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 four cement samples different in origin{ Iraqi (kofah) cement , Iraqi (sulaymaniyah) cement , Iranian cement , Kuwaitian cement } by using alpha-emitters registrations which are emitted from radon gas in (CR-39) nuclear track detector.

The obtained results have shown that the highest average radon gas concentration in cement samples was found in Iraq cement (kofah) sample, which was (**25.2** Bq/m^3), while the lowest average radon gas concentration in cement samples was found in Kuwait sample, which was (**9.17** Bq/m^3) . The present results show that the radon gas concentration in all cement samples is below the allowed limit from (International Commission of Radiation Protection) (ICRP) agency.

في هذا البحث تم قياس تركيز غاز الرادون في اربع عينات سمنت مختلفة المناشئ { سمنت عراقي (الكوفة) , سمنت عراقي (السليمانية) , سمنت ايراني , سمنت كويتي } باستخدام تقنية عد آثار جسيمات الفا المنبعثة من غاز الرادون في كاشف الأثر النووي (CR-39).

اظهرت النتائج أن أعلى معدل تركيز غاز الرادون في نماذج السمنت كان في نموذج سمنت العراق (الكوفة) حيث بلغت (**25.2** Bq/m^3) بينما كان اقل معدل تركيز غاز الرادون في نموذج سمنت الكويت (**9.17** Bq/m^3) . ومن استقراء النتائج التي تم الحصول عليها تبين ان تركيز غاز الرادون كان ضمن الحدود المسموحة للوكالة الدولية للوقاية من الإشعاع.

Introduction

The raw material which is used in production of some cements is containing various amounts of natural radioactive elements. During processing this material, owing to chemical properties of Radium, practically all (Ra^{226}) gets incorporated into cement and remains in disequilibrium status when it compared to radioactivity levels contained in the raw material. Most of the materials are considered waste and are stockpiled or discharged into the aquatic environment [1].Potential issues of concern resulting from waste disposal are its environmental impacts; possible increases in radio- nuclides in soils or in groundwater and consequential ingestion by humans through exposure routes such as drinking water and food chain [2]. Once ,deposited in bone tissue,(Ra^{226}) has a high potential for causing biological damage through continuous irradiation of human skeleton over many years and may induce bone sarcoma [3].

The natural radionuclides of concern are mainly Potassium, Uranium Thorium, and the radio-nuclides that are created as their radioactive decay chains. Emanation of Radon gas (e.g. Rn^{222} and Rn^{220} of lifetimes about

3.8 day and 55.6 s respectively) into air occurs as a product of uranium (U^{238}) and thorium (Th^{232}) decay chains, respectively. The short lived decay products of radon are responsible for most of the hazards by inhalation. The hazard of Radon comes from its radioactive progeny, which use their physical properties to spread or attach like aerosols do, trapped in the lung and depositing their alpha-particle energies in the tissue, producing higher ionization density than beta particles or gamma-rays. Lung cancer, skin cancer, and kidney diseases are the health effects attributed to inhalation of radon-decay products [4]. The sources of radon gas are the building materials and its components, ground water, and soil [5]. The radiological impact from the above nuclides is due to radiation exposure of the body by the gamma rays and irradiation of the lung tissues from inhalation of Radon and its progeny [6]. From the natural risk point of view, it is necessary to know the dose limits of public exposures and to measure the natural environmental radiation level provided by ground, air, water, foods, building interiors, etc., for the estimation of the exposures to natural radiation sources. Low level gamma-ray spectrometry is suitable for both qualitative and quantitative determinations of gamma-ray emitting nuclides in the environment [7].

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).

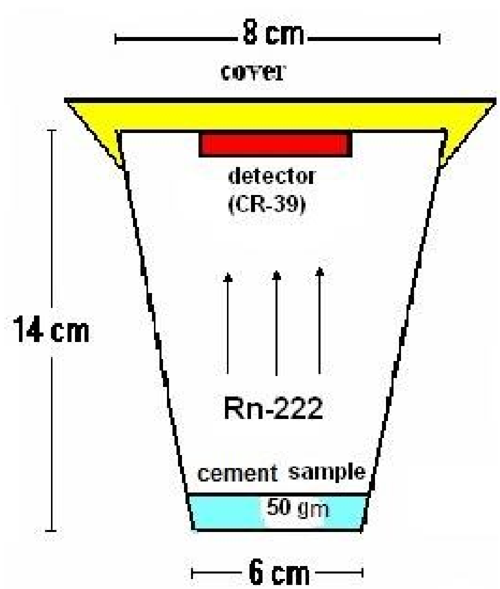

Fig. (1) A schematic diagram of the sealed-cup technique in cement sample.

