Asmaa A Aziz [1]
Nada F Tawfiq [2]
Lukman A. Hussein [3]

[1] *Department of Physics, College of Education for Pure Science, Tikrit University, Tikrit, IRAQ*
[2] *Department of Physiology and Medical Physics, College of Medicine, Al-Nahrain University, Baghdad, IRAQ*
[3] *Amerli Education, General Directorate of Salah al Din Education, Ministry of Education, Salah al Din, IRAQ*

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Determination of radon concentrations, surface emission rate and mass emission rate radon in the surface soils of the city of Tuzharmatu in Governorate of Salah Al-Din

CN-85 is used to measure the levels of radon. A total of twenty-one surface soil samples were distributed around Tuzkormato's outskirts, while six samples were gathered from the city center. The radon concentration in Tuzhurmato, Imam Ahmad district, ranged from 18.96 Bq.m^{-3} to 61.99 Bq.m^{-3}, while the radon concentration in the Albu Sabah village was 37.09 Bq.m^{-3}. The surface emission rate (Ex) was 1.14x10^{-4} Bq.M^{-2}.h^{-1} (Albu Sabah) to 3.73x10^{-4} Bq.M^{-2}.h^{-1} (Albu Hassan). The mass emission rate (Em) ranged between 0.12 x 10^{-4} Bq.M^{-2}.h^{-1} in Albu Hassan village and 2.81x10^{-4} Bq.M^{-2}.h^{-1} in Tuzhurmato-Iqsu district. When these results are compared to the allowable quantity of (ICRP) radon in the soil, which is (200) Bq.m^{-3}. The comparison revealed that all locations of study agree with these boundaries.

Keywords: Radon concentration; Surface emission; CN-85 detector; Pollution
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1. Introduction

The most important element of the environment that allows humans access to food sources is soil. It is the thin, fragile layer that lies between a few millimeters and several meters above crustal rocks. It consists of a mixture of air, water, organic and mineral components. The plant has the ability to cling to the soil with its roots and extract the components necessary for life. The presence of radioactive radon gas in the soil, with high radioactive concentrations, is considered a source of long-term environmental pollution, leading to the pollution of food, water, air, and thus humans [1]. Radon is a colorless, odorless, natural gas that is emitted when uranium series U-238 radioactively decays. Radon is mostly found in rocks and soil near the surface. Therefore, there is a direct danger to human life as a result of the presence of radioactive radon gas in the soil in proportions exceeding the normal limit [2, 3]. We looked at the effect of radon gas on the lives of individuals directly through food, drink and even air, and indirectly through the soil and irrigation water, and from there to plants and animals and then to humans. Numerous studies have been conducted to determine the concentration of radon in various fields [4-6]. Uranium and radon gas exposure is a significant health concern, linked to increased cancer incidence, kidney failure, and other dangerous diseases due to uranium presence in patients' blood and urine [7-10]. The long-term measurement method for measuring radon concentration was adopted in models of surface soils it uses solid-state nuclear impact detectors, the method is more effective in detecting the concentration of radon [11]. Where the detector are placed in sealed diffusion Chamber in a cylindrical shape and placed against a sample is used to measure radon concentration and tightly sealed to prevent leakage or air exchange with the ocean [12].

The study aims to determine the concentration and rate of surface and mass radon emission. in 27 samples of the surface soil of the city of Tuzkhurmatu and its outskirts in Salah al-Din Governorate, with Six samples were collected from the city center, while 21 samples were distributed in the areas located on the outskirts of the city using trace detector CN-85 which is an organic detector. Its chemical formula is N(C6H8N2) and it has exceptional sensitivity to alpha particles and other heavy particles. [13].

2. Experimental Part

Twenty-seven surface soil samples were collected from the center and outskirts of Tuzkhurmatu city. The study area included about 600 km^2, including the center of Tuzkhurmatu city, with 6 samples and 22 samples distributed over 20 areas on the outskirts of Tuzkhurmatu city. Nuclear track detectors are electrically insulating materials, and charged particles (protons, alpha particles, and fission fragments) produce tracks as they pass through these materials where they generate narrow

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paths of radiation damage consisting of atomic defects, clonal gaps, and molecular chain breaks [14]. These defects are called latent tracts, and the damaged areas can be seen using an optical microscope after being treated with a chemical that etches and shows the areas of damage formed. Important properties of SSNTDs are the possibility of extending the minimum damage intensity along the impact core by etching technique [15]. Irradiation dramatically changes the properties of polymers by splitting or mixing their molecules, leading to significant changes in their overall structure. Radiation falling on these polymers causes them to ionize and break the bonds between them, leading to damage or defects. This stored defect is known as the hidden effect. Also, the areas affected by ionizing radiation show a the individual has a greater capacity to interact with alkaline solutions such as NaOH compared to the healthy areas, because the affected areas have more energy than the healthy areas, so the chemical solution quickly penetrates the areas exposed to radiation, which leads to an increase in the depth of the visible path and an expansion of its diameter with the etching time increases, and the hidden ionization path after chemical treatment can be seen using an optical microscope[16]. After the end of the microscopic viewing phase, the radon concentration in the samples can be determined using the following equation [17].

