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Radon and Thoron Concentrations in the Air of Three Schools in East Baghdad

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ABSTRACT

Radon is continuously emitted from natural elements, especially because of the decomposition of U-238 and Thorium-232. Radon is ordered as a second cause of lung cancer. In this paper, the absorptions of radon and thoron were stately in schools east of Baghdad, namely Abtal Al-Taf, Batalat Karbala, and In Kaldoon Schools. The concentrations of the gases are measured using the SSNTD method (solid-state nuclear track detector method). Radon gas concentrations were different and ranged from 33.8 to 63.7 Bq/m^3, and a thoron from 48.8 to 127.1 Bq/m^3, which are within the permissible limits stipulated in the international organization ICRP. The mean annual dose of radon and thoron gases obtained by those in the schools under study was 3.4±0.9 mSv.y^{-1} and the maximum value of the annual dose was 4.7 mSv.y^{-1} in the room of the Batalat Karbala school, while the last value was 2.6 mSv.y^{-1} in the garden of Ibn Kaldoon School.

1. INTRODUCTION

Ninety percent of the distortions recorded indoors are due to indoor air, which is the most important substance of the day today. Numerous impurities can worsen the indoor midair value of radon [1]. A diversity of venoms is known to disturb the reputation of indoor air, and thus, the health of the residents of that area. One such natural pollutant is radon (^{222}Rn), which is a thick, colorless, odorless, inert gas [2]. Radon is continuously emitted from natural elements, especially as a result of the decomposition of U-238 and Thorium-232 [3]. Uranium (U-238) is a chemical element positioned in the actinide cycle of a cyclic table atomic content of 92 [4]. Radon is one of the elements that contain an atomic number of 86, it has the symbol ^{222}Rn, and it has a half-life of 3.82 days [5–11]. One of its most important counterparts is the element (isotope) thoron ^{220}Rn, which has a half-life of 55.2 sec [12, 13].

Radon - ^{222}Rn gas is chemically inert and the most important source of lung cancer. Therefore, knowing its concentration and presence in the air is very important [7, 11, 14]. Radon seeps from the soil into the air, where it decays and produces more radioactive particles. During respiration, the resulting particles are deposited on top of the cells, causing dangerous diseases because of DNA decomposition [15–17]. When radon decomposes, it breaks down into a group of elements, the most important of which are Po-218, Pb-214 and Bi-214/Po-214 (short radon daughters) have short half-lives they are elements that emit alpha, which is one of the chief causes of lung tumor, Therefore, exposure to harmful radon gas is considered to a large extent a health and environmental issue whose foundation is humanity [18–22].

In this work, the radon activity concentration will measure in the air of schools in East Baghdad. Schools' names are: Abtal Al-Taf, Batalat Karbala and Ibn Kaldoon. The solid-state nuclear track detector (SSNTD) method with LR-115 detectors type II is used. The annual dose of radon and thoron gases will be estimated and compare with recommended levels.

2. EXPERIMENTAL WORK

Table 1 presents the location coordinates of schools in East Baghdad Abtal Al-Taf, Batalat Karbala, and Ibn Kaldoon. Schools were chosen randomly, as the distance

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between one school and another was approximately 3 km. In these schools, the radon activity concentrations were measured in the air using the SSNTD method with LR-115 detectors of type II. LR-115 detectors have a thickness of 12 µm of cellulose nitrate on a basic solid-state nuclear detector man-made by the Kodak-Path, a French company according to specifications. This scale is a mixed measure of the radon and thoron concentrations and doses.

Detectors were placed inside the cups of a factory pair (chamber). These chambers, according to international standards, have a 4.1cm depth and 3.1 cm radius as shown Figure 1, to measure the preoccupation of radon and thoron in the air.

The detector was placed inside the chamber to measure the radon and thoron for a period of 100 days at a height of 2 m in three different sets of entrances, managers, and the garden of schools. The aching solution that was used to show tracks of alpha particles on the LR-115 detector, which were removed from the dosimeters, was 2.5 N from NaOH. This aching process was done at 60 C^0 for 90 min. using a water bath. An optical microscope at 100X magnification is used to count the recorded tracks [23, 24]. In addition, the radiation background was calculated using the reagents prepared for this purpose, and its value was directly subtracted from the obtained concentrations.

