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Estimation Hazard of Lung Cancer Due to Radiate Radon Gas in Diyala Governorate Schools

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Abstract

In this research, the concentration of radon gas has been calculated in the classrooms of schools in Diyala Governorate by using the nuclear track detector (CR-39), which was one of the organic solid-state nuclear detectors (SSNTDs). After calculating the radon gas concentration, the lung cancer cases were calculated. The results showed that the lowest value was found in (Alshumue) school (4.753) people. In contrast, the highest value was found in (Habhib) school (20.421). The average values of lung cancer cases in Diyala governorate were equal to (9.319) per person. The results showed that the number of lung cancer cases per year per million persons in Diyala Governorate schools was below the allowed limit from (ICRP) agency (170-230) people.

Keywords: Radon , Lung Cancer Hazard , (CR-39) Detector , Diyala.

1. Introduction

Radon is the most significant and variable source of public radiation exposure. The yearly effective dosage of radon and its offspring from inhaling air is estimated to be around (55%) of the natural public exposure dose rate, and long-term exposure to high levels of radon can cause lung cancer [1]. Because radon is a gas, it may escape into the air from the substance in which it is generated. It is also because uranium and radium are abundant in soil, rocks, and sand, radon gas is found everywhere outdoors and inside. Radon gas is a known radiation danger linked to increased lung cancer among underground miners [2]. Three isotopes from each natural radioactive disintegration series (uranium, thorium, and actinium) make up natural radon. Radon-222 (alpha emitter with a half-life of 3.823 days), the longest-lived isotope, was discovered in 1900 by German chemist Friedrich E. Dorn. The name Radon is sometimes used to distinguish this isotope from the other two natural isotopes. They are known as 'Thoron' (Radon-220: alpha emitter with a

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half-life of 55.6 seconds) and 'Actinon' (Radon-219: alpha and gamma emitter with a half-life of 3.92 seconds) because they come from the Thorium and Actinium series, respectively [3]. The radioactive decay of Radium produces Radon (Rn-222), a chemical element with an atomic number of 86, and a heavy radioactive gas of the Noble Gas Group on the periodic chart (Ra-226). It is colorless, odorless, and tasteless, with a density of 9.73g/liter (1 atm/0°C), and it may permeate through soil and rocks, with detection levels of 10 to 20 per million atoms. It is 7.5 times the weight of air and almost 100 times the weight of hydrogen. At -61.8°C, the gas liquefies, and at -71°C, it freezes. Until solid Radon is cooled further, it emits a mellow yellow light that becomes orange-red when it reaches the temperature of liquid air (-195°C).

Thousands of miners have been exposed to high levels of Radon and its decay products, which have been shown to cause lung cancer in studies (Radon is a major cause, second only to cigarette smoking, of lung cancer deaths)[4].

The present work aims to calculate the concentration of radon gas in air for ten schools in Diyala Governorate and determine the incidence of lung cancer per million people, as well as calculate the effective annual dose received as a result of exposure to radioactive radon gas.

Study Area

The research was carried out at various schools in Diyala Governorate, located in eastern Iraq, between latitudes (33.3 degrees - 35.6 degrees) north and longitudes (45.22 degrees - 46.56 degrees) east. The size is (17,685 km^2), and the population is predicted to be (4.4%), Iraq's total land area [5].

Table 1.shows the symbols of the samples, their locations, the names of the schools and their coordinates

NO.	**Code Sample**	**location sample**	**Coordinates GPS**	School names
1.	A3	Classroom	33°49'15.53"N 44°24'33.39"E	Alandalus
2.	B3	Classroom no.1	33°49'52.12"N 44°24'55.22"E	Bint Zuin
3.	B4	Classroom no.2		
4.	D3	Classroom no.1	33°51'29.31"N44°31'02.54"E	Alshumue
5.	D4	Classroom no.2		
6.	E3	Classroom no.1	33°51'19.70"N44°31'07.43"E	Alsamwl
7.	E4	Classroom no.2		
8.	F3	Classroom	33°50'58.08"N44°31'29.14"E	Albalagha
9.	G3	Classroom no.1	33°50'56.56"N 44°30'58.73"E	Eishtar
10.	G4	Classroom no.2		
11.	I3	Classroom no.1	33°47'05.55"N44°30'08.96"E	Habhib
12.	I4	Classroom no.2		
13.	J3	Classroom no.1	33°44'06.43"N44°28'45.46"E	Alshahid Muhamad Qasim Aleabaadi
14.	J4	Classroom no.2		
15.	K3	Classroom	33°41'22.95"N 44°25'24.87"E	Ibn Hazm
16.	L3	Classroom	33°56'08.64"N44°27'42.94"E	Bashayir Alkhayr

