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Measurements of Radon Concentrations in Some Dried Fruit and Grain Samples by (CR-39) Nuclear Track Detector

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Abstract

The purpose of this study was to measure the radon concentration of some dried fruit and grain samples which were consumed as a meal. This is performed by counting the alpha tracks emitted from radon by exposing the CR-39 detector. Measurements indicated that the highest concentration of radon in dried fruit samples was in dried coconut sample 69.89247 Bq/m^3, and the lowest concentration of radon was in figs 50.40323 Bq/m^3, while the highest concentration of radon was in grain samples in oats was 61.82796 Bq/m^3, The lowest concentration of radon was in Iraqi bulgur was 48.3871 Bq/m^3, These results are due to the type and characteristics of the soil. Also shows that the behavior of the surface exhalation rate is higher than the mass exhalation rate.The concentration of radon gas and the rate of exhalation of radon for samples of Dehydrated fruit and cereals are within the permissible global limit, and eating these foods will be healthy and safety for the public.

Keywords: Radon concentration, Surface Exhalation rate, Mass exhalation rate, dried fruit and cereals.

قياس تراكيز الرادون في بعض عينات الفواكه المجففة والحبوب بواسطة كاشف الاثر النووي(CR-39)

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الخلاصه

الغرض من هذه الدراسة هو قياس تركيز الرادون لبعض عينات الفواكه المجففة والحبوب التي تم تناولها كوجبة. يتم إجراء ذلك عن طريق حساب المسارات على كاشف CR-39 بسبب جسيمات الفا المنبعثة من الرادون أشارت القياسات إلى أن أعلى تركيز للرادون في عينات الفواكه المجففة كان في عينة جوز الهند المجفف 69.89247 Bq/m^3 ، وكان أقل تركيز للرادون في التين Bq/m^3 50.40323، بينما كان أعلى تركيز للرادون في عينات الحبوب في الشوفان 61.82796 Bq/m^3، وكان أقل تركيز للرادون في البرغل العراقي 48.3871 Bq/m^3، وتعود هذه النتائج إلى نوع وخصائص التربة . كما يوضح أن سلوك معدل الزفير السطحي أعلى من معدل الزفير الكتلي ، فتركيز غاز الرادون ومعدل زفيرغاز الرادون لعينات من الفاكهة والحبوب المجففة ضمن الحد العالمي المسموح به، وان تناول هذه الأطعمة ضمن الحدود العالمية المسموح بها وآمنة على الانسان .

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Introduction

There are certain concentrations of radionuclide within the human body.These either caused by constant exposure to natural radiation (cosmic rays, terrestrial sources, and radon) and to man-made sources of radiation, or are naturally present within the body from birth, such as ^{40}K, ^{14}C and ^{210}Pb [1]. Nuclei can undergo a variety of processes which result in the emission of radiation. Internal radiation exposure, affecting the respiratory tract is due to the inhalation of radon and its daughters[2, 3]. Radon is the decay product of the naturally occurring radionuclide ^{226}Ra, which in turn is a decay product of ^{238}U. Since radon is a gas, it can escape from the substance in which it is produced into the air, and since uranium and radium exist commonly in soil, rocks, and water, the inhaled air contains radon Radon gas is pervasive both outdoors and indoors, so it is considered as radiation health hazard that causes excess lung cancer [4, 5]. More attention has been paid to the impact of radiation exposure on animals and plants than before[6]. Radiation damage in plants is due to irregular form, low growth or yield, loss of reproductive ability, wilting and death (in high-exposure cases).When inhaled, radionuclides are distributed among body organs in accordance with the metabolism of the part concerned, which typically shows different radiation sensitivities[7-10].

With increasing of recognition and application of irradiation as a sanitary treatment of food based on the provisions of the Agreement on the Application of sanitary measures of the World Trade Organization, it is therefore important that appropriate dosimetry systems be used, to ensure that the trade in irradiated foodstuffs complies with national and international standards [11, 12]. Therefore, the main effect of the particles charged on these detectors such as (CR-39) is their degradation; these effects reflect substantial changes in the properties of the polymer detector. The fall of radiation leads to the irritation and ionization of these molecules in generaland thus severs the bonds between them and damage [13, 14, 15].

