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MEASUREMENT OF NATURAL RADIOACTIVITY IN BUILDING MATERIALS SAMPLES BY USING (HPGe) SYSTEM

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ABSTRACT: In the present work, we have measured natural radioactivity in twelve building materials samples for four kinds (Brick, cement, gypsum and sand) obtained from some Iraqi governorates by using High Purity Germanium (HPGe) radiation detectors system. 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 (24.236 ± 4.4 Bq/kg), (26.394 ± 4.0 Bq/kg) and (174.888 ± 29.1 Bq/kg), respectively., which were lesser than the corresponding recommended global values reported by (UNSCEAR, 2000) publication. The radiation hazard indices [Ra_{eq} D_V, $(AED)_{in}$, $(AED)_{out}$, H_{in} and H_{ex}] were also studied. The obtained results were also found to be lesser 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 building materials is used for construction of buildings

INTRODUCTION: The world is normally radioactive, and around 90% of human radiation presentation emerges from characteristic sources, for example, terrestrial radiation, introduction to Rn-222 and cosmic radiation [1]. All building materials contain different measures of radio-activity. For instance, materials got from shake and soil contains regular radionuclides of the (Th-232), and (U-238) arrangement and the radioactive isotope of (K-40). Counterfeit radionuclides can likewise be available, for example, (Cs-137), coming about because of aftermath from weapons testing and the Chernobyl mishap. All these can be wellsprings of both inside and outer radiation introduction.

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Inward presentation happens through the inward breath of radon gas, and outer introduction happens through the discharge of infiltrating gamma beams [2]. This paper plots the technique utilized for deciding the sort and particular action of the normally happening radionuclides found in regularly utilized building materials in the Republic of Iraq, the outcomes got and the radiological wellbeing essentialness of such results [3].

MATERIALS AND METHOD: Twelve samples of building materials (Brick, cement, gypsum and sand) were collected from various 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 at (3 × 3) inch (HPGe) system. An essential requirement for the measure 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 Europium-152, which has been prepared in this work with energies (964.0, 1408.0, 344.3, 444.6, 411.1, 778.9, 1112.0, 121.8, 1085.8 and 244.7 keV). The energy calibration source should be counted long enough to produce well-defined photo peaks. The specific activity concentrations of radionuclides in samples were obtained by using the equation: [4]

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

Where, A = The specific activity concentration of radionuclides, M = mass of the building materials sample, eff = The efficiency of the detectors at energy E_{γ}, $I_{\gamma}(E_{\gamma})$ = is the relative intensity, T = The sample counting time.

Radiation Hazard Indices Calculation:

Radium Equivalent Activity (Ra_{eq}):

$Ra_{eq} = 1.43A_{Th} + A_U + 0.077A_K$ ……………..2

Where, A_U, A_{Th} and A_K are the specific activity concentrations of U-238, Th-232 and K-40 respectively.

Absorbed Gamma Dose Rate (D_{γ}):

$D_{\gamma} = 0.604A_{Th} + 0.462A_U + 0.0417A_K$ …………....3

Annual Effective Dose Equivalent:

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

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

External (H_{ex}) & Internal (H_{in}) Hazard Indices:

$H_{ex} = A_U / 370 + A_{Th} / 259 + A_K / 4810$ 6

Internal exposure to Rn-222 and its radioactive progeny is controlled by the internal hazard index (Hin) and it is given by the relation:

$H_{in} = A_U / 370 + A_{Th} / 259 + A_K / 4810$ 7

RESULTS AND DISCUSSION: Our present investigation is based on the study of twelve samples of different available kinds of building materials (Brick, cement, gypsum and sand) which were available in the local markets, some of them were Iraqi origins and the others from different foreign origins, (cement Lebanon and cement Iran) for which the measured of radioactivity emitted from these building materials samples by using (HPGe) system.

Table 1 present specific activity concentration for different kinds of building material samples. It can be noticed that , The maximum value of A_U equal to (29.750 Bq/kg) cement sample (Lebanon origin), while the minimum value of A_U equal to (13.490 Bq/kg) brick sample (Najif origin), see **Fig. 1**, with an average value of (24.236 ± 4.4 Bq/kg). The present results have shown that values of A_U in building materials (Brick, cement, gypsum and sand) were lesser than the recommended value of (35 Bq/kg) for A_U [9]. The maximum value of A_{Th} equal to (33.530 Bq/kg) sand sample (Baghdad origin), while the minimum value of A_{Th} equal to (16.180 Bq/kg) gypsum sample (Baghdad origin), see **Fig. 1**, with an average value of (26.394 ± 4.0 Bq/kg).

