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# Measurement the Concentrations of Radon and Thoron and Their Progeny in the Air Samples of Al-Haswaa City in Babylon province

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**Abstract.** In this work, measurements of radon, thoron, and their progeny in dwellings and measurements of radon in air of Al-Haswaa city were displayed using SSNTD detection technique, which has a very low detection limit. The radon concentration were varied from 34.736 to 55.789 Bq.m<sup>-3</sup> with average value 47.60 Bq.m<sup>-3</sup> while the thoron concentration varied from 20.526 to 61.513 Bq.m<sup>-3</sup> with average value 33.552 Bq.m<sup>-3</sup>. The annual effective dose from the corresponding measured concentration of radon and thoron in the various dwellings were varied from 1.704 to 2.949 mS.y<sup>-1</sup> with average value 2.061 mSv.y<sup>-1</sup>, which is within the recommended ICRP intervention level of 3 -10 mSv.y<sup>-1</sup>.

## 1. Introduction

The most important issue now a day is the indoor air quality because most individuals spend 90% of their time indoors. There are many pollutants that can deteriorate indoor air quality however radon is a major pollutant for this and is an important global problem of radiation hygiene [1]. Even though measurement of radon, thoron and their progeny concentrations was done over the past 50 years in many countries, with the improvement of experimental apparatus and technical formulation, the same is going on till today. With these improvements, monitoring of radon, thoron and their progeny concentrations are well correlated with the prediction of earthquakes [2]. The measurement of radon, thoron and their progeny concentrations also leads to the knowledge of the presence of radioactive elements, which are the sources of these elements. Since Uranium-238 is the parent nuclei of Radon-222 and Thorium-232 that of Thoron, hence with the concentrations of these gases in air, one can predict the presence of high or low concentrations of the source radioactive elements.

Radon is a natural radioactive gas that occurs ubiquitously throughout the world. Radon having an atomic number of 86, is a colorless, odorless, tasteless and radioactive noble gas that generally lacks activity towards other chemical agents. It is the heaviest member of the rare gas group and has a half-life of 3.82 days. It is denoted by <sup>222</sup>Rn. Thoron is an isotope of radon, it has atomic number 86, mass number 220 and half-life of 55.3 seconds [3]. It is denoted by <sup>220</sup>Rn. The main characteristic of <sup>222</sup>Rn and <sup>220</sup>Rn among other natural radioactive elements is the fact that their behavior is not affected by chemical processes [4]. In addition, their concentration levels depend strongly on geological and geophysical conditions, as well as on atmospheric influences such as barometric pressure and rainfall.

Unprotected over-exposure to the radon emitting radium source and its daughter-contaminated dust aerosols when inhaled, can damage the cells that line the lungs and lead to lung cancer [5]. However dose to the lung from radon itself is rather low, since it is an inert gas and does not interact with lung tissue and has low dose rate per unit lung volume. Somehow equilibrium factor measurement provides



perfect idea of radioactive and chemically active radon and thoron decay products, which can be deposited on sensitive lung tissue [6]. The world average of annual effective dose to the human by natural radiation is 2.4 mSv/y and about half of which is due to internal exposure to progenies of radon and thoron [7].

Radon and thoron decay with the emission of alpha particles and produce daughter nuclei – polonium, lead and bismuth. These daughter nuclei emit alpha or beta particles. Among these daughter nuclei,  $^{218}\text{Po}$ ,  $^{214}\text{Po}$  from  $^{222}\text{Rn}$  and  $^{216}\text{Po}$  and  $^{212}\text{Po}$  from  $^{220}\text{Rn}$ , have short half-life, and these are the progenies which are under consideration [8, 9].

In the last few years, there are many researchers reported the link between exposure to radon and its decay products in mining situations and an increased risk of lung cancer such as: radon gas concentration in same region of Baghdad governorate [10], radon concentration and the annual effective dose in the soil samples of the midland refineries company - doura - Baghdad – Iraq [11], radon gas concentration measurement in air of Al - Haswaa city in Province of Baghdad [12] and determination of radon concentrations in AL- NAJAF Governorate by using nuclear track detector CR-39 [13].

