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MEASUREMENT OF RADIOACTIVITY IN SOME GRANITE SAMPLES BY USING (HPGE) DETECTOR

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Abstract-In this paper, the measurement of specific activity concentrations in eleven commercial granite samples from different countries (China, Brazil, Iran, Syria , Turkey , Spain , Italia ,Egypt , Lebanon , India, and Jordan) were carried out using (HPGe) detector. The results of measurements have shown that the average values specific activity concentrations for ^{238}U, ^{232}Th and ^{40}K which were equal to (22.944±2.71 Bq/kg), (23.195±2.77 Bq/kg) and (169.956±37.18 Bq/kg) , respectively., which were less than the corresponding recommended global values reported by (UNSCEAR , 2000) publication. The radiation hazard indices [Ra_{eq} ,$D_{□}$, $(AED)_{in}$,$(AED)_{out}$, $I_{□}$, I_{α}, H_{in} and H_{ex}] were also studied. The obtained results were also found to be less than the allowed limits given by (UNSCEAR , 2000) and (RPA, 2000). Thus all results obtained in the present work have shown no significant radiological hazard when the studied granites is used, for example, for construction of buildings .
Keyword: radioactivity, Radiation hazard indices, (HPGe) detector, granite samples.

I. INTRODUCTION

Radionuclides are found naturally in water,air, and soil, they are even found in our human body, being that we are products of our environment. Natural radioactivity is common in the soil and rocks that makes up our planet, therefore in our building materials and homes. Generally, natural building materials reflect the geology of their site of origin. It is well known that most of raw building materials, i.e granite, are derived from soil [1]. The content of natural radionuclides in building materials is caused 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 (^{238}U) 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. [2].
In this work continuation of our ongoing project related to the measurement of specific activity of ^{232}Th, ^{238}U and ^{40}K in environmental granite samples by using (HPGe) detector from different origins were also studied in the present work.

II. MATERIALS AND METHOD

Eleven samples of granite were collected from different countries (China, Brazil, Iran, Syria , Turkey , Spain , Italia ,Egypt , Lebanon, India, and Jordan) which was available in the local Iraqi market. The samples were dried in an oven to ensure moisture was removed , and then were stored in a tight Marinelli beakers for one month to a chieve secular equilibrium. In the present work a (3×3) inch (HPGe) detector. Measurement with an empty Marinelli beaker under identical conditions was also performed to estimate the background radiation.
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

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of one litter capacity of Marinelli beaker of Europium-152, which has been prepared in this work with energies (964.0,1408.0, 344.3, 411.1, 444.6, 778.9, 121.8, 1112.0, 1085.8 and 244.7 keV). The Energy calibration source should be counted long enough to produce well-defined photo peaks. The efficiency calibration of the (HPGe) detector was achieved using the same standard source of Europium-152.
The specific activity concentrations of radionuclides in granite samples were obtained by using the equation [3]:

$$A = (Net\ \ Area\ \ under\ \ the\ \ \ peak)/M \times I_{\gamma}(E_{\gamma}) \times eff \times T \ \ \ldots\ldots\ldots(1)$$

where:
A: the specific activity concentration of radionuclides (Bq/kg).
M: mass of the granite sample (kg).
eff: the efficiency of the detectors at energy E_{γ}.
$I_{\gamma}(E_{\gamma})$: is the relative intensity.
T: the sample counting time.

III. RADIATION HAZARD INDICES

1. Radium Equivalent Activity (Ra_{eq}):
Ra_{eq} (Bq/kg) = $A_U + 1.43A_{Th} + 0.077A_K$ [4] …… (2)
2. Absorbed Gamma Dose Rate (D_{γ}):
D_{γ} (nGy/h) = $0.462A_U + 0.604A_{Th} + 0.0417A_K$ [5] …… (3)
3. Annual Effective Dose Equivalent :
$(AED)_{in}$ (mSv/y)= D_{γ} (nGy/h)×10^{-6}×8760 h/y×0.80×0.7Sv/Gy [6] ………(4)
$(AED)_{out}$ (mSv/y)= D_{γ} (nGy/h)×10^{-6}×8760 h/y×0.20×0.7Sv/Gy [6] ……..…(5)
4. Activity gamma Index (I_{γ}) :

$$I_{\gamma} = \frac{A_U}{300} + \frac{A_{Th}}{200} + \frac{A_K}{3000} \qquad [7]\ \ldots\ldots\ldots(6)$$

5. External (H_{ex}) and Internal (H_{in}) Hazard Indices :

$$H_{ex} = \frac{A_U}{370} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \qquad [8]\ \ldots\ldots\ldots\ (7)$$

Internal exposure to radon ^{222}Rn and its radioactive progeny is controlled by the internal hazard index (H_{in}) and it is given by the relation:

$$H_{in} = \frac{A_U}{185} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \qquad [9]\ \ldots\ldots\ldots\ (8)$$

6. Alpha index (Iα):

$$I\alpha = \frac{A_{Ra}}{200} \qquad [10]\ \ldots\ldots\ (9)$$

Where ,A_U, A_{Th} and A_K are the specific activity concentrations of ^{238}U(^{226}Ra),^{232}Th and ^{40}K in (Bq/kg) units respectively.