2. Experimental Details

In this study, the number of lung cancer cases due to exposure to radioactive radon gas was calculated in ten schools in Diyala Governorate using the nuclear trace detector (CR-39), which is one of the organic solid-state nuclear track detectors (SSNTDs). The concentration of radon gas and the incidence of lung cancer per million people were calculated for one or two classrooms of each school, where the detector dimensions are (1 cm x 1 cm). The detector was placed and installed in a cloth bag to pass the alpha particles that have a weak penetrating ability to the materials, as shown in **Figure (1).** The detector was placed at a height of (160 cm) from the ground. After exposure of the detector to the alpha nuclear fragments for 30 days, the detector was removed from the study sites and chemically treated by chemical etching process. It was carried out using a solution of sodium hydroxide (NaOH) prepared by dissolving sodium hydroxide granules in distilled water equal to (6.25 N), placing the detector inside the chemical solution in a water bath at 60°C for 4 hours see **Figure (2)** and **Figure (3).** Then, the reagent was washed with distilled water and normal water to leave and dry after the chemical etching process became the reagents ready to calculate the alpha traces resulting from the dissolution of radon through the optical microscope shown in **Figure (4)** and calculate the density of the tracks. **Figure (5)** shows the tracks of alpha under a light microscope after being chemically treated.

Figure 1. represents how the detector is suspended

Figure 2. Placing the detector inside the Chemical solution

Figure 3. The water bath device

Figure 4. Optical microscope

Figure 5. shows the track of alpha particle under an Optical microscope

3. Calculations

1- After drying, the detector comes to the stage of counting and reading the traces of alpha on the surface of the detector and finding the density of traces for unknown samples through the following equation:

$$\rho_x = \frac{N_{av}}{A} \qquad (1)$$

Where :

ρ_x= the density of traces for the unknown samples in unit (track/mm^2).

N_{av}= the average tracks

A=the area of view of the optical microscope lens, which is (0.0676 mm^2).

2- Calculate the concentration of radon gas in units (Bq/m^3) through the following equation[6][7]:

$$C_{Rn} = \frac{\rho_x}{k\,.t} \qquad (2)$$

Where:

C_{Rn}= the concentration of radon gas

ρ_x= density of tracks

k = Calibration constant of the detector (CR-39).

After calculating the impact density of the standard samples (ρs) using equation (1) and calculating the exposure to radon for the standard samples, the relationship between them was drawn. Through this relationship, we obtained the calibration curve as in **Figure (1),** and the slope was equal to which is equal (Slope =K= 0.2544 Track .m^3/ Bq.day.mm^2).

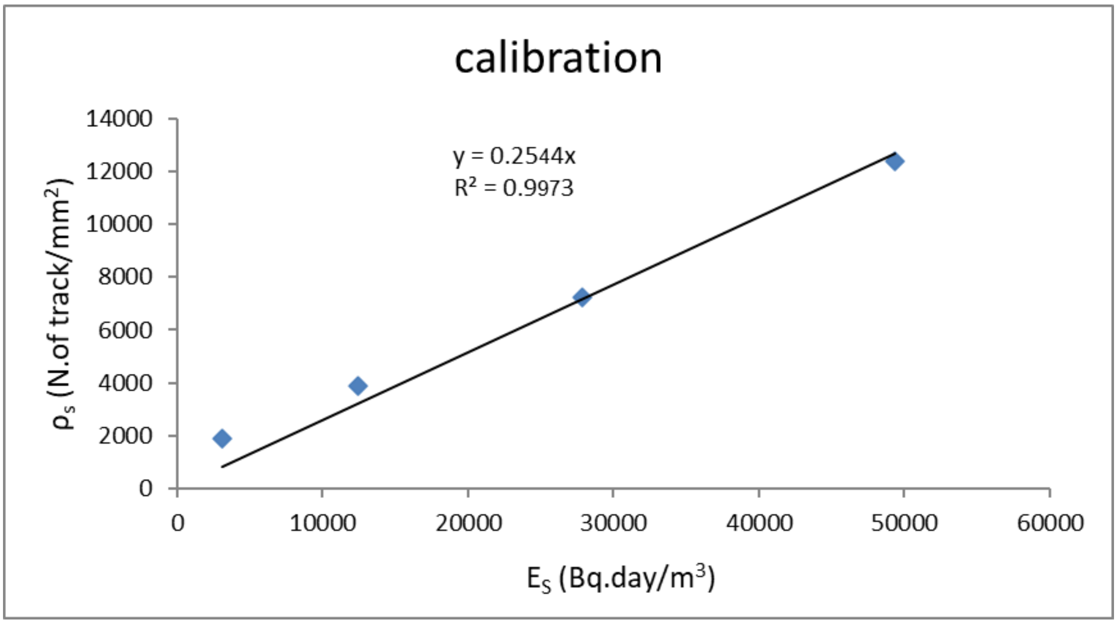

Figure 6. The relationship between impacts intensity (ρ_s) and exposure to radon (E_s) for standard samples.

