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Radioactivity level measurement of some cement samples

قياس مستوى الاشعاع في بعض نماذج الاسمنت

*Basim Abd Al-Hassen Al-Mayahi
*Dhia Amin Al Joher
**Muthana Hassan Hadi
**Raad Jalyl Ahmed
*Dept. Environmental - Faculty of Science - Kufa University
**Dept. Internal- Kufa University

Abstract

The radioactivity level of cement in some selected samples was determined and discussed .Five cement samples were collected from (Gasseem-Saudia Arabia, Medinaa-Saudi Arabia, Kufa-Iraq, Leon Mark-India, Mogaum Yamamh-Saudi Arabia).The activity concentrations of natural radio nuclides as well as that of the fission product were evaluated by gamma ray spectrometry using scintillation detector (NaI (Tl)).The average of rings concentrations in the surveyed cements samples were (217.44-3725.45) $BqKg^{-1}$, (31.87-387.33) $BqKg^{-1}$ and (157.28-3145.6) $BqKg^{-1}$ for ^{226}Ra, ^{232}Th and ^{40}K, respectively. The activity concentration values of ^{226}Ra, ^{232}Th and ^{40}K in Kufa-Iraq sample would produce minimum annual gonadal dose equivalent of ($1187\mu sy^{-1}$), and the maximum value of annual gonadal dose equivalent is ($12920\mu sy^{-1}$) was noted in Madinaa Saudi Arabia sample.

الخلاصة

تم تحديد ومناقشة المستوى الاشعاعي لبعض النماذج المنتخبة للاسمنت , حيث تم جمع خمسة نماذج للاسمنت من (القصيم-السعودية العربية،المدينة-السعودية العربية،الكوفة-العراق،علامة الاسد-الهند,مقاوم يمامة-السعودية العربية). حيث تم ايجاد تراكيز النويدات المشعة الناتجة من الانحلال بوساطة مطياف اشعة كاما بأستخدام الكاشف الوميضي ((NaI(Tl) .اذ ان معدل التراكيز لنماذج الاسمنت بحدود (217.44-3725.45) و (31.87-387.33)و(157.28-3145.6) بوحدات $BqKg^{-1}$ لكل من الراديوم226 والثوريوم232 والبوتاسيوم40 على التوالي.كما ان قيم التراكيز لكل من الراديوم226 والثوريوم232 والبوتاسيوم40 في نموذج (الكوفة-العراق) أنتجت اقل جرعة مكافئة سنويا"($1187\mu sy^{-1}$) وأعلى جرعة مكافئة سنويا" ($12920\mu sy^{-1}$) في نموذج (المدينة-السعودية العربية).

Introduction

Predominant part of the radioactivity of soils derives from the members of the radioactive decay series of ^{238}U (55.8%), ^{232}Th (14%), along with ^{40}K (13.8%).

In fact, natural radiation is the largest contributor to the collective dose of the world's population. Just about15 and 0.6% are from cosmic radiation and cosmogenic radionuclides, respectively.Men's exposure pathways to natural radiation have two distinct component: the external component due to the gamma ray emissions and the internal one partly due to radon and its decay products which are alpha particles emitters [1].

The assessment of radioactivity in natural soil and those concentrated by naturally occurring radioactive materials(NORM) has become a focus of great interest in European [2,3,4,5] Asian [6,7,8,9],Northern American [10,11] , and in some western and northern Africa[12] .

The major raw materials for the production of cement are limestone (CaCo3), shale ash and ion oxide. They also contain some elements like gypsum, which contains silicates and aluminates that have ionization tendency [13].

The natural radionuclide levels have been studied in surface soils in Ijero-Ekiti [14],in soil and water around a cement company in Ewekovo by [15] and in port Harcourt[16] and in rocks found in Ekiti [17] .

Results from these studies revealed non-significant levels of radio- nuclides in the environment.

Experimental procedure and experimental settings

1-Collections the samples

Five samples of cement were collected from (Gasseem-Saudi Arabia, Medinaa-Saudi Arabia, Kufa-Iraq, Leon Mark-India, Mogaum Yamamh-Saudi Arabia).

The collected samples were weighted and homogenized. The homogenized samples, each having a weight of 500g, were put into bags milestone. Cement samples were transferred to Marinelli beakers of 5000 ml.

