# Measurement of radon gas concentration in cement samples by using nucleartrack detector (LR115 II)

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Accepted date: 6/10/2013 Received date: 15/2/2012

## Abstract

**In this work, we have measured the concentration of radon gas in eight cement samples from different origins by using long-term measurement of radon decay products with solid state track detectors which alpha particles that emitted from radon gas was detected using (LR115II) nuclear track detector.**

**The obtained results show that, the highest average radon gas concentration in cement samples was found in Iraq cement (Samawa) sample, which was (10.625 Bq/m$^3$) ,while the lowest one was found in (Saudi) sample, and found to be (2.486Bq/m$^3$). The present results show that the radon gas concentration in all cement samples is not below the allowed limit from (ICRP) agency.**

**Keywords**:- **Radon gas , LR115II detector , Cement Samaea , Density track, Activity.**

# قياس تركيزغاز الرادون في نماذج السمنت بأستخدام كاشف الأثر النووي(LR115 II)

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تاريخ قبول النشر:2013/10/6 تاريخ استلام البحث:2012/2/15

## الخلاصة

في هذا البحث تم قياس تركيز غاز الرادون في ثمانية عينات من مادة السمنت المصنعة من مختلف المناشئ العالمية والمتوفرة بالاسواق المحلية في محافظة المثنى، أستخدام تقنية طويلة الأمد للكشف عن غاز الرادون بأستخدام كاشف الأثر النووي LR115 II، فأظهرت النتائج أن أعلى تركيز لغاز الرادون كان في نموذج سمنت السماوة حيث بلغ (10.625Bq/m$^3$) بينما كان أقل معدل لتركيز غاز الرادون في نموذج سمنت السعودي (2.486Bq/m$^3$). وان معدلات تركيز غاز الرادون ليست ضمن القيم المسموحة للأشعاع.

**الكلمات الدالة:** غاز الرادون، كاشف LR115II ، سمنت سماوة، كاشف الاثر النووي

## Introduction

Radon is constantly generated all over the earth due to the decay of radium present in crustal materials. The major motivation for initiating radon studies is to assess the risk to human population from indoor $^{222}$Rn. It is estimated that out of 98% of average radiation dose received by man from natural sources, about 52% is due to breathing of radon,thoron, and progeny present in the dwellings[1].

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 ($^{226}$Ra) gets incorporated into cement and remains in disequilibrium status when it is 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 [2,3]. 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 [2,4].

When radon decays to form its progeny($^{218}$Po and $^{214}$Po),they are electrically charged and can attach themselves to tiny dust particles, water vapors, oxygen, trace gases in indoor air and other solid surfaces. These daughter products remain air borne for a long time. These dust particles (aerosols) can easily be inhaled into the lung and can adhere to the epithelial lining of the lung, thereby irradiating the tissue [5].

Radon is an alpha emitter that decays with a half-life of about 3.5 days to a short-lived series of progeny as shown in Fig.1.[6]. Unlike radon, the progeny are solid and form into small molecular clusters or attach to aerosols in the air after their formation. The inhaled particulate progeny may be deposited in the lung on the respiratory epithelium; radon by contrast is largely exhaled, although some radon is absorbed through the lung. Radon itself is not responsible for the critical dose of radioactivity delivered to the lung that causes cancer. While radon was initially thought to be the direct cause of the lung cancer in the miners, Bale and Harley recognized in the early 1950s that alpha particle emissions from radon progeny and not from radon itself were responsible for the critical dose of radiation delivered to the lung. Alpha decays of two radioisotopes in the decay chain, $^{218}$Po and $^{214}$Po (Fig.1), deliver the energy to target cells in the respiratory epithelium that is considered to cause radon-associated lung cancer (National Research, 1991,). Alpha particles, equivalent to a helium nucleus, are charged and had a high mass.

Although their range of penetration into tissues is limited, they are highly effective and damaging the genetic material of cells. As reviewed in the report of the BEIR VI Committee, passage of even a single alpha particle through a cell can cause permanent genetic change in the cell [6,7].

Cement is a commonly used building construction material. The natural level of radio-activity in cement gives rise to internal and external indoor exposure. The external exposure is caused by gamma radiation originating from the members of the uranium ($^{238}$U) and thorium ($^{232}$Th) decay series and also from potassium ($^{40}$K) [8, 9].

The knowledge of radon levels in building is important in assessing population exposure.

Radon in indoor spaces may originate from exhalation from rocks and soils around the building or from construction materials used in walls, floors, and ceilings. Indoor radon concentrations are almost always higher than outdoor concentrations. Once inside a building, the radon cannot easily escape. The sealing of buildings to conserve energy reduces the intake of outside air and worsens the situation [10].

