and presents unique challenges indoors [4]. Understanding the properties of radon is essential to develop effective mitigation strategies as well as protecting residents from potential health risks due to long-term exposure, efforts such as raising awareness about radon health effects... are undertaken at the community level. Recognizing risks of radon in your home and implementing a mitigation system... these are important steps towards protecting your

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indoor environment (and interested parties) ... Research has shown that the concentration of radon gas in residential buildings depends on geological conditions... meteorological conditions, building materials and ventilation systems amongst others [6]. Buildings in the study area are constructed using various materials such as cement, concrete, clay, brick, granite, etc., which makes it highly challenging to determine the presence of radon activity. Moreover, the indoor concentration levels vary significantly across countries due to climatic parameters, underground geology and architectural characteristics differing based on geographical location. For instance: a study conducted on houses in Baghdad revealed unique features like Qaradar province being an Iraqi region with high incidence rates of radon exposure as well as environmental importance. An urgent problem is also brought up from that study area — through which possible risk factors can be identified without difficulty: lack of standard methods for assessment; low awareness among the public; absence of government regulations or laws demanding action by homeowners or constructors. This article aims to evaluate radon levels at home by discussing assessment techniques and factors that affect radon, as well as the standards of other countries based on it and the health effects due to exposure.

2 Materials and Methods

Fifteen households were surveyed for this study. Each room has one or two windows. The houses are either one-story or two-story. Each house has at least two rooms. In each selected house, dosimeters were installed in the bedrooms. Dosimeters are used in two-story houses. They were housed in a bedroom on the first floor. All residences checked were found to be single or two family homes. The dosimeters were placed in the ground floor bedrooms with each detector at head height for three months during November 2024 to January 2024 to test for radon. In this work we used detectors made by TASL (Track Analysis Systems Ltd, Bristol, UK). They are PADC Tastrak detectors with dimensions of 1.0 cm x 1.0 cm x 0.5 cm and are mounted on a wall using an arm that comes with a plastic box housing the CR-39 detector itself (10 cm high, 9 cm wide) as shown in figure 1 because squares are simple geometry figures: after 90 days these devices were removed from Karada houses located in different cities — and then chemically etched so tracks on them could be observed under a digital optical microscope named MICROS Crocus II MCX100LCD produced by MICROS Production, Vienna, Austria.The average correction factor K for the trace count was found to be equal to 0.00346 [Bq/m^{3}day/trace/m^2]. This represents typical sensitivity of CR- 39 detectors per unit area.

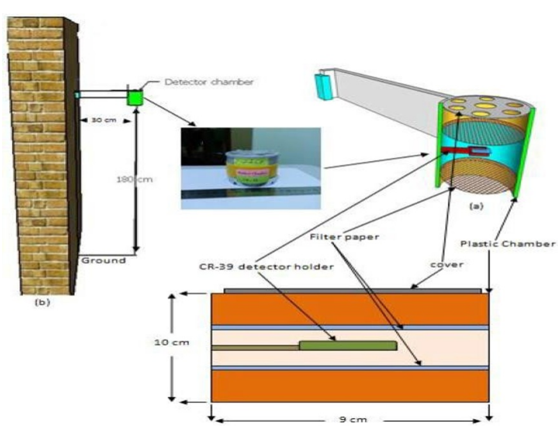

Fig. 1. The method of measurement used in this study (a) the shape of the radon room and (b) where the detectors were installed in the house [8]

2.1 Calibration of CR-39 detectors

Four detectors are laid in an area to a radium 226Ra of known activity which is solid source of radon gas. Radium produces radon gas using this formula: one gram of radium-226 produces 0.000 L ml of radon gas per day [8]. The period of exposure is marked by their subsequent chemical etching and K, the calibration standard for trace density as determined by the total exposure to radon sources. Calculate the average number of traces per cm2 from a simple statement that 'K was determined by dividing trace density by total exposure to radon source'. These two quantities depend on how much information each detected particle leaves behind after the etching process; these detectors have values between 10−4 cm^2 and 1 cm^2.