Radon and Thoron gases activity concentrations and working levels (WL) were calculated using the following equations [25, 26]:

$$C_{Rn}(Bq.m^{-3}) = \frac{\rho_{Rn}}{K_{Rnm}.T} \quad (\mathbf{1})$$

$$C_{Th}(Bq.m^{-3}) = \frac{(\rho_{Th} - T.C_{Rn}\,.K_{Rnf})}{K_{Thf}\,.T} \quad (\mathbf{2})$$

$$Radon\ progany\ level\ (WL) = \frac{C_{Rn}\,.F_{Rn}}{3700} \quad (\mathbf{3})$$

$$Thoron\ progany\ level\ (WL) = \frac{C_{Th}\,.F_{Th}}{3700} \quad (\mathbf{4})$$

Table (1): Locations of schools under study.

Location Name	N	E
Abtal Al-Taf	33° 21′ 44.36″	44° 30′ 01.85″
Batalat Karbala	33° 22′ 18.30″	44° 31′ 07.89″
Ibn Kaldoon	33° 21′ 22.72″	44° 31′ 32.12″

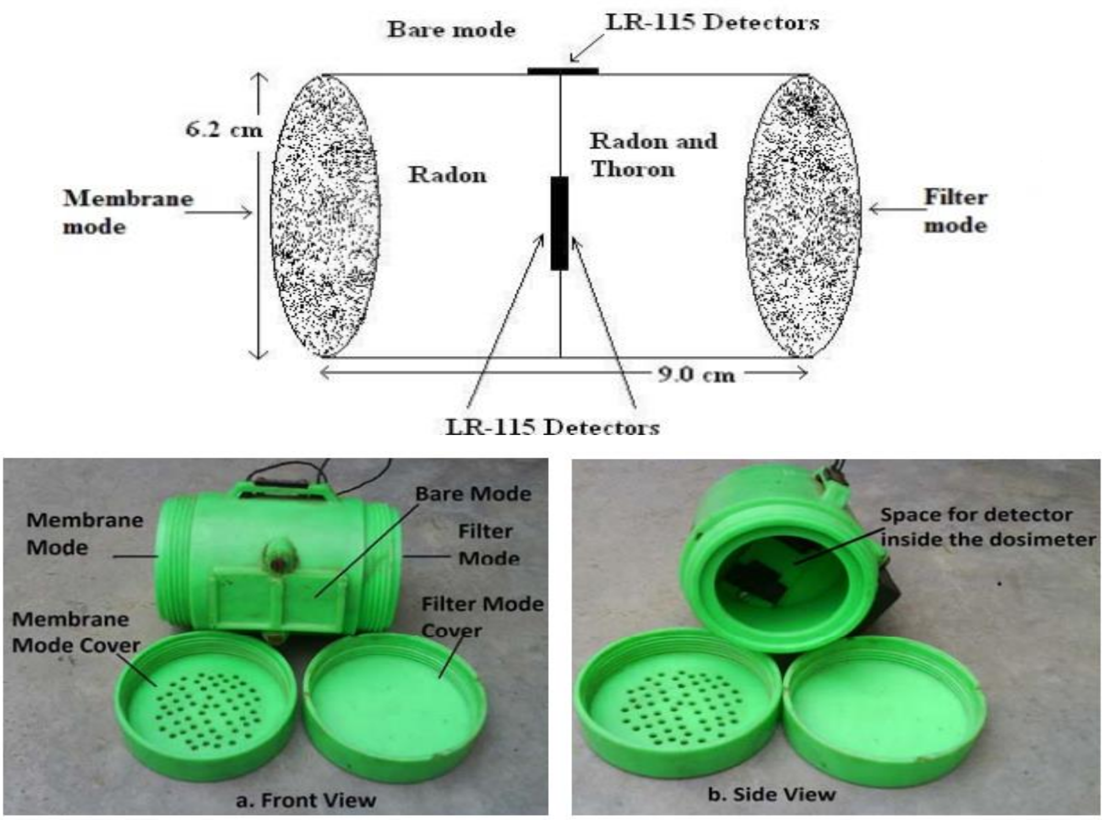

Fig. (1): The Schematic diagram of twin cup dosimeter.

