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Studying the Possibility of using Paint to Reduce the Amount of Radon Gas Emitted from Cement

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Abstract

In the present work, it had been measured the concentration of radon gas (C_{Rn}) for (10) samples of cement used in constructions before and after painting them using enamel paint, purchased from the local markets, to see the extent of its ability to reduce emissions of Rn-222 in the air. These samples were obtained from different sources available in the local markets in Baghdad and other provinces. The measurements were done by the American-made detector (RAD7). The results showed that the highest C_{Rn} in the air emitted from cement samples after coating was in the cement sample (Iranian origin) where the concentration was (58.27 Bq/m^3) while the lowest C_{Rn} was found in building material samples in the white cement sample (Turkish origin) was (15.74 Bq/m^3). In view of the present results, it has been confirmed that the concentration of Rn-222 emitted into the air in all building material samples is below the agency's permissible limit (ICRP).

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RAD7 detector, Cement, Radon, Painting, radiological hazards.

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1. Introduction

The principal source of radon-222 in the worldwide environment is radium-226 in the earth's crust [1, 2]. Because Ra-226 is found everywhere Rn-222 is ubiquitous throughout the geosphere, biosphere, and atmosphere. The radionuclide is extremely mobile [3]. Ionizing radiation is the most common type of radiation found in the earth's crust. The human being is constantly exposed to thorium, uranium, and their progeny in the environment [4-6]. The human radiation exposure is natural, with radon-222 accounting for the majority of it [7]. Rn-222 is a radioactive gas where it is a chemical element with the atomic number 86. It's a radioactive substance that's colorless, 28odourless, and tasteless [8-10]. It is a noble gas that occurs naturally in soils as an indirect decay product of uranium or thorium [11]. Because Rn-222 emitted in the air from the earth's crust or building floors reaches the walls inside or outside the building, the exposure to Rn-222 gas is higher in indoor air, which is evident in substandard buildings [12]. As ventilation improves and Rn-222 concentration rises, researchers in various countries have been examining and monitoring the Rn-222 gas released by building materials in recent years [13]. The purpose of the current study is to measure and investigate the C_{Rn} in cement samples before and after painting with enamel paint.

2. Experimental Work

Ten samples of building material (cement) were collected from various locations, see Fig. 1. Our current investigation is based on studying these samples from different sources available in the local market.

In the first stage of the work each sample was cut in size (40 × 40cm) and placed inside a sealed glass box containing two ports for air entry and exits from inside the box through plastic conductive tubes; see Fig. 2(a). In this way, the concentration of radon gas emitted from the sample to the atmosphere can be measured by the RAD-7 detector for 24 hours and note the difference in humidity and temperature during the measurements.

In the second stage of the work the samples were painted with enamel paint, see Fig. 2(b), and measured after painting in the same way as in the first stage. The measurement results were compared for the two cases.

Figure 1: Some of the measured cement samples.

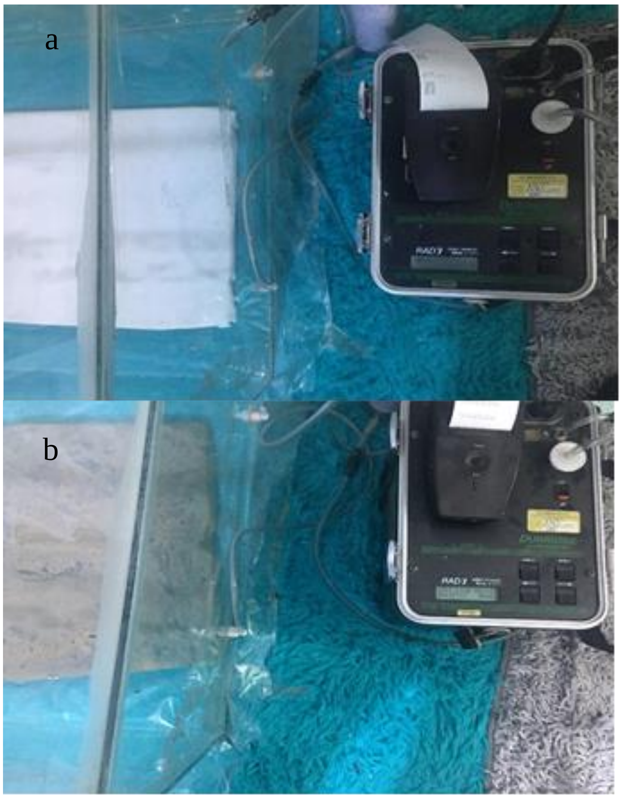

Figure 2: (a) Measurement setup of RAD7 detector (first stage). (b) Measurement setup of RAD7 detector (second stage).

