Measurement of Radioactivity in some mosaic samples by using (HPGe) detector

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Abstract

In this paper, measurement of specific activity concentrations for eight commercial mosaic samples from different countries were carried out using (HPGe) detector. The results of measurements have shown that maximum values of specific activity concentrations for ^{238}U, ^{232}Th and ^{40}K were equal to (28.073 Bq/kg), (28.054 Bq/kg), (274.265 Bq/kg), , Italian , Indian and Chinese origins respectively, which were less than their corresponding recommended global values reported by (UNSCEAR , 2000) publications. The radiation hazard indices [Ra_{eq} ,D_{γ} , (AEDEEE) $_{in}$,(AEDEEE) $_{out}$, H_{in}, H_{ex} and I_{γ}] were also studied. The obtained results were also found to be less than the allowed limits given by (UNSCEAR , 2000) . Thus all results obtained in the present work have shown no significant radiological hazard when the studied mosaic is used, for example, construction of housing floors.

Keyword: Radiation hazard indices, mosaic samples, (HPGe) detector.

قياس النشاط الإشعاعي لبعض نماذج الفسيفساء (الموزاييك) باستخدام كاشف الجرمانيوم عالي النقاوة

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الخلاصة

في الدراسة الحالية , تم قياس تراكيز الفعالية النوعية لثمانية نماذج تجارية من الفسيفساء (الموزاييك) من دول مختلفة باستعمال كاشف الجرمانيوم عالي النقاوة. بينت نتائج القياسات بان اعلى قيمة للفعالية النوعية بالنسبة الى (^{238}U,^{232}Th,^{40}K) كانت (28.073 Bq/kg) (28.054 Bq/kg),(274.265 Bq/kg) ايطالي و هندي و صيني المنشا على التوالي , وقد وجد بان جميع هذه القيم هي اقل من القيم العالمية و المعطاة من قبل اللجنة العلمية للامم المتحدة لتاثيرات الاشعاع الذري (UNSCEAR,2000) . كما تمت دراسة دلائل الخطورة الاشعاعية [I_{γ}, H_{ex}, H_{in} , (AEDEE) $_{out}$, (AEDEE) $_{in}$, D_{γ}, Ra_{eq}] وقد بينت النتائج المستخرجة لهذه المؤشرات بان جميعها كانت اقل من القيم المسموحة و المعطاة من قبل (UNSCEAR,2000). ان النتائج المستحصلة من البحث الحالي بينت بانه لا يوجد هناك أي خطورة اشعاعية عند استعمال نماذج الفسيفساء (الموزاييك) المدروسة مثلا في تشييد ارضيات المنازل.

الكلمات الافتتاحية : دلائل الخطورة الإشعاعية , نماذج الفسيفساء , كاشف الجرمانيوم عالي النقاوة .

Introduction

Radiation is transmission of energetic waves or particles from its source and travels through space and may be able to penetrate various materials. It can come from unstable nuclei or it can be produced by machines [1].. There are two kinds of radiation categorized: ionizing or non-ionizing according to the radiated particles energy. The ionizing is more energetic than the other [2]. The content of natural radionuclides in building materials might be affected by many factors: geological origin and composition of soil, its density and porosity, content of water in soil, diffusion rate and permeability rate, rate of emanation and exhalation, etc. In the ^{238}U series, the decay chain segment starting from (^{226}Ra) is radiologically the most important and, therefore, reference is often made to ^{226}Ra instead of ^{238}U. These radionuclides are sources of the external and internal radiation exposures in dwellings. [3].

Materials and Method

Eight commercial samples were collected from different local markets and factories. The samples were chosen in terms of the widely and most common types in Iraqi markets, see Figure (1) . All samples were pulverized into small pieces, then into fine powder by using jaw crusher. The samples were dried at 100 °C for one hour to ensure that any moisture was removed from the samples and in order to obtain uniform particle sizes, a (500 μm) mesh was used to sieve the samples , after that samples were weighted (one kg) and transferred to a Marinelli beaker (one Litter). In the present work a (3×3) inch (HPGe) system was employed, see Figure (2). An essential requirement for the measurement of gamma emitter is the exact identity of photo peaks presents in the spectrum produced by the detector system. The energy calibration was performed by using a standard source of (one Litter) capacity of Marinelli beaker of Eu-152, which has been prepared in this work with energies (411.1, 344.3, 1408.0 , 964.0, 444.6, 778.9, 1085.8, 121.8 , 1112.0 and 244.7 keV).