$$C_s = \lambda_{Rn} C_a ht/L \qquad (1)$$

where C_s concentration of Rn-222 within samples in Bq.m^{-3}. C_a The concentration of Rn-222 in the air space of Bq.m^{-3}. λ_{Rn} Fixed Rn-222 dissolution equals 0.1814 day^{-1}. h Height of the aerospace equal to 5.3 cm. L Thickness estimated value is about 1 cm. t Irradiation time is 55 d

The concentration of radon was determined using the following equation for its surface emission rate. [18]:

$$Ex = \frac{C\,\lambda\,V}{A[T+(e^{-\lambda T}-1)\lambda^{-1}]} \qquad (2)$$

where Ex: radon emission rate in terms of area(Bq/m^2.h). C: concentration of radon in unit (Bq/m^3), λ: radon decay constant and its value is 0.1814 day^{-1}. V: The size of the irradiation mug is 71.41 cm^3, A: The area of the cylinder is 75.17 m^2, T: The irradiation time in hours is 1320 hr.

The mass emission rate of radon was determined using the following equation [19]:

$$Em = \frac{C\,\lambda\,V}{M[T+(e^{-\lambda T}-1)\lambda^{-1}]} \qquad (3)$$

Here, Em Rn-222 emission rate in terms of mass (Bq.(kg.h)$^{-1}$), M: Models block is 10 gm

The samples were left in the sun for about a week to remove the moisture from them, then grind and sieve to keep the smooth part only to ensure the homogeneous distribution of the radioactive material. Use the CN-85 and 100 µm (1 x 2 cm^2 Solid-state nuclear path detectors are used to monitor the effects of alpha particles emitted by radon gas. Use a 10^{-2} gm sensitivity scale to calculate the weight of the soil models at 10 gm of each samples.

Samples were left for 22 days in enclosed test glasses to reach 98% of the balance between Ra226 radium and Rn222 radon. This time was calculated using the equilibrium relationship of radioactivity [20]:

$$A_{Rn} = A_{Ra}(1 - e^{-t\lambda_{Ra}}) \qquad (4)$$

Here, A_{Rn} the efficiency of radon, A_{Ra} the efficiency of radium, λ_{Ra} the decay of radium, 8.73× 10^{-8} s^{-1} and t the time needed to reach equilibrium state.

After the equilibrium state period ended, we quickly removed the cup lid to avoid changing the air inside the cup and replaced it with another lid with a piece of CN-85 reagent. The distance between the sample surface and the detector is approximately 5.3 cm and the sample is left for 55 days. The detector was then installed to prepare for the chemical etching process. The etching solution is created by dissolving a specific amount of NaOH granules in distilled water to obtain the required standard using a specific formula [21]

$$N = \frac{W(g)x000}{WeqV(ml)} \qquad (5)$$

N standard of solution, w(g) mass NaOH, V(ml) distilled water volume, weq equivalent weight of NaOH equal 40, the 6.25N Standardization was used for the etch solution for detector where 62.5g of sodium hydroxide granules were dissolved in 250ml of distilled water. Use the water bath to heat the NaOH solution to the required temperature of 60 °C, the etching process is carried out by placing the detector in the etching solution, which is placed in a flask inside the water bath after the finishing time of 2.5 hours. The detector is washed with distilled water and dried. The microscopic phase of the detector is then started. The ligands and synthesized complexes were characterized as follows.

3. Results and Discussion

Apart from the radiological background, the concentration of Rn-222 gas was determined for 27 soil samples using the CN-85 nuclear track detector. The surface and mass emission as well as the intensity of radon concentration were computed as shown in table (1).

According to the investigation, sample S3 had the greatest radon concentration (61.996 Bq.m^{-3}), sample S1 had the lowest value (18.961 Bq.m^{-3}) and the rate (37.09 Bq.m^{-3}) (Fig. 1). Also showed highest concentration of surface emission was recorded in sample S3 (3.732 Bq.m^{-2}.h^{-1}) and lowest in sample S1 (1.141 Bq.m^{-2}.h^{-1}) and 2.23 Bq.m^{-2}.h^{-1}) as shown in (Fig. 2), either As can be shown in (Fig. 3), sample S3 had the highest mass emission rate (2.810 Bq.kg^{-1}.h^{-1}), sample S21 had the lowest value (0.121 Bq.kg^{-1}.h^{-1}), and the average was 1.65 Bq.kg^{-1}.h^{-1}. According to the International Commission on Radiological Protection (ICRP), a comparison of

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these data with the allowable revealed a soil radon concentration of 200 $Bq.m^{-3}$ [14]. Comparison revealed that all research locations concurred with these limitations.