3 Theatrical Equations

The following formulas were used to calculate radon gas concentrations in the air of [11]:

$$C(Bq/m3)=\boldsymbol{\rho} \tag{1}$$

where, ρ is the track density on CR-39 detector surface which can be measured in tracks per square centimeter, [11],

The annual effective dose (AED) can be obtained in terms of mSv / y for all detectors whether closed or open dosimeters using relationship [12]

$$AED\ (m\ Sv/y) = C \times F \times H \times T \times D \tag{2}$$

Where; C: is the concentration of radon in both closed and open dosimeters. H is the percentage of occupied homes that is equal to (0.8) and (T) is the annual time in hours, T=7860 h/y, D is the dose conversion factor that is equal to [9×10-6 (m Sv) / (Bq.h.m-3)].

Potential Alpha Energy Concentration (PAEC) was obtained using the relation [20]:

$$PAEC\ (WL) = F \times C / 3700 \tag{3}$$

Exposure to radon progeny is related by following expression) [11]

$$EP\ (WLM\ Y^{-1}) = T\times H \times F \times C / 170 \times 3700 \tag{4}$$

Where (170): is the number of hours per working month

The lung cancer cases per year per million person (CPPP), was obtained using the relation [14]

$$(CPPP) = AED \times (18\times10^{-6}\ /mSv.y^{-1}) \tag{5}$$

4 Results and Discussion

Table 1. Results of C (Bq/m^3), AED (mSv/y), PAEC(mWL), CPPP/10^6

No. home	**C (Bq/m^3)**	**AED mSv/y**	**PAEC mWL**	**EP mWLMY^{-1}**
1	30.121	0.258	0.61	0.23
2	26.582	0.133	0.42	0.21
3	30.265	0.847	0.53	0.12
4	22.918	0.321	0.57	0.11
5	31.822	0.789	0.20	0.34

6	14.641	0.159	0.23	0.74
7	21.741	0.367	0.39	0.26
8	19.324	0.001	0.54	0.13
9	21.705	0.20	0.72	0.45
10	44.633	0.145	0.33	0.28
11	26.170	0.022	0.20	0.10
12	17.324	0.055	0.38	0.44
13	45.003	0.114	0.26	0.36
14	20.634	0.083	0.93	0.75
15	29.765	0.034	0.15	0.63
average	26.8432 ±2.216	0.2352 ±0.0647	0.4179 ±0.057	0.4943 ±0.111

Table (1) presents the findings. The radon concentration ranged from 17.324 to 45,000 Bq/m3 with an average value of 26.8432 ±2.216 Bq/m3 (Figure 2). Meanwhile, AED results varied between 0.001 mSv/year and 0.847 mSv/year averaging at 0.2352 ± 0.0647 mSv/year (Figure 3). The potential alpha energy concentration ranged from 0.26 mWL to 0.93 mWL; average value being 0.4179 ± 0.057 mWL (Figure 4). Radon daughter exposure spanned from 0.13 mWLM/Y to 0.44 mWLM/Y; average value was at .4943 ± .111, also shown on Figure number three with a different parameter scale for comparison.It is important to note that differences in city-wise concentrations are due to meteorological and geological conditions, lifestyle and building materials among others mentioned earlier in addition not exceeding international limits for radon or any other parameter as discussed previously based on the figure legends indicated by numbers inside circles placed around them this means they have varying permissible levels based on differing units used throughout each measure taken into consideration so make sure you refer back.

