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Impacts of Floor Levels and Geological Formation on the Concentrations of Indoor Radon and its Progeny of Iraqi Kurdistan Hospitals: Case Study in Spring Season

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ABSTRACT

An impact of floor levels and geological formation on the concentrations of indoor radon and its progeny studied inside 8 hospitals, and for three floor levels: ground, first and second. Locations of the selected hospitals had different geological formation and located in three main governorates: Erbil, Duhok and Sulaymaniya. Nuclear track detector type CR-39 (CR-39NTDs) used to measure track density of alpha particles that emitted from radon and its progeny. During spring season, 72 pair of exposure chambers (open-close chamber) equipped with 144 pieces of CR-39NTDs installed inside 24 rooms for three floors. After 90 day of exposure, exposed detectors etched in 6N NaOH at 70 ◦C for 10 h. The highest and lowest radon concentration was in the hospitals of Shaheed Aso (Sulaymaniya city: 71.09±4.32 Bq.m^{-3}) and Erbil Teaching (Erbil city : 48.02±3.77Bq.m^{-3}) .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. More details about the type of building materials of the hospitals are listed in full paper.

1. Introduction

Radon is a naturally occurring radioactive gas that originates from the decay of uranium. Due to its relatively longer half life of 3.82 days, the most concerned radon isotope is ^{222}Rn [1]. It is decay and produce a series of short lived particulate daughter products (^{218}Po, ^{214}Po, and ^{210}Po) . After inhalation, it may cause significant damage to the delicate inner cells of the bronchioles which may lead to the occurrence of lung cancer [1-2]. Deposition of the radon's daughter on the lung and trachea makes a risk of the carcinoma. Because radon's progeny produce by emitting a heavy particles (alpha particles) and this make a mutating of the DNA. And this refers to increase of the free radicals of the lung and trachea tissue [3].

Natural sources inherent to life on earth are considered to be major source of human exposure to ionizing radiation. Radon gas, gamma rays, cosmic (natural sources) radiations, and internal radiations constitute 2.4 mSv/y of the absorbed radiation dose. In addition, artificial and other sources contribute to 2.8 mSv/y [4-5] of the absorbed radiation dose. People may be exposed to external and internal radiations by inhalation and ingestion due to background radiations that exist in the environment. Radon exposure occupies 50% of the average annual dose contribution of population radiation exposure; thus, most of the risks are from the inhalation of radon gas[6].

The most significant characteristic of the radon-222 gas is the four short-lived progeny products from polonium-218 (^{218}Po) to polonium-214 (^{214}Po), which, shortly after their formation get attached themselves to aerosol particles. However, a small fraction of these particles remains in an unattached form, depending on the movement of the air mass, which in turn depends on the installed ventilation systems [7].

According to the last research of the risks of radon by Ismail & Jaafar [8], radon can be making an infertility of men. 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.

2. Material and Methods

Iraqi Kurdistan region consist of three main governorates; Erbil, Duhok and Sulaymaniya. These areas are different from each other geographical location is shown in Fig. 1. Passive radon dosimeter geometry is a closed-opened chamber into which radon diffuses, and it has been calibrated by Ismail and Jaafar [9]. The schematic diagram of the chamber is shown in Fig. 2. The technique used in this survey is based on CR-39NTDs (Moulding, UK, manufactures the detectors), it has 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 from the outside and that only radon gas. The design of the chamber ensures that the aerosol particles and radon decay

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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 dosimeters were distributed inside 8 government hospitals in three main regions (Erbil, Duhok and Sulaymaniya) in Iraqi Kurdistan region, in each hospital distributed on three floors (ground, first and second). Nuclear track detector type CR-39 (CR-39NTDs) used to measure track density of alpha particles that emitted from radon and its progeny. During spring season, 72 pair of exposure chambers (opened-closed chamber) equipped with 144 pieces of CR-39NTDs installed inside 24 rooms for three floors ; 3 rooms in each floor, on the top about 2m above the floor. After 90 day of exposure, exposed detectors etched in 6N NaOH at 70 ◦C for 10 h. The counting of alpha damage tracks was done using an optical microscope with a magnification of 400X was used.

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

Measurements of potential alpha energy concentration (PAEC) are necessary to estimate effective dose from ^{222} Rn progeny and its concentration in the present locations. PAEC be measure in terms of working level (WL) unit [10].

$WL=F\ C_{Rn} / 3700$………………………………… (1)

Where F is the equilibrium factors, which can be obtained from the following relation [11]

$F = a \exp (bD_O / D)$………………………………… (2)

D and D_O represents the track densities (track/cm^2. day) of the open (D: without filter) and closed (D_o: with a filter) – can technique respectively. The values of the two constant a and b are a =14.958 and b = -7.436.