3- Calculation of the annual effective dose (AED) in units (mSv/y)[8][9]:

$$AED = C_{Rn} \times H \times F \times T \times D \quad (3)$$

Where :

C_{Rn}= the concentration of radon gas.

H = the occupancy factor which equal (0.8)

F = the equilibrium factor which equal to (0.4) as suggested by (UNSCEAR, 2000)[10]

T = the time in hours in a year and its equal (8760 h/y)

D = the dose conversion factor which is equal to (9×10^{-6})

4- The Lung Cancer per year per million person (LCR)[6][11] :

$$LCR = AED \times (18 \times 10^{-6}\ mSv^{-1}.y) \quad (4)$$

4. Results and Discussion

From the obtained results, which appeared in **Table (2)** for ten schools in Diyala Governorate, the incidence of lung cancer per million people in these schools was calculated as a result of the dissolution of radioactive radon gas. The results showed that the concentration of radon gas, calculated by equation (2), ranged from the lowest value, equal to (10.467 Bq/m3) for sample D4, which was placed in classroom No. (2) in (Alshumue) school. The most significant value of radon gas concentration, equal to (44.968 Bq/m3) for sample I4, was placed in classroom No. (2) in the (Habhib) school, as shown in **Figure (7)**, where the average concentration of radon gas in Diyala schools was equal to (20.521 Bq/m3).

After calculating the concentration of radon gas, the annual effective dose (AED) was calculated in each area mentioned in **Table (1)**, where the results showed that the effective annual dose values ranged between the lowest value of the sample D4, which was equal to (0.264 mSv/y), placed in (Alshumue) school in Classroom No. (2) to the greatest dose value, which was equal to (1.134 mSv/y) for sample I4 placed in (Habhib) School in Classroom No. 2, as shown in **Figure (8)**. The average annual dose value in the governorate's schools was equal to (0.518 mSv/y).

After calculating the effective annual dose, the incidence of lung cancer per million people (LCR) in the schools of Diyala governorate was calculated by equation (4). **Table (2)** shows that the results ranged from the lowest value, equal to (4.753) person for sample D4 placed in classroom

No. (2) in the school of (Alshumue), to the most significant value, which is equal to (20.421) person for the sample I4 placed in classroom No. (2) in (Habhib) school, as shown in **Figure (9)**, where the average number of lung cancer cases per million people in the schools of Diyala Governorate was equal to (9.319) person

Table 2. shows the symbol of each sample, the rate of alpha tracks (N_{av}), the intensity of the track (ρ_x), the concentration of radon gas, the annual effective dose (AED) and The Lung Cancer per year per million person(LCR).

CODE	N_{av} (track)	ρ (track/mm^2)	C_{Rn} (Bq/m^3)	AED (mSv/y)	LCR *10^{-6} person
A3	15.000	221.893	29.074	0.734	13.203
B3	6.800	100.592	13.180	0.333	5.985
B4	12.400	183.432	24.035	0.606	10.915
D3	7.400	109.467	14.343	0.362	6.514
D4	5.400	79.882	10.467	0.264	4.753
E3	11.400	168.639	22.096	0.557	10.034
E4	9.400	139.053	18.220	0.460	8.274
F3	18.800	278.107	36.440	0.919	16.548
G3	14.600	215.976	28.299	0.714	12.851
G4	10.000	147.929	19.383	0.489	8.802
I3	7.600	112.426	14.731	0.372	6.690
I4	23.200	343.195	44.968	1.134	20.421
J3	6.200	91.716	12.017	0.303	5.457
J4	7.400	109.467	14.343	0.362	6.514
K3	6.200	91.716	12.017	0.303	5.457
L3	7.600	112.426	14.731	0.372	6.690
MIN	5.400	79.882	10.467	0.264	4.753
MAX	23.200	343.195	44.968	1.134	20.421
AV	10.588	156.620	20.521	0.518	9.319

