Use of the Long Range Measurement Detector to investigate the levels of certain radioactive elements in various building materials

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ABSTRACT

In this study, the content of radon gas Rn^{222} as well as the radioactive elements uranium U^{238} and radium Ra^{226} in some building materials, which included ten samples of (plaster, alabaster, cement, granite), using the long-term measurement method using the CR-39 nuclear trace detector. The results of the study showed that the maximum value of radon concentration in the samples of granite of Chinese origin was 480.76 Bq/m^3 in the sample air, and the effectiveness of radon was 0.0133 Bq in the same sample. A relationship was drawn between the concentration of radon gas in the sample air and its concentration in the sample itself, and it was a linear relationship with a correlation factor of one. The specific activity of radon gas was also found and its values were compared with what the researchers found and found to be within the values deduced by them. Then the number, mass and concentration of uranium U^{238} atoms in the studied samples were found to be lower than the International Organization for Radiological Protection (ICRP), which does not exceed 3ppm. Finally, the effectiveness of radium Ra^{226} in the samples was deduced through the effectiveness of radon gas and a relationship between the effectiveness of radon gas in the sample and the effectiveness of radium with a linear relationship that serves to find the effectiveness of radium Ra^{226} if the effectiveness of radon gas is available and in the end, the concentration of radon gas in granite of various origins was compared with a number of global values from previous studies, As well as comparing the concentration of radon gas in cement for the current study with previous studies and found that there are differences that may be due to the geography of the area from which the samples were taken or the types of granite rocks and their geological composition.

Keywords **:**Radon, Radium, Uranium, CR-39 Detector, Building Materials

دراسة محتوى لبعض العناصر المشعة في عدد من مواد البناء باستعمال كاشف القياس طويل الامد

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الملخص:

تم في هذه الدراسة الوقوف على محتوى غاز الرادون $\mathbf{Rn^{222}}$ وكذلك عنصري اليورانيوم $\mathbf{U^{238}}$ والراديوم $\mathbf{Ra^{226}}$ المشعين في بعض مواد البناء والتي شملت عشر عينات من (الجص والمرمر والسمنت والحلان وكذلك الكرانيت) وذلك باستعمال طريقة القياس طويل الامد باستخدام كاشف الاثر النووي **CR**-39 . بينت نتائج الدراسة ان اقصى قيمة لتركيز الرادون في عينات الكرانيت الصيني المنشأ وكانت بحدود 480.76 $\mathbf{Bq/m^3}$ في هواء العينة، اما فعالية الرادون فقد كانت 0.0133 **Bq** في العينة ذاتها. وقد تم رسم علاقة تربط بين تركيز غاز الرادون في هواء العينة مع تركيزه في العينة ذاتها وكانت علاقة خطية بعامل ارتباط مقداره واحد. كما تم ايجاد الفعالية النوعية لغاز الرادون ومقارنة قيمها مع ما وجده الباحثون وتبين انها ضمن القيم المستنتجة من قبلهم. ومن ثم تم ايجاد عدد ذرات اليورانيوم $\mathbf{U^{238}}$ وكتلته وتركيزه في العينات المدروسة وتبين انها اقل مما اقرته المنظمة العالمية للوقاية من الاشعاع (**ICRP**) والتي لا تتجاوز 3**ppm** . واخيرا تم استنتاج فاعلية الراديوم $\mathbf{Ra^{226}}$ في العينات من خلال فاعلية غاز الرادون وربط علاقة بين فاعلية غاز الرادون في العينة وفاعلية الراديوم بعلاقة خطية تخدم في ايجاد فاعلية الراديوم $\mathbf{Ra^{226}}$ في حال توفر فاعلية غاز الرادون وفي النهاية تم مقارنة تركيز غاز الرادون في الكرانيت بمختلف مناشئه مع عدد من القيم العالمية من الدراسات السابقة ، وكذلك مقارنة تركيز غاز الرادون في الاسمنت للدراسة الحالية مع دراسات سابقة وتبين ان هناك اختلافات قد تعود الى جغرافية المنطقة المأخوذة منها العينات او انواع الصخور الكرانيتية واصل تكوينها الجيولوجي .