C_{Rn} is the ^{222} Rn concentrations (Bq/m^3) which can be obtained by relation

$C_{Rn} = D_O / K$……………………………………… (3)

Where, K is the detector sensitivity (K = 0.23 track.cm^{-2} per Bq.m^3) obtained from the calibration experiment in the works of Ismail and Jaafar [9].

The effective dose (H in units' mSv/y) of radon and its progeny, can be calculate from the following relation [12].

$H= C \times F \times O\times T \times D$ ………………………….. (4)

Where C is the radon concentration in Bq.m$^{-3,}$ F equilibrium factor, O for occupancy factor (o.8 as taken in UNSCEAR 2000 report), T for time (8760 h.y^{-1}) and D for dose conversion factor (9 x 10^{-6} mSv.h^{-1} (Bq.m^{-3})$^{-1}$).

3- Results and discussion

The first part of this study involved measurement of indoor radon concentration (C_{Rn}), potential alpha energy concentration (PAEC), equilibrium factor (F) and annual effective dose (H) inside 8 government hospitals in Iraqi Kurdistan. Table (1) shows that the equilibrium factor (F) for each hospital different than other hospitals, because the ventilation rates are different. As well as, average of indoor radon concentration and annual effective dose for the hospitals of each governorate are different than other governorate. This is because the geological formation of Erbil government different than the geological formation of Duhok and Sulaiminia (they have a mountain region).

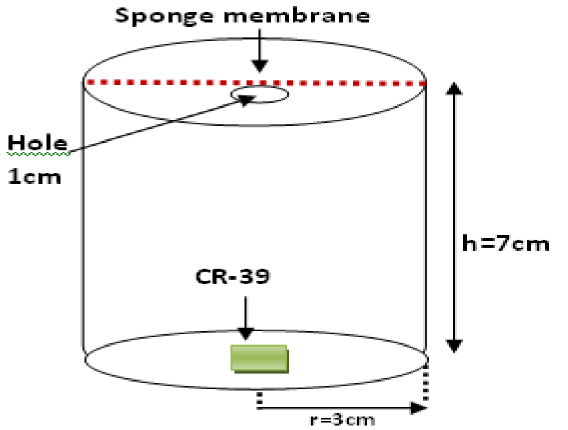

Fig.2: Schematic diagram of the optimum Radon [9]

Figure 3 shows the distribution of radon concentration inside 8 government hospitals in Iraqi Kurdistan region, the highest indoor radon concentration were found in Shahid Aso hospital in Sulaymaniya city (71.09±4.32 Bq.m^{-3}), and lowest indoor radon concentration were found in Erbil Teaching hospitals in Erbil city (48.02±3.77 Bq.m^{-3}), because these areas are different from each other by their geographical location and geological formation. On the other hand, Fig 4 shows a combination relation of annual effective dose and indoor radon concentration inside eight government hospitals.

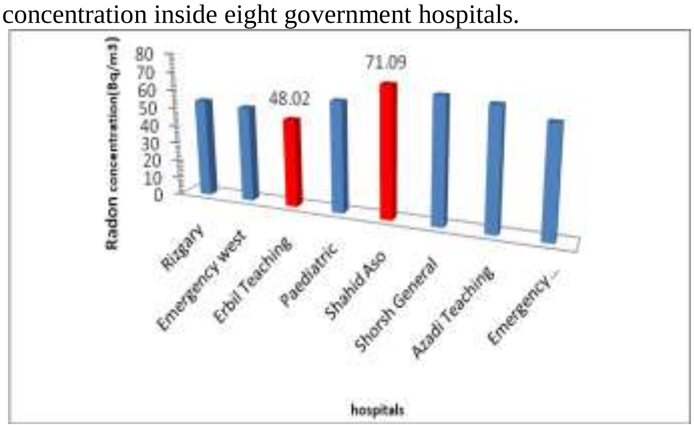

Fig. (3) Distribution of Radon Concentration Inside Government Hospitals in Iraqi Kurdistan

The second part of this study was to find an impact floor level of the hospitals on the concentration of indoor radon for each floor. Indoor radon concentration and annual effective dose for the floors of ground, first and second have been estimated, and the data are listed in Table 2.The highest indoor radon concentration and annual effective dose was found in ground floor and lower indoor radon concentration and annual effective dose in second floor, as shown in Fig.4

It is clear that the average indoor radon concentration decreases as the floor level increases and 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 to 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.