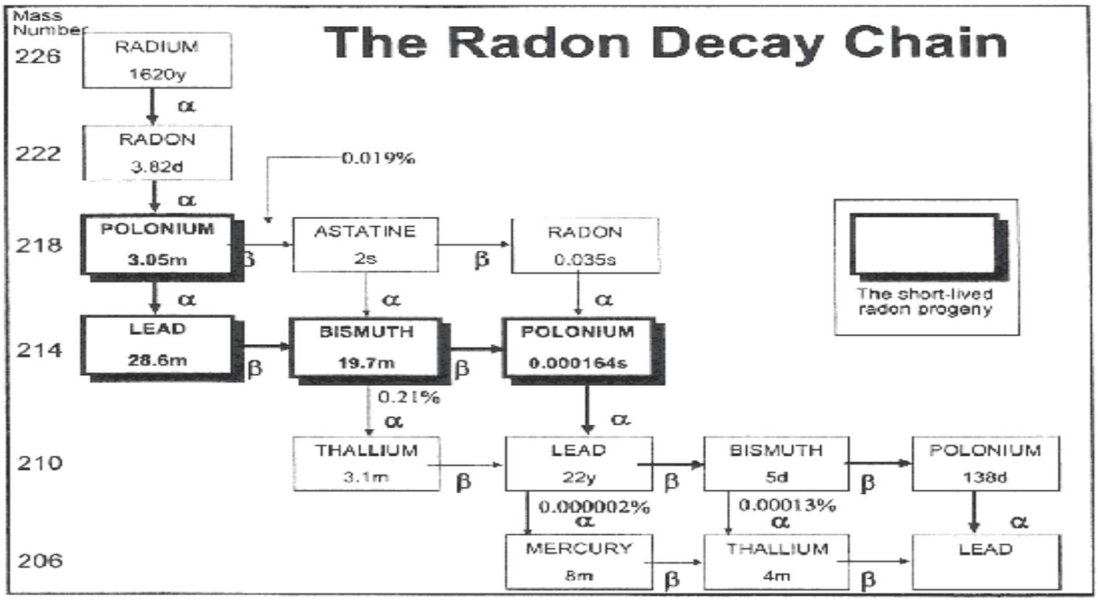


Fig. 1: The radon decay chain [6]

All building materials that originate from minerals may contain amounts of radio-nuclides such as uranium and thorium, which are created from their radioactive decay chains. the most significant one is radium ($^{226}Ra$). Presence of $^{226}Ra$ in building materials affects persons living in dwellings either by inhalation of radon daughters that decay from radium and released from the building materials to the indoor air or by hard gamma radiation released from the building material as a consequence of the radioactive decay of the natural radio-nuclides. In addition to the building materials, the natural gas used domestically, the underground-derived water supply and the cracks building materials are generally the second main source of radon indoors.

Solid State Nuclear Track Detectors (SSNTDs) have been widely used for measuring time integrated radon levels in dwellings under different conditions. The track detector used for this purpose must be calibrated for concentrations of radon and its daughters likely to be found in dwellings.

## Experimental Part

The determination of alpha particles concentrations emitted from radon gas in cement samples were performed by using the nuclear track detector(LR115II) of thickness (4.5 μm) and area of about ($1\times1cm^2$). The radon gas concentration in cement samples was obtained by using the Test tube technique.

After irradiation time of 60 days the LR115 track detectors were etched in (2.5N) of (NaOH) solution at temperature of (60 $^oC$) for (0.5 hr), and the tracks density were recorded by using an optical microscope with magnification of (40x).The density of the tracks (D) in the samples were calculated according to relation [11].

We used the test tube technique covered by tightly closed from the top and sealed , assuming the average density of track and proportional to cylinder volume (h .cm),between the detector surface and surface sample equal(7cm)[12]. We can find radon activity (radon concentration) to decay daughter ($^{218}Po$, $^{214}Po$) by using the relations:-

$$D_{R222} = KC \ldots\ldots(1)$$

$$D_{R222} = \frac{C}{4}(R_{MAX} - R_{MIN})\cos^2\theta_c \ldots\ldots(2)$$

Where D = Background corrected alpha track density due to radon (Track $cm^{-2}$)

C = radon gas concentration.( $Bq.m^{-1}$).

r = radius of tube (0.75 cm).

R=Alpha particles range in air product ($^{222}Rn$ equal) (4 cm). [13]

h = Distance between the detector and top of the sample (7cm)

A = Surface area of sample ($m^2$)

K = Sensitivity factor (Tracks $cm^{-2}$ $day^{-1}$ / Bq $m^{-3}$)

W = Mass of sample (gm) equal (10.2gm). .