2. Experimental Work

2.1. Samples Preparation: The practical part

Twelve samples were collected, six samples of dried fruit and six samples of grains , purchased from local Iraqi markets, as shown in the Table (1). These samples were milled, sieved, and placed inside a plastic cans(one sample per can). The can is 13cm high and 8 cm in diameter. A square piece (1 cm x 1 cm) of CR-39 detectors (British made) with a thickness of 500μm 250 gm of NaOH was used in the solution preparation process were positioned on the inner surface of the can covers, as shown in Figure 1. The samples were placed at a height of 3 cm inside these cans which were then sealed for 60 days to achieve the radioactive balance, After this time, the CR-39 detectors were etched in 6.25N NaOH solution at a temperature of 60 ˚C for 5 hours to reveal the alpha particles tracks.

Table 1- Dried fruits and cereals sample code, origin and date of manufacture.

No.	Sample		Code	Sample of origin	Date of manufacture
1	Dried Fruit	Figs	F1	Turkey	2019
2			F2	Iraq	2019
3		Apricot	F3	Iraq	2018
4		Raisin	F4	Iraq	2019
5		Dried cocout	F5	Iran	2019
6		Dates	F6	Iraq	2019
7	Cereals	Oats	C7	Iraq	2019
8		Barley	C8	Iraq	2018
9			C9	Turkey	2019
10		Millet	C10	Iraq	2018
11			C11	Egypt	2019
12		Bulgur(Wheat crushed)	C12	Iraq	2018

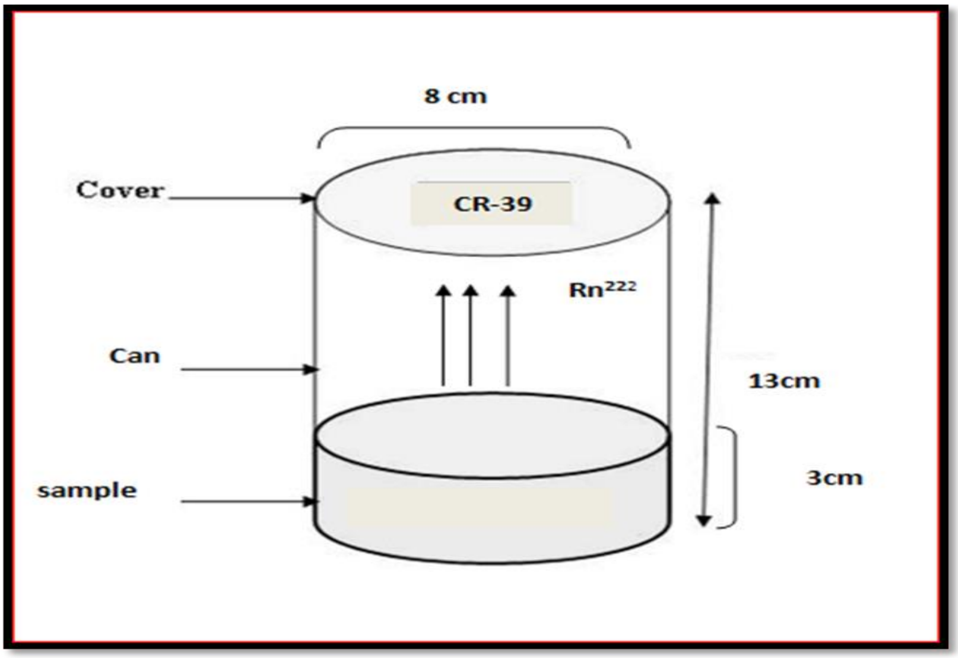

Figure -1 the dimensions of the used cans.

2.2 Density of the tracks

The density of the tracks (ρ) on the CR detector was calculated according to the following relation [16,17].

$$\textbf{Tracks density } (\rho) = \frac{\text{number of total pits (track)}}{\text{Area of field}} \qquad \textbf{(1)}$$

2.3 Calculation of Radon Exposure

The radon gas concentration in some dried fruit and grain samples were obtained, using the following relation [18].

$$C_{Rn}(\text{sample}) / \rho_{Rn}(\text{sample}) = C_s(\text{standard}) / \rho_s(\text{standard})$$

Where:

C_{Rn}: is the radon gas concentration in unknown sample (Bq/m^3).
C_S: is the radon gas concentration in standard sample (Bq/m^3).
ρ_{Rn} : is the track density of the unknown sample ($track/mm^2$).
ρ_S : is the track density of the standard sample ($track/mm^2$).
Figure 2 shows the relationship between track density (ρ_{Rn}) and radon exposure.
Therefore, from the slope of the graph k where $C_{Rn} = \rho_{Rn} / k$