Table 1: Radon concentration, equilibrium factor, PAEC and annual effective dose inside hospitals of Iraqi Kurdistan Region

Regions	Hospital	Equilibrium Factor (F)	PAEC (mwL)	Annual effective dose (mSv/y)	Radon Concentration ($Bq.m^{-3}$)
Erbil	Rizgary	0.307±0.079	4.41±0.93	1.19±0.13	54.04±6.08
	Emergency west	0.311±0.077	4.34±0.83	1.16±0.07	52.3±4.39
	Erbil Teaching	0.360±0.01	4.66±0.36	1.1±0.08	48.02±3.77
	Paediatric	0.364±0.001	5.93±0.61	1.38±0.14	60.38±6.34
Duhok	Azadi Teaching	0.37±0.003	6.53±0.52	1.52±0.13	65.36±5.07
	Emergency Teaching	0.362±0.009	5.77±0.55	1.34±0.12	59.05±4.49
Sulaymaniya	Shahid Aso	0.368±0.005	7.06±0.32	1.64±0.07	71.09±4.32
	Shorsh General	0.364±0.002	6.65±0.42	1.54±0.09	67.56±4.05

Table 2: Indoor radon concentration and Annual effective dose for different floors in inside hospitals in Iraqi Kurdistan Region

Hospitals	Levels	Radon Concentration ($Bq.m^{-3}$)			Annual effective dose (mSv/y)		
		Min	Max	Average	Min	Max	Average
Rizgary (Erbil)	Ground	56.99±0.22	61.58±0.62	59.34±2.23	1.28±0.016	1.32±0.032	1.3±0.098
	First	53.29±0.14	57.39±0.34	55.39±2.05	1.12±0.022	1.26±0.024	1.24±0.068
	Second	44.55±0.44	49.65±0.82	47.4±2.61	1.01±0.028	1.08±0.018	1.04±0.086
Azadi Teaching (Duhok)	Ground	67.16±0.34	73.64±0.44	70.22±2.98	1.56±0.022	1.68±0.032	1.65±0.092
	First	63.89±0.52	68.16±0.62	65.79±2.64	1.46±0.042	1.54±0.012	1.51±0.064
	Second	57.72±0.58	62.28±0.84	60.09±2.24	1.36±0.042	1.44±0.028	14±0.078
Shahid Aso (Sulaymany)	Ground	72.34±0.45	79.01±0.64	75.53±2.86	1.66±0.023	1.74±0.42	1.72±0.092
	First	68.33±0.26	73.72±0.48	70.82±2.64	1.59±0.042	1.65±0.032	1.64±0.068
	Second	64.44±0.12	69.76±0.56	66.94±2.28	1.54±0.012	1.58±0.018	1.57±0.082

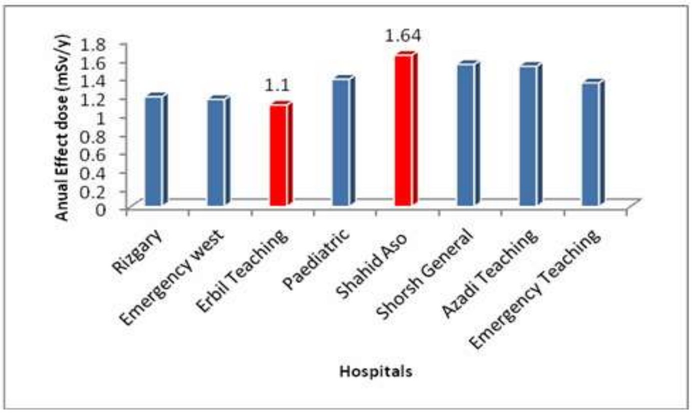

Fig. 4: Distribution of annual effect dose inside Hospitals of Iraqi Kurdistan

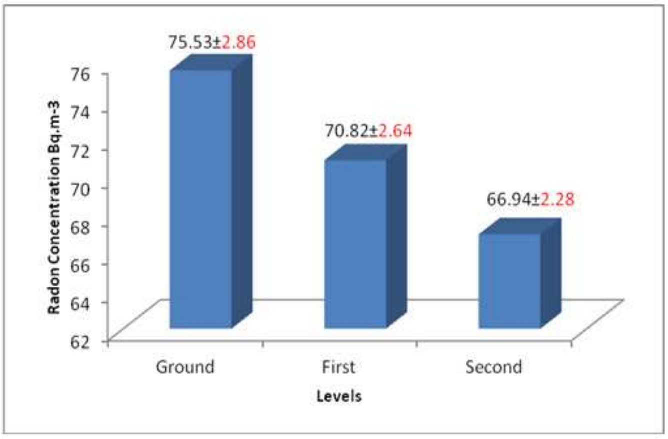

Fig. 4: Variation of radon concentration with floor levels in Shahid Aso Hospital

4- Conclusion

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. Nuclear track detector type CR-39 used to measure track density of alpha particles that emitted from radon and its progeny during spring season. The present study consisted of two main parts; first was the effect of the geological formation on indoor radon concentration, and this has been investigated. The highest and lowest radon concentration was in the hospitals of Shaheed Aso (Sulaymaniya city: mountain region) and Erbil Teaching (Erbil city). The second part related to the effects of floor level on the concentration of indoor radon. 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.

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