Ibn Al Haitham Journal for Pure and Applied Science

Journal homepage: http://jih.uobaghdad.edu.iq/index.php/j/index

Measurement of Radioactivity in Some Commercial Porcelain Samples by Using HPGe Detector

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Article history: Received 11 June 2019, Accepted 28 August 2019, Published in April 2020.

Doi: 10.30526/33.2.2439

Abstract

Estimations of specific activity concentrations in eight commercial porcelain tiles made in different countries were performed by the use of HPGe detector. We have found that the highest specific activity concentrations for ^{238}U, ^{40}K were equal to (21.120 Bq/kg) and (283.862 Bq/kg) respectively, Iranian origin, while the highest specific activity concentration for ^{232}Th was found to be equal to (29.292 Bq/kg), Iraqi origin; all of which were less than their corresponding recommended values given by (UNSCEAR, 2000). The radiation hazard indices [I_γ , H_{in} ,H_{ex} , Ra_{eq} ,D_γ , $(AEDE)_{in}$ and $(AEDE)_{out}$] were also studied and their values were less than the allowed values determined by (UNSCEAR, 2000). Therefore, all the studied tiles of commercial porcelain are safe when used, for example, in floor constructions.

Keyword: Radiation hazard indices, porcelain samples, HPGe detector.

1. Introduction

Humans are constantly presented to ionizing radiation because of radiation sources. Other than radiation made by human, the radiation primary source is a characteristic of radioactivity [1]. The radionuclides of ^{238}U, ^{40}K and ^{232}Th can be found nearly in a wide range of materials which are produced from the earth's crust [2]. These radionuclides enter into the bodies through the food, water and air [3]. These radionuclides and daughters dispose some dangers because of their emissions of beta and gamma rays and because of radon and its daughters which emits alpha particles [4].

The human body contains slight amounts of naturally occurring radioactive elements in muscles, bones and tissues. Specifically radioactive gases like radon are gathered in the distinctive segments of the body and add to the interior measurement by ingestion and inward breath. Since people spend the greater part of their time (about 80%) indoors, it is vital to get

Information about natural radioactivity to decide the amount of public exposure in flooring materials [5]. We use HPGe detector to determine the specific activity concentrations and radiation hazard indices for some commercial porcelain tiles, which is the aim of this paper.

2. Materials and Method

Eight commercial porcelain tiles were gathered from various different markets and industrial facilities. The tiles were picked from most regular Iraqi markets, see **Figure 1.** Each tile was pounded into small pieces, then into fine powder by utilizing jaw crusher. The tiles were dried at 100 °C for one hour to guarantee that any moisture was expelled from the tests. In order to acquire uniform molecular sizes, a (500 μm) mesh was utilized, and then, the tiles were weighted (one kg) and transferred to a Marinelli beaker. The HPGe system which was used in the present work was a (3×3) inch, see **Figure 2.** A fundamental prerequisite to estimate a gamma producer was the character of photo peaks showed in the spectrum made by the detector system. Calibration of energy was done by utilizing a standard source of Marinelli beaker of Eu-152, set up 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. Some porcelain tiles used in the present work.

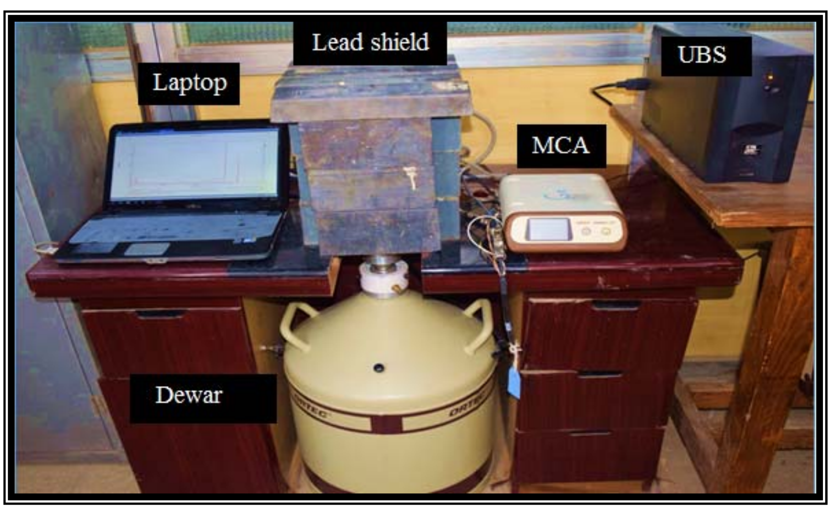

Figure 2. HPGe system used in the present work.