The following relation has been used to calculate the annual dose in mSv.y^{-1} of radon, thoron, and its progeny [1]:

$$D = [(0.17 + 9\, F_{Rn} C_{Rn}) + (0.11 + 32\, F_{Th})] * 7000 * 10^{-6} \quad (\mathbf{5})$$

where C_{Rn} and C_{Th} in $Bq.m^{-3}$, are represent the radon and thoron concentrations. ρ_{Rn} in $tracks.cm^{-2}$, is the track density for the radon detector which is placed on the membrane side. ρ_{Th} in $tracks.cm^{-2}$, is the track density for the thoron detector which is placed on the filter side. T in days, is the total exposure time. K_{Rnm} in $tracks\,.cm^{-2}d^{-1}/Bq.m^{-3}$, is the radon's calibration factor in membrane side $= 0.019 \pm 0.003$. K_{Rnf} in $tracks\,.cm^{-2}d^{-1}/Bq.m^{-3}$, is the radon's calibration factor in filter side $= 0.02 \pm 0.004$. K_{Thf} in $tracks\,.cm^{-2}d^{-1}/Bq.m^{-3}$, is the thoron's calibration factor in filter side $= 0.016 \pm 0.005$. F_{Rn} unit less, is the radon's indoor equilibrium factor = 0.4. F_{Th} unit less, is the thoron's indoor equilibrium factor = 0.1.

3. RESULTS AND DISCUSSION

LR-115 detectors type used to measure the radon and thoron concentrations (C_{Rn} and C_{Th}), which were placed inside the plastic cups. The detectors inside the dosimeters were left in place for 100 days to achieve the corneal equilibrium. Table 2 presents all estimated parameters that were studied and calculated in this study.

From Table 2: a higher value of C_{Rn} appears in Batalat Karbala (manager) School and was $63.68\, Bq\,.m^{-3}$, while the lowest value was $33.68\, Bq.m^{-3}$ in the Abtal Al-Taf (entrance) School, with an average value of $49.94\, Bq.m^{-3}$. In general, the radon concentration in Table 2 is the lowest in the Abtal Al-Taf (entrance) School among the rest of the schools under study as shown in Figure 2. These values are lower than those obtained in [27].

Regarding the concentration of thoron in the schools under study, the average concentration is 86.94 Bq.m^{-3}, and its greatest value is 127.13 Bq.m^{-3} in the garden of the Batalat Karbala school, and its lowest value is 78.61 Bq.m^{-3} in the room of the manager of the Abtal AL-Taf as shown in figure 3. These values are slightly higher than those obtained in [27], and less than the action level (200-300 Bq.m^{-3}) recommended by ICRP [28]. The obtained activity concentration at least two times less this recommended value.

Table (2): the C_{Rn}. C_{Th}, annual dose and working levels of radon and thoron.

Sample Name	Filter	Membrane	C_{Rn} ($Bq.m^{-3}$)	C_{Th} ($Bq.m^{-3}$)	D ($mSv.y^{-1}$)	WL_{Rn} (mWL)	WL_{Th} (mWL)
Abtal Al-Taf (Entrance)	203	69	36.32	81.48	2.91	3.93	2.2
Abtal Al-Taf (Manager)	210	80	42.1	78.62	2.99	4.55	2.12
Abtal Al-Taf (Garden)	199	64	33.68	82.27	2.86	3.64	2.22
Batalat Karbala (Entrance)	321	116	61.05	124.31	4.6	6.6	3.36
Batalat Karbala (Manager)	328	121	63.68	125.39	4.69	6.88	3.39
Batalat Karbala (Garden)	315	106	55.79	127.14	4.52	6.03	3.43
Ibn Khaldoon (Entrance)	187	97	51.05	53.06	2.62	5.52	1.43
Ibn Khaldoon (Manager)	196	112	58.95	48.82	2.72	6.37	1.32
Ibn Khaldoon (Garden)	192	89	46.84	61.44	2.71	5.06	1.66

