Studying the Existence of the Hidden Deadly Radioactive Radon Gas in Some Houses in Al-Ajilat City

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***Abstract*—This study was conducted to detect the presence of the hidden radioactive and deadly radon gas in 10 houses in Al-Zaramaqa area in the city of Al-Ajilat, using a solid-state device (RADEX MR107) for detecting the presence of this gas in buildings of various types. Through this study, the results showed that this gas is present in different proportions depending on the location and design of the building, as well as the type of building materials used in its construction, and the ventilation system employed in the area where the study was conducted. It was found that the radon values in the buildings under study ranged between 28 and 59 Bq/m^3. It was also found that these values obtained fall below the dangerous and non-permissible values referred to by the World Health Organization, estimated at (200 Bq/m^3) and therefore they are considered within the low risk levels. Lung cancer is one of the most serious consequences of exposure to this radioactive gas. Given the study's limited number of buildings and areas covered, it cannot be concluded that there are no other buildings in the city of Al-Ajilat with high radon concentrations.**

Keywords—building materials, natural radioactivity, radon, exhalation.

I. INTRODUCTION

This Human exposure to varying levels of radiation is undesirable, as high doses can cause harmful effects. Scientists have recently begun studying exposure to low doses of radiation emitted by naturally occurring radioisotopes, such as uranium and its decay products, including radon gas. Radon represents about half the average effective dose of natural radiation for the general population. Its concentration in residential areas varies greatly. Uranium is found in the Earth's crust in varying concentrations, generally at low levels, and is also present in many building materials. Radium, a uranium precursor, has a half-life of 1,600 years and continues to produce radon gas in its radioactive decay chain. Because radon is an inert gas with a half-life of 3.82 days, it can penetrate porous materials before decaying into its short-lived precursors. Suppose radon gas is generated in the floor of a building, or from used water, especially if it is drawn directly from underground sources. In that case, it can penetrate the building, depending on the balance between its rate of entry from the air and its rate of exit from it. These two ratios vary greatly from place to place and from building to building, depending on the location, building components, and dispersal method. Numerous scientific studies and research have proven that prolonged, excessive exposure to high doses leads to the most serious disease: cancer. When radioactive materials enter the human body, the risk of cancer depends on the location of the material in the body, and therefore, the type of cancer varies depending on the organ affected. The United Nations report (UNSCEAR, 1983) on natural radiation confirmed that radioactive radon gas represents more than 50% of the total radiation dose to which humans are exposed resulting from natural radiation [1]. This dangerous radioactive gas is known to be chemically inert, colorless, tasteless, and odorless. Its atomic number is 86, its density is 9.7 kg/m³, its boiling point is -61.8°C and its freezing point is -71°C. This element is produced from the decay series of uranium (238U), which passes through several elements to end with lead (206Pb), as shown in Figure 1.

The emission of energy through ionizing radiation from the Uranium-238 decay chain, which includes alpha and beta particles is shown above in Figure 1.

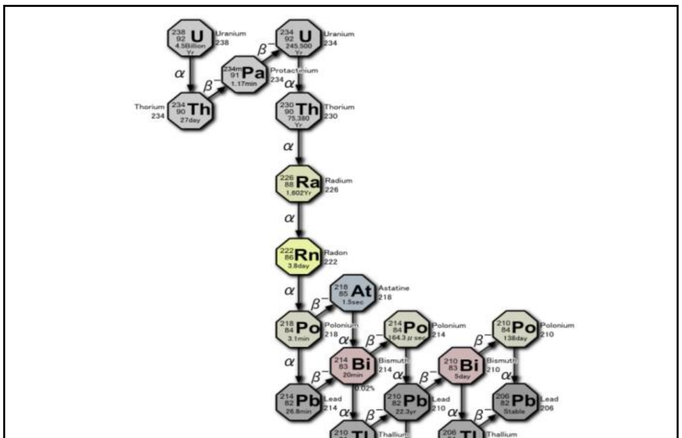

Fig. 1. Shows Uranium (U 238) Decay Series [2].

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The following segments of the decay chain describe the radio nuclides. Table I shows Uranium, its decay products, and the radiation energy released during the decay [3].

