Calculation of Radon Gas Concentration in the Buildings of Samara University Using the Nuclear Track Detector CR-39

Rasha W. Kleeb[1*], Sarwa A.M. Salah[2], Esam S. Ali[3]

Abstract

This research studies radon gas concentration in (24) samples in all buildings of Samarra University (old and new) using long-term measurement technique using the nuclear effect detector (CR-39) to record the effects of alpha particles emitted from radon included with the results. The results showed a variation in the radon concentration values, so it was the highest value in the buildings of the physics department's laboratories, specifically in the nuclear laboratory, it reached (175.9 Bq / m3), followed by in this value the Computer and Information Center if its value was (169.5 Bq / m3), but the lowest value was in a laboratory The English language sounds if it reaches (3.8 Bq / m3), compared to the background radiation of (39.3 Bq / m3). All the results that were obtained were within the internationally permitted limits, and there is no danger to the university staff, including employees and students, and also the fact that the university is newly formed, this quality gave it an advantage in not being exposed to a high level of radiation or environmental pollution.

Key Words: Presence of Uranium, Calculation of Radon, Nuclear Track Detector.

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Introduction

Radon is one of the elements of the periodic table, it is located within the noble elements, it is characterized as a radioactive natural gas of colorless and odor and because of these properties difficult to detect, it arises from the automatic decomposition (Sponta - decay) of the radium element Ra^{226} found in the Earth's crust, which depends on the presence of uranium U^{238} [1].

Radon is the main component of the radiation background, as it contributes to about 60% of the annual dose to which a person is exposed, so it is the second cause of lung cancer after smoking [2].

The danger of this gas is that it is an inert gas, and because of its inactivity, it is not retained in the respiratory system, except that its disintegration products with a short half-life are deposited in the lung and bronchus, so the alpha particles released by it and its dissociation products are emitted, as these particles have sufficient energy to penetrate the tissues and reach the inner section of cells. The destruction of these tissues [3] enters radon or products of disintegration of the human body in two ways, the first of which is digestion, which does not yet exist any link between the ingestion of radon and the increase of infectious cancerous conditions [4]. As for the case of radon inhalation, then a different matter here, as we mentioned previously, the danger lies in the alpha particles issued from Radon offspring, Polonium-216 and polonium-214, which, by inhalation, leads to a radiation dose more than 100 times that of radon radiation alone [5].

Corresponding author: Rasha W. Kleeb
Address: [1*]Department of Physics - College of Education / Samarra - University of Samarra – Iraq; [2]Department of Mathematics – College of Education for Women / Tikrit - University of Tikrit – Iraq; [3]Department of Physics - College of Education / Tuzkhurmatu - University of Tikrit – Iraq.
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Therefore, the International Agency for Research on Cancer (IARC) and the National Toxicity Program in the United States classified radon as one of the causes of human lung cancer according to the results of analyzing the data that was done in China, Europe and North America to study radon in buildings [6].

The soil, rocks, water, and building materials made from the components of the earth's crust are among the important natural sources of radon gas. For example, building materials made of soil and rocks such as (cement, blocks, ceramics .....) contain radioactive materials of natural origin such as uranium and radium generated. Including them to the outer medium, and materials of non-earth origin (such as wood, for example) contain a very low amount of radium [7].

In general, the increased concentration of radon in homes and public buildings depends on the habits and behaviors of its residents and the periods they spend within it. Ventilation is also one of the factors that affect radon concentration in buildings if the radon concentration is inversely proportional to the rate of ventilation in it. Radon concentration is inversely proportional to the rate of ventilation [8,9].

Therefore, it proves that the radon is present in nature and possesses a relatively short half-life, but its presence on the ground will be long in the future because thorium and uranium are among common elements on Earth and radon is among its natural products.