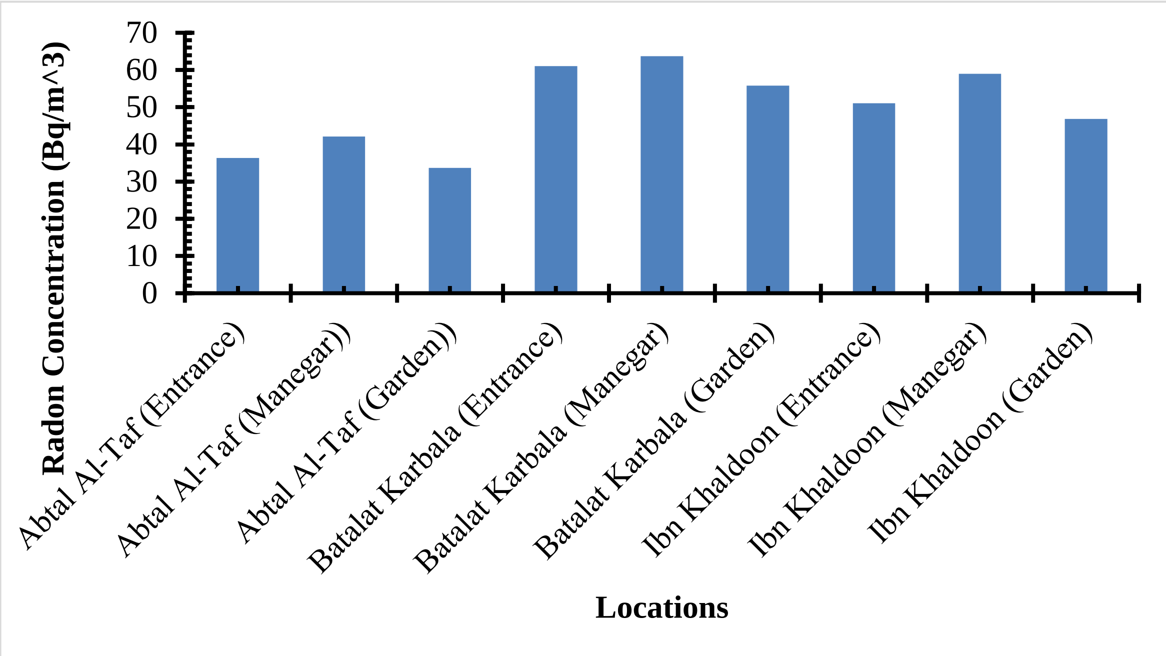

Fig. (2): Radon concentration in all studied locations.

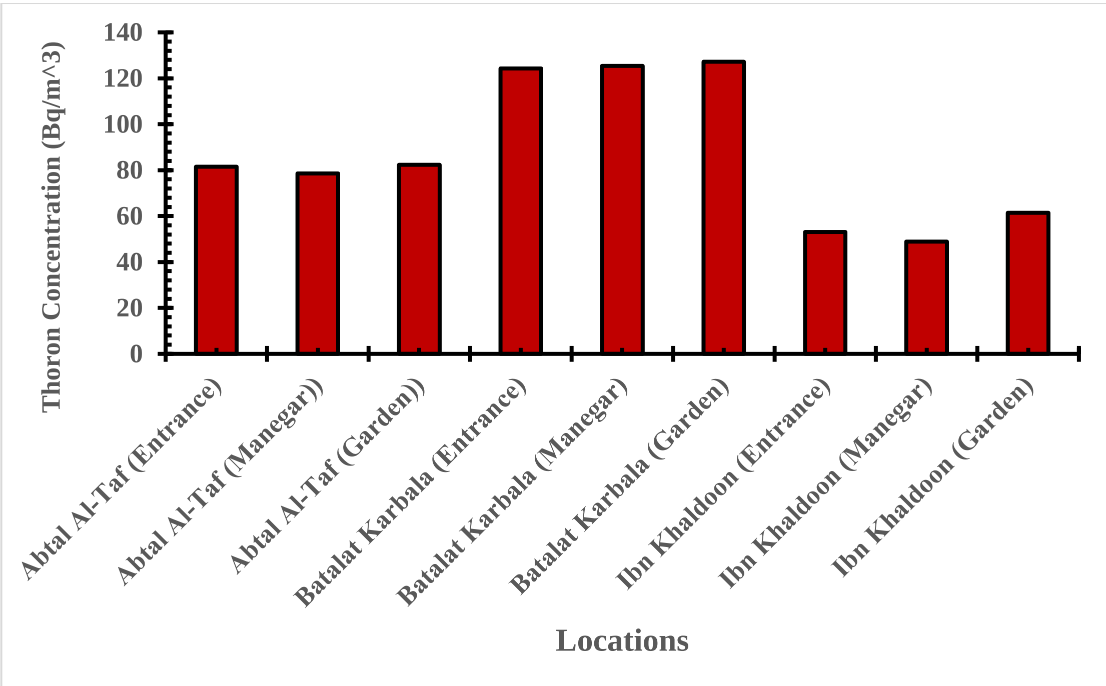

Fig. (3): Thoron concentration in all studied locations.

