Measurements of Indoor Radon-222 Concentration inside Iraqi Kurdistan: Case Study in the Summer Season

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Abstract

Exposure to natural sources of radiation, especially 222Rn and its short-lived daughter products has become an important issue throughout the world because sustained exposure of humans to indoor radon may cause lung cancer. Therefore, indoor radon concentration levels have been measured inside 8 government hospitals in three main regions (Erbil, Duhok and Sulaymaniya) in Iraqi Kurdistan region during summer season by using CR-39 nuclear track detector. The CR-39 detectors were placed in the all hospitals for three floors (ground, first and second). The highest average radon concentration value and annual effective dose was found to be in the Shaheed Dr. Aso hospital in Sulaymaniya city (52.89 ± 3.52 Bq. m⁻³, 1.37 ± 0.09 mSv/y) respectively and the lowest was found in the Erbil Teaching hospital in Erbil city (30.15 ± 2.85 Bq. m⁻³, 0.81 mSv/y) respectively. This depended on the geological formation, type of building material, and the floor level. Therefore, the results showed that the average radon concentration and annual effective dose decreases gradually as the floor level increases. The highest and lowest of annual effective dose was found in ground and second floor, respectively. Thus, according to the annual exposure dose data, the workers are safety in most of the hospitals.

Keywords: CR-39NTDs; Indoor radon; Lung cancer; The hospitals

Introduction

Radon (222Rn) is a radioactive noble gas emitted by the decay of 226Ra, an element of the 238U decay series. Radon-222 decays into a series of other radioactive elements, of which 214Po and 218Po are the most significant, as they contribute the majority of radiation dose when inhaled. Following a number of decay series, 210Po transforms into 210Pb and it decays into stable 206Pb. The 222Rn and its decay products are reported as major causes of lung cancer [1,2]. Assessment of health effects due to exposure to ionizing radiation from natural sources requires knowledge of its distribution in the environment. The estimated global average annual dose of the population receiving natural radiation equals 2.4 mSv [3]. It is well established that the inhalation of radon (222Rn) and mainly its radioactive decay products, contributes more than 50% of the total radiation dose to the world population from natural sources [4].

222Rn is an alpha emitter that decays with a half-life of 3.8 days into a short-lived series of progeny. A certain fraction of radon progeny may attach to aerosol particles. By inhalation, these particles may be deposited in lungs thereby exposing sensitive tissues with alpha radiation. Consequently, it may lead to lung cancer and has been identified to be the second leading cause of lung cancer [5,6]. In the United States of America, radon alone is reported to be responsible for ~15,000-20,000 lung cancer deaths per year [7]. The risk is reported to be proportional to the radon level down to EPA’s action level of 4 pCi l⁻¹ and probably below this level [7,8]. Therefore, in the present study, beside of measure indoor radon concentration, we have measure most of important that related to estimate a risks of inhalation of radon gas by the workers inside the hospitals. Potential alpha energy concentration, equilibrium factor between radon and its daughter, and the annual effective dose considered important parameters. As well as, and to find variation in radon concentration for three floors ground, first, and second.

Material and Methods

Region surveyed

Iraqi Kurdistan region include three main Governorates Erbil, Sulaymaniya and Duhok and these areas are different from each other by their geographical location and geological formation figure 1. The regions to be surveyed for 222Rn decay product concentrations were selected from a study of appropriate radiological and geological information. The characteristics for those hospitals building materials in general with clay bricks, limestone bricks and cement bricks, with a concrete and iron structure. The walls of the dwelling are often covered with gypsum and several of these materials are expected to contribute significantly to sources of indoor radon.

