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

Zakariya A Hussein[1]*, Mohamad S Jaafar[1] and Asaad H Ismail[2]

[1]Radiation and Medical Physics, School of Physics, Universiti Sains Malaysia, 11800, Pulau Penang, Malaysia
[2]Medical Physics, Physics Department, Education College, Salahaddin University-Erbil, 44002, Iraqi Kurdistan, Iraq

Abstract

Exposure to natural sources of radiation, especially ^{222}Rn 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 (^{222}Rn) is a radioactive noble gas emitted by the decay of ^{226}Ra, an element of the ^{238}U decay series. Radon-222 decays into a series of other radioactive elements, of which ^{214}Po and ^{218}Po are the most significant, as they contribute the majority of radiation dose when inhaled. Following a number of decay series, ^{218}Po transforms into ^{210}Po and it decays into stable ^{206}Pb. The ^{222}Rn 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 (^{222}Rn) and mainly its radioactive decay products, contributes more than 50% of the total radiation dose to the world population from natural sources [4].

^{222}Rn 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 ^{222}Rn 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 1.5×1.5 cm^2 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

***Corresponding author:** Zakariya A Hussein, Radiation and Medical Physics, School of Physics, Universiti Sains Malaysia, 11800, Pulau Penang, Malaysia, E-mail: zekishtayin@yahoo.com

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Figure 1: Sketch Map of the area under study (Kurdistan Region).

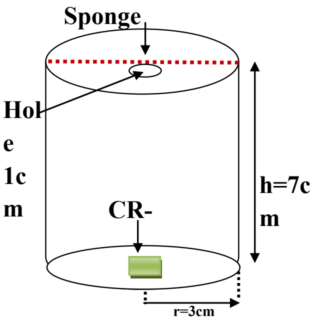

Figure 2: Schematic diagram of the optimum Radon.

from the outside and that only radon gas, among other constituents, diffuses through it to the sensitive volume of the chamber. The design of the chamber ensures that the aerosol particles and radon decay products are deposited on the sponge from outside and only radon, among other gases, diffuses through it to the sensitive volume of the chamber. The calibration process for the dosimeter of this type and dimension was done by Ismail and Jaafar [7].

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]:

$$H_E = C \times F \times O \times T \times D \quad (1)$$

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 (9×10^{-6} mSv. h^{-1} (Bq. m^{-3})$^{-1}$) [9].

Results and Discussion

Average value of indoor radon concentration (C_{Rn}), 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

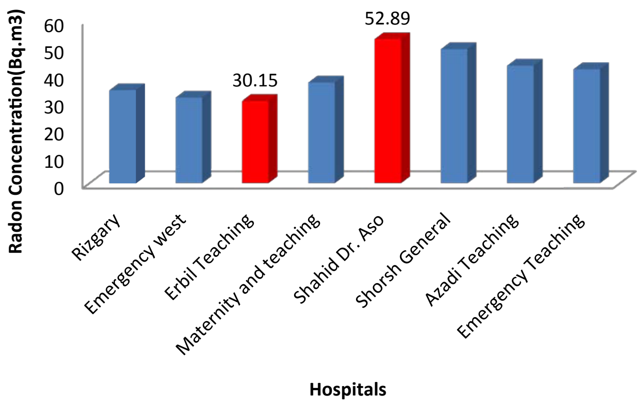

Figure 3: Distribution of Radon Concentration Inside Government Hospitals in Iraqi Kurdistan.

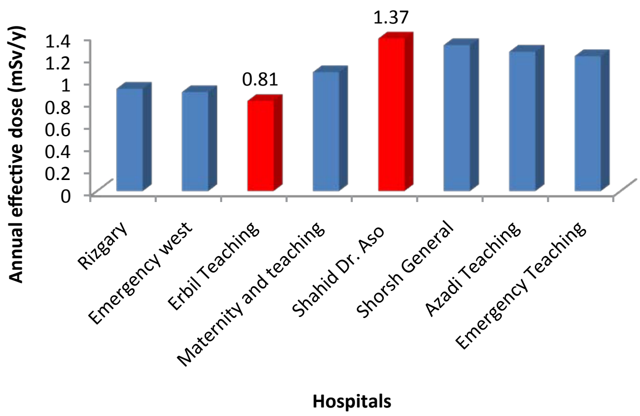

Figure 4: Distribution of Annual Effect Dose Inside Government Hospitals in Iraqi Kurdistan.

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 ± 0.09 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.

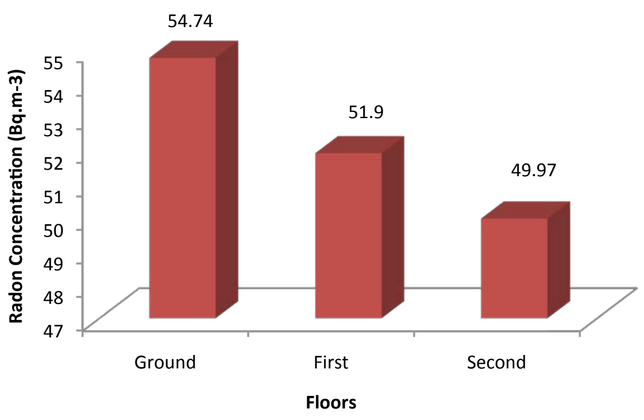

Figure 5: Variation of radon concentration with floor levels in Shahid Aso Hospital.

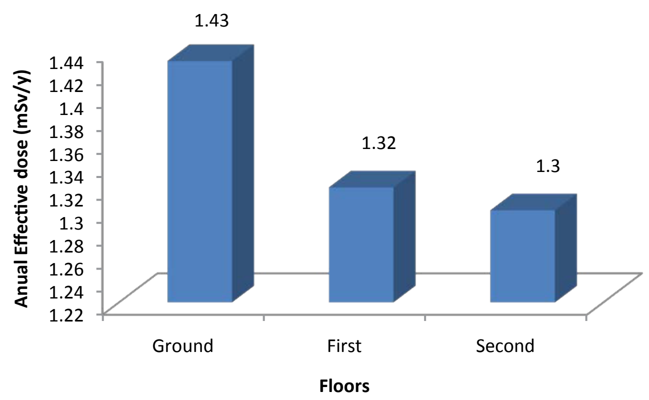

Figure 6: Variation of Annual effective dose with floor levels in Shahid Dr. Aso Hospital.

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	0.452 ± 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 ± 0.092	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	Rizgary	Region consists of the plains and hills. It consists of sandstone, limestone and shale	clay brick, cement concrete, gypsum and gypsum board
	Emergency west		
	Erbil Teaching		
	Paediatric		
Duhok	Azadi Teaching	Region consists of the plains, sediment logical and mountains. It consists of marly limestone, calcarenite shale, sand, limestone and conglomerate	clay brick limestone bricks , cement gypsum and gypsum board
	Emergency Teaching		
Sulaymaniya	Shahid Dr. Aso	Region consists of the Rocky Mountains and valleys. It consists of rocks, limestone, conglomerate, biogenic limestone, pebbly, calcarenite and sandstone	clay brick limestone bricks , cement concrete, gypsum and gypsum board
	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	0.82 ± 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 (Sulaymany)	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.

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