الكلمات المفتاحية: رادون ،راديوم، يورانيوم، كاشف **CR**-39 ،مواد البناء

Introduction

Building materials are one of the emitters of radioactive elements, especially radon gas and its derivatives, as the source of building materials in all their forms and types is the earth's crust, and since the earth's crust contains, by virtue of its Since uranium ^{238}U, thorium ^{232}Th and actinium ^{235} U, decay in a long series of decays, including the only gaseous element, radon ^{222}Ra, it is possible to investigate radon in various building materials to determine their content of radium ^{226}Ra as well as the concentration of uranium ^{238}U, and there are many methods for detecting radon, the most famous of which are SSNTD nuclear trace detectors, Nuclear trace detectors are defined as dielectric materials that have the ability to store the effect of ionizing radiation for a long time and show it in the form of traces. When exposed to radiation, they generate a narrow path of radiation damage called a hidden trace when alpha particles, fission fragments and uncharged particles such as neutrons pass through the detector material and the damage tracks are traces indicating the type and energy of the falling particle, so they are used as detectors for charged particles and neutrons.

The development of solid-state detectors, their different types and ease of application has led to their widespread use in many applications and wide fields, and the following is a review of some previous studies. (Fleisher and Morgo-Campero, 1978) conducted a survey of radon concentrations emitted from the earth's surface to determine the migration of gases and long distances using the CR-39 detector and the cone stone method and use the results as a signal or warning to predict the occurrence of an earthquake and to detect uranium (Fremlin and Abu Jarad, 1980), measured radon concentrations in a number of

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ordinary rooms as well as measuring radium emission from the walls using the LR-115 nuclear trace detector and showed that radon is likely to kill about (100) people every year with lung cancer in Britain. (Khan and Akber, 1980) completed an experimental study of radon detection using nuclear trace detectors to search for uranium using the cylindrical stone technique and mentioned the factors that must be taken into account when conducting this type of study, where they summarized these factors as the effect of the geometric dimensions of the tube and the detection site and the effect of exposure time and environmental conditions on the number of traces recorded and (Savvides, et al 1985) built an irradiation system for the calculation of radon concentrations emitted from the ground using the CA-80-15 detector with certain dimensions to ensure the exclusion of thoron influence when performing calculations to measure radon concentrations, as it was found that out of 1000 thoron atoms, only one atom could reach the detector using the designed system. Then (Al-Jumaili, 1996) detected the presence of depleted uranium in soil taken from the sites of Umm al-Maarak operations, where the concentration of
The results obtained indicated that there was a significant increase in the concentration of uranium in the sites of Muthanna (15.6 PPm) and Dhi Qar (26.4 PPm) governorates, where the guard forces were stationed in these two areas, while the average concentration of uranium in the rest of the sites was found to be equal to (6.73 ppm), while the concentration of uranium in the rest of the sites was equal to (6.73 ppm).Then (Turk, et al, 1996) conducted a study in which they concluded that radon concentrations in the upper soil layer depend on seasonal changes, that is, on the water content of radon in the soil, as the high concentration in the summer and the low concentration in the winter. (Narayana, et al, 1998) and others conducted research to measure the radon content of homes in a region located in southeast India using the LR-115 detector, and they found that the winter radon content is in the range of (97.0-30.8 $Bq.m^{-3}$), which is greater than its content in the summer (54-24.7 $Bq.m^{-3}$) due to the lack of ventilation in the winter. In 1999, Al-Jubouri determined the radon concentrations in different types of imported tea used in local markets
Also using the CR-39 detector. Then (Ahmed Khalaf and Wafaa Ali, 2000) studied the concentration of radon and uranium in some Iraqi building materials in Nineveh and Salah Din governorates and found that the radon concentration ranged from (34.76 - 32 Bq/m^3) while the uranium concentration was (0.889 - 0.4 ppm). (Al-Jarallah, 2001) also studied the radon emission rate in the acrylic rocks used in Saudi Arabia 9.85 Bq/kg) As for the effectiveness of radium (59.68 Bq/kg). (Panic, et al, 2006) also measured the concentration of radon in the air of middle schools in Serbia using the CR-39 detector for a period of three months, the radon concentration ranged from (21-35 Bq/m^3). (Younis and his group, 2010) studied radon concentrations in Maysan governorate using the CR-39 nuclear trace detector and found that the radon concentration in residential air ranged from(131.5-281.139 $Bq.m^{-3)}$ between the difference caused by the type