Passive radon dosimeter

This is a closed chamber into which radon diffuses. The plastic cup has dimensions of 6 cm diameter and 7 cm high is show in figure 2 [6]. The technique used in this survey is based on (CR-39) nuclear track detectors (NTDs). Page Moulding, UK, manufactures the detectors. The NTD has an area of 1.5 cm² which is fixed by double-stick tape at the bottom of the dosimeter. In the cover there is a hole covered with a 5 mm thick soft sponge. The design of the chamber ensures that all aerosols and radon decay products are deposited on the soft sponge

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Distribution of radon dosimeters

The dosimeters have been distributed inside 8 Government hospitals in Iraqi Kurdistan. The dosimeters installed on top about 2 m and for three floors in each hospital. Thus, the total dosimeters were 400 dosimeters. After an exposure time of 90 days, the detectors were collected and chemically etched using 6N NaOH at 70 ± 0.1°C for 10 h. The counting of alpha damage tracks was done using an optical microscope with a magnification of 400X. The correction was applied for the background alpha tracks in CR-39 plastic by subtracting the number of tracks observed in the unexposed detector. The number of tracks counted per unit area is proportional to the indoor radon concentration (Bq. m$^{-3}$) and the exposure time.

Calculation of annual effective dose

The effective dose ($H_e$) (mSv/Y) to the personal work of the hospitals was calculated from the following formula according [9]:

$$H_e = C \times F \times O \times T \times D$$  \hspace{1cm} (1)

Where $C$ is the radon concentration in Bq. m$^{-3}$, $F$ equilibrium factor, $O$ for occupancy factor (0.8), $T$ for time (8760 h. y$^{-1}$) and $D$ for dose conversion factor ($9 \times 10^{-6}$ mSv. h$^{-1}$ (Bq. m$^{-3}$)$^{-1}$) [9].

Results and Discussion

Average value of indoor radon concentration ($C_{in}$), potential alpha energy concentration (PAEC), equilibrium factor ($F$) and annual effective dose ($H_{e}$) inside 8 Iraqi Kurdistan hospitals summarized in table 1, figure 3 and figure 4 shows the distribution of radon concentration and annual effective dose inside the hospitals. The highest indoor radon concentration was found in Shahid Dr. Aso hospital in Sulaymaniya city (52.89 ± 3.52 Bq. m$^{-3}$). Lowest indoor radon concentration was found in Erbil Teaching hospital in Erbil city (30.15 ± 2.85 Bq. m$^{-3}$). $0.81$ mSv/y). This refer to the different building material, ventilation rate, and the geological formation. The geological formation of Erbil governorate different than the geological formation of Duhok and Sulaymaniya. More details about geological formation are listed in table 2 [10].

Table 3 shows the maximum and minimum radon concentration
and annual effective dose for each level. The highest average radon concentration and annual effective dose was found in ground floor in the Shaheed Dr. Aso hospital in Sulaymaniya city (54.70 ± 1.96 Bq. m⁻³, 1.43 ± 0.16 mSv/ y). The lowest was found in second floor in the Rizgary Teaching hospital in Erbil city (30.86 ± 2.05 Bq. m⁻³, 0.85 ± 0.03 mSv/ y), as shown in figure 5 and figure 6. Average indoor radon concentration decreases as the floor level increases, this due to the reduced effect of radon exhalations from the ground. This variation may be attributed to how close or how far the floor is from ground since soil represents the main source of indoor radon. In addition, many other reasons such as the fact that upper floors are better ventilated than lower floors that are exposed to dust and other forms of contaminations.

![Figure 5: Variation of radon concentration with floor levels in Shahid Aso Hospital.](image)

