Measurement of radon gas concentration in cement samples by using nuclear track detector (CR-39)

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Abstract

In the present work, we have measured the radon gas concentration in ten cement samples from different countries ,they are , (Iraq, Egypt ,Iran, Lebanon ,Turkyi and Jordan) by using alpha-emitters registrations which are emitted form radon gas in (CR-39) nuclear track detector.

The results obtained have shown that the highest average radon gas concentration in cement samples which was (200 Bq/m^3) origin Iran, while the lowest average radon gas concentration in cement samples which was (84.4 Bq/m^3) origin Iraq (Najif).The present results show that the radon gas concentration in all cements samples is below the allowed limit from (International Commission of Radiation Protection) (ICRP) agency.

Keywords: Radon gas concentration, Cement, Alpha-emitters.

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قياس تركيز غاز الرادون في نماذج السمنت باستخدام كاشف الأثر النووي (CR-39)

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الخلاصة

في هذا البحث تم قياس تركيز غاز الرادون في عشر نماذج من الأسمنت ولبلدان مختلفة (العراق، مصر، إيران، لبنان ، تركيا، الأردن) باستخدام تقنية عد آثار جسيمات الفا المنبعثة من غاز الرادون في كاشف الأثر النووي (CR-39).

وقد أوضحت النتائج التي حصلنا عليها أن أعلى معدل لتركيز غاز الرادون فمي نماذج الإسمنت ($200\ Bq/m^3$) إيراني المنشأ، بينما كان اقل معدل لتركيز غاز الرادون في نماذج الأسمنت ($84.4\ Bq/m^3$) عراقي المنشأ (نجف). النتائج الحالية تبين ان تركيز غاز الرادون في جميع نماذج الإسمنت كانت ضمن الحدود المسموحة للوكالة الدولية للوقاية من الإشعاع.

Introduction

Radon, as a natural noble gas, has three main natural isotopes; namely, radon-222(^{222}Rn),a decay product of (^{238}U) ، radon-220 (^{220}Rn, known as thoron), produced in the decay series of thorium-232 (^{232}Th), and radon-219 (^{219}Rn), a decay product from the chain originating with ^{235}U [1]. Both (^{238}U) and (^{232}Th) occur naturally in soil and rocks at variable concentrations of about (1 pCi/g) and also (^{226}Ra), the parent of (^{222}Rn) [2]. The (^{222}Rn) isotope has a half-life of 3.82 days ؛while (^{220}Rn) isotope has a half-life of (55) seconds and (^{219}Rn) isotope has a half-life of about (3.9) seconds .(^{222}Rn) decays into polonium-218 (^{218}Po), which in turn decays within minutes to lead-214) (^{214}Pb), bismuth-214 (^{214}Bi), and polonium-214 (^{214}Po) [3].

The radon gas can diffuse easily out of the soil surface into air or houses; it can be trapped in poorly ventilated houses and so its concentration can build up to higher levels. Although soil is considered to be the main source of indoor radon concentration, raw building materials

(especially cement, quartz, etc.) can make a significant contribution to the level of natural radioactivity in closed spaces such as stores and badly-ventilated dwellings [4]. Moreover, the production rate of radon in dwellings depends on the concentration of radium content in the subsoil, building materials (as the cement) [5,6]. The emission of radon from building materials is found to be a function of ventilation as well as of the radium content in building materials. The nongaseous (^{222}Rn) decay products are partially suspended in air as a mixture of attached and unattached fractions and partially deposited on walls and furniture [7].

The aim of the present work is to determine the radon gas concentration in different kinds of cement which was available in the local market, some of them were Iraqi made and the others from different countries by using alpha-emitters registrations which are emitted form radon gas in (CR-39) track nuclear detector.

Experimental Part

The determination of the concentrations of alpha particles emitted from radon gas in cement samples were performed by using the nuclear track detector (CR-39) of thickness (250 μm) and area of about (1×1 cm^2).

The radon gas concentration in cement samples was obtained by using the sealed-cup technique as shown in Fig. (1).