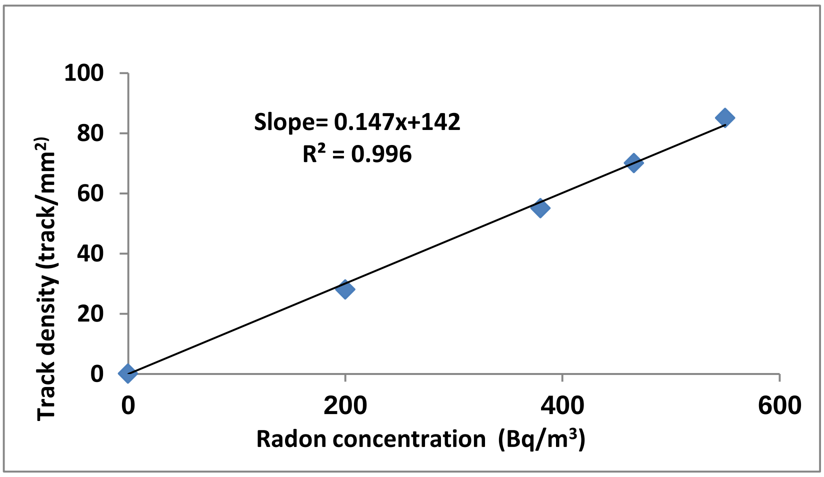

Figure 2-Relation of radon gas concentration and track density of the dried fruit samples and the grain samples.

2-4 Determination of Radon Exhalation Rate in Samples

The surface and mass exhalation rate (E_A, E_m) can be calculated as follows [19,20]:

$$E_A = \frac{CV\lambda}{A(T+\lambda^{-1}(e^{-\lambda T}-1)} \quad (2)$$

$$E_m = \frac{CV\lambda}{M(T+\lambda^{-1}(e^{-\lambda T}-1)} \quad (3)$$

Where:
C: is integrated radon emission as measured by the plastic detector, ($Bq.m^{-3}$).
V: is the volume of air in cup (m^3) =452.16 cm^3= 0.000452 m^3
λ :is the decay constant for 222Rn (h^{-1}) = 0.1812 day^{-1} =0.00755 h^{-1}
A: is sample surface area (m^2) = 2.5^2×3.14=19.62 cm^2=0.001962 m^2.
M:the mass of test sample.
T: is the time of exposure (h) = 30day =720 h.

3. Results and Discussion

Radon gas concentration, for the dried fruits and grain samples, was measured and the results are shown in Table (2). The mean radon gas concentration was shown to be higher in the dried fruit samples than in the grain samples, as shown in Figure 3. The concentration of radon gas in some dried fruits samples ranged from 50.40 Bq/m^3 in sample F1 to 69.89 Bq/m^3 in sample F5, while the concentration of radon gas in the grain samples varied from 48.387 Bq/m^3 in sample C11 to 61.827 Bq/m^3 in sample C7.

Table 2-The radon gas concentration C_{Rn} and radon exhalation rate(E_A,E_m) of the dried fruits and grain samples.

No.	Sample		C_{Rn} (Bq/m^3)	E_A (Bq/m^2.h)	E_m (Bq/Kg.h)
1	dried Fruit	Figs	50.403	6.7	5.2×10^{-6}
2			54.435	7.2	5.6×10^{-6}
3		Apricot	59.139	8.7	6.1×10^{-6}
4		Raisin	62.5	8.3	6.52×10^{-6}
5		Dried coconut	69.89	9.2	7.2×10^{-6}
6		Dates	64.516	8.5	6.7×10^{-6}
Mean±S.D			**60.14 ±2.6**	**4.54 ± 0.035**	**6.05×10^{-6} ± 0.21**
7	Cereals	Oats	61.827	8.0	6.3×10^{-6}
8		Barley	60.483	7.6	6.03×10^{-6}
9			57.795	7.2	5.6×10^{-6}
10		Millet	54.435	6.7	5.2×10^{-6}
11			48.387	6.4	5.0×10^{-6}
12		Bulgur	50.403	7.5	5.2×10^{-6}
Mean±S.D			**55.5 ±2.02**	**7.2 ±0.22**	**5.5×10^{-6} ±0.19**
Limit ICRP, 2009 [21]			**200-300**		