The equation which was used to obtain the specific activity concentrations in porcelain tiles is [6].

$$\boldsymbol{A} = \frac{\boldsymbol{N-BG}}{\boldsymbol{T}.\boldsymbol{I_\gamma}(\boldsymbol{E_\gamma}).\mathcal{E}(\boldsymbol{E_\gamma}).\boldsymbol{M}} \qquad (1)$$

Where:

A: represents the specific activity of radioactive elements.

N: area of the photo peak at energy (Eγ).

B.G: net peak area of the background.

Ɛ(Eγ): detector efficiency.

Iγ (Eγ): abundance.

M: mass of the sample (kg).

T: duration of measuring procedure (7200 s).

- **Radiation Hazard Indices**

1- Radium Equivalent Activity (Ra_{eq}) [6].

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

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

2- Absorbed Gamma Dose Rate (D_γ) [7].

$$D\gamma = 0.604A_{Th} + 0.0417A_K + 0.462A_U + \qquad (3)$$

3- The Annual Effective Dose Equivalent ($AEDE_{in}$, $AEDE_{out}$) [8].

$$(AEDE)_{in} = D\gamma\ (nGy/h) \times 10^{-6} \times (0.7\ Sv/Gy) \times 8760\ h/y \times 0.80 \qquad (4)$$

$$(AEDE)_{out} = D\gamma\ (nGy/h) \times 10^{-6} \times (0.7\ Sv/Gy) \times \times 8760\ h/y \times 0.20 \qquad (5)$$

4- Internal and External Hazard Indices (H_{in} , H_{ex}) [9].

$$H_{in} = \frac{A_U}{185} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \le 1 \qquad (6)$$

$$H_{ex} = \frac{A_U}{370} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \le 1 \qquad (7)$$

5- Activity Concentration Index (I_γ) [10].

$$I_\gamma = \frac{A_U}{300} + \frac{A_{Th}}{200} + \frac{A_K}{3000} \qquad (8)$$

3. Results and Discussions

Table 1. Contains the results of the present work. It can be noticed that the specific activity of (^{238}U) was found to be varied from (14.830 Bq/kg) (Syrian origin) to (21.120 Bq/kg) (Iranian origin), with a mean value of (17.968±2.248 Bq/kg), see **Figure 3.** Which do not reach the preferred value (35 Bq/kg) for the specific activity of ^{238}U specified by (UNSCEAR, 2000).

Specific activity of (^{232}Th) was found to be ranged from (19.564 Bq/kg) (Spanish origin) to (29.292 Bq/kg) (Iraqi origin), with a mean value of (24.282±3.168 Bq/kg), see **Figure 3.** Which do not reach the preferred value (30 Bq/kg) for the specific activity of ^{232}Th specified by (UNSCEAR, 2000).

Specific activity of (^{40}K) was found to be ranged from (154.070 Bq/kg) (Vietnamese origin) to (283.862 Bq/kg) (Iranian origin), with an average value of (222.715±47.09 Bq/kg), see **Figure 3.** Which do not reach the preferred value (400 Bq/kg) for the specific activity of ^{40}K specified by (UNSCEAR, 2000).

Radium equivalent activity (Raeq) was ranged from (59.289 Bq/kg) (Syrian origin) to (80.348 Bq/kg) (Iraqi origin), with a mean value of (69.841±5.756 Bq/kg). These values do not reach the preferred value (370 Bq/kg) for the (Raeq) specified by (UNSCEAR, 2000).

Absorbed dose rate (Dɣ) was ranged from (27.259 nGy/h) (Syrian origin) to (37.142 nGy/h) (Iraqi origin), with a mean value of (32.255±2.7 nGy/h). These values do not reach the preferred value (55 nGy/h) for the (Dɣ) specified by (UNSCEAR, 2000).

The (AEDE) was found to be ranged from (0.134 mSv/y) (Syrian origin) to (0.182 mSv/y) (Iraqi origin), with a mean value of (0.158±0.013 mSv/y which do not reach the preferred value (1 mSv/y) for the (AEDE)in specified by (UNSCEAR, 2000).

(AEDE)out was found to be ranged from (0.033 mSv/y) (Syrian origin) to (0.046 mSv/y) (Iraqi origin), with a mean value of (0.040±0.003mSv/y which do not reach the preferred value (1 mSv/y) for the (AEDE)out specified by (UNSCEAR, 2000).