After the irradiation time (45 day), the (CR-39) track detectors were etched in (6.25 N), (NaOH) at temperature of (70 °C) for (5 h), and the tracks density were recorded using an optical microscope with magnification (400 x). The density of the tracks (ρ) in the samples were calculated according to the following relation [8].

The radon gas concentration in the cement samples were obtained by the comparison between

$$\text{Track density } (\rho) = \frac{\text{Average number of total pits (tracks)}}{\text{Area of field view}} \quad \ldots\ldots (1)$$

track densities registered on the detectors of the sample and that of the standard cement samples which are shown in Fig.(2), using the relation [9]:

$C_X = \rho_X . (C_S / \rho_S)$ …..... (2)

Where :

C_X : alpha particles concentration in the unknown sample.

C_S : alpha particles concentration in the standard sample.

ρ_X : track density of the unknown sample (track/mm^2).

ρ_S : track density of the standard sample (track/mm^2).

Results and Discussion

Our present investigation is based on the study of (10) samples from different kinds of cement which was available in the local market, some of them were Iraqi made and the others from different countries like, (Iraq,Egypt,Iran,Lebanon,Turkyi and Jordan) and found the radon gas concentration by using alpha-emitters registrations which are emitted form radon gas in (CR-39) nuclear track detector.

Table (1) present radon gas concentration for cement samples in different countries, we can show that , the highest average radon gas concentration in cement samples which was (200 Bq/m^3) origin Iran, while the lowest average radon gas concentration in cement samples which was (84.4 Bq/m^3) origin Iraq (Najif).

The present results show that the radon gas concentration in all cements samples is below the allowed limit from (International Commission of Radiation Protection) (ICRP) agency which is (200 Bq/m^3) in soil sample [10].

It might be mentioned that ,thoron gas is an alpha emitter which is also present in cement environments, however ,the average diffusion distance of thoron gas is very small compared to that of radon, which means that the present results might also contained a small amount of

thoron , and therefore might be considered roughly as an upper limit results which are still within the allowed limit of (ICRP) agency . Also it should be remembered that the half -lives of radon and thoron are (3.82 d) and (56 s) respectively. However ,the present result might be more refined be using , for example ,a filter to separate radon gas from thoron gas [11].

Conclusions

From the present work, it can be concluded that the highest average radon gas concentration in cement samples which was (200 Bq/m^3) origin Iran, while the lowest average radon gas concentration in cement samples which was (84.4 Bq/m^3) origin Iraq (Najif).The present results show that the radon gas concentration in all cements samples is below the allowed limit from (International Commission of Radiation Protection) (ICRP) agency.

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Table (1) show the radon gas concentration for cement samples from different countries.

No. of sampl e	Origin		Samples				Mean
			1	2	3	4	
1	Iraq (Kirkuk)	Radon Concentration (Bq/m^3)	151.7	117.2	89.6	62	105.12
		Track density (Track .mm^{-2})	22	17	13	9	15.25
2	Iraq (Kabisa)	Radon Concentration (Bq/m^3)	131	103.4	62	48.2	86.15
		Track density (Track .mm^{-2})	19	15	9	7	12.51
3	Iraq (AL-Qaim)	Radon Concentration (Bq/m^3)	172.4	138	124.1	96.5	132.7
		Track density (Track .mm^{-2})	25	20	18	14	19.25
4	Iraq (Sulaymniya)	Radon Concentration (Bq/m^3)	186.2	172.4	144.8	110.3	153.4
		Track density (Track .mm^{-2})	27	25	21	16	22.25
5	Iraq (Najif)	Radon Concentration (Bq/m^3)	117.2	103.4	75.8	41.3	84.4
		Track density (Track .mm^{-2})	17	15	11	6	12.25

6	Iran	Radon Concentration (Bq/m^3)	262	200	200	138	200
		Track density (Track .mm^{-2})	38	29	29	20	29
7	Lebanon	Radon Concentration (Bq/m^3)	220.6	186.2	138	103.4	162
		Track density (Track .mm^{-2})	32	27	20	15	23.5
8	Egypt	Radon Concentration (Bq/m^3)	241.3	151.7	124.1	117.2	158.5
		Track density (Track .mm^{-2})	35	22	18	17	23
9	Turkyi	Radon Concentration (Bq/m^3)	172.4	151.7	110.3	69	125.8
		Track density (Track .mm^{-2})	25	22	16	10	18.25
10	Jordan	Radon Concentration (Bq/m^3)	227.5	200	165.5	117.2	177.5
		Track density (Track .mm^{-2})	33	29	24	17	25.75