After the irradiation time (45 days), the (CR-39) track detectors were etched in (6.25 N) of (NaOH) solution at temperature of (70 ^{o}C) for (5 hr), and the tracks density were recorded using an optical microscope with magnification (400x).The density of the tracks (ρ) in the samples were calculated according to relation [8, 9].

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

The radon gas concentration in the cement samples were obtained by the comparison between track densities registered on the detectors of the samples 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).

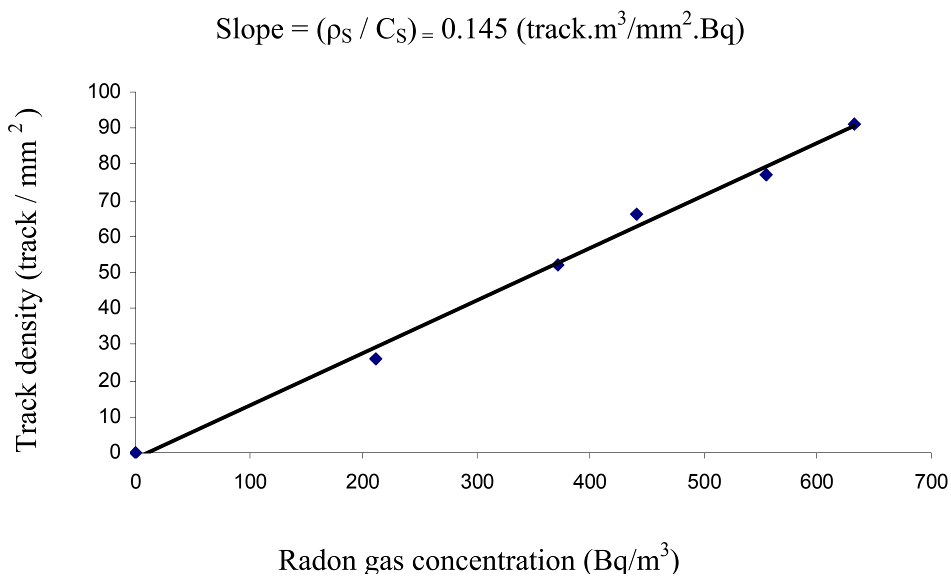

Fig. (2) relation of radon gas concentration and track density in standard samples.

Results and Discussion

Our present investigation is based on the study of 4 samples from different origin of cement which was available in the local markets, two of them were Iraqi made such as,(Iraq (kofah), Iraq (sulaymaniyah), and the others from different countries (Iran, Kuwait). We found the radon gas concentrations by using alpha-emitters registrations which are emitted form radon gas in (CR-39) nuclear track detector.

Table (1) represent the radon gas concentrations for cement samples in different countries. It can be noticed that, the highest average radon gas concentration in cement samples was found in Iraqi cement (kofah) sample, which was (**25.2** Bq/m^3), while the lowest average radon gas concentration in cement samples was found in Kuwait sample, which was (**9.17** Bq/m^3).

It might be mentioned that, thoron gas is an alpha emitter which is also present in soil and the other investigated materials. However, the average diffusion distance of thoron gas is very small compared to that of radon [10].

The present results indicate that the radon gas concentrations in all cement samples is below the allowed limit from (International Commission of Radiation Protection) (ICRP) agency which is (200 Bq/m^3) in soil sample [11].

Table (1) Radon gas concentration for cement samples from different countries

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No. of sample	Origin of cement		Samples			
			1	2	3	Mean
1	Iraq (kofah)	Radon Concentration (Bq/m^3)	27.5	13.8	34.4	25.2
		Track density (Track .mm^{-2})	4	2	5	3.66
2	Iraq (sulaymaniyah)	Radon Concentration (Bq/m^3)	13.8	20.7	13.8	16.07
		Track density (Track .mm^{-2})	2	3	2	2.33
3	Iran	Radon Concentration (Bq/m^3)	6.9	20.7	13.8	13.8
		Track density (Track .mm^{-2})	1	3	2	2
4	Kuwait	Radon Concentration (Bq/m^3)	6.9	13.8	6.9	9.17
		Track density (Track .mm^{-2})	1	2	1	1.33

Conclusions

From the present work, it can be concluded that the highest average radon gas concentration in cement samples was found in Iraq cement (kofah) sample, which was (**25.2** Bq/m^3), while the lowest average radon gas concentration in cement samples was found in Kuwait sample, which was (**9.17** Bq/m^3) .The present results show that the radon gas concentration in all cement samples is below the allowed limit from (International Commission of Radiation Protection) (ICRP) agency.

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