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Original Research Article

Calculation the Excess Lifetime Lung Cancer Risk and Human Health Risk Assessment by Inhalation of Radon Gas in the Health Centers of Al–Hay City in Wasit, Iraq Using LR-115 Detector

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Abstract: In this paper, the technology used to measure radon concentrations in 8 health centers of Al- Hay city in Wasit, Iraq (December 2019) is one of the types of solid state nuclear track detectors, LR-115. After that, the annual effective dose rate and the excess lifetime cancer risk were calculated for the selected positions in the study area. The detectors were exposed to radon for 45 days, the etched detectors, using an optical microscope, to calculate the track densities, essentially depend on the alpha ray emitted from radon which later on easy converted to radon concentration values. Radon concentration ranges are from (183.47±22.93 to 17.15±2.14) Bq/m^3 with a mean of (100.483Bq/m^3), which lower than the appropriate radon levels recommended by ICRP "International Commission on Radiological Protection". The readings of "Excess Lifetime Cancer Risk" (ELCR), which ranges from 3.9 ×10^{-3} to 8.05 ×10^{-3} with an average value of 0.53% showing that human health is not under risk even it does not develop any lung cancer while human inhale the radon.
Keywords: Lung Cancer Risk, Human Health Risk Assessment, Radon concentration, The track detector LR-115 type II, Annual effective dose.

INTRODUCTION

Uranium can be found in nature is widespread at tiny amounts in soils, rocks and different building materials (Mehta *et al.*, 2014). Through the spontaneous decay chain of the radionuclide ^{238}U, it produces (^{226}Ra, half-life 1600 years) which then decays into Radon(^{222}Rn) (Sani *et al.*, 2018). Radon is one of the chemical inert gases as heaviest noble gases, associated with low reactivity. It owned the total of the 36 isotopes; it was ranged from ^{193}Rn to the ^{228}Rn. These isotopes were radioactives. Moreover, the three of isotopes were constantly been produced from the^{238}U (^{222}Rn), the ^{235}U-(^{219}Rn, also known as the actinon, derived from its grandparents, the ^{227}Ac) and the ^{232}Th (^{220}Rn, also known thoron, the derived eventually from the ^{232}Th) (Baskaran,2016). The half-life of ^{222}Rn (3.82 day) is long adequate for a significant part of the gas to work out into the environment. One of the main and major fundamentals contributors to indoor radon is usually the soil and rocks beneath houses, which is usually (4-5) time more concentrate than radon outdoor, where greater air dilution occurs. Use of water, and the natural gas outside air and building materials bring some Additional contributions to indoor radon (James, 2007).

Radon contributes more than the half of the collective effective dose in the internal environment from all sources of exposure that the human population receives. The human receives about half of the 98% of radiation dose was breathing of progeny, radon and thoron and present in dwellings. If the radon gas was inhaled, high energy alpha particle has emitted by decay product of the 218Po and the 214Po, which are effective in the damaging tissue and it can causes lung cancer in the human beings. Additional, ^{222}Ra consider as a second popular cause for lung cancer after the major smoking issue, called a human carcinogen (Baskaran,2016, Pervin *et al.*,2018 and Sarma, 2013).

For radon monitoring, plastic detectors can be used (cellulose nitrate sheets). The Polycarbonates (PC) material, (CR-39) has ability tends ionization sensitivity and showing the stability when it used at different

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environmental condition. That CR-39 used as track detector in case environmental radon's. However, recently developed LR-115 based on twin-cup dosimeter as track detector used to measurement of indoor the ^{222}Rn and the ^{220}Rn. Alpha particles that appear in the decay series of the radioisotopes (^{222}Rn, ^{220}Rn and ^{219}Rn) will produce neighborhood radiation harm in the plastic fabric which can be etched with an the alkaline solutions (typically NaOH or KOH) to increase size of tracks, which the track density (number of track per unit) could be easy counted by the optical microscopy, or the automated scanning, and the counting technologies (Baskaran,2016, Grupen, 2010). The aim of research was to measure concentration of radon in air of eight health center of the Al- Hay city in Wasit. Also, calculate annual effective dose of the radon excess lifetime cancer risk to inhalations of the radon in air using SSNTDs and LR-115. The survey help to assess safety of these building, and take actions to reduce indoor radon level in the health center (if necessary).