AL-Haswaa city-Babil Governorate, represents high developed city in two main activities; the population growth and constructing development. Therefore, it is important to continue monitoring the radiation activities as shown in fig 1 and 2. The main goal of this study is to measure concentration of radon, thoron and their progeny levels using solid state nuclear track detectors LR-115 detectors by using twin cup technique. The samples are taken from January, 2018 to March, 2018.

## 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  $\mu\text{m}$  thick, LR-115 type II and cellulose nitrate based Solid State Nuclear Detectors (SSNTDs) manufactured by Kodak Pathe, France. Dosimeters were suspended at a height of 2 m from the ground surface at the entrances to the buildings. "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  $^{222}\text{Rn}$  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  $\mu\text{m}$  thickness having diffusion coefficient in Twin Cup Dosimeter is shown in Fig. 3 and 4.

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. 5. The image of LR-115 after etching was shown in Fig. 6 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 [14]:

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

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

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

$$\text{Progeny working level of thoron (WL)} = \frac{C_{Th}(Bq.m^{-3})XFT}{3700} \quad (4)$$

Where:

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

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

t = total exposure time in days.

KRM= Calibration factor of radon in membrane mode =  $0.019 \pm 0.003$  tracks cm<sup>-2</sup> d<sup>-1</sup> .Bq.m<sup>-3</sup>.

KRF= Calibration factor of radon in filter mode =  $0.02 \pm 0.004$  tracks cm<sup>-2</sup> d<sup>-1</sup> .Bq.m<sup>-3</sup>.

KTF= Calibration factor of thoron in filter mode =  $0.016 \pm 0.005$  tracks  $\text{cm}^{-2}\text{d}^{-1}\cdot\text{Bq}\cdot\text{m}^{-3}$ .

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  $\text{mSv}\cdot\text{y}^{-1}$  received due to  $^{222}\text{Rn}$  and its progeny, and  $^{220}\text{Rn}$  and its progeny, has been estimated using the following relation [15].

Indoor inhalation dose in  $\text{mSv}\cdot\text{y}^{-1}$  received due to  $^{222}\text{Rn}$  and its progeny, and  $^{220}\text{Rn}$  and its progeny, has been estimated using the following relation [15].

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

### 3. Results and Discussion

Measurements of indoor radon, thoron and their progeny levels were carried out using modified version of twin cup dosimeters fitted with LR-115 plastic track detectors in the dwellings of AL-Haswaa city. Table 2 gives a summary of the results of the concentration levels of indoor radon, thoron, work level month, the annual effective dose rate, the annual dose equivalent rate and excess lung cancer measured in 9 different houses in Al-Haswaa for the present study where the observation were taken from January, 2018 to March, 2018. The houses were selected at random situated at different areas, at least one a kilometer away from each other in the town. The average number of tracks per unit area was taken from the mean of the individual number of tracks per unit area. The present survey shows that the indoor radon, thoron concentrations obtained varied from (47.1 to 376.09)  $\text{Bq}\cdot\text{m}^{-3}$  with an overall mean value 176.07  $\text{Bq}\cdot\text{m}^{-3}$  and from (20.18 to 574.25)  $\text{Bq}\cdot\text{m}^{-3}$  with an overall mean value 140.31  $\text{Bq}\cdot\text{m}^{-3}$ , respectively, which are within the recommended ICRP action level of 200-600  $\text{Bq}\cdot\text{m}^{-3}$  [16] and compatible with [10 and 12].

The lowest value of radon concentration in Entrance to the city of Al-Haswaa sample was found to be 34.736  $\text{Bq}\cdot\text{m}^{-3}$  whereas the highest concentration in Near the Health Center sample was found to be 55.789  $\text{Bq}\cdot\text{m}^{-3}$  and the lowest value thoron concentration in Entrance to Sector No. 11 sample was found to be 20.526  $\text{Bq}\cdot\text{m}^{-3}$ , whereas the highest concentration in Near the Health Center sample was to be 61.513  $\text{Bq}\cdot\text{m}^{-3}$  as shown in figs. 7 and 8.

The annual effective dose from the corresponding measured concentration of radon and thoron in the various dwellings has-been calculated using Eq.5, which varied from (1.704 -2.949)  $\text{mSv}\cdot\text{y}^{-1}$  with a mean value 2.061  $\text{mSv}\cdot\text{y}^{-1}$ , as shown in fig. 9, which is within the recommended ICRP intervention level of 3 -10  $\text{mSv}\cdot\text{y}^{-1}$  [16].

