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## Estimation of Organs Doses for People (Male and Female) Exposed to Indoor Radon in Al-Najaf

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**Abstract.** In this paper, the radon concentrations in the houses of (10) locations were measured using real-time continuous radon monitor RAD-7 detector together with estimating the corresponding female and male organ doses using Monte Carlo (MC) simulation software at Al-Najaf city-Iraq. It is found that the radon concentrations varied from  $(8.75 \pm 1.1 \text{ Bq/m}^3)$  to  $(32.32 \pm 4.0 \text{ Bq/m}^3)$  with an average  $(20.57 \pm 2.90 \text{ Bq/m}^3)$ . The resulted data for male reveal that the bladder received the highest dose at  $9.78 \text{E-}05 \text{ } \mu\text{Gy/h}$  in Missan, while the salivary gland was noticed to have the highest dose in each of Jmhorria, Adalh, Saad and Milad regions with dose rates of  $4.65 \text{E-}05$ ,  $3.59 \text{E-}05$ ,  $5.72 \text{E-}05$  and  $3.45 \text{E-}05 \text{ } \mu\text{Gy/h}$  respectively. In Asskry Najaf regions the highest dose was seen to be with the Lung with  $9.30 \text{E-}05 \text{ } \mu\text{Gy/h}$ . In Asskiry Kufa and Mutnaby the highest organ doses were attributed to the bone surface at  $9.73 \text{E-}05$  and  $9.62 \text{E-}05 \text{ } \mu\text{Gy/h}$  respectively. In Tmoz and Sirai regions, the highest organ doses were with Extrathor airways and thyroid at  $6.64 \text{E-}05$  and  $9.65 \text{E-}05 \text{ } \mu\text{Gy/h}$  respectively. By contrast, the female findings reveal the doses for all organs and across all considered neighborhoods ranged from  $1. \text{E-}04 \text{ } \mu\text{Gy/h}$  to  $9 \text{E-}05 \text{ } \mu\text{Gy/h}$ . Finally, it can be concluded that all results of radon concentrations in ten locations samples were within the range allowed according to ICRP. The organ doses seem to be very low which in turn reduce the concern related to the effect of radiation.

**Keywords.**  $^{222}\text{Rn}$ , Monte Carlo, effective dose, Al-Najaf city and RAD-7.

### 1. Introduction

Having considered the International Atomic Energy Agency publications, the general public is exposed to a variety of radiation sources to include terrestrial, internal radionuclides, medical radiation exposure and different consumer products [1]. It is well known that radiation, with a sufficient energy, can lead to cancer. Nevertheless, high radiation exposure can also be used for cancer treatment. In this regards, exposure to ionizing radiation resulted from an environment, via the Earth's history, is an unavoidable



issue. The processes of nucleosynthesis that lead to formation of elements can cause both stable and unstable nuclei. The unstable nuclei together with their radioactive progenies that have very long half-life are forming the natural radioactivity today. Further to this, the huge interactions on the sun with other process elsewhere may lead to the bombardment of the Earth with cosmic rays [2]. Therefore, measuring the natural radioactivity of the environment allows for the estimation of the amount of the pollution that people are living with. On the other hand, tissues exposure to ionizing radiation can occur internally.

This is resulted from either bone surface or airborne contamination that has entered into the body. Radioactive materials can be existed in different format to include a gas, vapor or aerosol if they are in the airborne form. In this context, the fate of airborne radioactive substances after they entered into inside the respiratory system relies on the particles size and their solubility in the fluid of the lung. The contaminants of airborne can be found inform of radon gas and iodine vapor or centrifuge aerosols [3].

The radon can be defined as tasteless, colorless, odourless, non-flammable and  $\alpha$  emitted radioactive gas. Consequently, it is impossible to detect it using human sensation. Radon, as a gas element, has a density of ( $\sim 9.96$ )  $\text{kg/m}^3$  which is the highest among other elements, and this around seven times higher than air. The radon, as being noble, it has ability to freely flow through the soil, air, etc. [4]. Radon, as a radioactive gas, originated from the decay of 'uranium and thorium' series in time that these elements are existed elsewhere in the ground. Important isotopes that are belonging to them are:  $^{238}\text{U}$  and  $^{232}\text{Th}$  [2]. The main sources of the radon and its daughters in buildings are as follow: the soil close to the buildings, potable water together with the building materials [5]. To illustrates, this gas enters house from the ground via the existed cracks in concrete floor and wall, then via gaps between floor and slab, around drains and pipes, and small pores of hollow-block walls [6]. Building materials such as bricks, wallboard and concrete are characterized by being porous enough to allow the radon to pass through into the indoor air. However, other types of material that are not originated from the earth's crust such as 'wood' featured by having a low radium concentration [7].

