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Research paper

Radon and thoron concentrations and resulting dose in air of southeast Baghdad regions

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Abstract

The levels of radon, thoron and their progeny concentrations in Al-Nayriya, Al-Musbah Street, Nawab Al-dhubat and Al-mashtel, as well as Canal Street in southeast Baghdad were studied by using The Twin Cup Dosimeter. A total of 15 samples selected from 5 regions (3 samples from each region) in Baghdad city have been placed in the dosimeters for 100 day. The average radon and thoron concentrations were found to be 45.47 and 43.15 Bq/m3 respectively. Their average progeny concentrations were found to be 4.91 and 1.16 mWL.
The dose received by persons living in the studied areas is less than the internationally permissible limits, which were determined by the ICRP of 3-10 mSv /y.

Keywords: *Radon; Thoron; Twin Cup Dosimeter; Working Level.*

1. Introduction

Radon is a radioactive material in a gas form. It is dry, scentless and heavy, and radon is nine times thicker than air. It is thusly the heaviest known gas. Radon is made out of one particle and due to its particles, it effectively infiltrates normal materials, for example, paper, gypsum gas can be broken up in water and in other natural solvents, radon is a respectable gas and can be found in two types of characteristic isotopes. Radon-220 is a characteristic result of thorium 232, radon - 222 is a net normal Uranium - 238 [1].
Radon is naturally radioactive gas and comes from the natural breakdown of radioactive uranium. Radon is present in soil, volcanic rocks, groundwater and well water. Radon helps in the treatment of rheumatoid arthritis, multiple sclerosis, depression and cataracts. Radon is used to study the atmosphere, explore oil [2] and uranium, because the radon rapidly dissolves and disappears quickly in the air, and uses radon in the field of hydrological research to study the interactions between groundwater and riverbeds [2], [3].
Researchers have additionally discovered that radon focuses are expanding or changing quickly around potential seismic destinations, so radon can be utilized to foresee quakes. Likewise, radon gas can impact compound responses, and additionally being utilized to examine surface responses and whole discovery [3]. Radioactive components that can be breathed in and enter the lungs and after that go to these components rot and transmitted beams, the most essential alpha particles, are consumed by the tissues neighboring the lung and cause nearby harm and this harm can prompt lung disease [4], [5].
A few investigations recommend that radon presentation by kids might be more delicate to radon. This might be because of high respiratory rate and cell division, which might be more helpless to radiation harm. Essential techniques for potential human presentation to radon are inward breath and ingestion because of its essence in substances in the ground, for example, uranium and water. Albeit high groupings of radon in water can add to radon presentation by ingestion and inward breath of radon produced from water is typically more critical [6-7].
Radon focuses in homes are typically much lower than normal radon fixations in underground metal mines, where underground diggers are presented to the most elevated amounts of radon gas, and alert ought to be practiced when utilizing natural radioactive materials [8].
Radon estimation units, work Level (Working Level (WL)), this unit was first presented in 1956 as a measure of the relative danger of fleeting radon deterioration items that could be presented to laborers in uranium mines. It has turned out to be realized that the results of radon deterioration inside the lung and vesicles will be set specifically in the vision when these items separate the primary danger of introduction to radon. This unit communicates an environment of 100 pico Ci of radon per cubic meter in balance with its dismantled yields. The Working Level Month (WLM) unit is likewise in view of the way that specialist's burn through 173 hours in a month's work on the supposition that they work eight hours per day in five days seven days. In this way, WLM was characterized as introduction to one working level for 173 hours [9-10].
The health influences of radon are in the alpha particles discharged and the debasement items. These particles have adequate vitality to enter the tissues and achieve the inward area of the cells and harm the tissues. There are two ways that radon and its deteriorating items can enter the human body - breathing and assimilation [11]. It is trusted that assimilation isn't perilous as the nearness of sustenance in the stomach, even with a thickness of not more than 1.5 mm, can stop a large portion of the alpha particles coming about because of the breakdown of radon and its introduction to the world.
It is evaluated that 6% of lung growth cases in the UK can be ascribed to radon [12]. As announced in the fourth report of the Panel, which is intended to ponder the natural impact of ionizing radiation, around 10% of disease cases are the consequence of radon. In their report, they expected that the hazard cover amongst radon and smoking was a striking one and not an accumulation relationship. This theory was found to relate to the data gathered about diggers

in Colorado and Mexico City [12]. A few examinations have additionally demonstrated that a few tumors, for example, leukemia, kidney growth and protozoa can be credited to presentation to radon [13], [14].