Related work

Abid, *et al.* (2017) reported that radon using SSNTD techniques, and calculated the excess lifetime's cancer risks from the radon exposures in buildings of Kufa technical institutes. The radon concentration is ranged 38.4 to 77.2 Bq/m^3, with the mean of 50 Bq/m^3. Abood (2018), investigated that indoor radons level, and associated effectives dose rates determination the Al-Elaf distinguish secondary schools for girls in Basrah governorate. The values of concentrations of radon range 28 to 128 Bq/m^3 with the average values 57 Bq/m^3.

Rejah (2018) has explained radon and the thoron concentration, and resulting doses in air of southeast Baghdad region by LR-115 type II. The mean radon, and the thoron concentrations were 45.47 and 43.15 Bq/m3 respectively. The radon concentration in air of the nineteen schools in the Karbala city measured by Hashim and Nayif (2019) using include solid-state nuclear tracks using LR-115 type II and CN-85. The radon concentration ranged 13.140±4.11 Bq/m^3 to 38.439±6.79 Bq/m^3, and ranged 13.842±2.35 Bq/m^3 to 36.867±4.28 Bq/m^3 with the average values (25.408±4.54, and 25.317±3.15) Bq/m^3 for LR-115, and CN-85 respectively (Hashim and Nayif, 2019).

Ahmed *et al.* (2019) have found that indoor the radon concentration measurement for chosen the dwellings in Some districts of Baghdad using RAD7. Radon concentration was varied 89 Bq/m3 (Hay Ur district) to 191 Bq/m3 (Al-Mansour district) with the average 123.3±24.3 Bq/m3.

MATERIALS AND METHODS

Study Area

Al- Hay city is one of Wasit governorate, located to southeast 220 km of Baghdad, the capital of Iraq, 45 km south of Al-Kut. It is placed on river sides of Al- Gharraf, with the position (32.166667°North, 46.05°East). The total area of Al- Hay city is (2000 km^2). The population of the city is estimated at about 171,000 inhabitants, while the judiciary is about 280,000 inhabitants. The health centers selected for study are eight, five of which are located in the city and three in the adjacent districts and villages to it.

The experimental for the radon detections and measurement was obtained from alpha particle counting of radon. The plastic tracks (LR-115 type-II) red color based on cellulose nitrates with the thickness of 12 µm used to record alpha track manufacture by the Kodak Pathe, France (Eappen and Mayya,2004). This plastic detectors film of area (1cm×1cm) was attached to the bottom of the container inside with adhesive tape (Fig.3). These detectors were fixed at distance 168 cm above floor. The exposure time of 45 days, the NaOH solution is the solution used to etched it for 1.5 hour with normality 2.5 at 70°C. Etched detectors finally have been dried in the air after showered with distilled water and count the wide variety of tracks by using the track counting technique, which was carried out the used microscope at the magnification of four hundred x. The integrated track density equation showed the measure signal of the etched detector (Al-Hamidawi, 2015):

$$\rho\left(\frac{Track}{cm^2}\right) = \frac{No.Track}{Area\ of\ View},$$

where ρ (track/cm^2) track density measured on the detector, the concentration of radon can be computed as follows (Al-Koahi,1992, Corporation *et al.*,1981):

$$C_{Rn}\left(\frac{Bq}{m^3}\right) = \frac{\rho}{K\times t},$$

where C_{Rn} = the concentration of ^{222}Rn within a container below the detector is installed (Bq / m^3), t = time of exposure (days) and K is the factor of calibration (tracks. cm^{-2} day^{-1} per Bq m^{-3}). By exposing the reference dose measuring devices for the period ranging from (5-30) days to radium the ^{226}Ra (radon sources) for activity 3.3 kPa, the calibration factor was acquired which measured (0.0217±0.0013) (track.cm^{-2}), per (Bq.d.m^{-3}) [6]. The last amount is roughly analogous to preceding studies (Eappen and Mayya, 2004, Pundirl *et al.*2014, Verma and Khan,2014 and Duggal,2014).