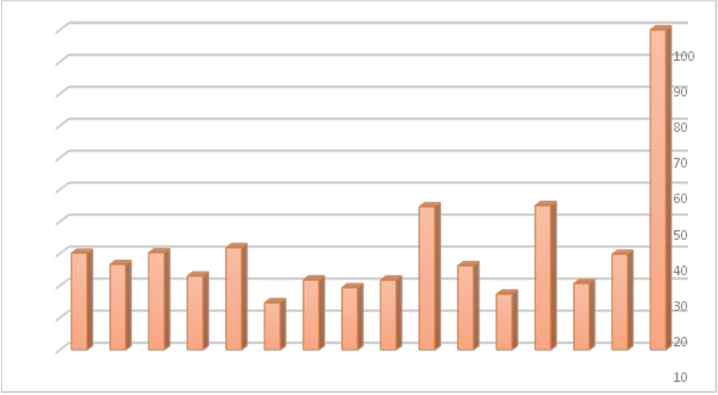

Fig. 2. Comparison of the results of the radon concentrations with the world average.

https://doi.org/10.1051/bioconf/202414002011

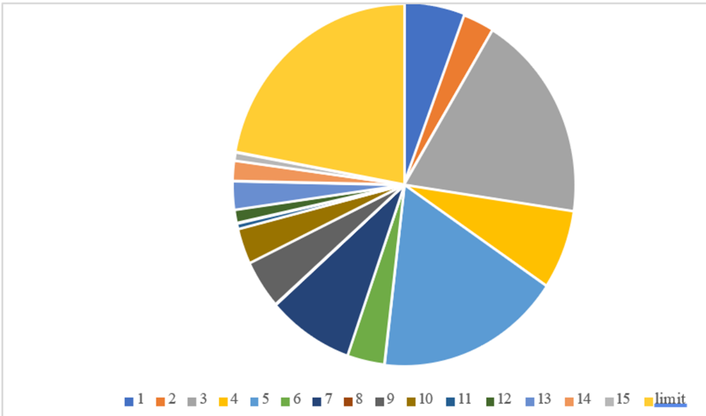

Fig. 3. Comparison of the results of the AED (mSv/y) with the world average

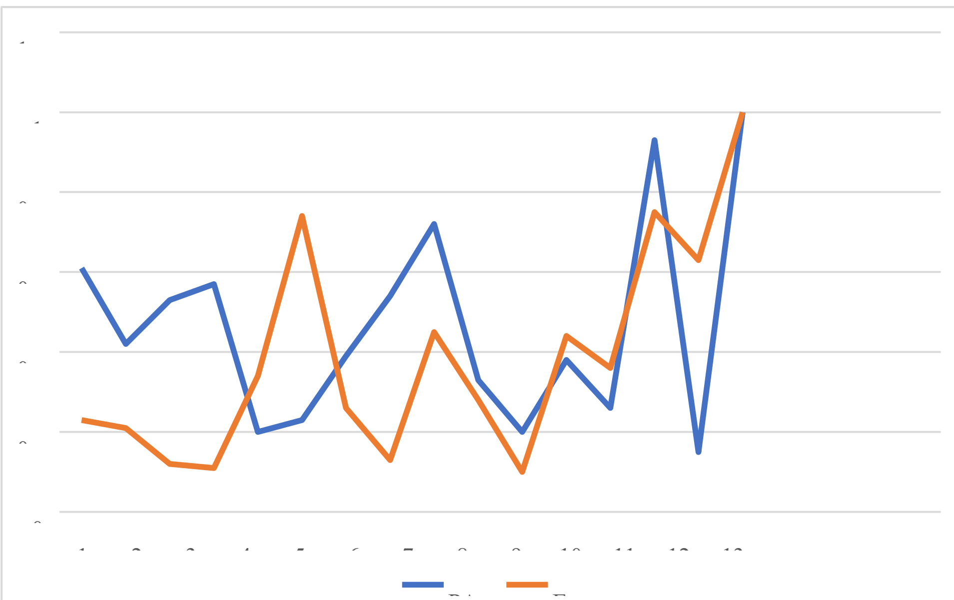

Fig. 4. Comparison of the results of the PAEC(mWL),CPPP/10^6 with the world average

5 Conclusion

Given our results, it appears that the majority of indoor radon levels are significantly lower than the US EPA's action level of 148 Bq/m3. Most estimates fall within normal risk levels, although remember that smoking significantly raises your risk for radon-induced lung cancer. The findings imply a call for more focus on radon exposure and its health effects; take note to ensure public health in efforts to mitigate cancer rates as well.

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