In this regards, indoor radon level must not exceed the limits of ( $200 - 300\text{Bq/m}^3$ ) that recommended by the International Commission on Radiological Protection Statement on Radon (ICRP) [8]. High exposure to the radon gas via breathing process of air may increase the risk of developing lung cancer; in which alpha particles can lead to damage the tissues through attaching the DNA of cells [9]. So, the incidence of cancer requires the occurrence of at least one mutation to happen [10]. A good body of researches has been conducted to assess the radon concentration in dwellings using a variety of techniques [11-14].

Having considered the great importance of investigating the radon levels on people's lives, and the corresponding consequences of the exposure to it, it is necessary to study the concentrations of radon gas in the buildings of Al-Najaf city. The current work is aimed at investigating the radon concentrations in the houses, at different locations, in Al-Najaf city, Iraq using RAD-7 detector. Also, to estimate the human organs doses using MC Simulation.

## 2. Study area

The governorate of Al Najaf situated between the coordinates of latitudes  $32^{\circ}21' \text{N}$  and  $29^{\circ}50' \text{N}$ , the coordinates of longitudes  $44^{\circ}44' \text{E}$  and  $42^{\circ}50' \text{E}$  with a  $28,824 \text{ km}^2$  total area (6.6% of Iraq) [15]. It comprises three main districts namely, Al-Manatheria, Al-Kufa and Al-Najaf district). These districts can be seen in Figure 1.

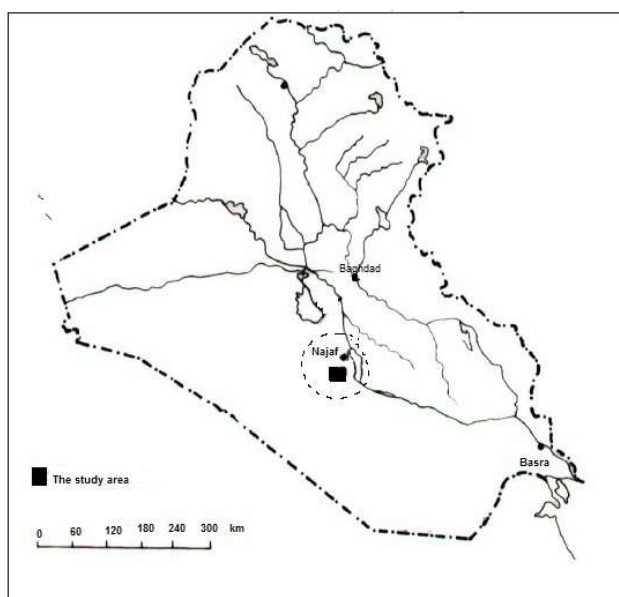


Figure 1. Map of study area

### 2.1. Locations and Collection of the Samples

In the current work 10 regions were fairly selected in Al-Kufa and Al-Najaf cities as demonstrated in Figure 2.