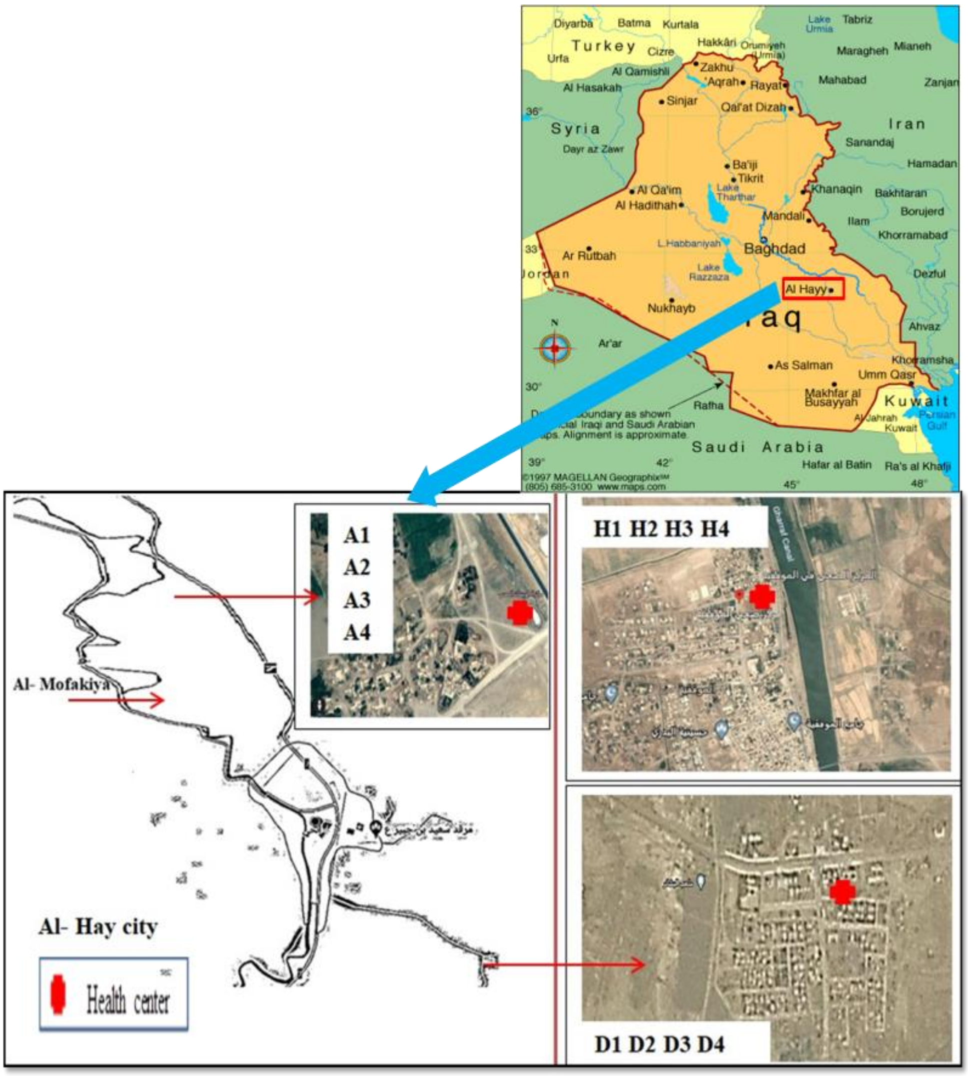

Fig.1. Adjacent districts and village to Al- Hay city

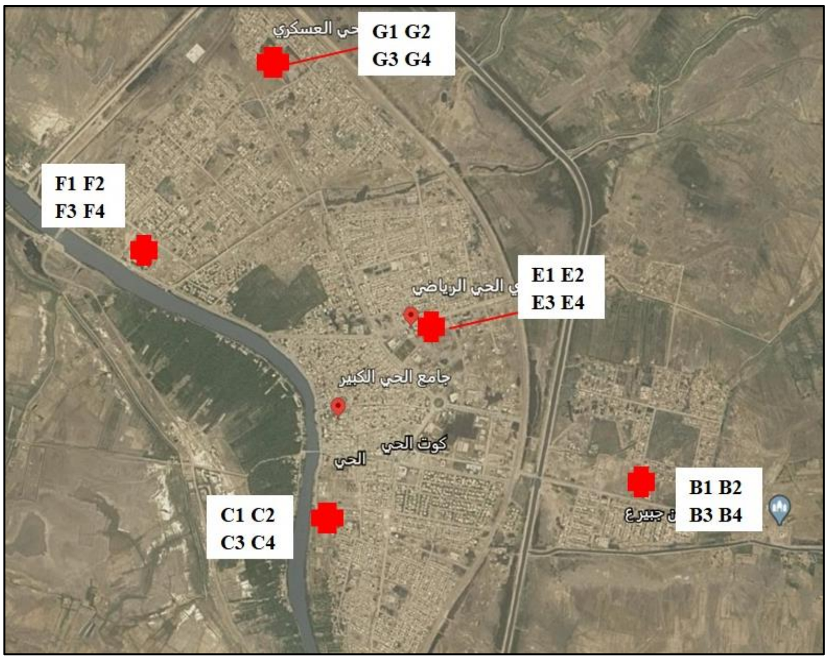

Fig.2. Map of Al- Hay city indicating the locations of health centers (Google earth)