Many researchers are concerned with pollution problems and those interested in the environment have studied radiation pollution and at various times. (Rouwaida Tariq Mahdi) measured radon gas concentration in several areas of Baghdad governorate using the technique of counting the effects of alpha particles emitted from radon gas in the nuclear impact detector (CR-39) and the results obtained by it showed that the annual effective dose rate was almost within the permissible natural limits [10]. (Mahmoud Salem Kareem) [11] Determined radon gas for different environmental models (air, water, soil) in Baghdad governorate also using a detector the nuclear effect CR-39, and the results showed that there is a malignancy Radon concentrations are varied according to environmental and geographical factors.

Ali Hassan and others [12] measured the concentration of radon gas in the Caesarean city of Erbil. 18 areas were chosen within the market to place the measurement reagents. The energy concentration of the emitted alpha particles and the annual dose was calculated and it was found that there is a direct relationship between the annual effective dose and the radon concentration in the area that Included in the study.

(JabbarMadhi Rashid) [13] has determined concentrations of radon gas in the air in the homes of 12 cities in DhiQar Governorate using the nuclear impact detector CR-39 if he distributed 176 detectors to homes that were randomly chosen in all the cities under study. The results of all studies were within the limits permitted and recommended by the US Environmental Protection Agency (EPA).

(Walid Hamid Al-Mousawi)and (Abdul-Redha Hussein Jabr)[14] also studied radon gas emissions in the nearby residences of Basra Sports City. The aim of the study was to find a special database for the city's location and used the mixed calibration method between the direct radon method and the direct method for measuring the calibration of a reagent CR-39 nuclear effect the results were also within recommended limits.

Method

The soil is one of the sources of natural ionizing radiation to which man is exposed, represented in the outer layer of the Earth's crust and is the result of deformation of rocks through complex physical and chemical processes, so the soil contains long-lived radionuclides such as U^{238}, thorium Th^{232} and K^{40} and these elements are already present in Rocks and soil and thus in many building materials, where the radiation issued by it contributes to the background of the ground radiation to which the human body is exposed [15] This is known as natural radioactivity, which depends on geological and geographical conditions. As for industrial radioactivity, it arises from reactors and nuclear weapons, mining, oil and gas extraction, and some electrical devices such as television, computers, and the use of radioisotopes in medicine, agriculture, industry, scientific research, and the phosphate industry and others [16]. The so- called (TENORM) Technically Enhanced Naturally occurring Radioactive).

The techniques for detecting radiation and its offspring and measuring their concentrations in materials have varied and have varied according to the diversity of its sources. Among these techniques is the long-term measurement method that mainly depends on the use of nuclear reagents. Conductors [17], both of the above classes are highly sensitive

to alpha particles that emit radon, but the first type is preferable to the second in the case of long-term measurements, which take place in harsh environmental conditions or in remote locations that do not have a Electrical capability, it is also characterized by simplicity and lack of need for complex devices as it is an inexpensive [18,19] .

CR-39 was discovered in 1978 at the University of California, which is an abbreviation of (Columbia Resin) [20,21] and is insoluble in chemical solvents with a ionization potential of (70.2 ev) with a density of (1.32 gm. Cm^{-3}). It is made from the polymerization of the liquid monomer with a hydrogen composition (C_{12} H_{18} O_{7}) [22].Therefore, according to the above, the CR-39 detector is one of the best recorded detectors of nuclear effects, according to its specifications.

The topic of the case study was chosen based on the importance of air in human life and living organisms, and also the lack of research and studies for such topics in the study area.

The study was carried out in the buildings of the University of Samarra, due to the lack of a previous study to determine the concentrations of radioactive radon. The study included about (24) buildings of the university, and different rooms were chosen from each college according to the places where students, staff, and teaching staff exist for long periods in addition to the places that contain ventilation Little or no ventilation, and samples were taken from all buildings, whether old or modern, because building materials are nhjjjjrjn4one of the reasons that have an impact on radon concentration**.**

The city of Samarra is located on flat terrain and on the east bank of the Tigris River in Salah al-Din Governorate. It is located about 125 km north to the capital Baghdad, bordered to the north by the city of Tikrit, to the west by Ramadi, and to the east by Baquba. As for its university, it is located in the center of the city. Overlooking the Tigris River, it is characterized by a cold winter, dry and hot summer.