To start the measurement, the detector systems had to be tuned according to Table 1.

Table 1: Tuning of the detector system (RAD7) to measure C_{Rn} in all samples.

Protocol	cycle	re cycle	mode	thoron	pump
1 day	0:30	48	auto	off	auto

The annual effective dose (AED) in terms of (mSv/y) units was obtained using the relation [14, 15]:

$$\mathrm{AED}\left(\frac{\mathrm{mSv}}{\mathrm{y}}\right) = \mathrm{C_{R_n}} \times \mathrm{H} \times \mathrm{D} \times \mathrm{F} \times \mathrm{T} \quad \textbf{(1)}$$

where C_{Rn} is the indoor concentration of radon in Bq/m^3; F is the adjustment factor (0.4 for indoor measurements); H is the occupancy factor (0.8 for indoor measurements); T is the number of hours in a year (8760 hours); and D is the dose conversion factor for the whole-body dose calculation (0.9 nSv per Bq m^{-3} h^{-1}) [16].

The lung cancer cases per year per million people (CPPP) were obtained using the relation [17, 18]:

$$(\mathrm{CPPP}) = \mathrm{AED} \times (18 \times 10^{-6}\mathrm{mSv^{-1}y}) \quad \textbf{(2)}$$

3. Results and Discussion

Building materials have been identified as a source of Rn-222 emissions and it is critical to know the Rn-222 gas exhalation rate for samples set of cement material. The current research is based on examining ten samples of cement available in the Iraqi markets and warehouses and the work was done within the Baghdad governorate.

The C_{Rn} of selected building materials samples was measured in units (Bq/m^3) before and after painting with enamel paint to know the effect of painting on Rn-222 concentrations. The annual effective dose was measured in units (mSv/y) for each sample of building materials after painting.

From Table 2 and Fig. 3 it was observed that the lowest level of C_{Rn} was found in the sample (CE8) after painting which was equal to (15.74 Bq/m^3) after it was (25.19 Bq/m^3) and the highest value was found in the sample (CE9) which was with a value of (58.27 Bq/m^3) after it was (124.18 Bq/m^3) before painting. The effect of painting with enamel paint on the concentration of Rn-222 emitted from cement samples was observed.

The general average of C_{Rn} for the group of samples is (38.22 Bq/m^3) after painting. The present results showed that the C_{Rn} in the measured building samples is below the lower range (200-300 Bq/m^3) [19]. So, the results showed that these samples are safe from radiological hazards with respect to C_{Rn}.

Using Eq.(1), Table 2 shows the internal annual effective dose (AED) received by the population due to the use of cement in construction after painting the samples was obtained. The measured results were with an average value (0.977 mSv / year). It ranges between (0.396 mSv / year) in sample (CE8) to (1.468 mSv / year) in the sample (CE9). Fig. 4 shows that all samples of building materials studied in the current work have annual effective doses less than the minimum range allowance (3-10 mSv/year) [20].

Table 2 also shows the annual incidence of lung cancer per million people (CPPP) was obtained. It was found that the risks of developing lung cancer when exposed to C_{Rn} by samples of cement used in construction after painting ranged from (7.12) in (CE8) sample to (26.42) in (CE9) sample with an average value of (17.59) per million persons. Fig. 5 shows that these values that appeared and for all samples are less than the minimum allowed (170-230) [20].

Table 2: The concentrations of (C_{Rn}) Before and after painting, (AED), (CPPP).