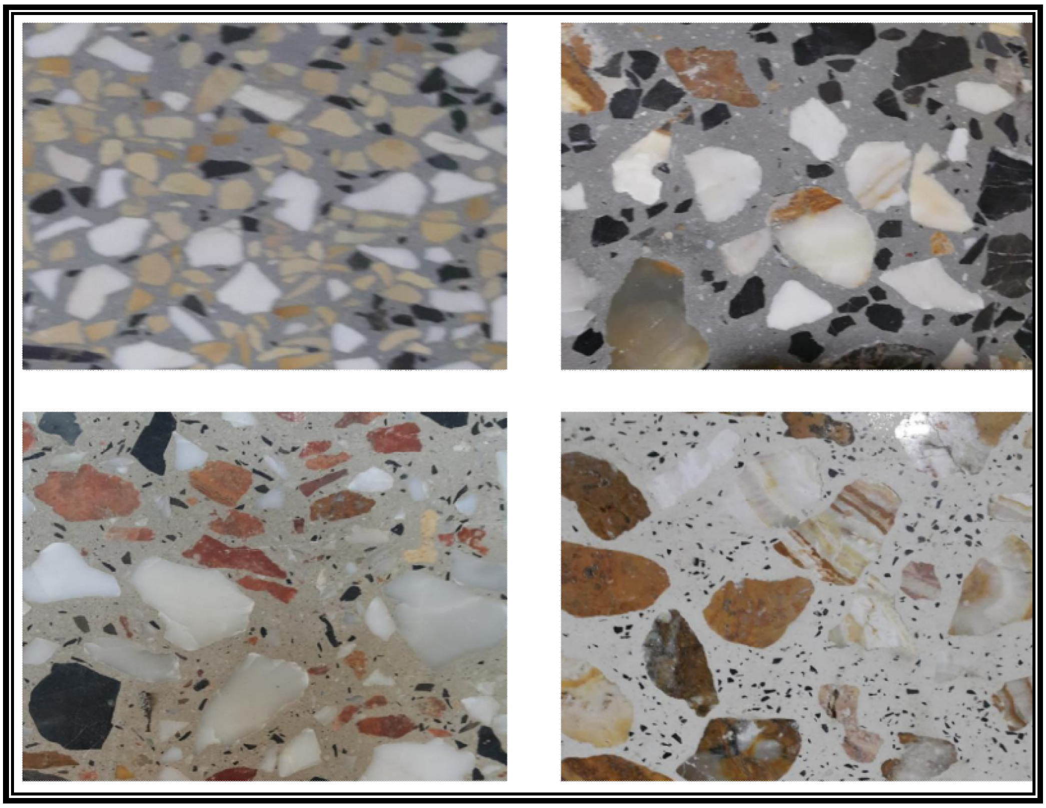

Figure (1): Samples of mosaic tile studied in the present work.