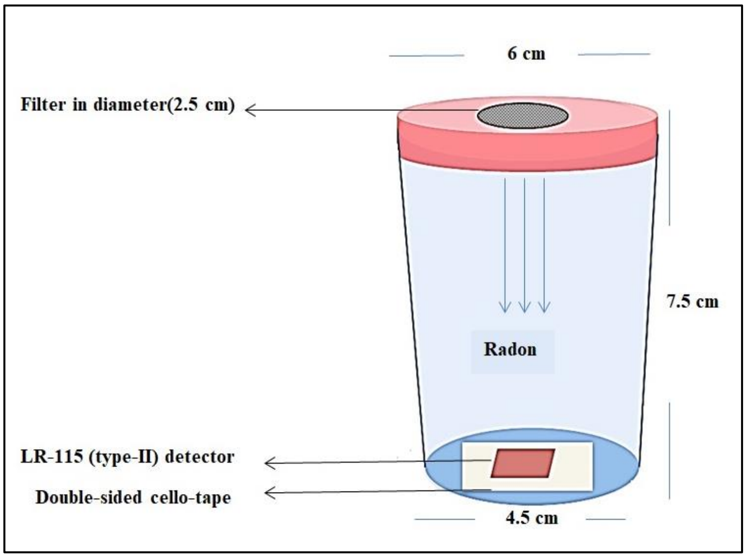

Fig.3. Sketch shows the solid state nuclear track detector sticks to the bottom of the plastic container and from the inside