The internal hazard Index (Hin) was ranged from (0.200) (Syrian origin) to (0.266) (Italian origin), with an average value of (0.237±0.019). Which do not reach the preferred value (1) for the (Hin) specified by (UNSCEAR, 2000).

The external hazard Index (Hex) was ranged from (0.160) (Syrian origin) to (0.217) (Iraqi origin), with an average value of (0.189±0.015). Which do not reach the preferred value (1) for the (Hex) specified by (UNSCEAR, 2000).

Activity concentration index (Iɣ) was found to be ranged from (0.216) (Syrian origin) to (0.296) (Iraqi origin), with an average value of (0.256±0.021) which do not reach the preferred value of (1) for the (Iɣ) specified by (UNSCEAR, 2000).

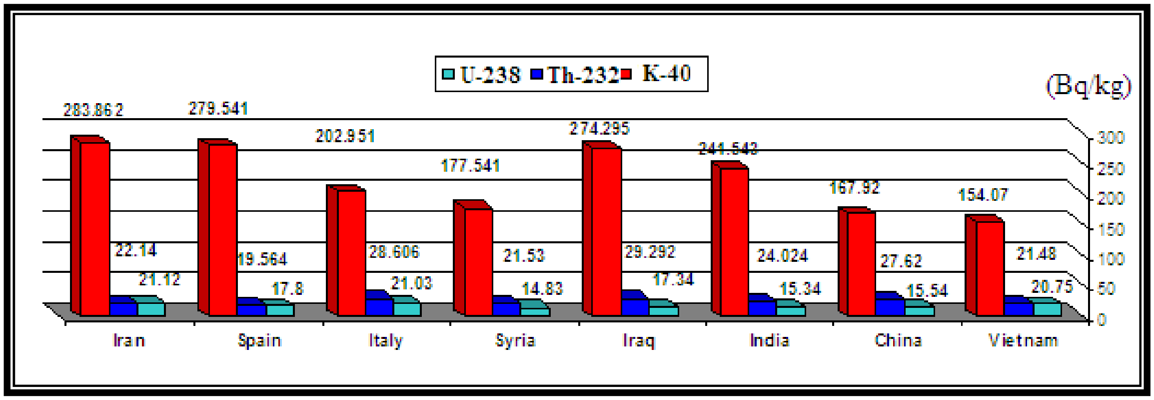

Figure 3. specific activity of (^{238}U, ^{232}Th and ^{40}K) for all porcelain tiles studied in the present work.

4. Conclusion

All results concerning values of the specific activity for (^{238}U, ^{232}Th and ^{40}K) and radiation hazard indices [I_γ , H_{in} ,H_{ex} , Ra_{eq} ,D_γ , $(AEDE)_{in}$ and $(AEDE)_{out}$] were found to be less than their permitted limits and it will not pose relatively serious health risk when used, for example, in floor contractions.

Table 1. Origin, specific activity concentrations and hazard indices for the commercial porcelain samples studied in the present work.

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) Indoor E_{in}	Outdoor E_{out}	Hazard index H_{in}	H_{ex}	I_γ
1	**Vietnam**	20.750	21.480	154.070	63.330	28.985	0.142	0.036	0.227	0.171	0.228
2	**China**	15.540	27.620	167.920	67.966	30.864	0.151	0.038	0.226	0.184	0.246
3	**India**	15.340	24.024	241.543	68.293	31.670	0.155	0.039	0.226	0.184	0.252
4	**Iraq**	17.340	29.292	274.295	80.348	37.142	0.182	0.046	0.264	0.217	0.296
5	**Syria**	14.830	21.530	177.541	59.289	27.259	0.134	0.033	0.200	0.160	0.216
6	**Italy**	21.030	28.606	202.951	77.564	35.457	0.174	0.043	0.266	0.209	0.281
7	**Spain**	17.800	19.564	279.541	67.301	31.697	0.155	0.039	0.230	0.182	0.250
8	**Iran**	21.120	22.140	283.862	74.638	34.967	0.172	0.043	0.259	0.202	0.276
Min.		14.830	19.564	154.070	59.289	27.259	0.134	0.033	0.200	0.160	0.216
Max.		21.120	29.292	283.862	80.348	37.142	0.182	0.046	0.266	0.217	0.296
Average		17.968 ±2.248	24.282 ±3.168	222.715 ±47.09	69.841 ±5.756	32.255 ±2.7	0.158 ±0.013	0.040 ±0.003	0.237 ±0.019	0.189 ±0.015	0.256±0.021
worldwide average [11]		35	30	400	370	55	1	1	1	1	1

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