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No. of sample	Sample name	Sample mass w(g)	C_{Rna} (Bq/m^3)	A_{Rna} Bq	C_{Rns} $Bq.m^{-3}*10^3$	A_{Rns} Bq	Ca $Bq.kg^{-1}$

of soil and different building materials and the EPA indicated that the highest concentration of radon was in buildings in Sweden and Finland due to the use of a type of clay rich in uranium and was (400$Bq.m^{-3}$).
The research aims to study the radon and uranium content in some building materials (granite - cement - clay - plaster - alabaster) from different origins and commonly used in modern construction to determine the extent of environmental pollution if they contain radioactive sources, especially uranium ^{238}U, which is the main source of radon ^{222}Ra and radium ^{226}Ra, using the CR-39 nuclear trace detector technology available to us. Through this study, we determined that some imported materials should be radiologically monitored in order to minimize issues resulting from radioactive contamination.

Method of work

After collecting local and imported samples, which included plaster and cement of two types, samples of granite of different origins, Iraqi and Italian alabaster, and Iraqi halan for the study, and after determining the number of effects caused by alpha particles emitted by radon gas (the only gaseous element of uranium U^{238}), there were several calculation steps that were developed in the form of A simple program was implemented in MATLAB and many results were obtained, which can be used to identify the range of radon concentrations in both the air space and the sample, as well as the effectiveness of radon in addition to the effectiveness of radium and uranium concentration in PPm) and thus try to relate the variables to each other and compare the results with what other researchers who have worked in this field have found.

Results and discussion: -

From Table (1), it is clear that there are (10) samples under study, including plaster, cement and Alabaster, aluminium and granite of various origins. In addition to the sample number and name, the radon concentration in the airspace of the sample (CRna, Bq/m^3) and in the sample (CRns, Bq/m^3) as well as their potency and specific activity (Ca, $Bq.kg^{-1}$) have been labelled in addition to the sample number and name.) for the sample.

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1	Plaster (Iraqi)	47.8	160.250	0.0044	1.64	0.048	1.01
2	Alabaster (Iraqi)	43.2	227.03	0.0063	2.32	0.068	1.58
3	Cement (Iraqi)	33	120.12	0.0033	1.23	0.036	1.09
4	Cement (Turkish)	46.5	80.120	0.0022	0.82	0.024	0.51
5	Halan (Iraqi)	46.5	53.420	0.0015	0.55	0.016	0.34
6	Amber (Italian)	51.6	146.90	0.0041	1.50	0.044	0.85
7	Cranite (Indian)	53	280.44	0.0078	2.87	0.084	1.59
8	Cranite (Turkish)	54	74.780	0.0021	0.76	0.022	0.43
9	Cranite (Italian)	53.5	77.450	0.0021	0.79	0.023	0.41
10	Cranite (Chinese)	54.5	480.760	0.0133	4.90	0.145	2.66

Table (1) shows the radon concentrations and effectiveness in the airspace of the samples and in the samples and the specific effectiveness of radon

It is clear from Table (1) that the radon concentration in the airspace of the sample in units of Bq.m^{-3}) The lowest value in sample (5) was Iraqi halan (253.4 Bq.m^{-3}) , while the highest value was in sample (10) (Chinese granite) (480Bq.m^{-3}) .
Returning to Table (1), we find that the radon concentrations in the sample in units of Bq.m^{-3} range from the lowest values in sample No. 5 (Iraqi halan (0.547Bq.m^{-3}) to the highest value in sample No. 10 (Chinese granite (4.9Bq.m^{-3}) In general, these values seem to be relatively high as they indicate the value of radon within the sample and not in the air space of the sample, noting that the values for radon concentrations in the sample air and compared with what was found in the study (Fathiya, 2012), where it was found that the average radon concentrations in imported granite were (0.547Bq. m^{-3}).These values are close to what was found in samples (7) and (10), i.e.
Chinese and Indian granite of Indian origin and somewhat distant from the values found for Turkish and Italian granite of Italian origin, i.e. sample (8) (9), and there are many local studies and a study in Baghdad in the Riyadh and Wardia indicated that there was a significant increase in radon concentration in the sample air and was in the range of 697.18 Bq.m^{-3} and 164.45 Bq.m^{-3} respectively, (Karim, 200 .(4

The results of radon concentrations in the air of the studied samples are shown in Figure (1), through which it is clear that the highest value, as mentioned earlier, is in sample No. (10) and the lowest value is in sample No. (5).