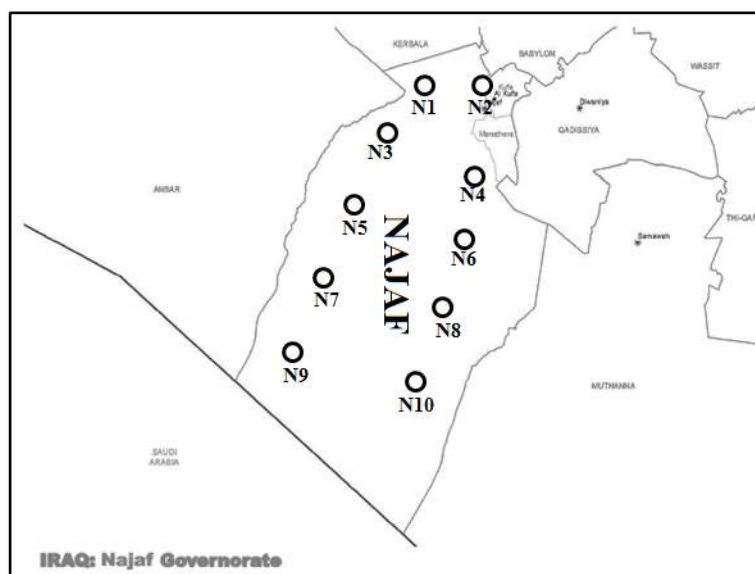


Figure 2. Location samples on study area

### 3. The Monitoring system (RAD-7)

This detector is characterized by being real time and continuous radon monitor system. This, in turn, indicates for the ability of this system to observe the variations in the radon level can during the period of measurement. In fact, this is very useful in investigating those factors that impacting the radon concentration throughout time. For example, the factors can include changes in temperature, speed of wind and relative humidity [16]. Continuous monitoring of radon is based on the principle of particles detection. The RAD-7 detector includes semiconductor materials. It possesses a periodic-fill cell. This

cell is filled with air by the technique of a small pump that draws the air into this cell one time in each pre-selected interval. In aforementioned cell, the radon may disintegrate, and the disintegrations are counted. This cycle will be repeated throughout [17]. Figure (3) shows the RAD-7™ electronic radon monitor.



Figure 3. RAD-7™ electronic continuous radon monitor.

#### 4. Sample collection

The procedure of collecting the samples can be described as follows: Four samples were taken from each house of each region. Forty samples of air were measured using RAD-7 detector. The sniff mode and time was set to be one hour. To assess the radon from each sample, the sample was enclosed into a column and airborne radon/thoron was measured with a continuous monitor of type (RAD-7, DurrIDGE Company, USA). The flow rate of air was 0.7 L/min. A room geometry of  $3 \times 3 \times 4 \text{ m}^3$  was designed to estimate the human organ radiation dose due to the exposure to the indoor radon.

#### 5. VMC Validation

This program has been written in the Instituto de Radioproteção e Dosimetria for simulating the radiation transport throughout specific voxel model. Basically, the VMC was written using visual basic. It can be applied for both internal and external dose calculations which resulted from photons [18]. It was then extended to include alpha particle, electron and proton transport through a specified voxel structure. To assess the validity of this program, it has previously been benchmarked via comparisons with many other models and MC software [19]. The results of these validation attempts show that there is a good agreement for the estimation of effective dose and organ doses due to cloud immersion obtained using VMC and Federal Guidance Report No.12. In this paper, the program provides conversion factors that based on the M C simulation to calculate both the organ and effective dose as a result of exposure to radiation.

#### 6. Results and Discussion

The results of radon concentrations in houses air at 10 locations at Al-Najaf area are shown in Table (2). From Table (2), it can be seen that radon concentrations were varied from  $(8.75 \pm 1.1 \text{ Bq/m}^3)$  in location (N10 sample) to  $(32.32 \pm 4.0 \text{ Bq/m}^3)$  in location (N1 sample) with an average value of  $(20.57 \pm 2.90 \text{ Bq/m}^3)$ . The observed variations of radon concentrations across different regions can be attributed to a number of factors such as geological structure of the sites, the different types of materials used for the construction of the houses, and ventilation levels, and the aging impact on the houses as well as the daily habits of the of people living at these houses.

According to the resulted data of the current study, the highest value of  $^{222}\text{Rn}$  concentration is much lower than those recommended by ICRP indoor radon (200-400)  $\text{Bq/m}^3$  [20]. By way of comparison, these results when compared with those of the Arabic countries, it was found that the range of average radon concentration in Jordan (west of Iraq) buildings is  $(9.95 - 68.15) \text{ Bq/m}^3$  [21] and in Egypt particularly in some regions, the average radon concentration in air of buildings was reported to be around  $79.505 \text{ Bq/m}^3$  in range  $(38.62-120.39) \text{ Bq/m}^3$  [22].