![Figure 6: Variation of Annual effective dose with floor levels in Shahid Dr. Aso Hospital.](image)

| City       | Hospital            | Equilibrium Factor (F) | PAEC (mwL) | Annual effective dose (mSv/ y) | Radon Concentration ( Bq.m⁻³) |
|------------|---------------------|------------------------|------------|-------------------------------|-------------------|
| Erbil      | Rizgary             | 0.431 ± 0.072          | 3.964 ± 0.92 | 0.925 ± 0.12                  | 34.03 ± 3.32      |
|            | Emergency west      | 0.462 ± 0.064          | 3.828 ± 0.58 | 0.893 ± 0.084                 | 31.34 ± 2.77      |
|            | Erbil Teaching      | 0.428 ± 0.048          | 3.487 ± 0.46 | 0.813 ± 0.088                 | 30.15 ± 2.85      |
|            | Maternity and teaching | 0.462 ± 0.084       | 3.607 ± 0.24 | 1.075 ± 0.11                  | 36.90 ± 3.12      |
| Duhok      | Azadi Teaching      | 0.555 ± 0.018          | 6.46 ± 0.78  | 1.5 ± 0.098                   | 43.12 ± 2.87      |
|            | Emergency Teaching  | 0.516 ± 0.008          | 5.82 ± 0.62  | 1.35 ± 0.11                   | 41.78 ± 2.27      |
| Sulaymaniya| Shahid Dr. Aso      | 0.411 ± 0.005          | 5.87 ± 0.88  | 1.37 ± 0.082                  | 52.89 ± 3.52      |
|            | Shorsh General      | 0.425 ± 0.004          | 5.65 ± 0.64  | 1.31 ± 0.16                   | 49.25 ± 2.22      |

Table 1: Radon Concentration, Equilibrium Factor, PAEC and annual effective dose inside hospitals in Iraqi Kurdistan Region.

| Regions      | Hospital            | Equilibrium Factor (F) | Building materials |
|--------------|---------------------|------------------------|-------------------|
| Erbil        | Region consists of the plains and hills. It consists of sandstone, limestone and shale | clay brick, cement concrete, gypsum and gypsum board |
|              | Rizgary             |                        |                   |
|              | Emergency west      |                        |                   |
|              | Erbil Teaching      |                        |                   |
|              | Paediatric          |                        |                   |
| Duhok        | Region consists of the plains, sediment logical and mountains. It consists of marly limestone, calcarcite shale, sand, limestone and conglomerate | clay brick limestone bricks , cement gypsum and gypsum board |
|              | Azadi Teaching      |                        |                   |
|              | Emergency Teaching  |                        |                   |
| Sulaymaniya  | Region consists of the Rocky Mountains and valleys. It consists of rocks, limestone, conglomerate, biogenic limestone, pebbly, calcarcite and sandstone | clay brick limestone bricks , cement concrete, gypsum and gypsum board |
|              | Shahid Dr. Aso      |                        |                   |
|              | Shorsh General      |                        |                   |

Table 2: Geological formation of Iraqi Kurdistan region as related to the case study.

| Hospitals       | Levels | Radon Concentration (Bq.m⁻³) | Annual effective dose (mSv/ y) |
|----------------|-------|-------------------------------|------------------------------|
|                 |       | Min   | Max   | Average | Min   | Max   | Average |
| Rizgary (Erbil) | Ground | 35.21 ± 0.16 | 39.80 ± 0.48 | 37.5 ± 2.29 | 0.94 ± 0.018 | 1.08 ± 0.038 | 1.01 ± 0.07 |
|                 | First  | 30.86 ± 0.36 | 36.62 ± 0.32 | 33.74 ± 2.88 | 0.92 ± 0.025 | 0.96 ± 0.028 | 0.94 ± 0.02 |
|                 | Second | 28.81 ± 0.42 | 32.92 ± 0.65 | 30.86 ± 2.05 | 0.62 ± 0.022 | 0.88 ± 0.033 | 0.85 ± 0.03 |
| Azadi Teaching (Duhok) | Ground | 43.92 ± 0.38 | 48.11 ± 0.48 | 46.01 ± 2.09 | 1.25 ± 0.016 | 1.35 ± 0.024 | 1.30 ± 0.05 |
|                 | First  | 41.06 ± 0.57 | 45.18 ± 0.64 | 43.12 ± 2.06 | 1.16 ± 0.018 | 1.32 ± 0.018 | 1.24 ± 0.085 |
|                 | Second | 37.25 ± 0.54 | 43.22 ± 0.46 | 40.23 ± 2.98 | 1.17 ± 0.048 | 1.25 ± 0.026 | 1.21 ± 0.04 |
| Shahid Dr. Aso (Sulaymaniya) | Ground | 52.83 ± 0.26 | 56.75 ± 0.26 | 54.79 ± 1.96 | 1.34 ± 0.024 | 1.52 ± 0.445 | 1.43 ± 0.09 |
|                 | First  | 49.22 ± 0.27 | 54.58 ± 0.36 | 51.9 ± 2.68  | 1.27 ± 0.032 | 1.38 ± 0.028 | 1.32 ± 0.055 |
|                 | Second | 47.56 ± 0.18 | 52.38 ± 0.22 | 49.97 ± 2.41 | 1.22 ± 0.016 | 1.38 ± 0.016 | 1.30 ± 0.08 |