The present results have shown that values of A_{Th} in building materials (Brick, cement, gypsum and sand) were lesser than the recommended value of (30 Bq/kg) for A_{Th} [9]. The maximum value of A_K equal to (223.270 Bq/kg) brick sample (Najif origin), while the minimum value of A_K equal to (115.830 Bq/kg) gypsum sample (Baghdad origin), see **Fig. 1**, with an average value of (174.888 ± 29.1 Bq/kg). The present results have shown that values of A_K in building materials (Brick, cement, gypsum and sand) were lesser than the recommended value of (400 Bq/kg) A_K [9]. The maximum value of specific activity of (Ra_{eq}) equal to (93.257 Bq/kg) sand sample (Baghdad origin), while the minimum value of specific activity of (Ra_{eq}) equal to (60.010 Bq/kg) brick sample (Baghdad origin), see **Fig. 2**, with an average value of (75.446 ± 6.3 Bq/kg). The present results have shown that values of specific activity for (Ra_{eq}) in building materials (Brick, cement, gypsum and sand) were lesser than the recommended value of (370 Bq/kg) for the specific activity of (Ra_{eq}) [9]. The maximum value of D_{γ} equal to (42.496 nGy/h) sand sample (Baghdad origin), while the minimum value of D_{γ} equal to (27.713 nGy/h) brick sample (Baghdad origin), see **Fig. 2**, with an average value of (34.432 ± 2.7 nGy/h). The present results have shown that values of specific activity for D_{γ} in building materials (Brick, cement, gypsum and sand) were lesser than the recommended value of

(55 nGy/h) for the D_Y [9]. The maximum value of $(AED)_{in}$ equal to (0.208 mSv/y) sand sample (Baghdad origin), while the minimum value of $(AED)_{in}$ equal to (0.136 mSv/y) brick sample (Baghdad origin), see **Fig. 3**, with an average value of (0.169 ± 0.01 mSv/y) [5-8].

TABLE 1: A_U, A_{Th}, A_K FOR BUILDING MATERIAL SAMPLES (CEMENT, BRICK, GYPSUM AND SAND)

No. of sample	Kind of building materials & origin	U-238 (Bq/kg)	Th-232 (Bq/kg)	K-40 (Bq/kg)	Ra_{eq} (Bq/kg)	D_Y (nGy/h)	(A.E.D) (mSv/y) IndoorE$_{in}$	(A.E.D) (mSv/y) OutdoorE$_{out}$	Hazard index H_{in}	Hazard index H_{ex}
1	Cement (Najif)	23.640	29.670	153.580	77.894	35.247	0.173	0.043	0.274	0.210
2	Cement (Sulaymniya)	20.870	32.180	183.820	81.042	36.744	0.180	0.045	0.275	0.219
3	Cement (Lebanon)	29.750	21.720	201.580	76.331	35.269	0.173	0.043	0.287	0.206
4	Brick (Iran)	13.490	27.890	223.270	70.564	32.388	0.159	0.040	0.227	0.191
5	Brick (Najif)	27.090	27.540	123.860	76.009	34.315	0.168	0.042	0.279	0.205
6	Brick (Baghdad)	21.920	17.850	163.180	60.010	27.713	0.136	0.034	0.221	0.162
7	Sand (Karbala)	28.830	33.530	214.010	93.257	42.496	0.208	0.052	0.330	0.252
8	Sand (Najif)	18.840	25.580	221.510	72.476	33.391	0.164	0.041	0.247	0.196
9	Sand (Karbala)	29.350	28.650	153.910	82.171	37.282	0.183	0.046	0.301	0.222
10	Gypsum (Baghdad)	29.120	16.180	115.830	61.176	28.056	0.138	0.034	0.244	0.165
11	Gypsum (Diyala)	28.210	27.230	164.260	79.797	36.330	0.178	0.045	0.292	0.216
12	Gypsum (Karbala)	19.720	28.710	179.840	74.623	33.951	0.167	0.042	0.255	0.202
	Ave.	24.236	26.394	174.888	75.446	34.432	0.169	0.042	0.269	0.204
		±4.4	±4.0	±29.1	±6.3	±2.7	±0.01	±0.003	±0.02	± 0.01
	Min.	13.490	16.180	115.830	60.010	27.713	0.136	0.034	0.221	0.162
	Max.	29.750	33.530	223.270	93.257	42.496	0.208	0.052	0.330	0.252