2-The Gamma spectroscopy technique

2.1 Procedural of the spectrometer

The Gamma spectroscopy system was used for the quantitative and qualitative determination of radionuclides (see fig.1), Gamma spectroscopic measurement were performed using a NaI (Tl) detector (diameter 1.76" & thickness 1.56",) a leybold cassy lab multi channel analyzer with model (Pocket-CASSY 524058) 2k ADC and gain =1.92 were used for the measurements. The detector was shield in a 5 cm thickness lead well.

Energy calibration and efficiency calibration of the gamma spectrometer were carried out using (Co-60, Cs-137, Na-22, Am-241and Ra-226) calibration sources in 5000ml Marinelli beaker covering the energy range from 25 to 2500 kev.The counting time for each sample , as well as for background, was 1 hour.

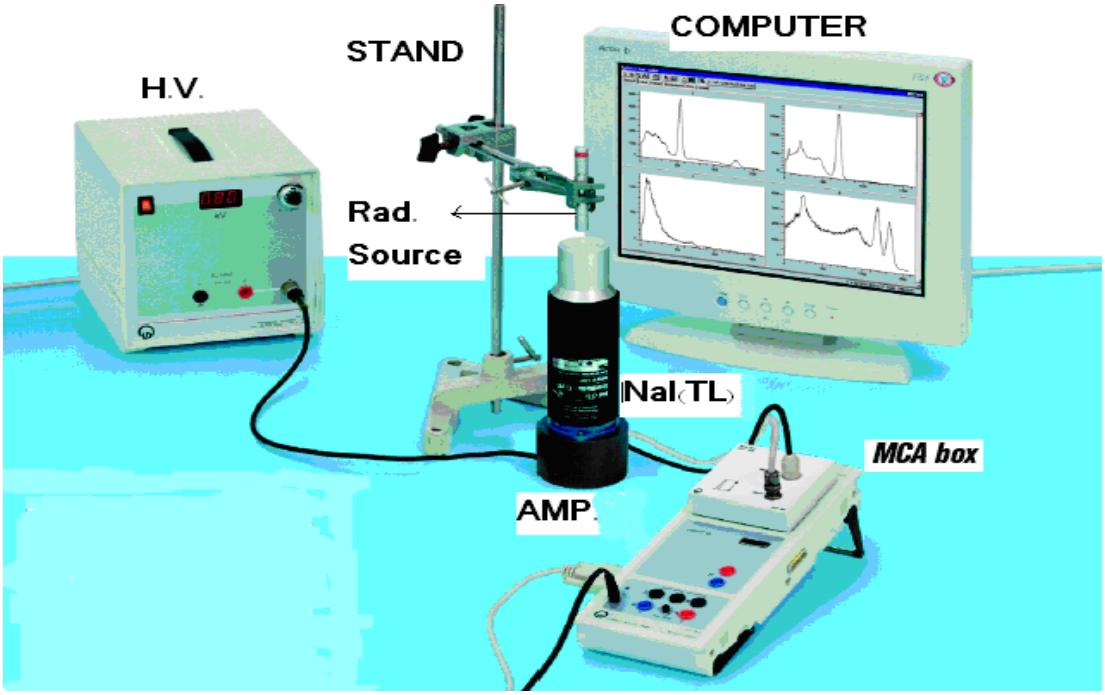

Figure (1) shows striped of the system of electronic used

The relative stability of the voltage detector, which equal to 590 volts (see fig.2)