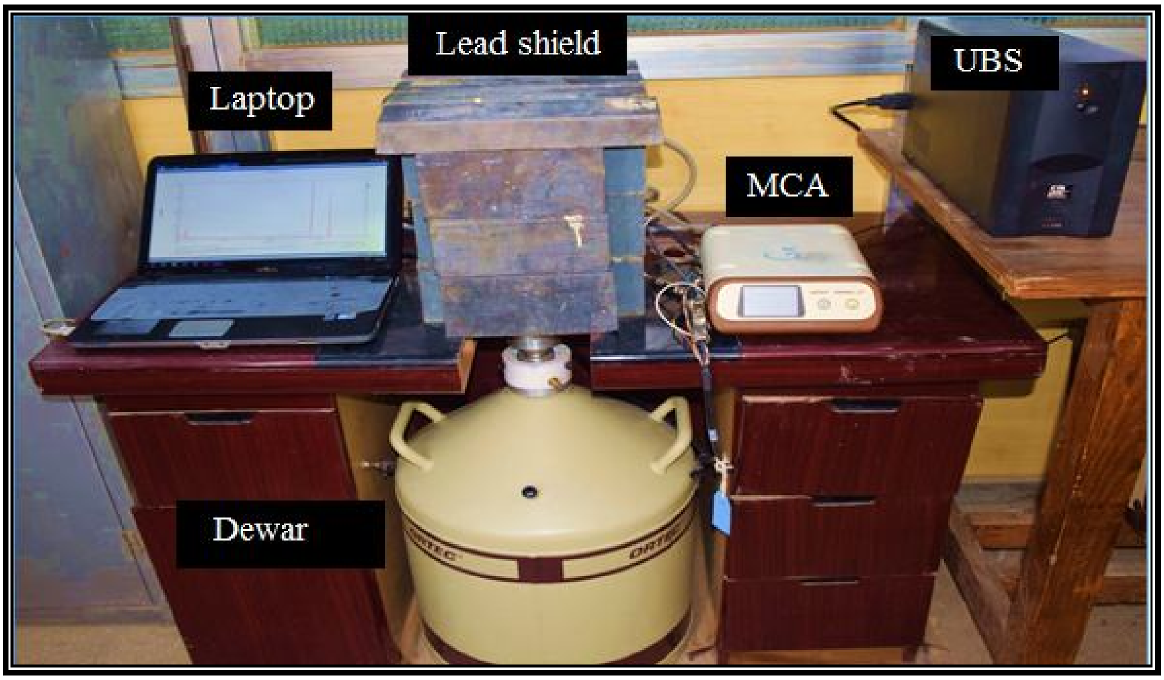

Figure (2) : (HPGe) system employed in the present work.

The specific activity concentrations of radionuclides in mosaic samples were obtained by using the equation [4]:

$$A = \frac{N - BG}{T.I_{\gamma}(E_{\gamma}).\varepsilon(E_{\gamma}).M} \quad \text{.......... (1)}$$

Where:
A: is the specific activity concentration of radioactive elements measured .
N: is the area under the photo peak at energy (Eγ) .
B.G: is the net peak area of the background.
Ɛ(Eγ): is the detector efficiency at energy (Eγ).
Iγ (Eγ): is the abundance at energy (Eγ).
M: is the mass of the sample .
T: the measured time, which equal to (7200 s).

Determination of some Gamma Radiation Parameters (Radiation hazard indices)

1- Radium Equivalent Activity (Ra_{eq}) [4]

$$Ra_{eq} = 1.43A_{Th} + A_U + 0.077A_K \quad \text{............ (2)}$$

Where A_U, A_{Th}, A_k are specific concentrations of (^{238}U),(^{232}Th) and (^{40}K) in (Bq/kg) units respectively.

2- Absorbed Gamma Dose Rate (D_{γ}) [5]

$$D_{\gamma} = 0.604A_{Th} + 0.0417A_K + 0.462A_U \quad \text{............ (3)}$$

3- The Annual Effective Dose Equivalent ($AEDEEE_{in}$, $AEDEEE_{out}$) [6]

$$(AEDEEE)_{in} = D_{\gamma}\ (nGy/h) \times 10^{-6} \times 8760\ h/y \times (0.7\ Sv/Gy) \times 0.80 \quad \text{...(4)}$$

$$(AEDEEE)_{out} = D_{\gamma}\ (nGy/h) \times 10^{-6} \times 8760\ h/y \times (0.7\ Sv/Gy) \times 0.20 \quad \text{... (5)}$$

4- Internal and External Hazard Indices (H_{in} , H_{ex}) [7]

$$H_{in} = \frac{A_{Th}}{259} + \frac{A_U}{185} + \frac{A_K}{4810} \quad \text{.......................... (6)}$$

$$H_{ex} = \frac{A_{Th}}{259} + \frac{A_U}{370} + \frac{A_K}{4810} \quad \text{.......................... (7)}$$

5- Activity Concentration Index (I_{γ}) [8]

$$I_{\gamma} = \frac{A_{Th}}{200} + \frac{A_{Uh}}{300} + \frac{A_K}{3000} \quad \text{......................(8)}$$

Results and Discussion

The results of the present work were summarized in Table (1), from which it can be noticed that, the maximum value of specific activity concentration of (^{238}U) for the studied samples was found in mosaic sample of Italian origin which was equal to (28.073 Bq/kg), while the minimum value for specific activity concentration of (^{238}U) was found in mosaic sample of Chinese origin which was equal to (15.373 Bq/kg) . The present results have shown that values of specific activity concentration for (^{238}U) in all studied samples were less than the recommended value of (35 Bq/kg) for the specific activity concentration of (^{238}U) [9], see fig (3).