No.	Sample Code	Origin	C_{Rn} (Bq /m^3) Before painting	C_{Rn} (Bq /m^3) after painting	(AED)in (mSv/y) after painting	CPPP/10^6 after painting
1	CE1	Iraq/ Karbala	80.12	43.22	1.089	19.60
2	CE2	Iraq/ Najaf	60.96	34.51	0.869	15.64
3	CE3	Iraq/ Anbar	104.31	48.24	1.215	21.87
4	CE4	Iraq/Sulaymaniyah	115.45	55.21	1.391	25.03
5	CE5	Iraq/ Babylon	68.52	29.86	0.752	13.53
6	CE6	Iraq/ Samawah	77.49	33.84	0.852	15.33
7	CE7	Turkey	78.81	38.92	0.980	17.64
8	CE8	Turkey (white)	25.19	15.74	0.396	7.12
9	CE9	Iran	124.18	58.27	1.468	26.42
10	CE10	Iran (white)	66.37	30.41	0.766	13.78
Minimum			25.19	15.74	0.396	7.12
Maximum			124.18	58.27	1.468	26.42
Average± Standard Deviation			80.14±28.85	38.22±12.832	0.977±0.323	17.59±5.823
Standard Error			9.12342	4.05807	0.102288	1.841539
Global Limit			**(200-300)** [19]	**(200-300) [19]**	**(3-10) [20]**	**(170-230) [20]**

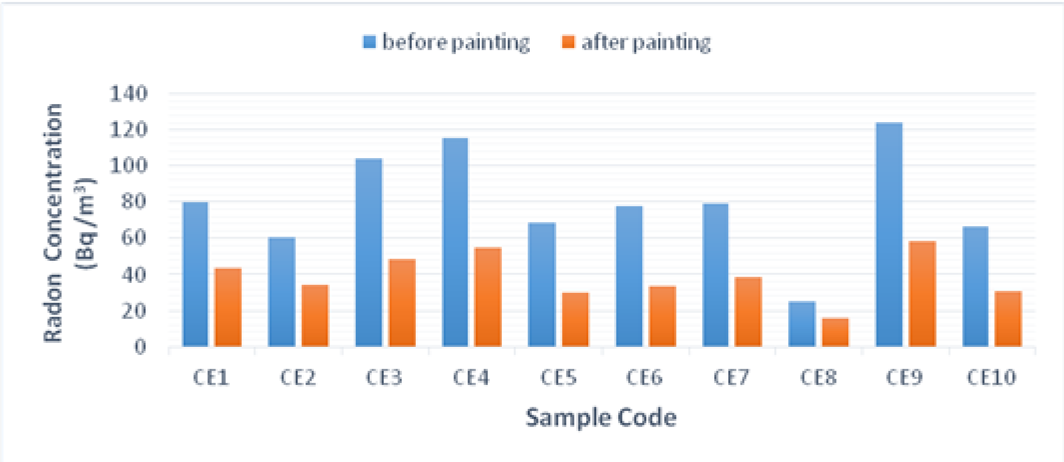

Figure 3: C_{Rn} levels for cement samples before and after painting.

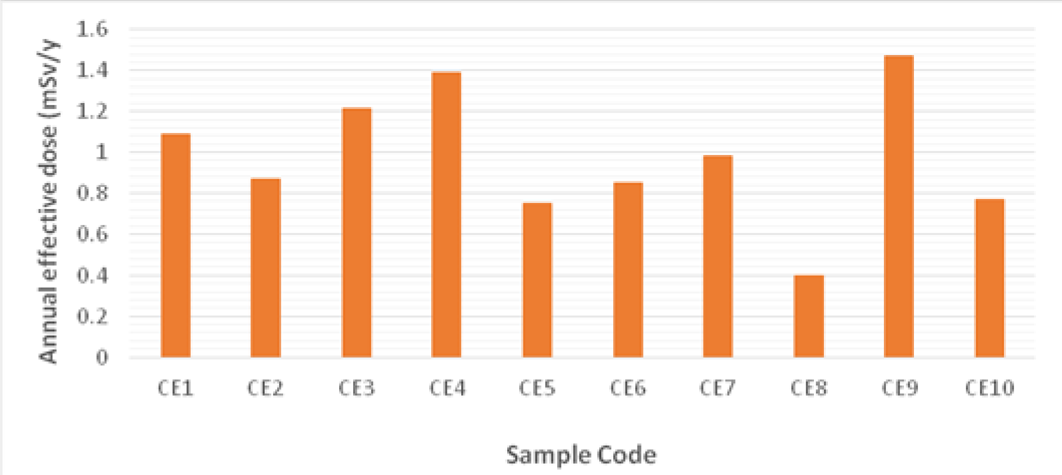

Figure 4: The annual effective dose of cement samples after painting.