Practical Part

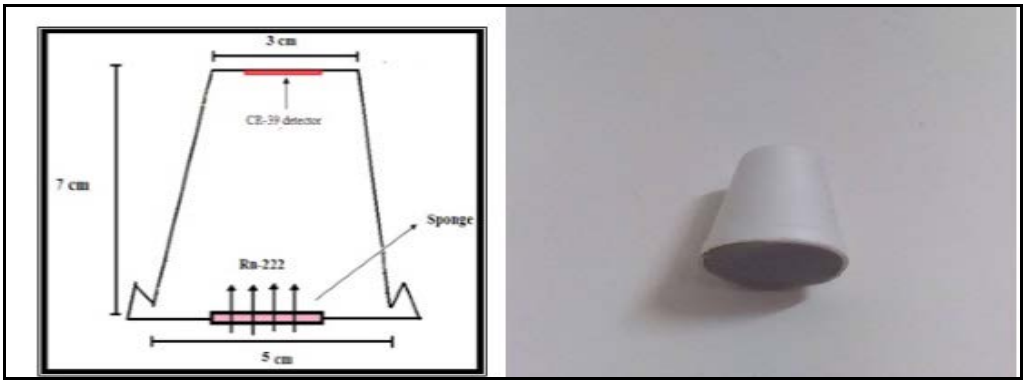

Figure 1. How to deploy reagents inside cups

Figure 2. Represents a reagent

Radon gas concentration was obtained by installing the detector by a 1.5cm sponge hung in the locations as shown in Table (1-1) with the sealed Cup technology as shown in Figures (1) and (2). A fine, thin sponge was used to seal the cup nozzle in order to prevent the short-half-life thorn gas from reaching the detector, and to leave radon gas to reach the detector at an average height of 150cm. Individual length for 47 days, then raised from the measurement site to note that when alpha particles resulting from Radon gas decomposes on these plastic reagents, and it creates effects or points that are not visible to the naked eye. Therefore, these reagents are subjected to a chemical treatment with sodium hydroxide of a specific concentration and heated for a certain period until they get bigger and show the effects left by the alpha particles and can be counted by the wave. R. After that it was collected and prepared for the skimming operation.

Chemical Skimming

The chemical skimming process is conducted for the exposed reagents for 47 days using aqueous

sodium hydroxide solution (NaOH), which is one of the alkaline bases and interact with solid state nuclear effect detectors (SSNTDs) and standard (6.25 mole / L) in this study. It is obtained from dissolving Sodium NaOH hydroxide granules by (62.5gm) in (0.25) liters of distilled water where a volumetric bottle was used to dissolve the granules in it. The water level decreases as a result of high temperature and the evaporation of the solution so water is added after the solution is balanced with the surrounding.

The abrasive solution was placed in a glass beaker inside the water bath that is heated to a degree of (70^{o}C) after the reagents were suspended inside the conical glass beaker with a thermal or copper wire for seven hours . the scraping solution was shaken continuously to prevent the deposition of the solution. It also must be take into account the closure of the beaker seal tightly to prevent the evaporation of the skimming solution and changing its concentration during the chemical skimming process. Finally, the reagents are then taken to be washed with distilled water and dried.Figure (3) illustrates the skimming process.