The present work will help in understanding the status of outdoor radon, thoron and their progeny concentrations and status of the exhalation of these gases from air. This will extensively help in finding out the contribution of the building materials used for dwellings to the radon, thoron and their progeny concentrations besides the atmospheric air and will also further enable the determination of the activity and type of radioactive elements in and around the dwellings. This will help in assessment assumes to consider the grouping of radon and thoron noticeable all around and the dosage coming about because of them in a few zones: Al-Nayriya, Al-Musbah Street, Nawab Al-dhubat and Al-mashtel, as well as Canal Street that lies in southeastern of Baghdad city and calculation of radiation doses resulting from them. The coordinates of the studied area are shown in the table 1:

Table 1: The Coordinates of the Studied Area

No.	Region name	East	North
1	Al-Nayriya	29º44'27"	18º33'00"
2	Al-Musbah Street	28º44'00"	18º33'19"
3	Nawab Al-dhubat	30º44'35"	18º33'50"
4	Al-mashtel	29º44'43"	19º33'00"
5	Canal Street	28º44'51"	19º33'58"

2. Materials and experimental

The radon–thoron mixed field dosimeter employed for the measurements is made up of a twin chamber cylindrical system using 12 µm thick, LR-115 type II and cellulose nitrate based Sold State Nuclear Detectors (SSNTDs) manufactured by Kodak Pathe, France. "Twin cup" was manufactured by us according to international standards, each chamber has a longitude of 4.1 cm and a diameter of 6.2 cm. The SSNTD1 placed in chamber M calculates ^{222}Rn only which diffuses into it from the ambient air through a semi-permeable membrane (e.g. latex, cellulose nitrate, which is used here) of 25 µm thickness having diffusion coefficient in Twin Cup Dosimeter is shown in Figure 1 and Figure 2.

Fig. 1: The Twin Cup Dosimeter.

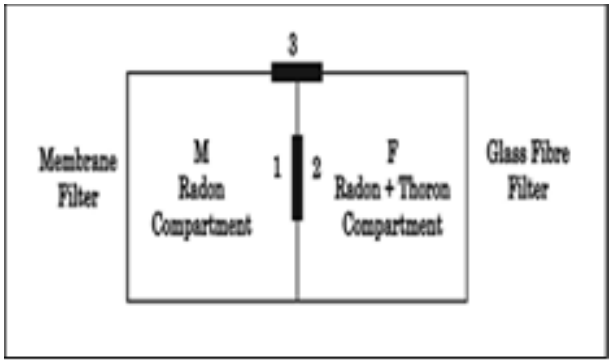

Fig. 2: The Twin Cup Dosimeter.

LR-115 detectors (1 x 1) cm, were put in the assigned territories of the Twin Container that hanged and high of 2 m from the ground. The meter was suspended in the demeanor of the zones specified in the winter for 100 days. The tracks were then etching with NaOH at 2.5 N and after that set in a water bath 60 °C for 55 minutes and afterward 20 screenings were taken for every identifier utilizing a light magnifying lens and a CCD camera fastened to the PC as in Fig. 3. The image of LR-115 after etching was shown in Fig. 4.