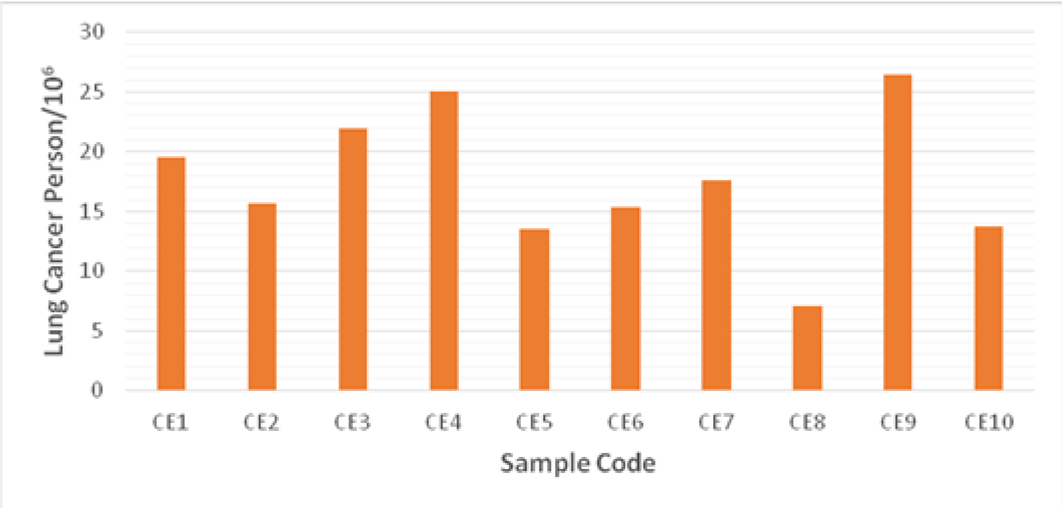

Figure 5: Lung cancer cases per million people annually for cement samples after painting.

4. Conclusions

After knowing the highest C_{Rn} rate of the samples after they were painted was (58.27 Bq/m^3) in a sample (Iranian origin) and it was found that the lowest C_{Rn} rate was (15.74 Bq/m^3) in the white cement sample (Turkish origin).

The conclusion is coating cement with enamel paint reduces Rn-222 emissions into the air and that all samples of cement used in construction in this study were within international limits so they are safe for consumption and do not pose a radiological hazard to people's health.

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Conflict of Interest

We have no conflict of interest.

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دراسة إمكانية استخدام الدهان لتقليل كمية غاز الرادون المنبعث من الأسمنت

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الخلاصة

في العمل الحالي، تم قياس تركيز غاز الرادون (C_{Rn}) في (10) عينات من الأسمنت المستخدم في الإنشاءات قبل وبعد دهانها لمعرفة مدى قدرت الدهان على تقليل انبعاثات Rn-222 في الهواء. تم الحصول على هذه العينات من مصادر مختلفة متوفرة في الأسواق المحلية في بغداد والمحافظات الأخرى. تم إجراء القياسات بواسطة كاشف أمريكي الصنع (RAD7). أظهرت النتائج أن أعلى تركيز لغاز الرادون في الهواء المنبعث من عينات الأسمنت بعد الطلاء كان في عينة الأسمنت (من أصل إيراني) حيث كان التركيز (58.27Bq/m^3) بينما كانت أقل قيمة في عينات مواد البناء في عينة الأسمنت الأبيض (تركي الاصل) بلغت (15.74 Bq/m^3). في ضوء النتائج الحالية، تم ملاحظة أن تركيز Rn-222 المنبعث في الهواء في جميع عينات مواد البناء أقل من الحد المسموح به عالميا.