The maximum value of specific activity concentration of (^{232}Th) for the studied samples was found in mosaic sample of Indian origin which was equal to (28.054 Bq/kg), while the minimum value of specific activity concentration of (^{232}Th) was found in mosaic sample of Spanish origin which was equal to (17.074 Bq/kg). The present results have shown that values of specific activity concentration for (^{232}Th) in all studied samples were less than the recommended value of (30 Bq/kg) for the specific activity concentration of (^{232}Th) [9], see fig (3).

The maximum value of specific activity concentration concentration of (^{40}K) for the studied samples was found in mosaic sample of Chinese origin which was equal to (274.265 Bq/kg), while the minimum value of specific activity concentration of (^{40}K) was found in mosaic sample of Syrian origin which was equal to (175.571 Bq/kg). The present results have shown that values of specific activity for (^{40}K) in all studied samples were less than the recommended value of (400 Bq/kg) for the specific activity of (^{40}K) [9] , see Fig.(3).

The maximum value of (Ra_{eq}) for the studied samples was found in mosaic sample of Iranian origin which was equal to (83.440 Bq/kg), while the minimum value of (Ra_{eq}) was found in mosaic sample of Syrian origin which was equal to (65.494 Bq/kg) . The present results have shown that values of (Ra_{eq}) for all studied samples were less than the recommended value of (370 Bq/kg) for the (Ra_{eq}) [9].

The maximum value of (D_Y) for the studied samples was found in mosaic sample of Iranian origin which was equal to (38.748 nGy/h), while the minimum value of (D_Y) was found in mosaic sample of Syrian origin which was equal to (30.056 nGy/h). The present results have shown that values of (D_Y) in all studied samples were less than the recommended value of (55 nGy/h) for the (D_Y) [9].

The maximum value of $(AEDE)_{in}$ for the studied samples was found in mosaic sample of Iranian origin which was equal to (0.190 mSv/y), while the minimum value of $(AEDE)_{in}$ was found in mosaic sample of Syrian origin which was equal to (0.147 mSv/y) . The present results have shown that values of $(AEDE)_{in}$ in all studied samples were less than the recommended value of (1 mSv/y) for the $(AEDE)_{in}$ [9].

The maximum value of $(AEDE)_{out}$ for the studied samples was found in mosaic sample of Iranian origin which was equal to (0.048 mSv/y), while the minimum value of $(AEDE)_{out}$ was found in mosaic sample of Syrian origin which was equal to (0.037 mSv/y). The present results have shown that values of $(AEDE)_{out}$ in all studied samples were less than the recommended value of (1 mSv/y) for the outdoor annual effective dose equivalent [9].

The maximum value of (H_{in}) for the studied samples was found in mosaic sample of Italian origin which was equal to (0.301), while the minimum value of (H_{in}) was found in mosaic sample of Syrian origin which was equal to (0.230). The present results have shown that values of (H_{in}) for all studied samples were less than the recommended value of (1) for the (H_{in}) [9].

The maximum value of (H_{ex}) for the studied samples was found in mosaic sample of Iranian origin which was equal to (0.225), while the minimum value of (H_{ex}) was found in mosaic sample of Syrian origin which was equal to (0.177). The present results have shown that values of (H_{ex}) for all studied samples were less than the recommended value of (1) for the (H_{ex}) [9].

The maximum value of ($I_γ$) for the studied samples was found in mosaic sample of Iranian origin which was equal to (0.304), while the minimum value of ($I_γ$) was found in mosaic sample of syrian origin which was equal to (0.237) . The present results have shown that values of ($I_γ$) in all studied samples were less than the recommended value of (1) for ($I_γ$) [9].Since the highest values for all the studied parameters were less than their corresponding allowed limits, it is then obvious that the average values for all the studied parameters will be less than their corresponding allowed limits and hence it was thought there was no need for obtaining average values for all the parameters studied in the present work which , however , can be obtained easily .

The present results of mosaic samples have revealed that most samples have low specific activity concentrations due to absence of minerals containing radioactivity, but these results vary according to different origins of mosaics because mosaic is a metamorphic rock and it is affected by the presence of different minerals and also locations.