IV. RESULTS AND DISCUSSION

The results of the present work were summarized in Table (1), from which it can be noticed that, the highest value of specific activity of (^{238}U) in the studied samples was found in granite sample of Iran origin which was equal to (29.870 Bq/kg), while the lowest value of specific activity of (^{238}U) was found in granite sample of Jordan origin which was equal to (18.920 Bq/kg) ,with an average value of (22.944±2.71 Bq/kg). The present results have shown that values of specific activity for (^{238}U) in all studied samples were less than the recommended value of (35 Bq/kg) for the specific activity of (^{238}U) given by (UNSCEAR , 2000) [11].
The highest value of specific activity of (^{232}Th) in the studied samples was found in granite sample of Iran origin which was equal to (30.580 Bq/kg), while the lowest value of specific activity of (^{232}Th) was found in granite sample of India origin which was equal to (17.120 Bq/kg), with an average value of (23.195±2.77 Bq/kg). The present results have shown that values of specific activity for (^{232}Th) in all studied samples were less than the recommended value of (30 Bq/kg) for the specific activity of (^{232}Th) given by (UNSCEAR, 2000) [11].
The highest value of specific activity of (^{40}K) in the studied samples was found in granite sample of Italia origin which was equal to (223.190 Bq/kg), while the lowest value of specific activity of (^{40}K) was found in granite sample of Brazil origin which was equal to (103.840 Bq/kg), with an average value of (169.956±37.18 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) given by (UNSCEAR , 2000) [11], see Fig.(1).

The highest value of (Ra_{eq}) in the studied samples was found in granite sample of Iran origin which was equal to (90.355 Bq/kg), while the lowest value of (Ra_{eq}) was found in granite sample of India origin which was equal to (60.559 Bq/kg) ,with an average value of (69.198±4.68 Bq/kg). The present results have shown that values of (Ra_{eq}) in all studied samples were less than the recommended value of (370 Bq/kg) for the (Ra_{eq}) given by (UNSCEAR , 2000) [11].

The highest value of (D□) in the studied samples was found in granite sample of Iran origin which was equal to (41.345 nGy/h), while the lowest value of (D□) was found in granite sample of India origin which was equal to (27.697 nGy/h), with an average value of (31.697±2.16 nGy/h). The present results have shown that values of (D□) rate in all studied samples were less than the recommended value of (55 nGy/h) for the (D□) given by (UNSCEAR , 2000) [11].

The highest value of $(AED)_{in}$ in the studied samples was found in granite sample of Iran origin which was equal to (0.203 mSv/y), while the lowest value of $(AED)_{in}$ was found in granite sample of India origin which was equal to (0.136 mSv/y) ,with an average value of (0.155±0.01 mSv/y). The present results have shown that values of $(AED)_{in}$ in all studied samples were less than the recommended value of (1 mSv/y) for the $(AED)_{in}$ given by (UNSCEAR, 2000) [11] .

The highest value of $(AED)_{out}$ in the studied samples was found in granite sample of Iran origin which was equal to (0.051 mSv/y), while the lowest value of $(AED)_{out}$ was found in granite sample India of origin which was equal to (0.034 mSv/y), with an average value of (0.039±0.004 mSv/y). The present results have shown that values of $(AED)_{out}$ in all studied samples were less than the recommended value of (1 mSv/y) for the outdoor annual effective dose equivalent given by (UNSCEAR, 2000) [11] .

The highest value of (I□) in the studied samples was found in granite sample of Iran origin which was equal to (0.325 mSv/y), while the lowest value of (I□) was found in granite sample of India origin which was equal to (0.214 mSv/y) ,with an average value of (0.249±0.018 mSv/y). The present results have shown that values of (I□) in all studied samples were less than the recommended value of (1) for (I□) given by (UNSCEAR, 2000) [11].

The highest value of (I_{α}) in the studied samples was found in granite sample of Iran origin which was equal to (0.149), while the lowest value of (I_{α}) was found in granite sample of Jordan origin which was equal to (0.095), with an average value of (0.115±0.014).The present results have shown that values of (I_{α}) in all studied samples were less than the recommended value of (1) for (I_{α}) given by (UNSCEAR, 2000) [11].

The highest value of (H_{in}) in the studied samples was found in granite sample of Iran origin which was equal to (0.325), while the lowest value of (H_{in}) was found in granite sample Egypt origin which was equal to (0.234) ,with an average value of (0.249±0.014). The present results have shown that values of (H_{in}) in all studied samples were less than the recommended value of (1) for the (H_{in}) given by (UNSCEAR, 2000) [11].