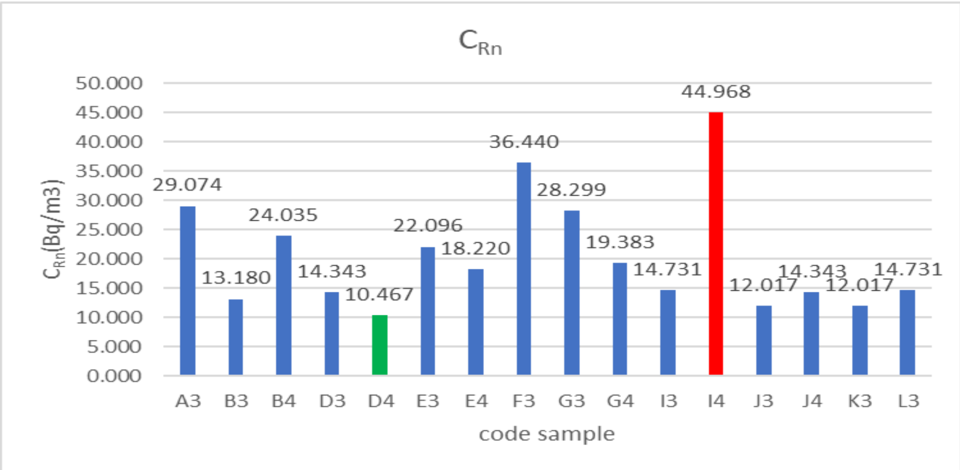

Figure 7. concentration of radon gas in classroom of Diyala Governorate schools.

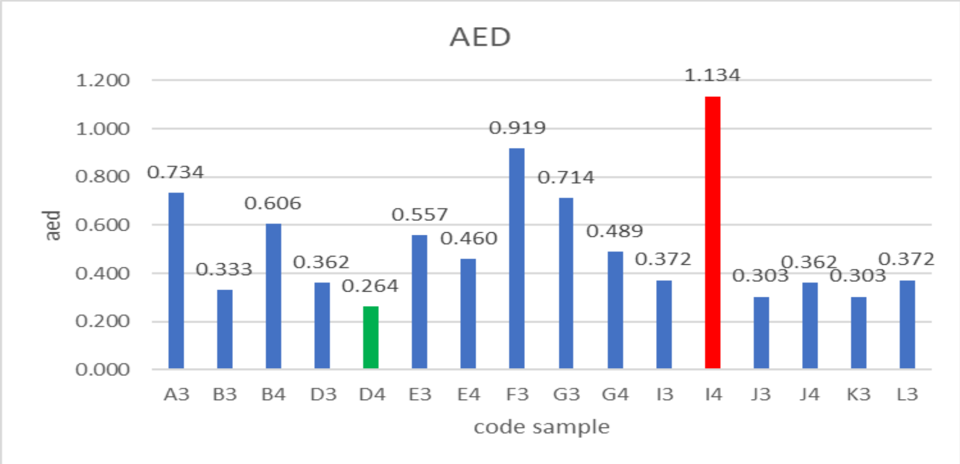

Figure 8. The annual effective dose in classroom of Diyala Governorate schools.

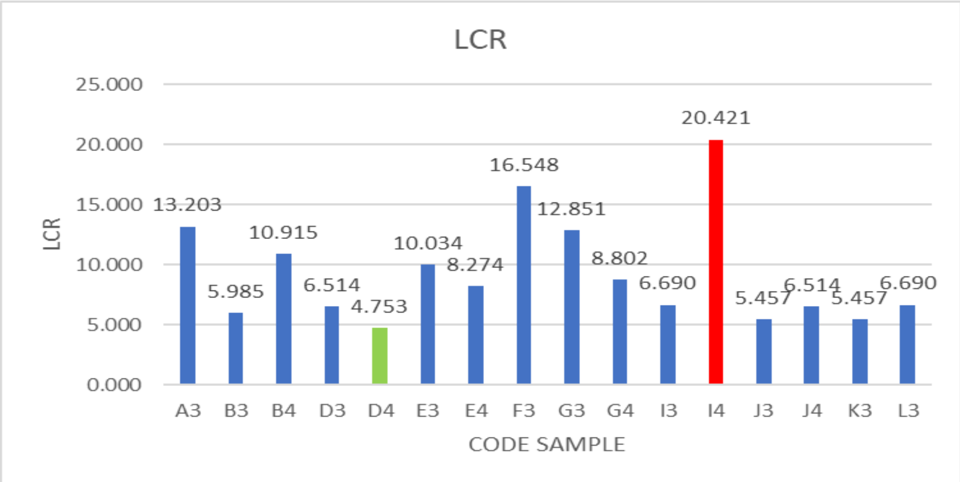

Figure 9. The Lung Cancer per year per million persons in classroom of Diyala Governorate schools.