### 4. Conclusions

In this work, measurements of radon, thoron, and their progeny in dwellings and measurements of radon in air of Al-Haswaa city were displayed using SSNTD detection technique which has a very low detection limit. From this study one can conclude that the radon concentration were varied from 34.736 to 55.789  $\text{Bq}\cdot\text{m}^{-3}$  with average value 47.60  $\text{Bq}\cdot\text{m}^{-3}$  while the thoron concentration were varied from 20.526 to 61.513  $\text{Bq}\cdot\text{m}^{-3}$  with average value 33.552  $\text{Bq}\cdot\text{m}^{-3}$ . The annual effective dose from the corresponding measured concentration of radon and thoron in the various dwellings were varied from 1.704 to 2.949  $\text{mSv}\cdot\text{y}^{-1}$  with average value 2.061  $\text{mSv}\cdot\text{y}^{-1}$ , which is within the recommended ICRP intervention level of 3-10  $\text{mSv}\cdot\text{y}^{-1}$ .

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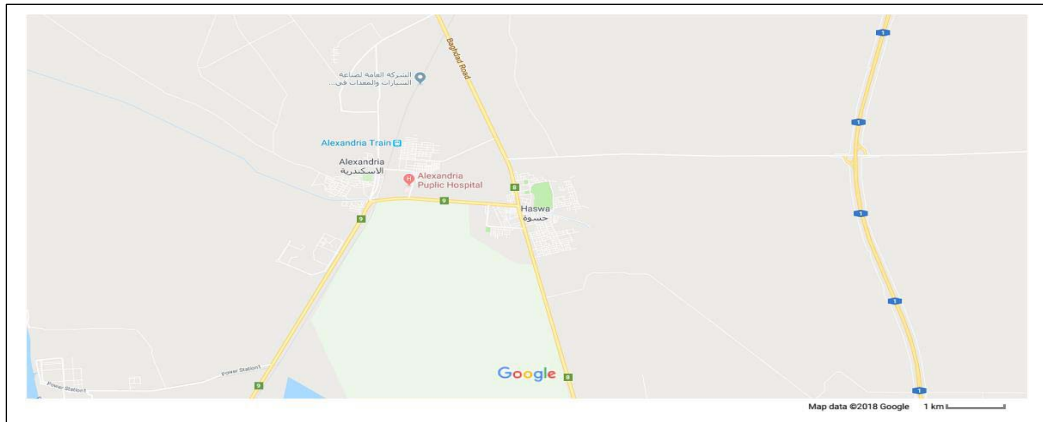
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**Table 1.** Table 1: The symbol of the studied samples.

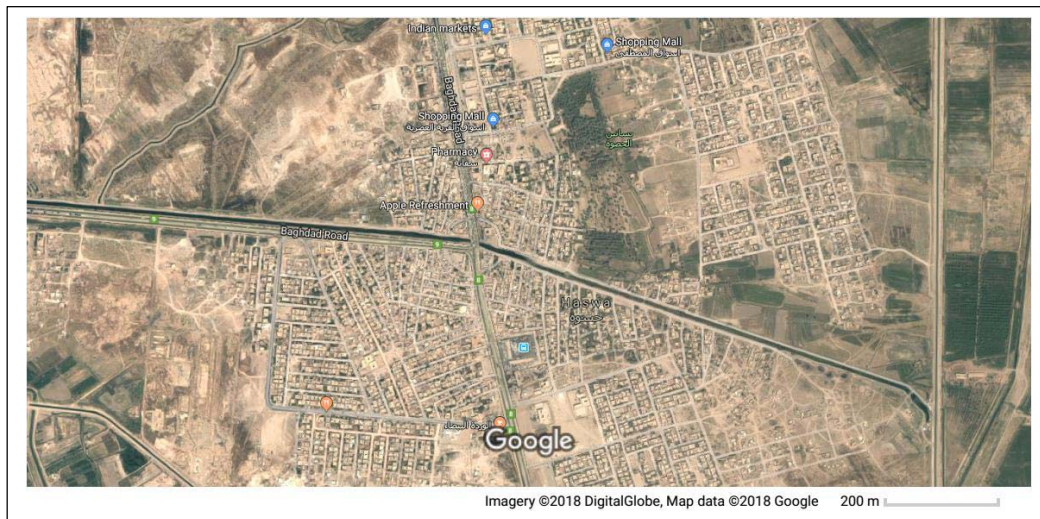
No.	Sample Name	Symbol	No.	Sample Name	Symbol
1	Entrance to the city of Hasswa	A1	5	Near the Al-Anwar Mosque	A5
2	Near the Civil Defense	A2	6	Near the Al-Shaab School for Girls	A6
3	Near Mostafa Gawad Secondary School For Girls	A3	7	Entrance to Sector No. 11	A7
4	Near the Health Center	A4	8	Entrance of Al-Intesar discrit	A8
9	Entrance of Al-Anwar Mosque	A9			