The highest value of (H_{ex}) in the studied samples was found in granite sample of Iran origin which was equal to (0.244), while the lowest value of (H_{ex}) was found in granite sample India origin which was equal to (0.164), with an average value of (0.187±0.013). The present results have shown that values of (H_{ex}) in all studied samples were less than the recommended value of (1) for the (H_{ex}) given by (UNSCEAR, 2000) [11].

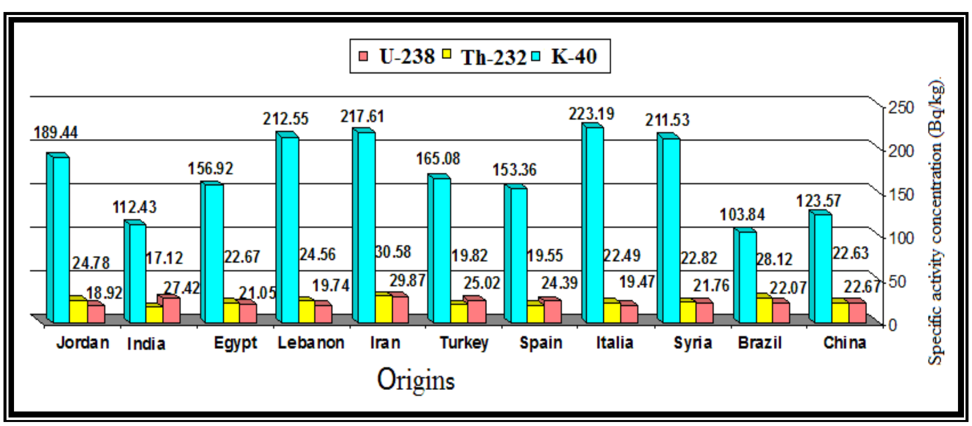

Figure (1). The specific activity of (^{238}U, ^{232}Th and ^{40}K) for all granite samples.

V. CONCLUSIONS

All results of the present work concerning the values of specific activity for (^{238}U, ^{232}Th and ^{40}K) and radiation hazard indicies [Ra_{eq} ,D□ , $(AED)_{in}$,$(AED)_{out}$, I□ , I_{α}, H_{in} and H_{ex}] , were found to be lower than their corresponding allowed limits, and hence will pose relatively none series health risk.

Table- (1) specific activities of radionuclides with significant radiological hazard for all granite samples.

No. of sample	Country	U-238 (Bq/Kg)	Th-232 (Bq/Kg)	K-40 (Bq/Kg)	Ra_{eq} (Bq/Kg)	D□ (nGy/h)	Annual effective dose (mSv/y)		I□	(Iα)	Hazard index	
							Indoor (AED_{in})	Outdoor (AED_{out})			H_{in}	H_{ex}
1	China	22.670	22.630	123.570	64.546	29.295	0.144	0.036	0.230	0.113	0.236	0.174
2	Brazil	22.070	28.120	103.840	70.277	31.511	0.155	0.039	0.249	0.110	0.249	0.190
3	Syria	21.760	22.820	211.530	70.680	32.657	0.160	0.040	0.257	0.109	0.250	0.191
4	Italia	19.470	22.490	223.190	68.816	31.886	0.156	0.039	0.252	0.097	0.238	0.186
5	Spain	24.390	19.550	153.360	64.155	29.471	0.145	0.036	0.230	0.122	0.239	0.173
6	Turkey	25.020	19.820	165.080	66.074	30.414	0.149	0.037	0.238	0.125	0.246	0.178
7	Iran	29.870	30.580	217.610	90.355	41.345	0.203	0.051	0.325	0.149	0.325	0.244
8	Lebanon	19.740	24.560	212.550	71.227	32.817	0.161	0.040	0.259	0.099	0.246	0.192
9	Egypt	21.050	22.670	156.920	65.551	29.961	0.147	0.037	0.236	0.105	0.234	0.177
10	India	27.420	17.120	112.430	60.559	27.697	0.136	0.034	0.214	0.137	0.238	0.164
11	Jordan	18.920	24.780	189.440	68.942	31.608	0.155	0.039	0.250	0.095	0.237	0.186
Ave.		22.944 ±2.71	23.195 ±2.77	169.956 ±37.18	69.198 ±4.68	31.697 ±2.16	0.155 ±0.01	0.039 ±0.003	0.249 ±0.018	0.115 ±0.014	0.249 ±0.014	0.187 ±0.013
Min.		18.920	17.120	103.840	60.559	27.697	0.136	0.034	0.214	0.095	0.234	0.164
Max.		29.870	30.580	223.190	90.355	41.345	0.203	0.051	0.325	0.149	0.325	0.244
world wide average [11]		**35**	**30**	**400**	**370**	**55**	**1**	**1**	**1**	**1 [10]**	**1**	**1**

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