Expected annual effective doses were calculated using the UNSCEAR (2000), WHO model (2009):

$$AED\left(\frac{mSv}{y}\right) = C \times H \times F \times D \times T,$$

Where, H: occupancy factor (0.8)
F, equilibrium factor (0.4)
T, time that people spend indoor (7008 hrs) (Hashim and Nayif, 2019)
D, dose conversion factor (9×10^{-6} m Sv/h per Bq/ m^3).
The equation that describes the excess lifetime cancer risk (ELCR), that depended on AED, DL " duration of Life which it is equal seventy years "and RF symbolize to" risk factor " that equal (0.055 Sv^{-1}) as recommend by ICRP (2011), is as follows (Abid *et al.*, 2017, Al-Hamidawi and Husain,2016).

$$ELCR = AED \times DL \times RF$$

RESULTS AND DISCUSSIONS

The results show that the value of the radon concentrations ranged from 17.15±2.14 Bq, to $m^3$183.47± 22.93 Bq / m^3in Table 1. The value found that lower than the permitted limit (200-300Bq/m^3) as suggested by the (the International Commission of the Radon Protection) (ICPR,2011). The higher values of the radon concentrations in the Al- Towaisat center (Doctor's unit) coded (A1) might be ascribed to the structure, and it is without good ventilation. In the location coded (B2,C1,D1,G3,H1 and H3) unventilated because windows kept closed in winter to conserves heat, but radon concentrations lower than the locations coded (A1) because of building, and coating material (cement) contains radioactive material ^{26}Ra, the ^{40}K and the ^{232}Th in higher proportions whereas the average of radon concentrations in Al- Towaisat health center (103.65±28.53 Bq/m^3) higher than radon concentrations average of other centers.

The lower values of the radon concentrations in the Al- Wahda center (care unit) coded (B2) because it has a good ventilation, and unit volume larger than other unit in same center (75 m^3).

In Fayrouz hospitals, average of the radon concentration (62.3±17.21 Bq/m^3), whereas units hospital were very larg, and has a direct cross-ventilation although hospital was old built that established in 1966. In advisory unit coded (F1) was concentration of the radon (94.88±11.86 Bq/m^3) higher than concentration of the radon in children advisory unit (20.58± 2.57Bq/m^3) because the radon was seven time heavier than the air.

The healths center in the Saeed is a caravan, and the radon concentration were assumed to be the low because there is no building material that contribute to the increasing of radon concentration. However, the results noticed that radon concentrations in care unit, and the doctor's unit was higher compared to others. This is because to presence of cracks in ground, in addition to the lack of good ventilations.

Table (2) showed that the value of the annual effective dose (D_{Rn}), and excess lifetime cancer risk (ELCR). The annual effective dose of the study area varies from 0.15 mSv/y to 3.7 mSv/y with the average 1.382 mSv/y. This mean was lower than permissible limit that recommended by International Commission of Radon Protection (ICPR, 2011), which was equal to (3-10) mSv/y. Table (2) found that the radon lung cancer risks for all healths centers in the Al-Hay city was studied and varies 3.9 $\times10^{-3}$ to 8.05$\times$ 10^{-3} with an average value of 5.319$\times10^{-3}$or 0.53%. Generally, these evaluations showed that the health centers for present study are distinguished by under ^{222}Rn concentrations, so the worker in these health center submit to especially low-risk things for ^{222}Rn due to lung cancer.