Radon and thoron activity concentration box charts with range, mean and median lines are shown in Figure 4. Thoron activity concentration has a wide range compared to radon activity concentration with mean value upper the median line for thoron but under the med line for radon respectively. In the same way, Figure 5 shows the correlation between thoron and radon activity concentration. It's clear that thoron activity concentration doesn't depend on radon activity concentration in the three cases of schools under study.

From Table 2, the mean annual dose of radon and thoron gases obtained in the schools under study is 3.41 $mSv.y^{-1}$ with a maximum value of 4.69 $mSv.y^{-1}$ in the manager room of the Batalat Karbala school, and minimum value of 2.71 $mSv.y^{-1}$ in the garden of Ibn Kaldoon School as shown in figure 6. The Box chart with range, mean and median line for air absorbed dose (D), radon, and thoron working level (WL) are shown in Figure 7. Also, the statistical parameters: The Mean, Standard Deviation, Lower 95% CI of Mean, Upper 95% CI of Mean, Variance, Sum, Minimum, Median, and Maximum are listed in Table 3 for the five parameters of radon, and thoron activity concentration air absorbed dose (D), radon and thoron working level (WL).

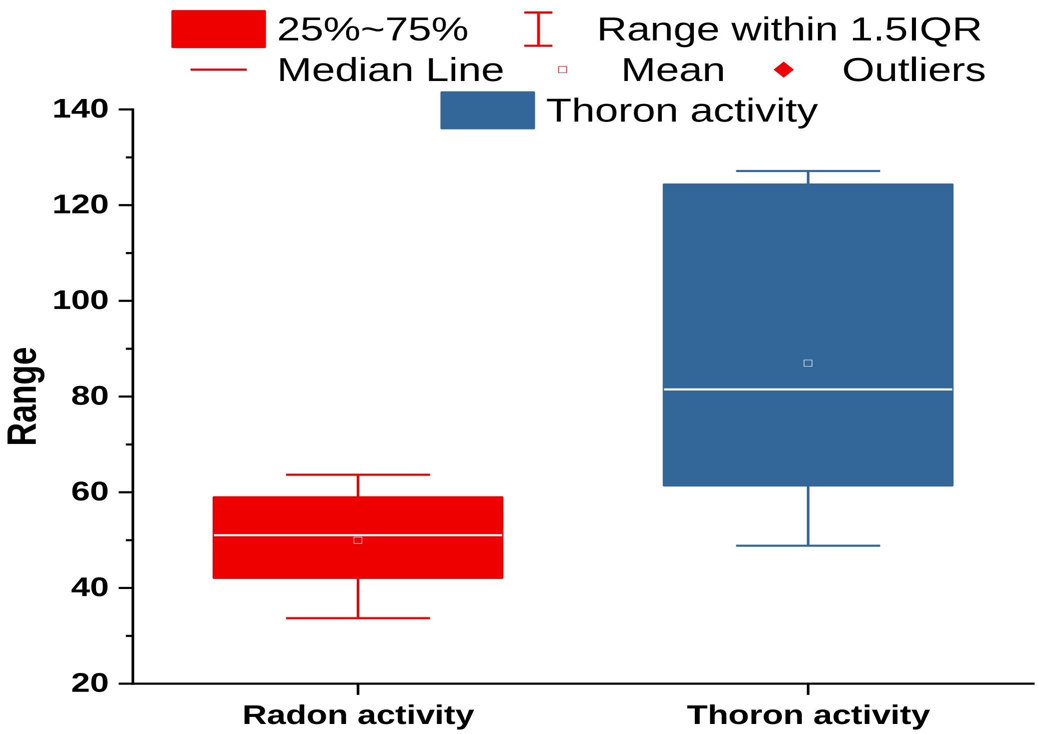

Fig. (4): Box chart with rang, mean and median line for radon and thoron activity concentration.