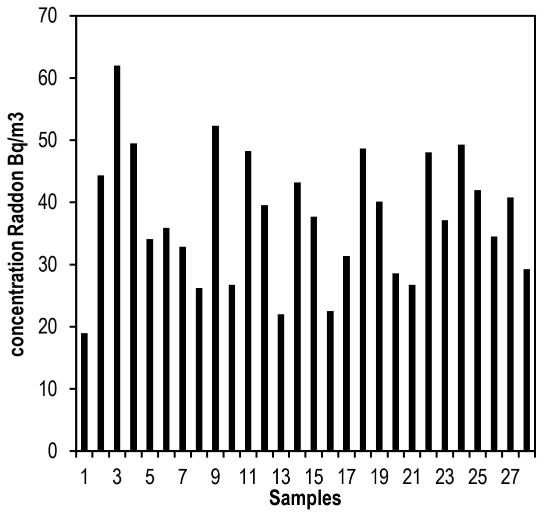

Fig. (2) Concentration of radon gas in surface soil models

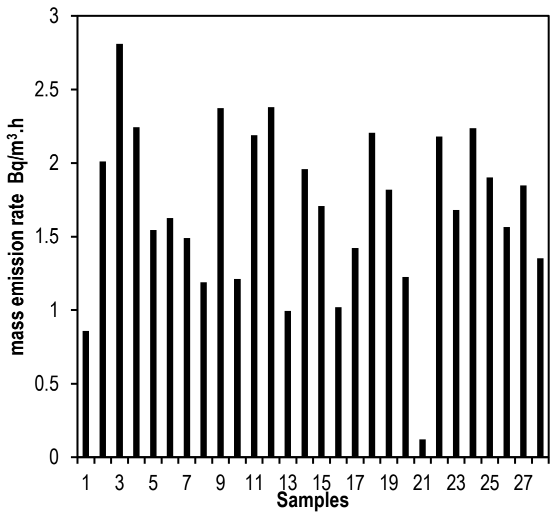

Fig. (3) Mass emission rate for radon

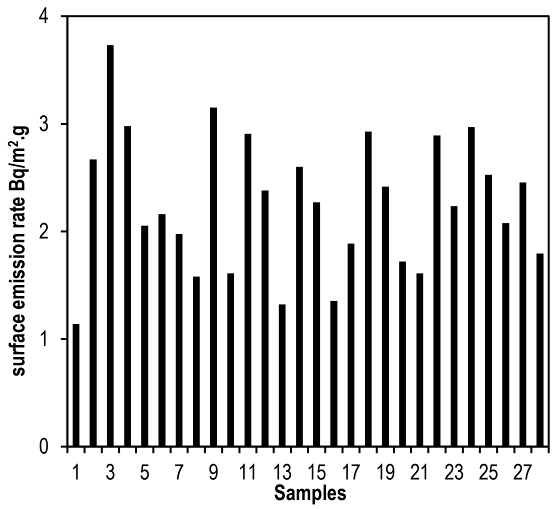

Fig. (4) Surface emission rate of radon

4. Conclusion

Along with the radiological background, the concentration of radon gas, its intensity, and its surface and mass emission were calculated, and the concentration of Rn-222 gas was determined for twenty-seven soil samples using the CN-85 nuclear track detector. Based on a comparison of these findings with the allowable level, the International Commission on Radiological Protection (ICRP) reported a radon concentration of 200 $Bq.m^{-3}$ in soil. The comparison revealed that these limitations were accepted by all research locations.

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Table (1) The intensity of the effects, the concentration of radon and the surface and mass emission rate

Symbol	Intensity of effects (track/mm^3)	Concentration of radon C_{Rn}(Bq/m^3)	Surface Emission Rate (EX) x10^{-4} Bq/m^2.hr	Mass emission Rate (EM) x10^{-4} Bq/kg.hr
S 1	445±1.34	18.961	1.141	0.859
S 2	1042±1.67	44.357	2.670	2.010
S 3	1455±1.16	61.996	3.732	2.810
S 4	1162±1.21	49.486	2.979	2.243
S 5	800±1.63	34.087	2.054	1.545
S 6	842±2.77	35.877	2.160	1.626
S 7	771±1.03	32.852	1.977	1.489
S 8	616±1.46	26.247	1.580	1.189
S 9	1228±1.82	52.324	3.150	2.372
S 10	628±1.66	26.758	1.611	1.213
S 11	1133±4.34	48.276	2.906	2.188
S 12	928±1.38	39.541	2.380	2.380
S 13	516±0.68	21.986	1.323	0.996
S 14	1014±1.24	43.206	2.601	1.958
S 15	885±1.95	37.709	2.270	1.709
S 16	528±0.88	22.497	1.354	1.019
S 17	737±0.99	31.351	1.887	1.421
S 18	1142±1.59	48.660	2.929	2.206
S 19	942±0.90	40.138	2.416	1.819
S 20	671±0.88	28.591	1.721	1.226
S 21	628±1.66	26.758	1.611	0.121
S 22	1128±1.03	48.063	2.893	2.179
S 23	871±1.66	37.112	2.234	1.682
S 24	1157±0.33	49.299	2.968	2.235
S 25	985±2.16	41.970	2.526	1.902
S 26	811±1.66	34.524	2.078	1.565
S 27	957±2.25	40.777	2.455	1.848
Radiation back ground	700±1.19	29.286	1.795	1.352
Min.	445±0.33	18.961	1.141	0.121
Max.	1455±4.34	61.996	3.732	2.810
Ave.	882.92±1.51	37.09	2.23	1.65

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