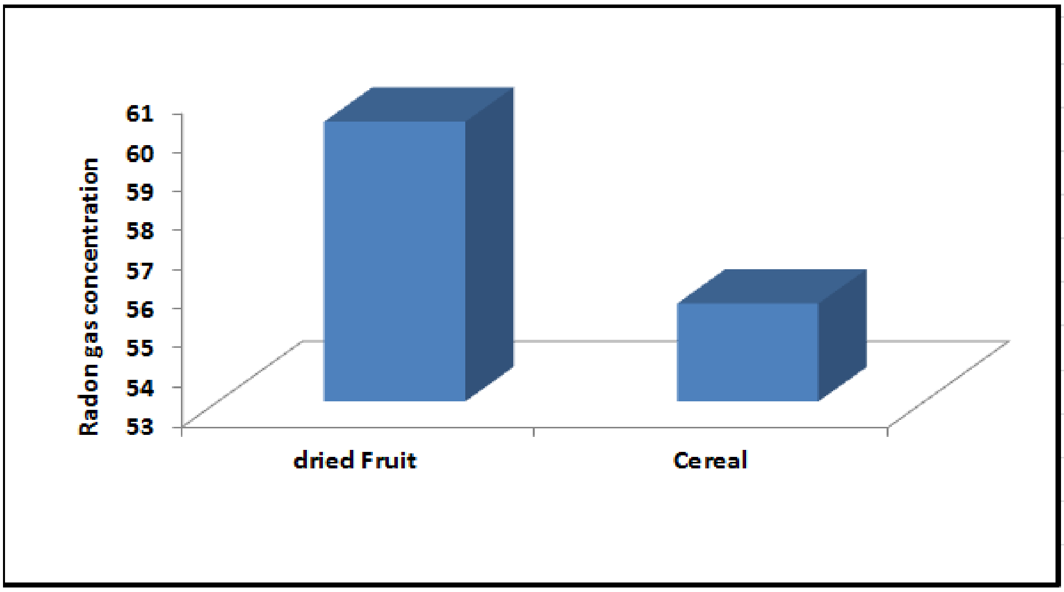

Figure 3-Mean radon gas concentration of the dried fruits and gain samples.

The exhalation rate of radon was measured where the surface exhalation rate and the mass exhalation rate are shown in Table 2 and Figures 4 and 5.

The surface exhalation rate for the dried fruits samples varied from 6.7 Bq/ m^2.h in sample F1(figs) to 9.2 Bq/m^2.h in sample F5 (dried coconut). While the surface exhalation rate for the grain samples varied from 6.4Bq/ m^2.h in sample C11 (Millet) to 8.0 Bq/m^2.h in sample C7 (Oats).

Also, mass radon exhalation rate was calculated . The mass exhalation rate varied from 5.2×10^{-6}(Bq/Kg.h) in sample F1 (figs) to the highest value of 7.2×10^{-6}Bq/Kg.h in a sample F5 (Dried coconut) with mean values of 6.05×10^{-6} ± 0.12 Bq/Kg.h. While the mass exhalation rate varied from 5×10^{-6}Bq/kg.h in millet sample(C11) to the highest value 6.3×10-6 Bq/kg.h in Oats(C7), with mean values of 6.05×10^{-6} ± 0.12 Bq/Kg.h and 5.5×10^{-6}± 0.19 Bq/kg.h, respectively.