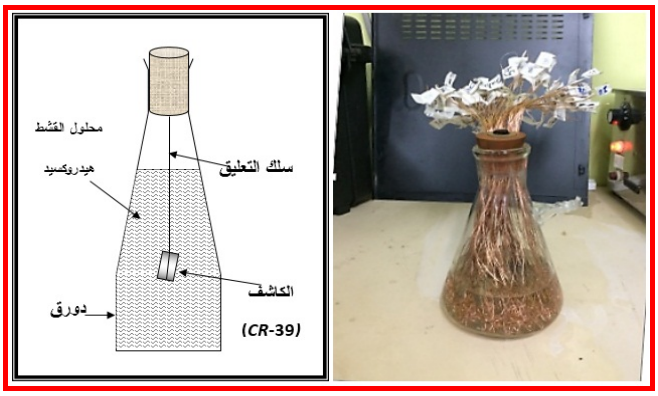

Figure 3. Chemical skimming of the nuclear impact detector (CR-39).

After the process of drying the reagents, the number of traces formed is calculated using a Chinese-made optical microscope that contains four object lenses and the magnification for these lenses is (10x, 20X, 40X, 100X) and by selecting the appropriate magnification force (the magnification capacity is equal to 400X) by using a calibration lens divided into several squares through which the area of square A is calculated, and then the effects are calculated for the unit area (10 attempts are taken for each detector). To calculate the effects of the effects, the N_{avg}rate is divided for each detector by the area of the square and that the determination of the magnification force of the microscope is done using the following relationship:

Zoom area = magnification of the eyepiece X magnification of the objective lens

As for photographing the effects of alpha particles formed on the detector, a MDCE-5C digital camera was installed directly on the optical microscope and connected to the computer if it operates according to an attached program to facilitate the process of transferring and viewing the effects.

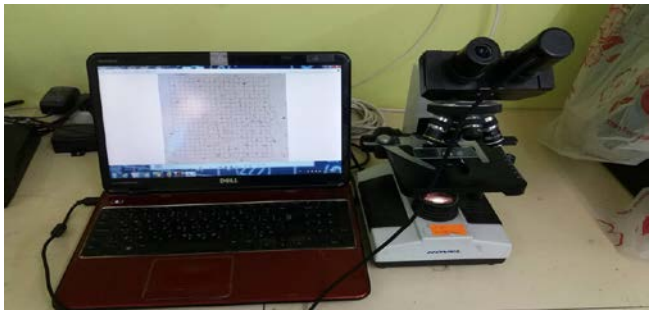

Figure 4. Optical microscope

Before starting the calculations, it is necessary to know the spreading constant (K) of the system used, as the spreading constant varies from one organization to another depending on the engineering dimensions of the irradiation rooms, so the system spread constant used in the current research (K) equals (0.169) [23]. Using the equation:

$$C_{Rn} = \frac{\rho}{TK} \qquad (1)$$

Since (C_{Rn}) indicates the concentration of radon in the airspaceρeffects intensity, T exposure time for the air, and Equilibrium Factor [24].

EEC, which represents the concentration Equivalent Equilibrium, can be found from the following relationship [25].

$$EEC = C_{Rn} * K \qquad (2)$$

EEC is measured in units ($Bq.m^{-3}$)

As for D, it represents the Effective Annual Dose and its unit (mSv / y) and can be found from the following relationship [26].

$$D = \boldsymbol{C_{Rn}} * K * H * t * \boldsymbol{D_f} \qquad (3)$$

$\boldsymbol{C_{Rn}}$: It represents the concentration of radon in $Bq.m^{-3}$

H: is the occupancy factor = 0.8 (occupancy factor)

T: represents the number of hours per year = 8760y / h

D_f: dose actor conversion d = $9 * 10^{-6}$ (msv / $Bq.m^{-3}$.h)

Results and Discussion

After the distribution of CR-39 solid-state nuclear reagents in the selected buildings from Samarra University, for a period of (47) days, the reagents were collected and skimming process with NaOH solution, then washed and dried so that the

microscopic examination was carried out after that to obtain the effects density per unit area Where the results of radon gas concentrations and the effects of the effects are listed as in Tables (1).