**Table 2.** The results of this study.

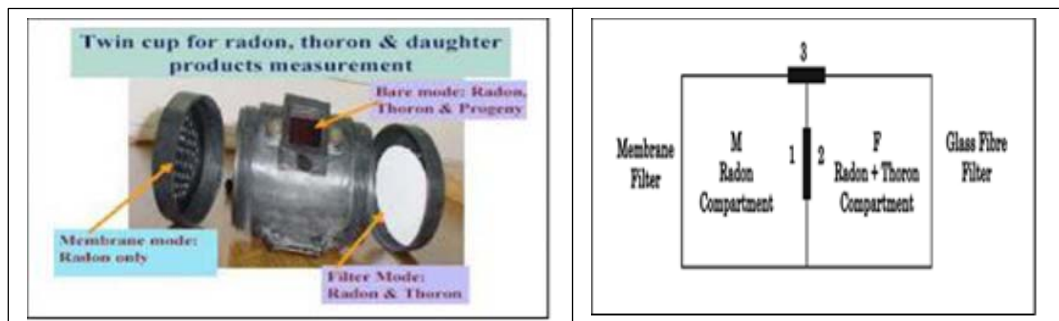
Sample Name	Filter	Membering	$C_{Rn}$ (Bq.m <sup>-3</sup> )	$C_{Th}$ (Bq.m <sup>-3</sup> )	D (mSv/y)	Progeny levels of Radon CR (mWL)	Progeny levels of Thoron CT (mWL)
Entrance to the city of Haswaa	122	66	34.736	32.828	1.704	3.755	0.887
Near the Civil Defense	132	72	37.894	35.131	1.843	4.096	0.949
Near Mostafa Gawad secondary School For Girls	202	92	48.421	65.723	2.855	5.23470	1.776
Near the Health Center	210	106	55.789	61.513	2.949	6.031	1.662
Near the Al-Anwar Mosque	134	96	50.526	20.592	1.827	5.462	0.556
Near the Al-Shaab School for Girls	132	92	48.421	21.973	1.805	5.234	0.593
Entrance to Sector No. 11	136	98	51.578	20.526	1.854	5.576	0.554
Entrance of Al-Intesar discrit	133	95	50	20.625	1.814	5.405	0.557
Entrance of Al-Anwar Mosque	139	97	51.052	23.059	1.9	5.519	0.623
Average			47.60	33.552	2.061	5.14619	0.906