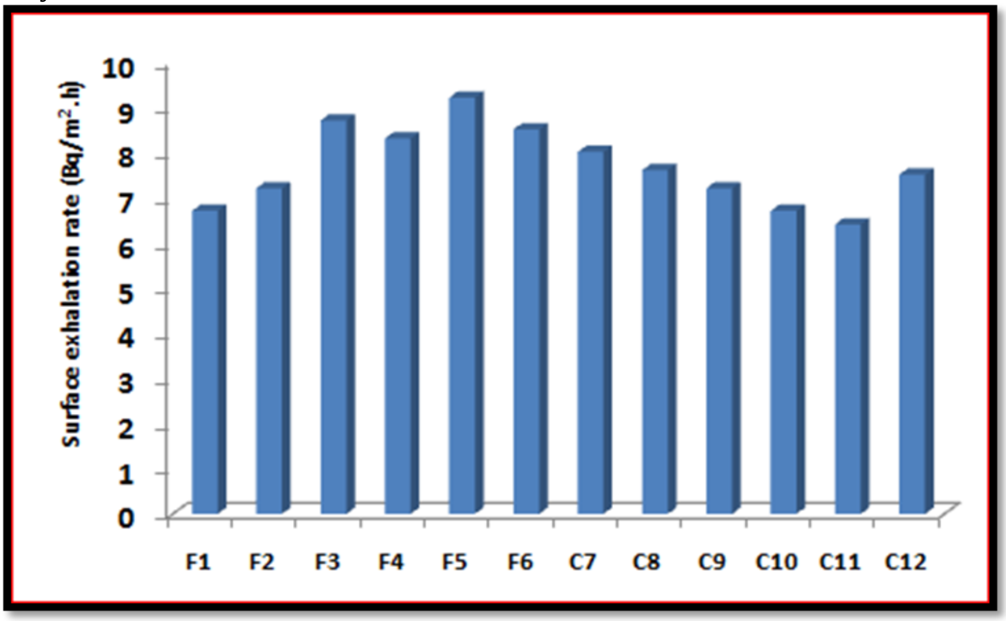

Figure 4-Surface exhalation rate in the dried fruits and the grain samples.

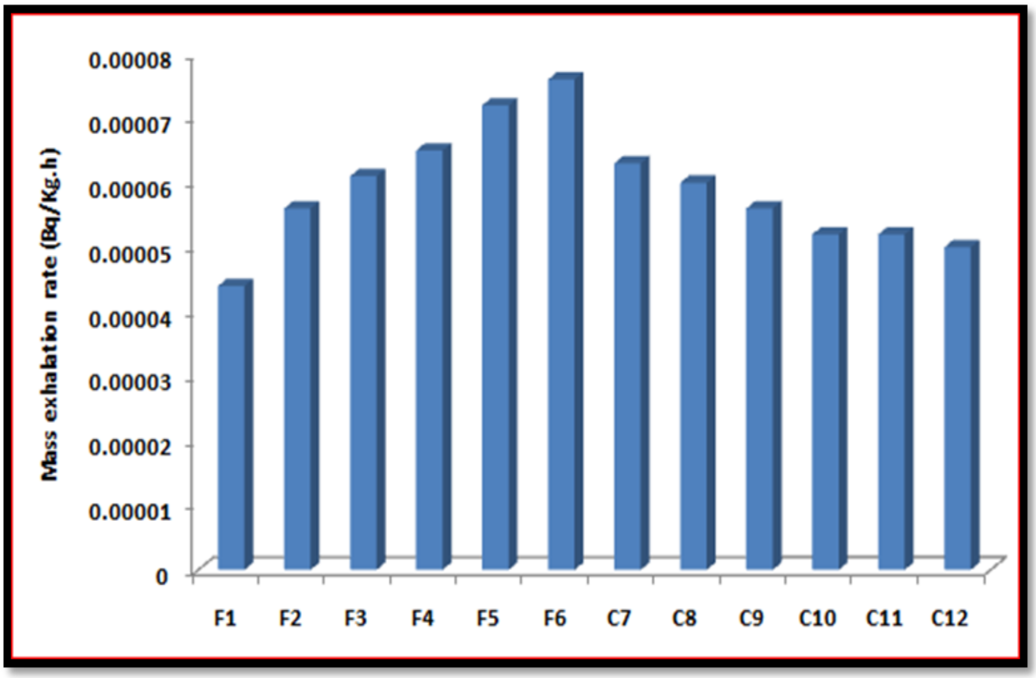

Figure 5-Mass exhalation rate in some dried fruits and grains samples.

CONCLUSUONS

The Iraqi figs among the dried fruit samples and Iraqi bulgur among the grain samples showed the lowest concentration of radon gas. Also, they showed the lowest surface exhalation rate and mass radon exhalation rate. The findings showed that all the dried fruit and grain samples under study had radon gas concentration at the acceptable global limit recommended by ICRP.

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References

[1] Arnoux Devaux, G. Alves, S. Balboa, D. Balorin, I. Balshaw, C. and De Pablos, J. L.“ A protection system for the JET ITER-like wall based on imaging diagnostics” . *Review of Scientific Instruments*, vol.83,no.10, 2012.

[2] Rasheed, E.M. “ Determination the concentrations of radon gas and exhalation rate in some phosphate fertilizer using CR-39 track detector” . *Iraqi Journal of Physics*, vol. 15, no.32, pp.136-144. 2017.