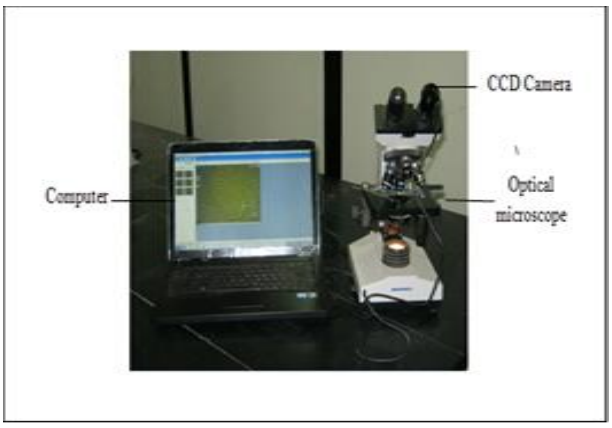

Fig. 3: System of Counting of Tracks.

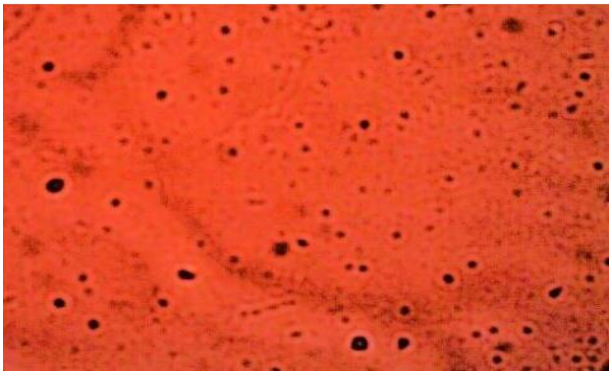

Fig. 4: Image of LR-115 after Etching.

The concentration of radon C_{Rn}, C_{TH}, C_{Rn} (WL), and C_{TH} (WL) as well as the resulting dose, were calculated by using the following mathematical relationships [15]:

$$C_{Rn}(Bq.m^{-3}) = \frac{TM}{t\,K_{RM}} \quad (1)$$

$$C_{TH}\,(Bq.m^{-3}) = \frac{TF - K_{RF}C_{Rn}t}{t\,K_{TF}} \quad (2)$$

$$Progeny\ working\ levels\ of\ Radon\ (WL) = \frac{C_{Rn}(Bq.m^{-3})XFR}{3700} \quad (3)$$

$$Progeny\ working\ levels\ of\ Thoron\ (WL) = \frac{C_{TH}(Bq.m^{-3})XFT}{3700} \quad (4)$$

Where:

TM= track density of detector in membrane compartment in (tracks/cm^2).

TF= track density of detector in filter Compartment in (tracks/cm^2).

t = total exposure time in days.

K_{RM}= Calibration factor of radon in membrane mode = 0.019 ± 0.003 tracks cm^{-2} d^{-1} /Bq.m^{-3}.

K_{RF}= Calibration factor of radon in filter mode = 0.02 ± 0.004 tracks cm^{-2} d^{-1}/Bq.m^{-3}.

K_{TF}= Calibration factor of thoron in filter mode = 0.016 ±0.005 tracks $cm^{-2}d^{-1}/Bq.m^{-3}$.
FR= Indoor equilibrium factor for Radon having value of 0.4.

FT= Indoor equilibrium factor for Thoron having value of 0.1

Indoor inhalation dose in $mSv.y^{-1}$ received due to ^{222}Rn and its progeny, and ^{220}Rn and its progeny, has been estimated using the following relation [16].

$$D = \{(0.17+9FR)\, C_{Rn} + (0.11+32FT)\, C_{TH}\} \times 7000 \times 10^{-6} \quad (5)$$

3. Results and discussion

Radon concentration C_{Rn}, Thoron concentration C_{TH}, C_{Rn} (WL), and radon daughters concentration, thoron daughters concentration and inhalation dose present in some areas of southeast Baghdad, are shown in Table 2. The values of radon and thoron concentration were the average value of three detectors were putted.