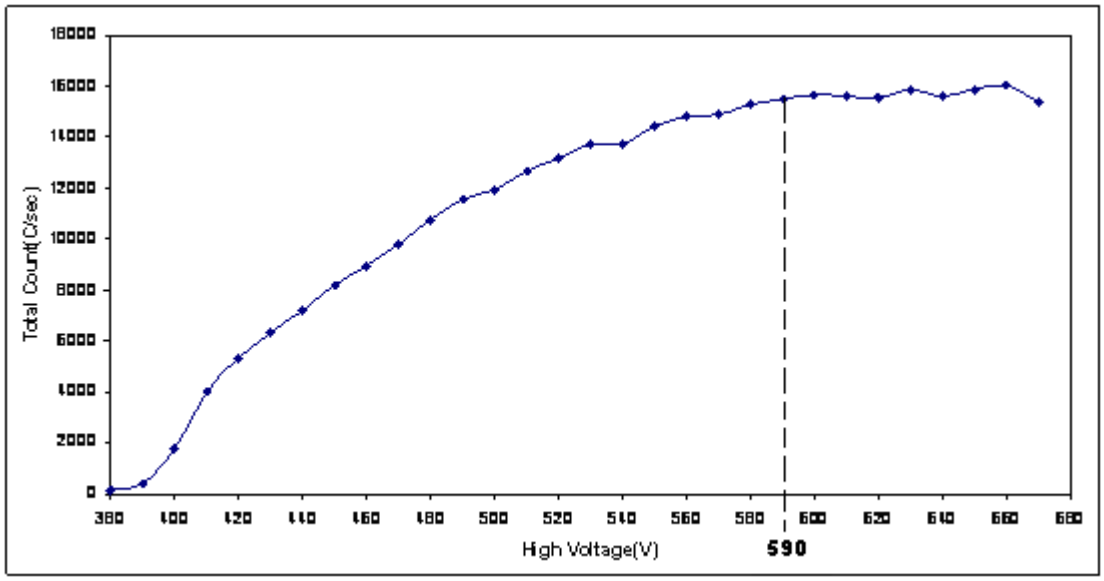

Figure (2) shows relative stability of the voltage detector

Measuring Method

The natural radioactivity of cement samples is usually determined from the ^{226}Ra, ^{232}Th and ^{40}K contents .Since 98.5% of the radiological effects of the Uranium series are produced by radium and its daughter products, the contribution from the ^{238}U and the daughter ^{226}Ra precursors are normally ignored.

The naturally occurring radionuclides of relevance for the present work are mainly gamma ray emitting nuclei of ^{226}Ra and ^{232}Th, and a single occurring ^{40}K .Activity concentration of ^{40}K can be measured directly by its own gamma ray at 1460.8 Kev, while activity of ^{226}Ra and ^{232}Th were calculated based on the average activities of their respective decay products (Table 1) [18].

Table (1) the measured radio nuclides used for activity level determinations of ^{232}Th, ^{226}Ra and ^{40}K

Radio nuclides of interest	Measured radio nuclides	Photon intensity%	Energy (Kev)
^{232}Th	^{212}Pb	47	238.62
	^{228}Ac	15	338.5
^{238}U	^{234}Th	3.5,4	63.3,93
	^{214}Pb	19,36	295.2,351.9
	^{214}Bi	47	609.3
^{40}K	^{40}K	11	1461

The activity levels for radionuclides in the measured samples were computed using the following equation [19]:

$$A=\frac{C}{\varepsilon PW}(BqKg^{-1}) \quad \ldots\ldots\ldots\ldots (1)$$

Where A is the activity level of a certain radionuclide expressed in $BqKg^{-1}$ dry weight ,C is the net counting rate of sample subtracted from background (count per seconds), ε is the counting efficiency of the used detector, P is the absolute transition probability of gamma decay [20], and W is the dried sample weight expressed in Kg.

Results and discussion

Activity levels of the various cement materials were determined and are presented in Table (2).

Table (2) average activity concentration in the cements samples

Sample	Activity concentration $BqKg^{-1}$		
	^{226}Ra	^{232}Th	^{40}K
Gasseem-Saudi Arabia	3593± 20.56	47.81±22.56	2621±7.40
Medinaa-Saudi Arabia	3725.45±14.93	124.31±14.93	2831.07±9.27
Kufa-Iraq	217.44±13.25	111.51±10.95	157.28±8.25
Leon Mark-India	531.43±10.40	387.34±8.26	157.28±11.99
Mogaum Yamamh-Saudi Arabia	626.85±20.77	31.87±20.69	3145.6±16.92

It is well know that the average worldwide activity levels of U, Th and K are 50, 50 and 500Bq, respectively [21].

Based on these criteria, high activity levels (>50$BqKg^{-1}$) of ^{226}Ra, ^{232}Th and (>500 $BqKg^{-1}$) were found in cements samples .Therefore, use of cements must be carefully regulated.

Assuming equilibrium exists in U and Th decay series, the activities (A) of U and Th can be converted into the corresponding mass concentrations based on equation (2)[18].

$A = N \lambda$…… (2)

Where N and λ are number of radionuclides and decay constant (s^{-1}) of radionuclide, respectively. Activity levels are in Bq kg^{-1}.With Eq. (2) and Avogadro's number (6.02×10^{23} g mol^{-1}),one can calculate that 10^{-3} g of U and Th corresponds to12.36 and 4.04, respectively, and 252 Bq kg^{-1} of ^{40}K corresponds to 1% as K_2O. It is observed that a high percentage of Uranium as U_3O_8, thorium as ThO_2 and potassium as K_2O were in sample (Medinaa Saudi Arabia ,Leon Mark-India,Mogaum Yamamh-Saudi Arabia) respectively (Table 3). The calculated ratio between Th and U concentrations showed that Th was enriched in Kufa-Iraq and Leon Mark-India samples, while U was enriched in Gassem Saudi Arabia, Medinaa Saudi Arabia and Mogaum Yamamh-Saudi Arabia samples.