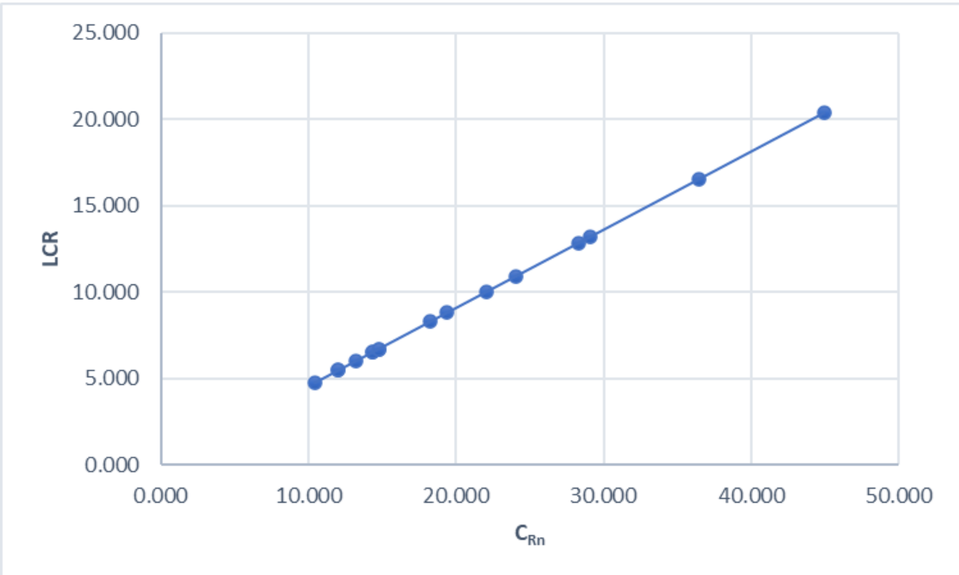

Figure 10. The relationship between radon gas concentration and lung cancer incidence per million people.

From **Figure (10)**, we noticed that the increase in the concentration of radon gas led to increase the incidence of lung cancer, and from this principle, the importance of studying radon gas for its negative consequences on the health of society and the risks that resulted from radon exposure.

Table 3. Shows the comparison of the results of the current study with the local and global results of radon concentration.

NO.	The Country	location of study	Av.C_{Rn} (Bq/m^3)	Ref.
1.	Pakistan	Dwelling	95.1	[12]
2.	Italian (Parma)	Kindergarten and schools	30	[13]
3.	Greece (Patras)	Schools	35	[14]
4.	Tunisia (Tunis)	Schools	26.9	[15]
5.	Osijek	Schools	70.6	[16]
6.	Egypt (Cairo)	Schools	57.6	[17]
7.	Greece (Patras)	Dwelling	38	[18]
8.	Palestine (Hebron)	School	34.1	[19]
9.	Kuwait	School	16	[20]
10.	Iraq (Baghdad)	Dwelling	51.688	[21]
11.	Iraq (Karbala)	Dwelling	62.071	[22]
12.	Jordon (Amman)	Kindergarten	76.8	[23]
13.	Turkey (Batman)	Schools	49	[24]
14.	Saudi Arabia	Dwelling	6.71	[25]
15.	**P.W**	**Schools**	**20.521**	

In **Table (3)**, it turns out that our study's results were higher than those of the study conducted in Kuwait [20]. Also, they were higher than the results of the study conducted in the Kingdom of Saudi Arabia [25] and less than the rest of the other studies shown in the table.

5. Conclusion

Indoor radon concentrations have been measured inside Diyala Governorate schools. The results showed that the concentration of radon gas was within the permitted limits and did not pose a risk to human health according to the International Commission on Radiological Protection Publication (ICRP), which was (200-300Bq/ m^3) [26]. After calculating the radon gas concentration, lung cancer cases were estimated to be much lower than the maximum limits recommended by (ICRP), which were (170-230) persons.

The low concentration of radon gas in schools was because they were open all day long. This helped to increase the ventilation factor and thus reduced the concentration of radon gas. Schools are restored and painted from time to time, preventing radon gas from leaking from building materials to the air or atmosphere of the rooms.

6. Recommendations

Our study and previous studies proved that the concentration of radon gas decreased by increasing the ventilation factor in government buildings or home buildings. So, we recommend that architects and those who build governmental buildings, including schools, take into account the risks of radon that cause lung cancer and work to increase ventilation before constructing the building or working on radon-resistant buildings. We also recommend that schools be maintained or renovated from time to time and paint the walls to prevent radon from seeping into the interior.

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