Table 1: Result of radon concentrations

No.	Name of health center	Location	Sample spiecmen	Radon concentrations (Bq/m^3)
1		Doctor's unit	A1	183.47±22.93
2	Towaisat	Care unit	A2	93.96±11.75
3		Immunization unit	A3	89.16±11.15
4		The laboratory	A4	48.01±6.00
		Average		103.65±28.53
5		Doctor's unit	B1	72.02±9.00
6	Saeed	Care unit	B2	118.31±14.79
7		Immunization unit	B3	26.29±3.29
8		The laboratory	B4	29.15±3.64
		Average		61.44±21.64
9		Doctor's unit	C1	135.12±16.89
10	Al-	Care unit	C2	7.54±0.94
11	Wahda	Immunization unit	C3	29.15±3.64
12		The laboratory	C4	62.87±7.86
		Average		58.67±27.91
13		Doctor's unit	D1	161.18±20.15
14	Al-	Care unit	D2	17.15±2.14
15	Bashaer	Immunization unit	D3	30.86±3.86
16		The laboratory	D4	27.43±3.43
		Average		59.15±34.13
17		Doctor's unit	E1	34.29±4.29
18	Al- Salam	Care unit	E2	51.44±6.43
19		Immunization	E3	78.88±9.86
20		The laboratory	E4	35.44±4.43
		Average		50.013±10.39
21		Advisory unit	F1	94.88±11.86
22	Fayrouz	Children advisory unit	F2	20.58±2.57
23	hospital	Emergency unit	F3	85.73±10.72
24		The laboratory	F4	48.01±6.00
		Average		62.3±17.21
25		Doctor's unit	G1	41.15±5.14
26	The	Care unit	G2	51.44±6.43
27	military	Immunization unit	G3	170.32±21.29
28	district	The laboratory	G4	33.15±4.14
		Average		74.015±32.32
29		Doctor's unit	H1	113.17±14.15
30	Al-	Care unit	H2	24.01±3.00
31	Mofakiya	Immunization unit	H3	117.74±14.72
32		The laboratory	H4	58.30±7.29
		Average		78.31±22.58
Average				100.483

Table2: Results of annual effective dose and excess lifetime cancer risk

No.	Sample spiecmen	Annual effective dose (mSv/y)	Excess lifetime cancer risk (ELCR) ×10^{-3}
1	A1	3.70±0.46	14.3±1.8
2	A2	1.90±0.24	7.3±0.9
3	A3	1.80±0.22	6.9±0.9
4	A4	0.97±0.12	3.7±0.5
	Average	2.0925	8.05
5	B1	1.45±0.18	5.6±0.7
6	B2	2.39±0.30	9.2±1.1
7	B3	0.53±0.07	2.0±0.3
8	B4	0.59±0.07	2.3±0.3
	Average	1.24	4.78
9	C1	2.73±0.34	10.5±1.3

No.	Sample spiecmen	Annual effective dose (mSv/y)	Excess lifetime cancer risk (ELCR) $\times 10^{-3}$
10	C2	0.15±0.02	0.6±0.1
11	C3	0.59±0.07	2.3±0.3
12	C4	1.27±0.16	4.9±0.6
	Average	1.185	4.58
13	D1	3.25±0.41	12.5±1.6
14	D2	0.35±0.04	1.3±0.2
15	D3	0.62±0.08	2.4±0.3
16	D4	0.55±0.07	2.1±0.3
	Average	1.93	4.58
17	E1	0.69±0.09	2.7± 0.3
18	E2	1.04±0.13	4.0±0.5
19	E3	1.59±0.20	6.1±0.8
20	E4	0.72±0.09	2.8±0.3
	Average	1.01	3.9
21	F1	1.91±0.24	7.4±0.9
22	F2	0.42±0.05	1.6±0.2
23	F3	1.73±0.22	6.7±0.8
24	F4	0.97±0.12	3.7±0.5
	Average	1.26	4.85
25	G1	0.83±0.10	3.2±0.4
26	G2	1.04±0.13	4.0±0.5
27	G3	3.44±0.43	13.2±1.7
28	G4	0.67±0.08	2.6±0.3
	Average	1.495	5.75
29	H1	2.28±0.29	8.8±1.1
30	H2	0.48±0.06	1.9±0.2
31	H3	2.38±0.30	9.1±1.1
32	H4	1.18±0.15	4.5±0.6
	Average	1.58	6.075
Average		1.382	5.319