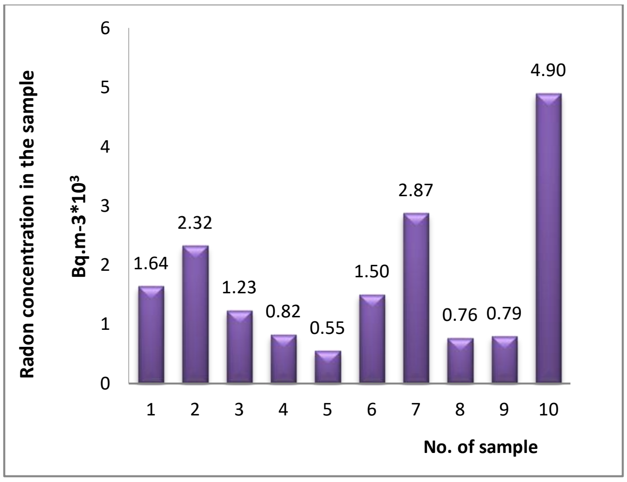

Figure (2) shows the radon concentration in the samples ($Bq.m^{-3}$)

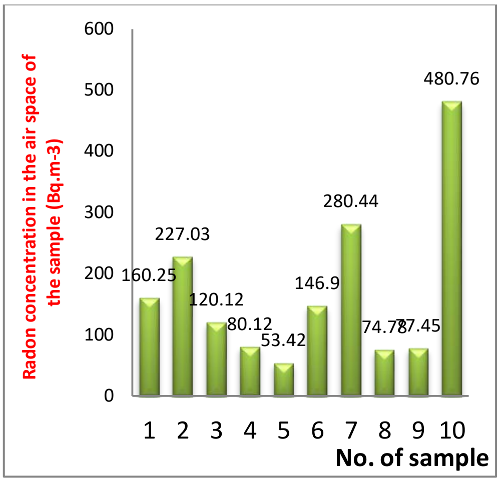

Figure (1) shows the radon concentration in sample air($Bq.m^{-3}$)

Figure (2) shows the radon concentrations in the samples under study. In order to correlate the relationship of radon concentration in the sample air with its concentration in the sample itself, the relationship was drawn as in Figure (3) and it is clear that it is a linear relationship with a correlation factor of one and that the relationship ($y = 0.010x + 0.005$) serves to find the concentration of radon in the sample and then find it in the air.
As for the effectiveness of radon in the sample air and in the sample, as shown in Table (2), it is clear that the highest values for the effectiveness of radon in the sample air were (0.0133 Bq), in sample No. (10), and the lowest value was (0.0015 Bq) in sample No. (5), and it is noted that the highest effectiveness was in granite of Chinese origin and the average values for all granite samples were within (0.0062 Bq).
It is noticeable that the radon effectiveness in the samples was in sample No. (10) which is the highest value (0.145 Bq) and the lowest value in sample No. (5) which is (0.016 Bq) and the rest of the values range between the above two values as shown in Figure (4). As for the specific potency, which represents the potency per unit mass of the material, it was found, as shown in Table (2), that the average values for granite samples were (1.27 $Bq.kg^{-1}$), and through these results we notice that the relationship between specific potency and mass is inversely related as in equation (7), and when comparing these values with the results of (2012, Fathiya) we notice that this rate is lower than the average values for granite samples, where its value was about (4.23 $Bq.kg^{-1}$).Figure (5) shows the relationship between the specific activity and the different types of

samples under study. Comparing the current results with the findings of (Al-Jarallah, 2001) for different types of granite, the value ranged between (0.35-40.2 $Bq.Kg^{-1}$).