Table 3: Indoor radon concentration and Annual effective dose for different floors in inside hospitals in Iraqi Kurdistan Region.
Conclusion

Indoor radon concentrations have been measured inside 8 government hospitals in Iraqi Kurdistan region in summer season. Floor levels and geological formation of the Iraqi Kurdistan hospitals affect on the concentrations of indoor radon and its progeny. Locations of the selected hospitals had different geological formation and located in three main governorates: Erbil, Duhok and Sulaymaniya. The highest average radon concentration value and annual effective dose was found to be in the Shaheed Dr. Aso hospital in Sulaymaniya city (52.89 ± 3.52 Bq. m\(^{-3}\), 1.37 ± 0.09 mSv/Y). The lowest was found in the Erbil Teaching hospital in Erbil city (30.15 ± 2.85 Bq. m\(^{-3}\), 0.81 mSv/Y). The average indoor radon concentration decreases as the floor level increases, the highest radon concentration and annual effective dose was found in the ground floor and lowest was found in the second floor level in addition to many other reasons such as the fact that upper floors are better ventilated than lower floors that.

References

1. International Commission on Radiological Protection (ICRP) (1987) Lung Cancer Risk from Indoor Exposure to Radon Daughters Oxford. ICRP Publication 50: 17.
2. International Commission on Radiological Protection ICRP (1984) Non-stochastic Effects of Irradiation. ICRP Publication.
3. Ismail AH, Jaafar MS (2011) Interaction of low-intensity nuclear radiation dose with the human blood: using the new technique of CR-39NTDs for an in vitro study. Appl Radiat Isot 69: 559-566.
4. Ismail AH, Jaafar MS (2010) Indoor radon concentration and its health risks in selected locations in Iraqi Kurdistan using CR-39 NTDs. The 4th International conference on Bioinformatics and Biomedical Engineering (ICBBE 2010), 18-20 June, Chengdu-China.
5. Ismail AH, Jaafar MS (2010) Relationship between radon concentration, ventilation rate and male infertility: A Case study in Iraqi Kurdistan. Int J of Low Radiation 7: 175-187.
6. Ismail AH, Jaafar MS (2011) Design and construct optimum dosimeter to detect airborne radon and thoron gas: Experimental study. Nuclear Instruments and Methods in Physics Research B 269: 437-439.
7. Bochicchio F (2005) Radon epidemiology and nuclear track detectors: methods, results and perspectives. Radiat Meas 40: 177-190.
8. Somlai J, Széler G, Szabó P (2009) Radiation dose of workers originating from radon in the show cave of Tapolca, Hungary. Journal of Radioanalytical and Nuclear Chemistry 279: 219-225.
9. UNSCEAR (2000) Sources and Effects of Ionizing Radiation. Report to the General Assembly with Scientific Annexes. (Volume I), United Nations Scientific Committee on the Effects of Atomic Radiation, United Nations, New York.
10. Kamal HK, Ali MS (2004) Geological formation in Iraqi Kurdistan. Kurdistan Academicians Journal 4: 19-39.