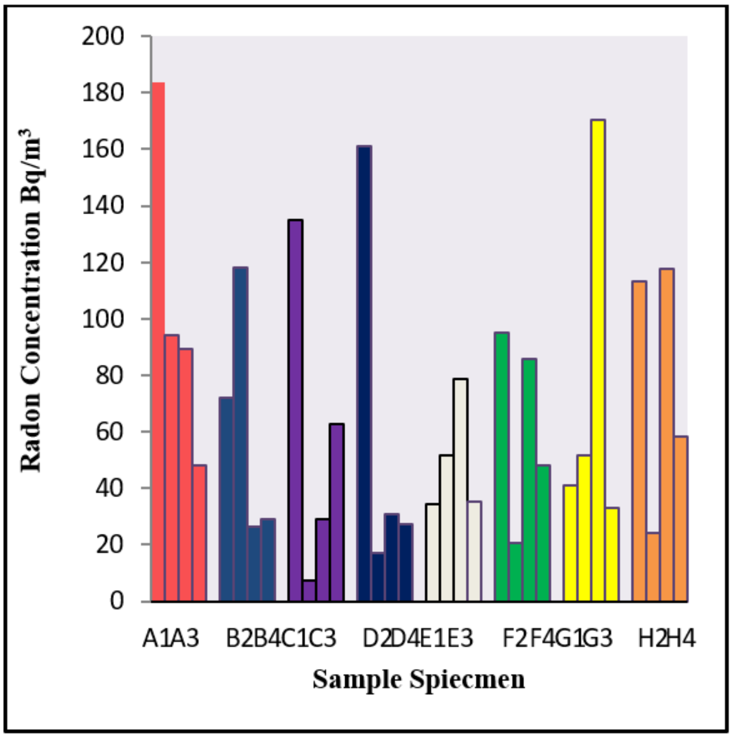

Fig.4. The concentration of radon in the locations of health centers of Al-Hay city

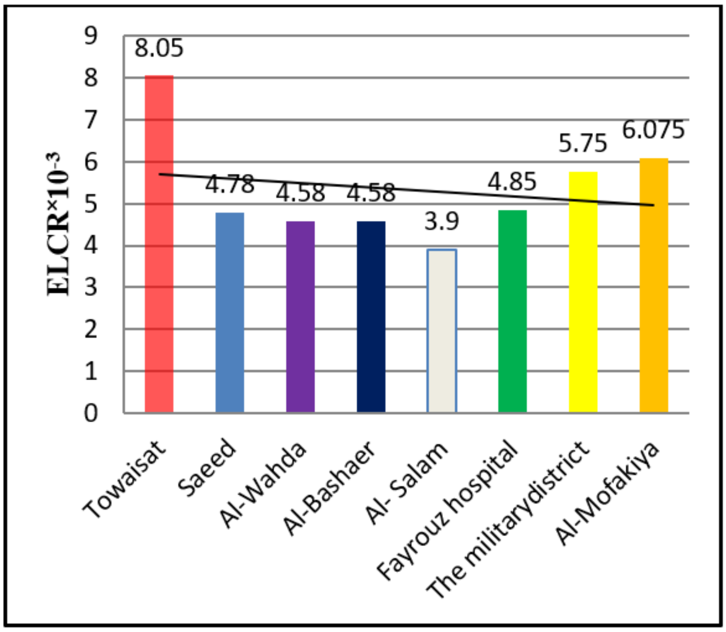

Fig.5: Excess lifetime cancer risk of health centers of Al-Hay city

CONCLUSIONS

From the research that has been performed, it is possible to conclude that the values of radon concentration lower the permissible limits (200-300 Bq/m^3) with average equal to the (100.483) Bq/m^3. They were within the permissible limits recommended by ICRP, and there are no health risk. The building materials, for example, cement, and insufficient ventilation was considered as main sources of the higher radon concentration, in addition, the presence of crack in ground. Ventilated units have lower than the radon concentration than unventilated units. The best way to reduce radon entry to health units: floors and walls must be tightly closed, improve ventilation of health center units, and install a special radon collection system under a solid floor.

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