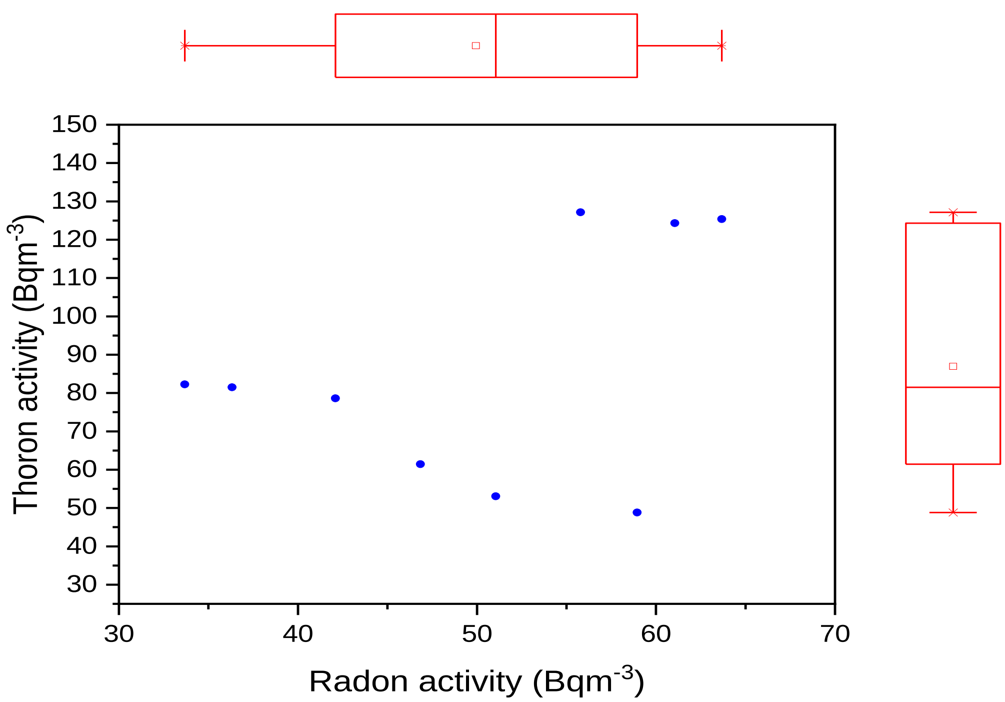

Fig. (5): The correlation between thoron and radon activity concentration.

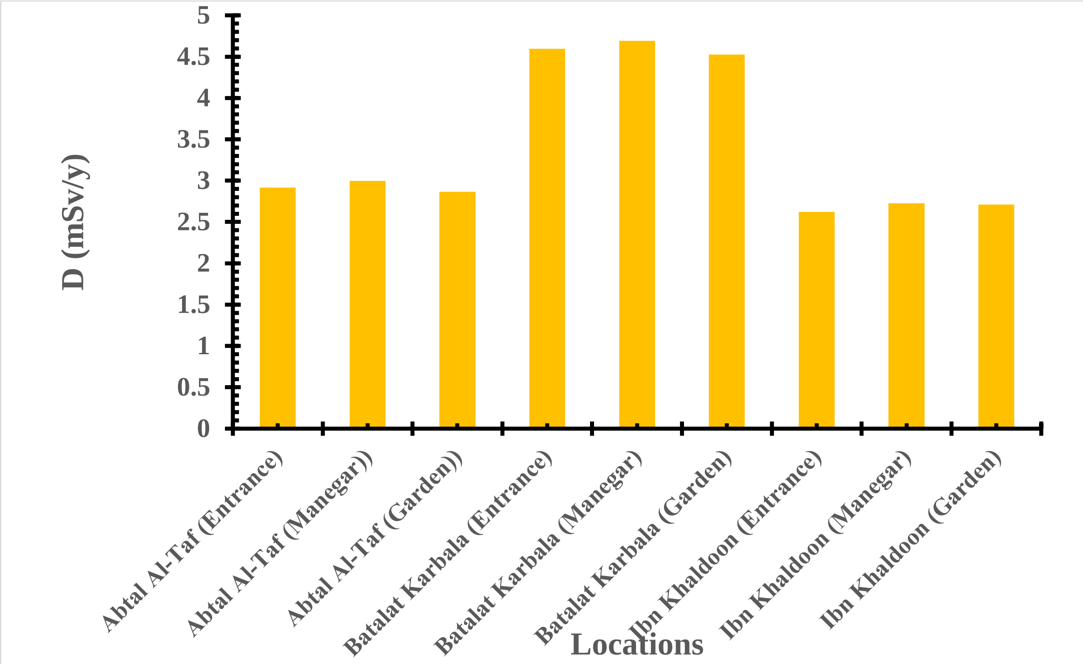

Fig. (6): annual dose of radon and thoron gases obtained in the schools under study.