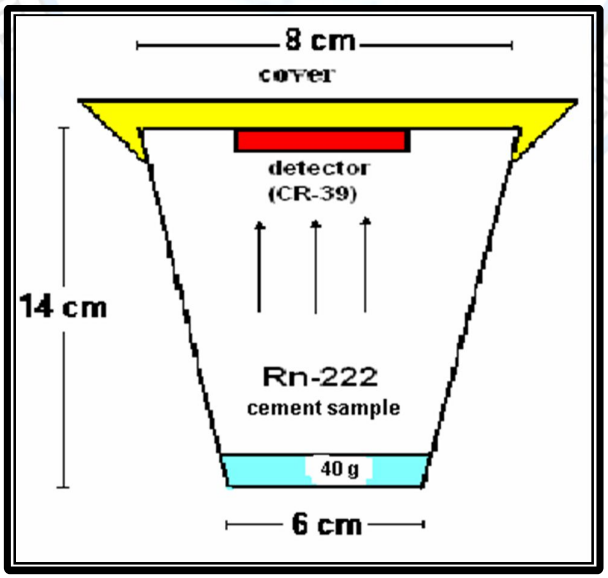

Fig. (1) A schematic diagram of the sealed-cup technique in cement sample.

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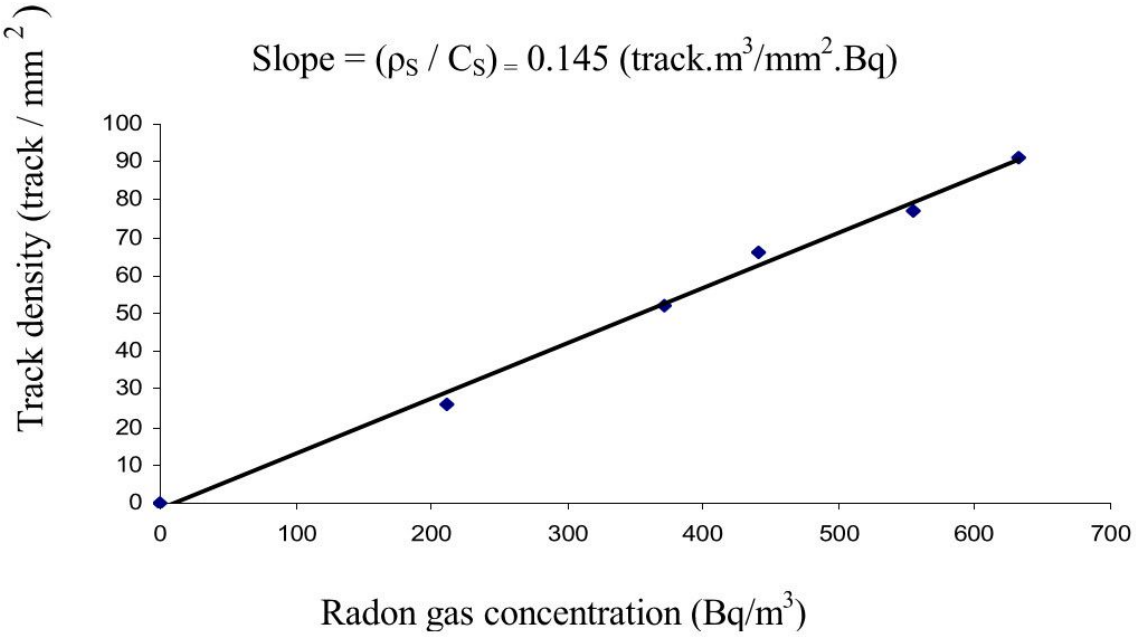

Fig.(2) relation of radon gas concentration and track density in standard samples.