Table 2 shows that the average value of radon concentration was 45.47 Bq / m^3 and that the highest concentration of radon was 55.78 Bq / m^3 in the Al-Mashtel area and a minimum value of 34.73 Bq / m^3 in Al-Nayriya area.
The average concentration value of Thoron gas was 43.15 Bq / m^3 and the highest value of the Thoron gas concentration was 65.72 Bq / m^3 in the Nawab Al-Dhubat area. The lowest concentration was 20.59 Bq / m^3 in the Canal Street area.
As for the dose received by residents of these areas as a result of these concentrations of radon and thoron, the average value was 2.23 mSv / y and the highest value was 2.94 mSv / y in the Al-Mashtel area, the lowest value was 1.7 m Sv / y in the area of Al-Nayriya.
The average level of radon generation in the above-mentioned areas was 4.91 mWL and the highest value was 6.03 mWL in the Al-Mashtel area. The lowest value was 3.75 mWL in Al-Nayriya area while the average level of their progeny concentration was 1.16 mWL, highest value was 1.77 mWL in the Nawab Al-Dhubat area while its lowest value was 0.55 mWL in the Canal Street area.

Table 2: Full Information from the Study Area Regarding Radon, Thoron and their Progeny and the Amount of Dose Received by the Occupants of These Areas

Samples	Corrected track density for Radon (tr. cm^{-2})	Corrected track density for thoron (tr. cm^{-2})	C_R ($Bq.m^{-3}$)	C_{TH}($B.m^{-3}$)	D(mv/y)	Progeny levels of Rdon C_R (mWL)	Progeny levels of Thron C_{TH} (mWL)
Al-Nayriya	122	66	34.73	32.82	1.676	3.75	0.88
Al-Musbah Street	132	72	37.89	35.13	1.813	4.09	0.94
Nawab Al-Dhubat	202	92	48.42	65.72	2.80	5.23	1.77
Al-Mashtel	210	106	55.78	61.51	2.897	6.03	1.66
Canal Street	134	96	50.52	20.59	1.80	5.46	0.55
Average			45.47	43.15	2.23	4.91	1.16
Standard Deviation			8.85	19.53	0.7	0.95	0.52

The results varies between areas of this study because of the different population density and ventilation methods used in homes, as it increases in areas with high population density and low ventilation, and decreases in other areas.
Figure 4 shows the relation between radon concentration and annual effective dose.

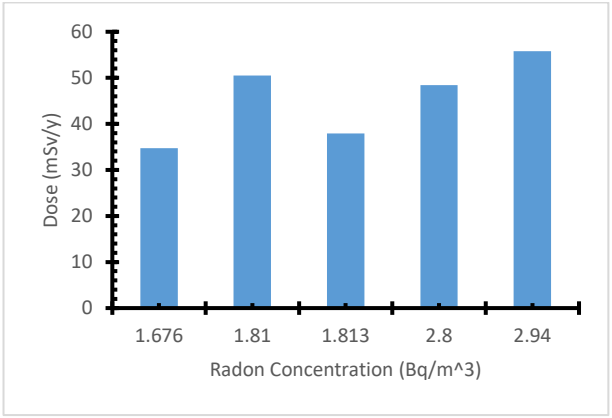

Fig. 4: Relation between Annual Effective Dose and Radon Concentration.

4. Conclusions

In this work, measurements of radon, thoron, and their progeny in dwellings and measurements of radon in air of southern of Baghdad city were displayed using SSNTDs detection technique which has a very low detection limit. According to the results, some remarkable conclusions can be listed.

The radon, thoron, radon's progeny concentrations, the equilibrium equivalent radon concentration, working level month, annual effective dose, and excess lung cancer per million person per year (ELC) were measured and estimated. The results showed that there is a large variation in the values of concentration of radon. This is due to the wide variation in the construction of the houses in in air of southern of Baghdad city. However, all investigated locations have radon concentration below the action level 200-600 $Bq.m^{-3}$ recommended by ICRP [7].
Painting materials on the plastered Walls, ceilings reduce the concentration of radon, thoron and their progeny in the dwellings. Ventilation also plays an important role in reducing indoor radon levels. From this study, we conclude that the dose received by persons living in the studied areas is less than the internationally permissible limits, which were determined by the ICRP of 3-10 mSv/y recommended by ICRP [7].

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