[3] OECD, “Exposure to radiation from natural radioactivity in building materials” . Nuclear Energy Agency (NEA) Report by NEA Group of Experts OECD, Paris,1979.

[4] IAEA, “Radiation protection against Radon in workplaces other than mines ” . International atomic energy agency, safety reports series. 33, 3 Vienna,2003.

[5] Karim, M.S. “Determine Uranium and Radon Concentration in Soil Taken from Area Situated in South East of Baghdad by Using the Nuclear Track Detector (CR-39) ” . M.Sc. Thesis, College of Education, University of Al-Mustansiriyah, Iraq, 2005.

[6] UNEP, United Nations Environment Programme. “Radiation effects and sources,2016.

[7] UNSCEAR,“Sources and Effects of Ionizing Radiation” . vol.2, Scientific Annexes C, D and E. United Nations, New York, 2011.

[8] Ridha, A.A. Jameel, A.N. and Kadhim, N.F. " Transfer factor of natural radionuclides from soil to silhouette plants using gamma spectroscopy" . *AIP Conference Proceedings 2213*, 020124. 2020.

[9] Kramer, R. Vieira, J. W. Khoury, H. J. Lima, F. R. A. Fuelle, D. "All about MAX: a male adult voxel phantom for Monte Carlo calculations in radiation protection dosimetry" . *Physics in Medicine and Biology*, vol.48,no 10,1239. 2003.

[10] Azeez, H. N. Kheder, M. H. Slewa, M. Y., & Sleeman, S. Y." Radon Concentration Measurement in Ainkawa Region Using Solid State Nuclear Track Detector" . *Iraqi Journal of Science*,vol.59, 482-488,2018.

[11] IAEA. "Measurement of Radionuclides in Food and the Environment " . A Guidebook, Vienna, Technical Reports Series No. 295, Section 2,pp. 2-5,1989.

[12] Leung, S.Y.Y. Nikezic, D. Leung J. K. C. and Yu, K. N . " Derivation of V function for LR 155 SSNTD from its sensitivity to ^{220}Rn in a diffusion chamber ". *Applied Radiation and Isotopes*, vol.65,no.3,pp. 313-317,2007.

[13] Singh, N. P. Singh, M. Singh, S. Virk, H. S.. "Uranium estimation in Siwalik vertebrate fossil bones using SSTD" . *International Journal of Radiation Applications and Instrumentation. Part D. Nuclear Tracks and Radiation Measurements*, vol.12.no.(1-6),pp. 793-796. 1986.

[14] Aziz, A.A. "Evaluation of radioactivity of cereals and legumes using a nuclear impact detector CN-85" . *Iraqi Journal of Physics*,vol.16 ,no.38,pp.139-146,2018.

[15] Yu, K. N. Koo, V. S.Y. and Guan, Z. J. "A simple and versatile 222/220Rn exposure chamber" . *Nuclear Instrument and Methods in Physics Research A*, vol.481.no.(1-3),pp. 749-755. 2002.

[16] Amalds, O. Custball, N.H. and Nielsen, G.A. "Cs-137 in Montana Soils" .*Health Physics*, vol.57,no.6,pp.955-958, 1989.

[17] Ahmed, O. M." Use of Nuclear Pollution Detector Technology (CR-39) for the Control of Radioactive Radiation in Depleted Uranium in Specific Areas of Salah al-Din Governorate" . Proceedings of the First Scientific Conference of the Faculty of Science - Tikrit University – Iraq,2009.

[18] Chen, J. Rahman, N.M. and Atiya, I.A. "Radon exhalation from building materials for decorative use" . *Journal of Environmental Radioactivity*,vol.101,no. 17-22, 2010.

[19] Ferreira, A.O. Pecequilo, B.R. and Aquino, R.R. Application of a Sealed Can Technique and CR-39 detectors for measuring radon emanation from undamaged granitic ornamental building materials" . *Radioprotection Journal*, vol.46,no.6,pp.49-54, 2011.

[20] Abu-Jarad, F. Fremlin, J. H. and Bull, R. "A study of radon emitted from building materials using plastic α-track detectors" . *Physics in Medicine & Biology*, vol.25,no.4, pp.683-694,1980.

[21] ICRP. International Commission on Radiological Protection, Statement on Radon, ICRP . 2009.