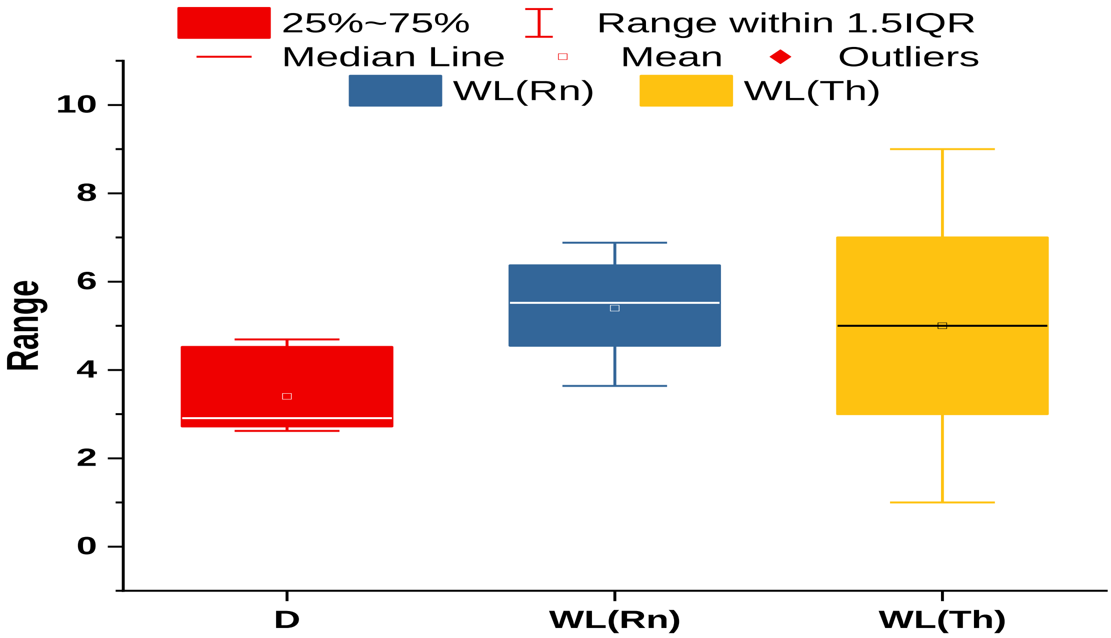

Fig. (7): Box chart with rang, mean and median line for air absorbed dose (D), radon and thoron working level (WL).

Table (3): Statistical Parameters.

	Mean	Standard Deviation	Lower 95% CI of Mean	Upper 95% CI of Mean	Variance	Sum	Minimum	Median	Maximum
^{222}Rn	49.9	10.9	41.6	58.3	118.7	449.5	33.7	51.1	63.7
^{220}Th	86.9	31.4	62.8	111.0	982.9	782.5	48.8	81.5	127.1
D	3.4	0.9	2.7	4.1	0.8	30.6	2.6	2.9	4.7
WL(Rn)	5.4	1.2	4.5	6.3	1.4	48.6	3.6	5.5	6.9
WL(Th)	5.0	2.7	2.9	7.1	7.5	45.0	1.0	5.0	9.0

Mean radon and thoron working level (WL) are 5.4 and 5.0 with standard deviations of 1.2 and 2.7 respectively. The results obtained in this study showed a clear convergence with those of previous local studies, which is within the permissible limits stipulated in the International Organization ICRP [28].

4. CONCLUSIONS

n this study, radon and thoron absorptions were measured in three schools east of Baghdad using the SSNTD technology. The variation in C_{Rn} and C_{Th} in $Bq.m^{-3}$ was from 33.8 to 63.7 and 48.8 to 127.1 with average values of 49.9±10.9 and 86.9±31.4 respectively. The annual dose in $mSv.y^{-1}$ that resulted from radon and thoron gases varied from 2.6 to 4.7 with a mean value of 3.4±0.9. The mean WL of radon and thoron are 5.4±1.2 (3.6-6.9) and 5.0±2.7 (1-9) respectively. The obtained results in this study show a clear convergence with those of previous local studies. Also, they are within the permissible limits stipulated by the International Organization ICRP. In the same way for continuity, more effective studies are recommended.

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Ethical Compliance: I will continue to learn, observe, read, connect, listen, and search for knowledge.

Data Access Statement: Data supporting this study are included within the article and/or supporting materials.

Conflict of Interest declaration: There is no financial or non-financial conflict of interest.

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