**Table 1.** Results of Radon Concentrations

No.	Location Sample	222Rn Concentrations	
		Mean	±Standard Error
1	N1	32.32	4.0
2	N2	28.62	3.6
3	N3	27.95	3.5
4	N4	11.78	1.5
5	N5	17.17	2.1
6	N6	28.28	3.5
7	N7	9.09	1.1
8	N8	14.48	1.8
9	N9	27.27	3.4
10	N10	8.75	1.1
Average ± S.E		20.57±2.90	

### 7. Organ dose Calculation

The results of organ doses which were obtained from the MC simulation for the above considered geometry ( $3 \times 3 \times 4 \text{ m}^3$ ) for those humans exposed to indoor radon are presented in the table 2 and 3 for each of male and female respectively.

**Table 2.** Male organs doses resulted from the exposure to radon

Organ	$\mu\text{Gy/h}$	$\mu\text{Gy/h}$	$\mu\text{Gy/h}$	$\mu\text{Gy/h}^4$	$\mu\text{Gy/h}$	$\mu\text{Gy/h}$	$\mu\text{Gy/h}$	$\mu\text{Gy/h}$	$\mu\text{Gy/h}$	$\mu\text{Gy/h}$
Red bone marrow	1.04E-04	9.07E-05	8.97E-05	3.78E-05	5.51E-05	9.08E-05	2.92E-05	4.65E-05	8.75E-05	2.81E-05
Colon	1.02E-04	8.90E-05	8.81E-05	3.71E-05	5.41E-05	8.91E-05	2.86E-05	4.56E-05	8.59E-05	2.76E-05
Lung	1.10E-04	9.63E-05	9.53E-05	4.02E-05	5.85E-05	9.64E-05	3.10E-05	4.94E-05	9.30E-05	2.98E-05
Stomach	1.02E-04	8.90E-05	8.81E-05	3.71E-05	5.41E-05	8.91E-05	2.86E-05	4.56E-05	8.59E-05	2.76E-05
Breast	1.25E-04	1.10E-04	1.08E-04	4.56E-05	6.65E-05	1.10E-04	3.52E-05	5.61E-05	1.06E-04	3.39E-05
Remainder	1.03E-04	9.04E-05	8.94E-05	3.77E-05	5.49E-05	9.05E-05	2.91E-05	4.63E-05	8.73E-05	2.80E-05
Testes	1.00E-04	8.77E-05	8.68E-05	3.66E-05	5.33E-05	8.78E-05	2.82E-05	4.50E-05	8.47E-05	2.72E-05
Bladder	9.78E-05	8.55E-05	8.45E-05	3.56E-05	5.19E-05	8.55E-05	2.75E-05	4.38E-05	8.25E-05	2.65E-05
Oesophagus	1.06E-04	9.27E-05	9.17E-05	3.86E-05	5.63E-05	9.28E-05	2.98E-05	4.75E-05	8.94E-05	2.87E-05
Liver	1.01E-04	8.80E-05	8.70E-05	3.67E-05	5.35E-05	8.80E-05	2.83E-05	4.51E-05	8.49E-05	2.72E-05
Thyroid	1.10E-04	9.65E-05	9.54E-05	4.02E-05	5.86E-05	9.65E-05	3.10E-05	4.94E-05	9.31E-05	2.99E-05
Bone surface	1.11E-04	9.73E-05	9.62E-05	4.06E-05	5.91E-05	9.74E-05	3.13E-05	4.99E-05	9.39E-05	3.01E-05
Brain	1.25E-04	1.09E-04	1.08E-04	4.56E-05	6.64E-05	1.09E-04	3.52E-05	5.60E-05	1.05E-04	3.38E-05
Salivary gland	1.28E-04	1.12E-04	1.10E-04	4.65E-05	6.78E-05	1.12E-04	3.59E-05	5.72E-05	1.08E-04	3.45E-05
Skin	1.23E-04	1.08E-04	1.07E-04	4.50E-05	6.56E-05	1.08E-04	3.47E-05	5.53E-05	1.04E-04	3.34E-05
Adrenals	1.07E-04	9.38E-05	9.27E-05	3.91E-05	5.70E-05	9.38E-05	3.02E-05	4.80E-05	9.05E-05	2.90E-05
Extrathor airways	1.25E-04	1.09E-04	1.08E-04	4.56E-05	6.64E-05	1.09E-04	3.52E-05	5.60E-05	1.05E-04	3.38E-05
Gall bladder	8.94E-05	7.81E-05	7.73E-05	3.26E-05	4.75E-05	7.82E-05	2.51E-05	4.00E-05	7.54E-05	2.42E-05
Heart	1.01E-04	8.80E-05	8.70E-05	3.67E-05	5.35E-05	8.81E-05	2.83E-05	4.51E-05	8.49E-05	2.72E-05
Kidneys	9.64E-05	8.43E-05	8.34E-05	3.52E-05	5.12E-05	8.44E-05	2.71E-05	4.32E-05	8.14E-05	2.61E-05
Lymphatic nodes	1.04E-04	9.10E-05	9.00E-05	3.79E-05	5.53E-05	9.11E-05	2.93E-05	4.66E-05	8.78E-05	2.82E-05
Muscle	1.09E-04	9.53E-05	9.42E-05	3.97E-05	5.79E-05	9.54E-05	3.07E-05	4.88E-05	9.20E-05	2.95E-05
Oral mucosa	1.23E-04	1.08E-04	1.07E-04	4.50E-05	6.56E-05	1.08E-04	3.47E-05	5.53E-05	1.04E-04	3.34E-05
Pancreas	1.00E-04	8.77E-05	8.67E-05	3.66E-05	5.33E-05	8.78E-05	2.82E-05	4.49E-05	8.46E-05	2.72E-05