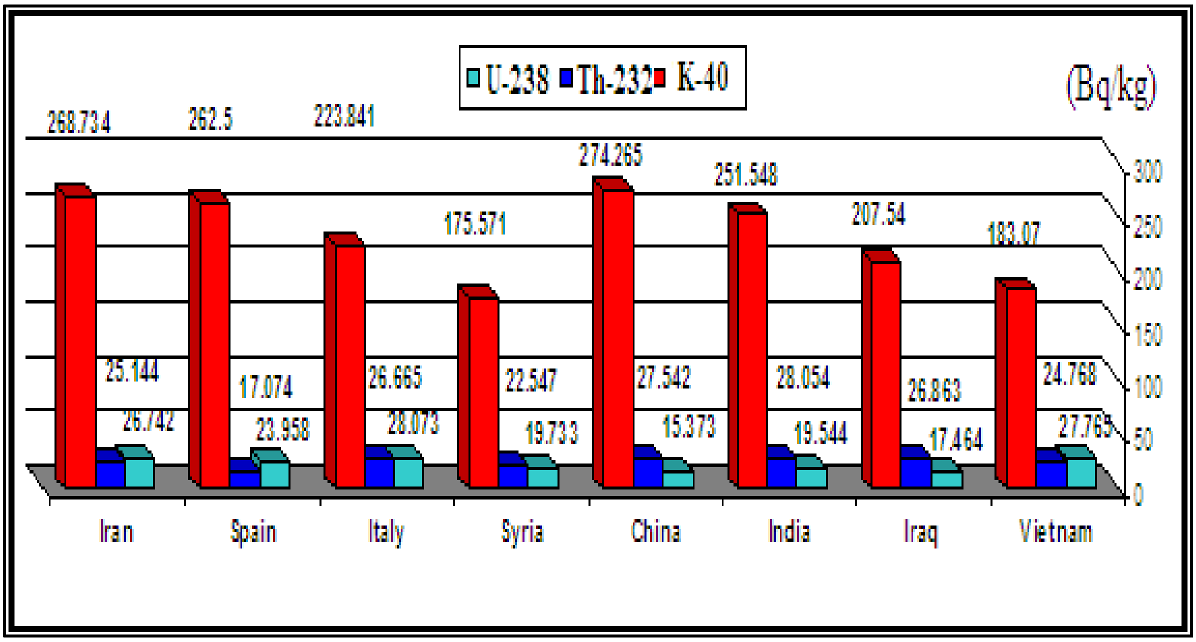

Figure (3) Specific activity of (U-238, Th-232 and K-40) in all studied mosaic samples.

Conclusions

The results of the present work for the studied commercial mosaic samples concerning values of the specific activity concentration for (^{232}Th, ^{40}K and ^{238}U) and the radiation hazard indices [Ra_{eq} ,D_{γ} , $(AEDE)_{in}$,$(AEDE)_{out}$, H_{in} , H_{ex} and I_{γ}] ,all were found to be lower than their corresponding allowed limits, and hence will pose relatively none series health risk.

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Table (1) specific activities of radionuclides and radiation hazard indices for all studied mosaic samples.

No.	Origin	^{238}U (Bq/kg)	^{232}Th (Bq/kg)	^{40}K (Bq/kg)	Ra_{eq} (Bq/kg)	$D_{γ}$ (nGy/h)	(A.E.D.E) (mSv/y)		Hazard index		$I_{γ}$
							Indoor E_{in}	Outdoor E_{out}	H_{in}	H_{ex}	
1	Vietnam	27.765	24.768	183.070	77.280	35.421	0.174	0.043	0.284	0.209	0.277
2	Iraq	17.464	26.863	207.540	71.859	32.948	0.162	0.040	0.241	0.194	0.262
3	India	19.544	28.054	251.548	79.030	36.463	0.179	0.045	0.266	0.213	0.289
4	China	15.373	27.542	274.265	75.876	35.175	0.173	0.043	0.246	0.205	0.280
5	Syria	19.733	22.547	175.571	65.494	30.056	0.147	0.037	0.230	0.177	0.237
6	Italy	28.073	26.665	223.841	83.440	38.410	0.188	0.047	0.301	0.225	0.302
7	Spain	23.958	17.074	262.500	68.586	32.328	0.159	0.040	0.250	0.185	0.253
8	Iran	26.742	25.144	268.734	83.390	38.748	0.190	0.048	0.298	0.225	0.304
Min.		15.373	17.074	175.571	65.494	30.056	0.147	0.037	0.230	0.177	0.237
Max.		28.073	28.054	274.265	83.440	38.748	0.190	0.048	0.301	0.225	0.304
worldwide average		35	30	400	370	55	1	1	1	1	1