Isotope	Half life	The energy of the outgoing radiation		
		Α	*β*	*γ*
Radon 222	3.823 days	5.49	0.67	0.295
Polonium 218	3.05 min	6.00	0.73	0.352
Lead 214	26.8 days	-	1.32	0.609
Bismuth 214	19.7 min	-	1.51	1.12
Polonium 214	167 µ sec	7.69	-	-
Lead 210	22.3 years	-	0.015	0.047
Bismuth 210	5.01 days	-	0.161	-
Polonium 210	138.4 days	5.3	-	-
Lead 206	stable	-	-	-

TABLE I. SHOWS URANIUM ITS DECAY PRODUCTS

II. RADON ISOTOPES

Radon has three isotopes:

A. *Actinon 219Rn,*

This isotope belongs to the actinium series. Its presence in nature is rare compared to the other two isotopes. This is due to the fact that the concentration of 235U in rocks and soil is less than 1% of the concentration of 238U. In addition, the half-life of actinon is very short (4 seconds), which explains the impossibility of measuring its concentration in the air.

B. *Thorne 220Rn,*

Thorne is the most abundant of the three isotopes and belongs to the thorium series. Due to its short half-life of 55 seconds, it quickly disappears from the atmosphere.

C. *Radon 222Rn:*

This element is the longest-lived of the three isotopes, with a half-life of 3.82 days. Because it belongs to uranium-238 (238U), it is emitted from the soil at a rate 100 times lower than radon-220 (220Rn) and because it has a relatively long half-life, it is widely distributed in the air [4].

III. RADON SOURCES IN HOMES

It was well known that one of the most important sources of the radioactive radon gas inside homes in general is the soil on which these houses were built, where radon gas leaks from the soil into the house through cracks and fissures that exist in the foundation and floor. 80% of the radon gas leaking into the external environment and its presence in the soil is due to the presence of radium-226 (226Rn) and uranium-238 (238U) used in kitchens, bathrooms and other places where water is used inside the buildings and spreads into the air inside it [5]. Many studies have proven that prolonged exposure to high concentrations of this gas can lead to lung cancer [6]. As for materials that are not extracted from the earth's crust, such as wood, they contain very low percentages of radon [7]. Other scientific studies and research have also proven that a high percentage of radon gas is emitted from ceramics and cement. Therefore, the use of adhesive surfaces on walls and floors, such as veneer, can reduce the emission of radon gas. There are several factors that determine the distribution of this gas within buildings of various types. These factors include the rate of its emission from the source and the rate of ventilation within buildings. Low ventilation in buildings leads to an increase in the percentage of radon, and vice versa. Among the dangers of this gas are the radioactive materials it emits. It is found in the air of rooms, either free or combined with small particles present in the air. When a person breathes, these particles enter the respiratory system and stick to the walls of the bronchi and lungs [8], where they emit dangerous radiation that causes lung cancer.

IV. OBJECTIVE of the research:

It is very difficult to educate people about the dangers caused by exposure to the radioactive radon gas which is known as a hidden killer that exists in buildings, water and air. This is due to the nature of this dangerous radioactive gas and as a result of its chemical properties, which were mentioned in the introduction. This research aims to clarify and attempt to educate people about the nature and danger of this gas, as well as methods of prevention from it. Its main goal is to detect the presence of radioactive radon gas in some houses and calculate the annual effective dose that people lived in these houses were exposed to during the year.

V. DEVICE USED IN THE STUDY.

In this study, a Sensitive Solid State Sensor, known as

(RADEX MR107), was used to detect the radioactive radon gas (222Rn) which emits radioactive alpha particles in the air of some houses in Ajilat City. The measurement process using this device is subject to a number of variables, namely temperature, Humidity percentage and detection time. Figure 2 shows the RADEX MR107 device used in this research.

Fig. 2. The Device Used in this Research.

TABLE II. SHOWS THE TECHNICAL SPECIFICATIONS OF THE DEVICE MENTIONED ABOVE.

Device specifications		
Measuring cycle	H	1
Battery run time in measuring mode	H	140
Maximum stored data points		1000
Detection range of EEVA radon	Bq/m^3	up to 9999<
Audio alarm thresholds of EEVA	Bq/m^3	up to 9999<
Operating temperature range	ºC	+10 to +35
Data transfer method	USB	
Dimensions	155 x 80 x 58 mm	
Battery type	Internal Li-Ion battery	

VI. RESULTS AND DISCUSSION

An experimental work was carried out to detect the existence of the radioactive radon (222Rn) gas in the air of 10 houses in Al-Zaramaqa area in the city of Al-Ajilat. This work was carried out as mentioned above using a solid-state detector (Radex MR107) for measuring the hidden deadly radioactive radon gas activity and its danger to human health in buildings of various types. The experimental work was carried out for a short time to detect the Radon activity in different places in each house according to the way that the place was designed, built and ventilated. From the results shown in Table 3, it was found that the lowest value of radioactive radon gas activity in these houses was (28 Bq/m^3) while the highest value was (59 Bq/m^3) which is less than the (200 Bq/m^3) percentage that determined by the World Health Organization (WHO) [10].