Prostate	8.62E-05	7.54E-05	7.46E-05	3.14E-05	4.58E-05	7.55E-05	2.43E-05	3.86E-05	7.28E-05	2.33E-05
Small intestine	9.73E-05	8.51E-05	8.42E-05	3.55E-05	5.17E-05	8.52E-05	2.74E-05	4.36E-05	8.21E-05	2.64E-05
Spleen	1.02E-04	8.91E-05	8.81E-05	3.71E-05	5.41E-05	8.91E-05	2.87E-05	4.56E-05	8.60E-05	2.76E-05
Thymus	1.03E-04	9.05E-05	8.95E-05	3.77E-05	5.50E-05	9.05E-05	2.91E-05	4.64E-05	8.73E-05	2.80E-05
Eye lens	5.10E-05	4.46E-05	4.41E-05	1.86E-05	2.71E-05	4.47E-05	1.44E-05	2.29E-05	4.31E-05	1.38E-05
Neighborhood	Missan	Asskiry	Mutnaby	Jmhorria	Tmoz	Sriai	Adalh	Saad	Asskry Najaf	Milad

According to table 2, it can be seen that that highest organ doses resulted from the exposure to radon for the following regions (i.e. Missan, Asskiry, Mutnaby, Jmhorria, Tmoz, Sriai, Adalh, Saad, Asskry, Milad) were as follows: Bladder - 9.78E-05  $\mu\text{Gy/h}$  (Missan), Salivary gland -1.12E-04  $\mu\text{Gy/h}$  (Asskiry and Mutnaby), Salivary gland - 4.65E-05  $\mu\text{Gy/h}$  (Jmhorria), Salivary gland-4.65E-05  $\mu\text{Gy/h}$  (Tmoz), Salivary gland-1.12E-04  $\mu\text{Gy/h}$  (Sriai), Salivary-3.59E-05  $\mu\text{Gy/h}$ (Adalh), Salivary gland -5.72E-05  $\mu\text{Gy/h}$  (Saad), Salivary gland -1.08E-04  $\mu\text{Gy/h}$  (Asskry Najaf) and Salivary gland - 3.45E-05  $\mu\text{Gy/h}$  (Milad) respectively.