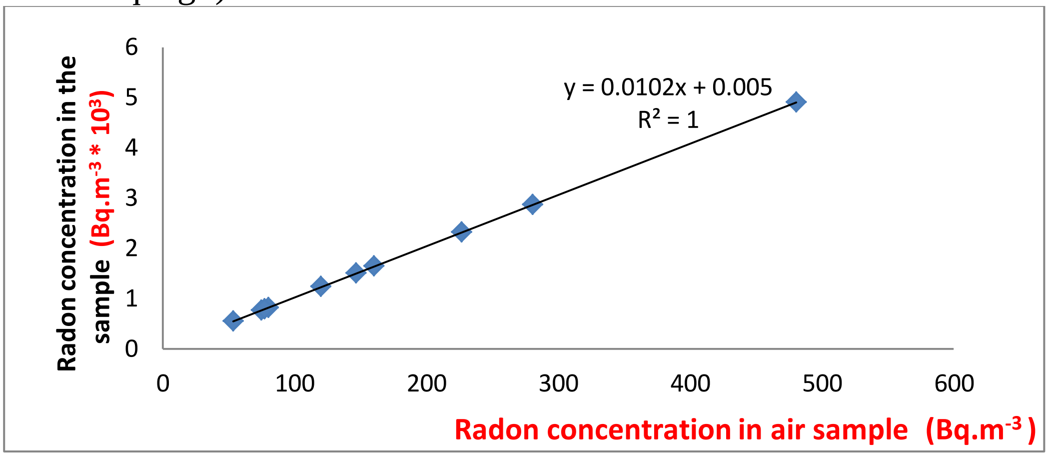

Figure (3) shows the relationship between the radon concentration in the sample and the sample airspace

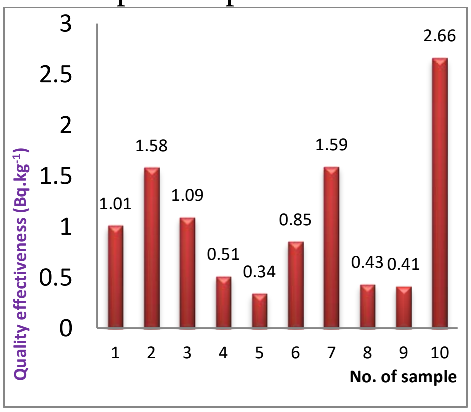

Figure (5) shows the qualitative effectiveness in the studied samples

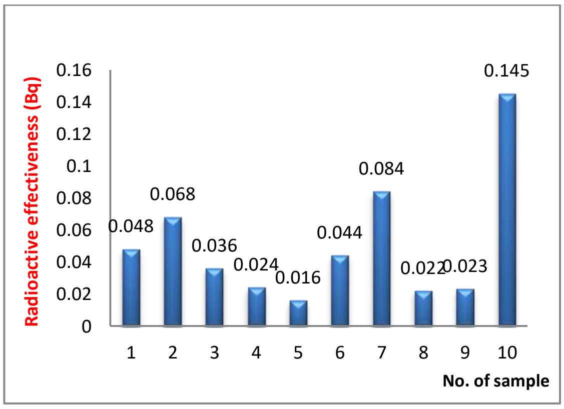

Figure (4) shows the radioactivity in the studied samples

It is clear from the figure that the specific potency ranges between the highest value in the Chinese-origin granite and the lowest value in the Iraqi halan, while the rest of the samples range between the two samples above. The number of uranium atoms, mass and concentration of uranium in the samples as well as the effectiveness of radium were also found through the program designed to find the results. Table (3) shows the above variables and it is clear that the uranium concentration in ppm appears to be within what is allowed globally as it does not exceed 3PPm as approved by the International Organization for Radiological Protection (ICRP, 1999) and the highest value of uranium concentration was in sample No. (10) with (0.214 PPm.).

Sample number	Sample Name	Number of uranium atoms N_U*10^{15}	Uranium mass $W_U(gm)*10^{-6}$ 525	concentration Uranium C_U	Radium potency A_{Ras} Bq

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1	Plaster (Iraqi)	9.80	3.89	0.081	78.47
2	Alabaster (Iraqi)	13.9	5.50	0.123	100.46
3	Cement (Iraqi)	7.40	2.90	0.088	40.63
4	Cement (Turkish)	4.90	1.95	0.042	38.16
5	Halan (Iraqi)	3.20	1.29	0.027	25.40
6	Amber (Italian)	9.00	3.57	0.069	77.64
7	Cranite (Indian)	17.2	6.80	0.129	152.26
8	Cranite (Turkish)	4.60	1.81	0.033	41.36
9	Cranite (Italian)	4.70	1.88	0.035	42.45
10	Cranite (Chinese)	29.5	11.6	0.214	268.4