Table 1. Represents the radon gas concentration values in the buildings of the University of Samarra

PAEC (WL)	LCR*10^6	AED (mSv/y)	EEC ($Bq.m^{-3}$)	C_{Rn} ($Bq.m^{-3}$)	رمز العينة	اسم الموقع	N
18.3	32.5	1.8	28.7	169.5	S_1	Computer and Informatics Center	1
0.8	1.4	0.1	1.2	7.1	S_2	Queries	2
4.1	7.3	0.4	6.5	38.2	S_3	University Presidency Building	3
1.2	2.1	0.1	1.8	10.9	S_4	Faculty of Islamic Sciences	4
3.1	5.6	0.3	4.9	29	S_5	Department of Quranic Sciences	5
3	5.2	0.3	4.6	27.3	S_6	Mutawakki Hall	6
1.6	2.8	0.2	2.5	14.8	S_7	Al-Mu'tasim Hall	7
19	33.8	1.9	29.7	175.9	S_8	Nuclear Laboratory - Department of Physics	8
0.6	1	0.1	0.9	5.5	S_9	Continuing Education Center	9
1	1.8	0.1	1.6	9.3	S_{10}	University Chapel	10
1.9	3.4	0.2	3.0	17.5	S_{11}	Maintenance Laboratory - Faculty of Archeology	11
8.9	15.7	0.9	13.9	82	S_{12}	Material store	12
0.4	0.7	0	0.6	3.8	S_{13}	English Lab Sound Department	13
2.5	4.4	0.2	3.9	22.9	S_{14}	Analytical Department - Teachers' Room	14
1.3	2.3	0.1	2	12.0	S_{15}	the magazine	15
3.4	6	0.3	5.3	31.1	S_{16}	Girls internal departments	16
4.5	8.1	0.4	7.1	42.1	S_{17}	Organic Laboratory - Department of Chemistry	17
2.8	4.9	0.3	4.3	25.7	S_{18}	Department of History – Examination Committee	18
3.7	6.5	0.4	5.7	33.9	S_{19}	Soil Laboratory - College of Engineering	19
2.7	4.7	0.3	4.2	24.6	S_{20}	Environment Laboratory - Biology Department	20
11.6	20.7	1.1	18.2	107.6	S_{21}	Computer lab	21
2.2	3.9	0.2	3.4	20.2	S_{22}	Teaching room - Physics Department	22
4.7	8.4	0.5	7.4	43.7	S_{23}	Student Club	23
4.3	7.5	0.4	6.6	39.3	S_{24}	Radiological background	24
0.4	0.7	0	0.6	3.8	Min		
19	33.8	1.9	29.7	175.9	Max		
4.5	7.9	0.4	7	41.4	Average		

Discussion

The results taken from (24) show that there is a variation in radon concentrations, as shown in the table (1), and the reason is the difference in buildings and the amount of their ventilation. Small offices with little ventilation were of high levels of radon gas concentration in contrast to buildings with large area and good ventilation.

The main source of radon in buildings is the earth with its uranium ore, and building materials also have a major participation in that because of the natural uranium they contain. Doors and windows participate in the accumulation of radon gas released from the walls, floors and ceilings. The solution to this problem lies in ventilating the rooms at least twice a day to reduce the radon concentration.

The highest percentage obtained is the nuclear laboratory and the reason is attributed to the presence of radioactive sources devoted to scientific experiments. The university's computer and information center, as well as the reason that the center room is closed and less ventilated and also because it contains several computers that are also a source of radiation. While the lowest rate of radon gas pollution was in the audio lab for the Department of English due to the location's capacity and good ventilation.

In general, it was found that the radon concentration in the buildings of the University of Samarra is within the permissible natural limits set by the competent organizations and the results are compared with the international equipment of the International Radiation Protection Organization. all the buildings inside are within the permissible limits, which gives an indication of the absence of dangerous or radioactive contamination in radon in the air.

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