**Table 3.** Female organs doses resulted from the exposure to radon

Organ	$\mu\text{Gy/h}$	$\mu\text{Gy/h}$	$\mu\text{Gy/h}$	$\mu\text{Gy/h}$	$\mu\text{Gy/h}$	$\mu\text{Gy/h}$	$\mu\text{Gy/h}$	$\mu\text{Gy/h}$	$\mu\text{Gy/h}$	$\mu\text{Gy/h}$
Red bone marrow	0.00010 7	9.34E-05 05	9.24E-05 05	3.89E-05 05	5.67E-05 05	9.35E-05 05	3E-05	4.79E-05 05	9.01274E-05 05	2.89188E-05 05
Colon	0.00010 4	9.08E-05 05	8.98E-05 05	3.78E-05 05	5.52E-05 05	9.09E-05 05	2.92E-05 05	4.65E-05 05	8.76185E-05 05	2.81138E-05 05
Lung	0.00011 6	0.00010 1	0.0001 05	4.23E-05 05	6.16E-05 05	0.00010 2	3.26E-05 05	5.2E-05	9.78993E-05 05	3.14125E-05 05
Stomach	0.00011 8	9.65E-05 05	9.54E-05 05	4.02E-05 05	5.86E-05 05	9.65E-05 05	3.1E-05	4.94E-05 05	9.30998E-05 05	2.98725E-05 05
Breast	0.00012 8	0.00011 1	0.00011 05	4.65E-05 05	6.77E-05 05	0.00011 2	3.59E-05 05	5.71E-05 05	0.00010758 05	3.45188E-05 05
Remainder	0.00010 6	9.3E-05	9.2E-05	3.88E-05 05	5.65E-05 05	9.31E-05 05	2.99E-05 05	4.77E-05 05	8.97456E-05 05	2.87963E-05 05
Ovaries	8.93E-05 05	7.81E-05 05	7.72E-05 05	3.25E-05 05	4.74E-05 05	7.81E-05 05	2.51E-05 05	4E-05	7.5347E-05	2.41763E-05 05
Bladder	0.0001 7	8.77E-05 05	8.67E-05 05	3.66E-05 05	5.33E-05 05	8.78E-05 05	2.82E-05 05	4.49E-05 05	8.46188E-05 05	2.71513E-05 05
Oesophagus	0.00010 7	9.33E-05 05	9.23E-05 05	3.89E-05 05	5.67E-05 05	9.34E-05 05	3E-05	4.78E-05 05	9.00183E-05 05	2.88838E-05 05
Liver	0.00010 8	9.42E-05 05	9.31E-05 05	3.93E-05 05	5.72E-05 05	9.42E-05 05	3.03E-05 05	4.82E-05 05	9.08636E-05 05	0.00002915 5
Thyroid	0.00011 9	0.00010 4	0.00010 3	4.34E-05 05	6.32E-05 05	0.00010 4	3.35E-05 05	5.33E-05 05	0.00010043 5	3.22263E-05 05
Bone surface	0.00011 3	9.87E-05 05	9.76E-05 05	4.11E-05 05	6E-05	9.88E-05 05	3.18E-05 05	5.06E-05 05	9.52541E-05 05	3.05638E-05 05
Brain	0.00012 9	0.00011 3	0.00011 1	4.7E-05	6.85E-05 05	0.00011 3	3.63E-05 05	5.78E-05 05	0.00010878 05	3.49038E-05 05
Salivary gland	0.00011 4	0.0001 05	9.89E-05 05	4.17E-05 05	6.08E-05 05	0.0001 05	3.22E-05 05	5.13E-05 05	9.65358E-05 05	0.00003097 5
Skin	0.00012 6	0.00011 9	0.00010 9	4.59E-05 05	6.7E-05	0.00011 05	3.55E-05 05	5.65E-05 05	0.00010635 3	0.00003412 5
Adrenals	9.65E-05 05	8.44E-05 05	8.34E-05 05	3.52E-05 05	5.13E-05 05	8.44E-05 05	2.71E-05 05	4.32E-05 05	8.1401E-05	2.61188E-05 05
Extrathor airways	0.00011 3	9.91E-05 05	9.8E-05	4.13E-05 05	6.02E-05 05	9.92E-05 05	3.19E-05 05	5.08E-05 05	9.56632E-05 05	0.00003069 5
Gall bladder	9.91E-05 05	8.66E-05 05	8.57E-05 05	3.61E-05 05	5.26E-05 05	8.67E-05 05	2.79E-05 05	4.44E-05 05	8.36098E-05 05	2.68275E-05 05
Heart	0.00011 5	0.00010 1	9.94E-05 05	4.19E-05 05	6.11E-05 05	0.00010 1	3.23E-05 05	5.15E-05 05	9.70267E-05 05	3.11325E-05 05
Kidneys	0.00010 2	8.95E-05 05	8.85E-05 05	3.73E-05 05	5.44E-05 05	8.96E-05 05	2.88E-05 05	4.59E-05 05	8.63914E-05 05	0.00002772 05
Lymphatic nodes	0.00010 8	9.41E-05 05	9.31E-05 05	3.92E-05 05	5.72E-05 05	9.42E-05 05	3.03E-05 05	4.82E-05 05	9.08364E-05 05	2.91463E-05 05
Muscle	0.00011 1	9.66E-05 05	9.56E-05 05	4.03E-05 05	5.87E-05 05	9.67E-05 05	3.11E-05 05	4.95E-05 05	9.32634E-05 05	0.00002992 5
Oral mucosa	0.00012 7	0.00011 1	0.00011 05	4.63E-05 05	6.74E-05 05	0.00011 1	3.57E-05 05	5.69E-05 05	0.00010708 9	3.43613E-05 05