Table (3) average mass concentration and mass ratio of Thorium and Uranium in cements samples

Samples	Concentration (wt %)			
	Uranium as U_3O_8	Thorium as Tho_2%	Potassium K_2O%	Th/U ratio
Gasseem	0.029	0.0011	1.038	0.037
Madinaa	0.03	0.003	1.123	0.1
Kufa	0.0017	0.0027	0.062	1.58
Leon Mark	0.0042	0.0095	0.062	2.56
Mogaum Yamamh	0.005	0.00078	1.24	0.156

In order to evaluate the annual gonadal dose equivalent (AGDE) for a resident of a house built with cement material with given concentration of K, Ra and Th, the model described by equation (3) [22], was used:

$D\ (\mu sy^{-1}) = 0.314C_K+3.09C_{Ra}+4.18C_{Th}$……. (3)

This model considers a house as a cavity with infinitely thick walls. It makes possible a comparison of (AGDEs) of a house containing concentrations of ^{40}K, ^{226}Ra and ^{232}Th equal to the world average values in soil (370, 26 and 26 $BqKg^{1}$, respectively).

The annual gonadal dose equivalents generated by the concentration materials were calculated with this model, and the results obtained are shown in figure (3).

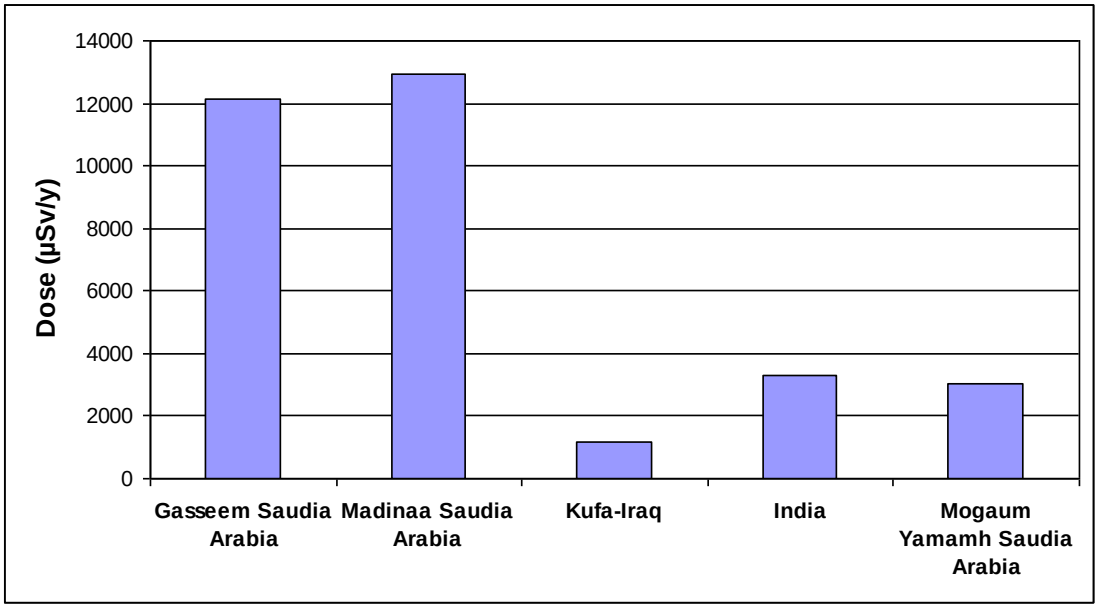

Figure (3) annual gonadal dose equivalent from cement samples

Conclusions

It is concluded that activity concentrations were high in Madinaa Saudi Arabia compared to these in the Kufa-Iraq.

The activity concentration values of ^{226}Ra, ^{232}Th and ^{40}K in Kufa-Iraq sample would produce minimum AGDE of (1187µsy^{-1}), and the maximum value of AGDE is (12920µsy^{-1}) was noted in Madinaa Saudi Arabia sample.

Use of cements needs some careful regulations to reduce the hazardous radiation released into surroundings.

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