Figure (6) shows the uranium concentrations in ppm in the samples under study and their values ranged between the highest value (0.214 ppm) in sample (10) and the lowest value (0.0279 ppm) in sample (5) and all values between the above two values and as mentioned earlier, the World Radiation Protection Organization recommended that the highest permissible value for uranium concentrations does not exceed(3ppm), that is, the uranium concentrations in the studied samples are lower than approved by the organization.
Finally, the effectiveness of radium in the samples was deduced by knowing the effectiveness of radon, Figure (7) shows the effectiveness of radium in
units of Bq in the samples under study and it is noted that all values range between the highest value in sample No. (10) and the lowest value in sample No. (5) was 25.4 Bq and 268.4 Bq respectively.
Table (2) shows the mass and number of uranium atoms as well as the concentration of uranium and the effectiveness of radium

In order to compare and correlate the relationship between the radon potency in the samples and the radium potency in them, the relationship was drawn as in Figure (8) and the relationship appears to be linear and from the relationship
$y = 55.27X - 9.582$

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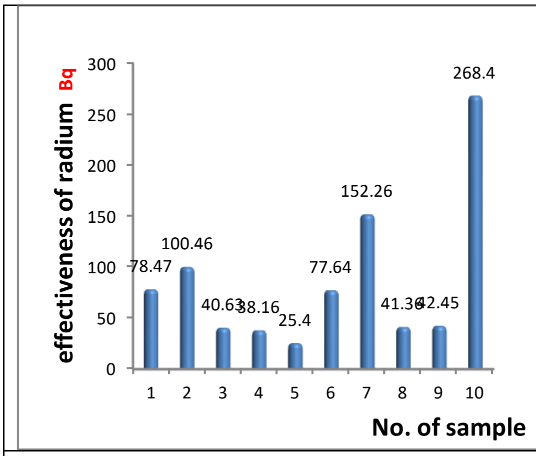
Where y represents the effectiveness of radium in the sample and x represents the effectiveness of radon in the sample, the effectiveness of radium in the samples can be found. In order to compare the results of the radon concentration in the samples, especially in granite, as its value always seems to be the highest relative to the radon concentrations in the rest of the samples, Figure (9) was drawn to show the concentration of radon in granite samples of different origins, which included (Indian, Turkish, Italian, Chinese), Turkish, Italian, Italian, Chinese) with other studies that included Chinese, Spanish, Saudi, Italian, Palestinian and American origin granite (Fathiya,2012) We notice from the figure that the highest concentration of radon was in the Chinese origin granite (4900 Bq.m^{-3}) and this rise may be due to the type of rocks and geological structures of the region, the lowest concentration was in the Saudi granite (76.62 B.m^{-3}). As for the rest of the other types of granite, the value ranged between the above two values, and the difference may be due to the geography of the region and the types of granite rocks and their geological composition.



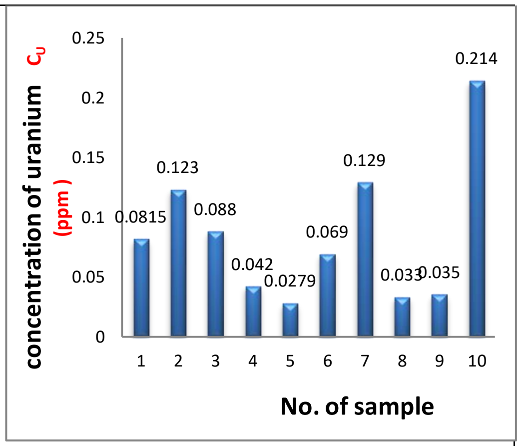


Figure (7) shows the effectiveness of radium in all samples	Figure (6) shows the concentration of uranium in all samples