$\theta_c$ = detector Critical angle for LR115 equal ($40^o$)] 11]

When the values of (R, r, h, $\theta_c$ ) are substituted in eq. 2, the values of activity can be found by Bq unit as in eq.3.

$$A = CV \ldots\ldots(3)$$

The valume (V) and specific activity (S.A) were calculated from eqs (4) and (5) respectively

$$V = \pi r^2 h \ldots\ldots(4)$$

$$S.A = A/W \ldots\ldots(5)$$

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

| Sample (origin of cement) | N of track | Net no. of Track | Radon gas concentration $Tr.cm^{-2}.hr^{-1}$ | Activity | Specific Activity |
|---|---|---|---|---|---|
| سعودي (مقاوم) | 90 | 33 | 0.048043326 | 2.486861897 | 0.24380999 |
| باكستاني فالكون(مقاوم) | 162 | 105 | 0.152865129 | 7.9127424 | 0.775759059 |
| هندي علامة الأسد(عتيادي) | 180 | 123 | 0.17907058 | 9.269212526 | 0.908746326 |
| عراقي السماوة(مقاوم) | 198 | 141 | 0.205276031 | 10.62568265 | 1.041733593 |
| باكستاني( مقاوم) | 185 | 128 | 0.186349872 | 9.646009783 | 0.945687234 |
| عراقي النجف (أعتيادي) | 150 | 93 | 0.135394829 | 7.008428983 | 0.687100881 |
| اماراتي(مقاوم) | 146 | 89 | 0.129571395 | 6.706991177 | 0.657548155 |
| عراقي المثنى(مقاوم) | 100 | 43 | 0.06260191 | 3.240456412 | 0.317691805 |

## Results and Discussion

Our present investigation is based on the study of eight samples from different origin of cement which was available in the local markets; we found the radon gas concentrations by using Long-term method which alpha particles are emitted from radon gas in (LR115II) 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 (Samawa) sample, which was (3189.79 $Bq/m^3$ ),while the lowest average one was found in saudi sample, which was (342.70 $Bq/m^3$) as shown in Fig .2. 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 not below the allowed limit from (ICRP)agency which is (200 $Bq/m^3$)in soil sample [14].

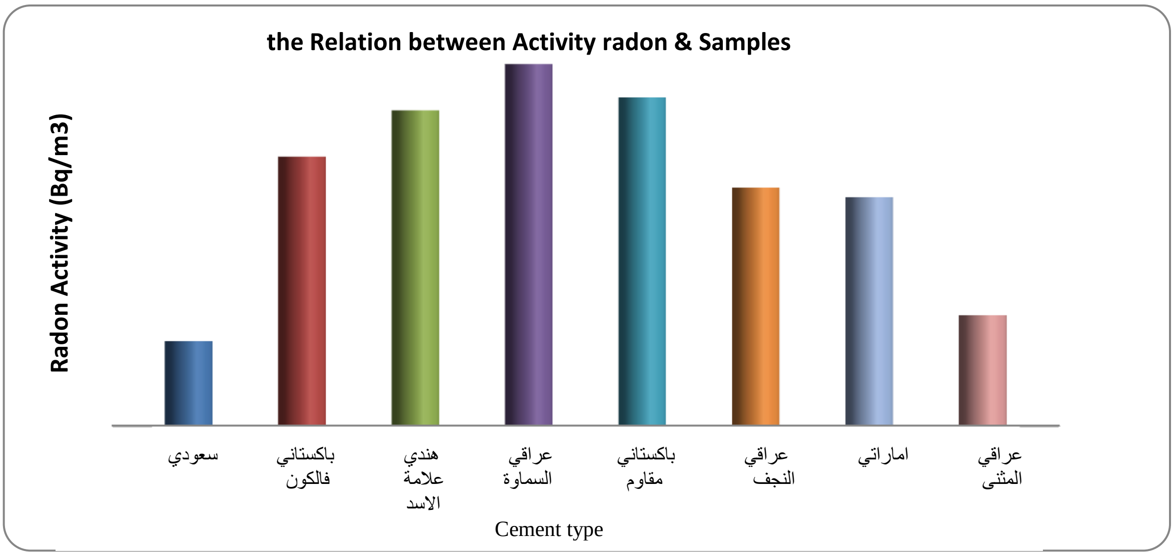


Fig 2. Relation of Activity radon gas concentration and samples.

## Conclusions

From this work, one can conclude that, the highest average radon gas con-centration in cement samples was found in Iraq cement (Samawa) sample, which was (10.625 $Bq/m^3$) , while the lowest average radon gas concentration in cement samples was found in Saudi sample, which was ( 2.486 $Bq/m^3$) .The present results show that the radon gas concentration in all cement samples is not below the allowed limit from (ICRP) agency.

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