No	Place Code	Humidity [%]	Temperature [ºC]	Radon Activity CRn [Bq/m^3]	Annual effective dose [msv/y]
1	R 1	55	29	29	0.23
2	R 2	47	30	49	0.39
3	R 3	47	31	49	0.39
4	R 4	47	31	29	0.23
5	R 5	52	32	29	0.23
6	R 6	61	29	33	0.26
7	R 7	73	31	28	0.22
8	R 8	52	33	29	0.23
9	R 9	56	29	28	0.22
10	R 10	44	34	59	0.47

TABLE 3: SHOWS RADON ACTIVITY OBTAINED IN THIS STUDY.

The values of the radon concentration mentioned above were due to the good ventilation, the way that these houses were designed and the building materials that have been used. This research also dealt with calculating the annual equivalent dose to which people living in these houses were exposed to and it was found that the lowest value was (0.22 msv/y) while the highest value was (0.47 msv/y). Most of these values were less than the internationally permissible level, which is equal to (1 msv/y) [11]. Table 3 presents the concentration of the radioactive radon gas obtained from this study, it also presents the annual affective dose which people living in these house were exposed to. Figures 3 and 4 show the plots that present the maximum value of radon gas concentration and the annual effective dose. The annual equivalent dose that was calculated in this study and is assumed to be exposed to people in these buildings was obtained using equation (1) based on UNSCEAR [12].

$$ED = CRn \times D \times F \times H \times T \quad (1)$$

Where CRn (Bq/m^3) is the radon concentration, D is the dose conversion factor (9 x 10-6 mSv.h-1 per Bq/m^3), (F) is the equilibrium factor (0.4), H is the occupancy factor (0.25) and T is the annual time in hours [13].

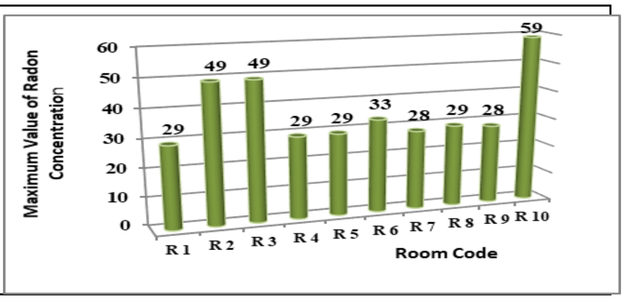

Fig. 3. Maximum Value of Radon Concentration (CRn).

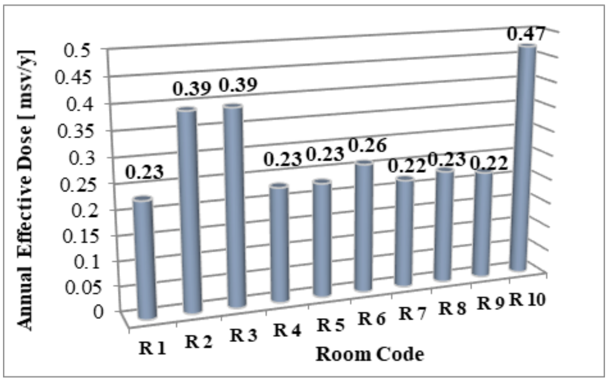

Fig. 4. Annual effective dose.

highest value was (59 Bq/m^3) which is less than the (200 Bq/m^3) percentage that determined by the World Health Organization (WHO) [10]. The values of the radon concentration mentioned above were due to the good ventilation, the way that these houses were designed and the building materials that have been used. This research also dealt with calculating the annual equivalent dose to which people living in these houses were exposed to and it was found that the lowest value was (0.22 msv/y) while the highest value was (0.47 msv/y). Most of these values were less.

VII. CONCLUSION

When studying the results and measurements obtained in this research, no increase or exceedance of the permissible limit in the activity of radioactive radon gas in the houses that were subject to the study was found, as it is less than the internationally permissible rate. In general, the results of the study show that the concentration of radon gas and the annual dose rate resulting from this study did not have a significant impact on people living in these houses. It was found that both cases were lower than the levels allowed globally by the World Health Organization (WHO) and (UNSCEAR), which are estimated at (1msv/y). The reason for the concentration values been lower than the value assumed by the (WHO) and (UNSCEAR) was the good ventilation and the way that these houses were designed and built as well as the building materials used and the land on which they were built.

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