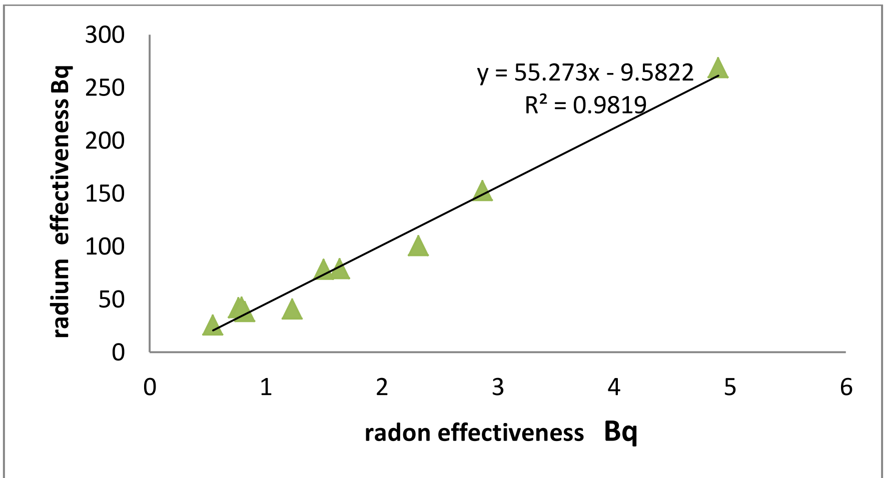


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Figure (8) shows the relationship between Radon effectiveness and radium effectiveness

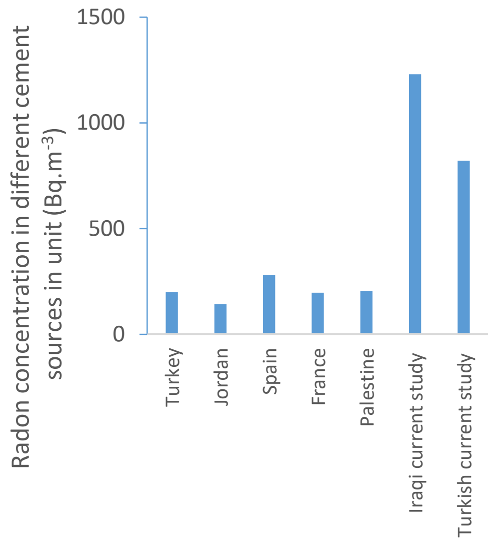

Figure (10) Comparison of radon concentration in cement for different origins for the current study and the study

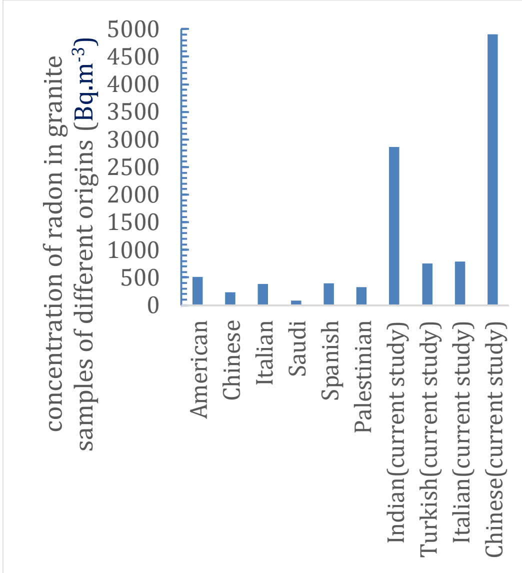

Figure (9) Comparison of radon concentration in granite for different origins for the current study and previous studies

Figure (10) represents the relationship between radon concentrations in cement for the current study and the Turkish and Iraqi types and its comparison with cement from different origins and international studies, and as shown in the figure below from (Palestine, France, Spain, Turkey, Jordan) and it is clear that the highest rate of radon concentrations was in the cement of Iraqi origin followed by the Turkish concentration, while the rest of the types had a lower radon concentration than found in Iraqi and Turkish cement and the difference may be due to the type of limestone and clay used.

Conclusions.

1 -Radon concentration and thus uranium concentrations and radium effectiveness appear to be high in granite of Chinese origin compared to other types of granite and even to other types of building materials such as plaster, cement, alabaster and granite.

2 - There is a linear relationship between the concentration of radon in the sample and its concentration in the air with a correlation factor of one.

3 - A linear relationship was concluded between the effectiveness of radium and the effectiveness of radon with a correlation coefficient of 0.9819.

4 - It was possible to find the effectiveness of radium by relying on the effectiveness of radon, that is, in other words, on the concentration of radon in the sample through the relationships between them.

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