Pancreas	0.00010 2	8.9E-05	8.8E-05	3.71E- 05	5.41E- 05	8.9E-05	2.86E- 05	4.56E- 05	8.5846E-05	0.00002754 5
Small intestine	9.98E- 05	8.73E- 05	8.63E- 05	3.64E- 05	5.3E-05	8.74E- 05	2.81E- 05	4.47E- 05	8.4237E-05	2.70288E- 05
Spleen	0.00010 4	9.12E- 05	9.02E- 05	3.8E-05	5.54E- 05	9.13E- 05	2.93E- 05	4.67E- 05	8.80003E- 05	2.82363E- 05
Thymus	0.00011 8	0.00010 3	0.00010 2	4.31E- 05	6.28E- 05	0.00010 3	3.33E- 05	5.3E-05	9.97809E- 05	3.20163E- 05
Uterus	8.72E- 05	7.62E- 05	7.54E- 05	3.18E- 05	4.63E- 05	7.63E- 05	2.45E- 05	3.91E- 05	7.35472E- 05	2.35988E- 05
Eye lens	0.00010 6	9.28E- 05	9.18E- 05	3.87E- 05	5.64E- 05	9.29E- 05	2.99E- 05	4.76E- 05	8.9582E-05	2.87438E- 05
Neighborhood	Missan	Asskiry	Mutnaby	Jmhorria	Tmoz	Sriai	Adalh	Saad	Asskry Najaf	Milad

When considering the data presented in table 3 which demonstrates the organ doses for female people living in the houses of the above regions of the this study. The highest reported organ doses as related to the considered regions are as follow: Stomach - 0.0001 $\mu$ Gy/h (Missan), Salivary gland -0.0001  $\mu$ Gy/h (Asskiry), Heart-9.94E-05 $\mu$ Gy/h (Mutnaby), Salivary gland - 4.65E-05 $\mu$ Gy/h (Jmhorria), Brain - 6.85E-05 $\mu$ Gy/h (Tmoz), Salivary gland-0.0001  $\mu$ Gy/h (Sriai), Brain-3.63E-05 $\mu$ Gy/h(Adalh), Brain - 5.78E-05 $\mu$ Gy/h (Saad), Thymus - 9.97809E-05 $\mu$ Gy/h (Asskry Najaf) and Brain - 3.49038E-05 $\mu$ Gy/h (Milad) respectively. From the results mentioned above for male, it is clear that the Salivary gland had received the highest dose among other organs and for the majority of Najaf regions considered in this study (9 out of 10 regions). By contrast, when examining the results of the female organ doses, it is clear that the highest dose received by organs almost fairly distributed between the brain and salivary gland.

## 8. Conclusions

From the present work, we conclude that: all results of radon concentrations were obtained in this study are less than the allowed concentration level. Concerning the organ dose for either gender is low. Nevertheless, this estimation is considered for one hour, so one required to take a caution of having good ventilation and with recommended building materials proved to have low radioactivity.

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