**Figure 1:** The location of Al-Haswaa city.

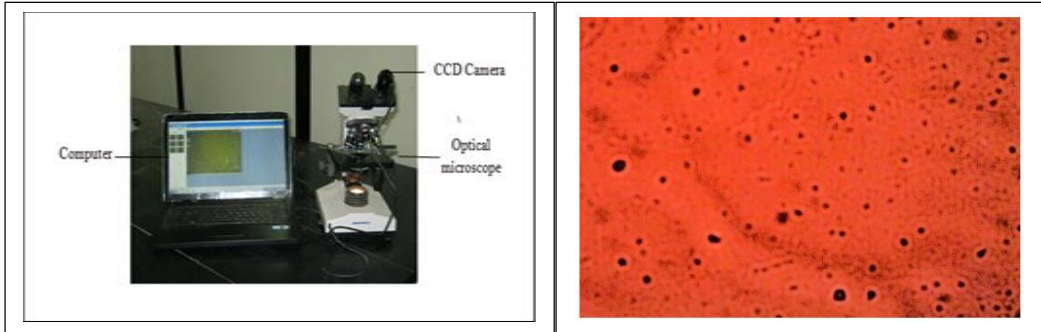


**Figure 2:** The geological map of the studied area.

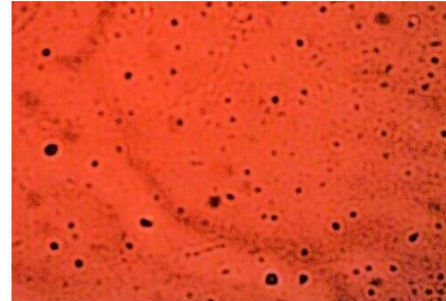


**Figure 4:** The Twin Cup Dosimeter.

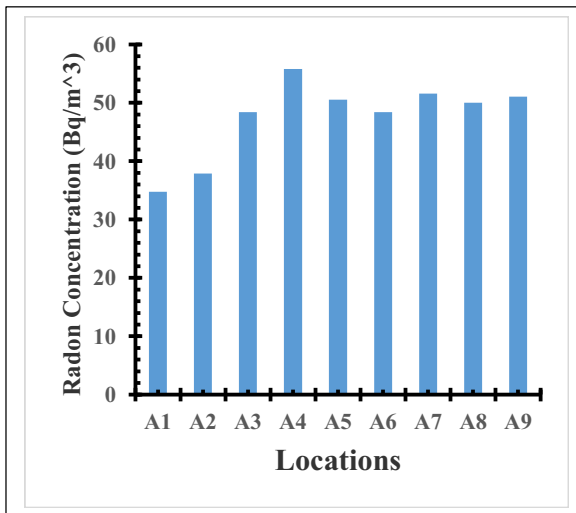
**Figure 3:** The Twin Cup Dosimeter.



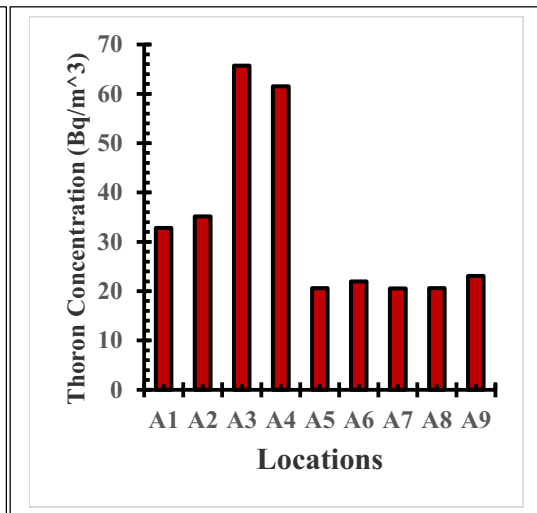
**Figure 5:** System of counting of tracks.



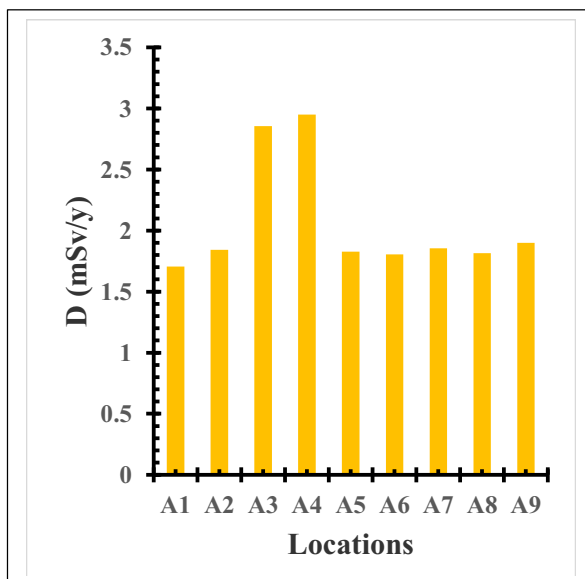
**Figure 6:** Image of LR-115 after exposure.



**Figure 7:** Radon Concentration in all Locations.



**Figure 8:** Thoron Concentration in all Locations.



**Figure 9:** Annual Effective Dose in all Locations due to Radon and Thoron.