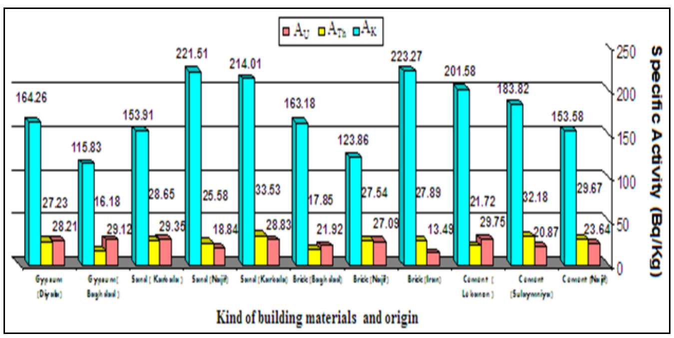

FIG. 1: A_U, A_{Th}, A_K FOR ALL BUILDING MATERIALS SAMPLES SITES

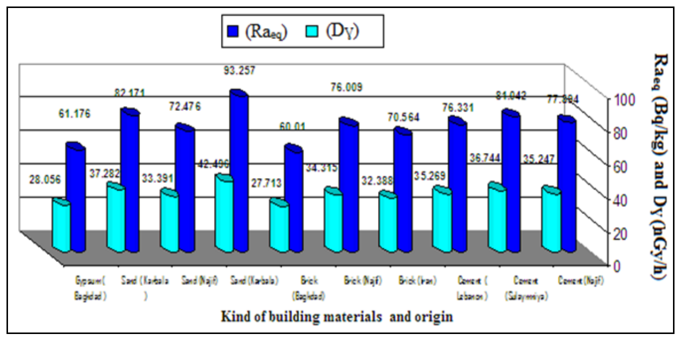

FIG. 2: Ra_{eq}, D_Y FOR ALL BUILDING MATERIALS SAMPLES SITES

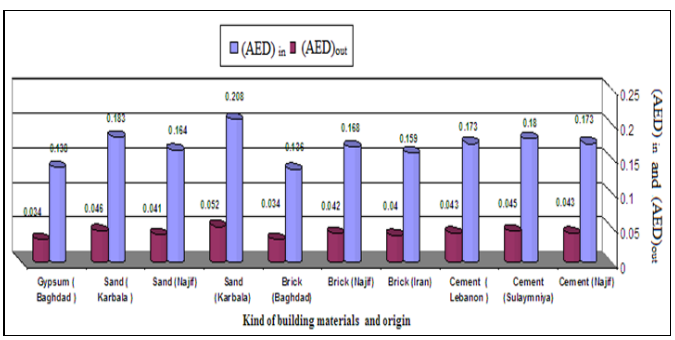

FIG. 3: $(AED)_{in}$, $(AED)_{out}$ FOR ALL BUILDING MATERIALS SAMPLES SITES

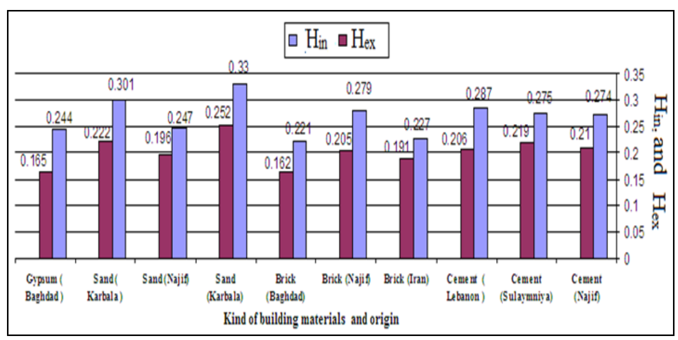

FIG. 4: H_{in}, H_{ex} FOR ALL BUILDING MATERIALS SAMPLES SITES

The present results have shown that values of specific activity for $(AED)_{in}$ in building materials (Brick, cement, gypsum and sand) were lesser than the recommended value of (1 mSv/y) for the $(AED)_{in}$ [9]. The maximum value of $(AED)_{out}$ equal to (0.052 mSv/y) sand sample (Baghdad origin), while the minimum value of $(AED)_{out}$ equal to (0.034 mSv/y) brick sample (Baghdad origin), see **Fig. 3**, with an average value of (0.042 ± 0.003 mSv/y). The present results have shown that values of specific activity for $(AED)_{out}$ in building materials (Brick, cement, gypsum and sand) were lesser than the recommended value of (1 mSv/y) for the $(AED)_{out}$ [9]. The maximum value of (H_{in}) equal to (0.330) sand sample (Baghdad origin), while the minimum value of (H_{in}) equal to (0.221) brick sample (Baghdad origin), see **Fig. 4**, with an average value of (0.269 ± 0.02). The present results have shown that values of specific activity for (H_{in}) in building materials (Brick, cement, gypsum and sand) were lesser than the recommended value of (1) for the (H_{in}) [9]. The maximum value of (H_{ex}) equal to (0.252) sand sample (Baghdad origin), while the minimum value of (H_{ex}) equal to (0.162) brick sample (Baghdad origin), see **Fig. 4**, with an average value of (0.204 ± 0.01). The present results have shown that values of specific activity for (H_{in}) in building materials (Brick, cement, gypsum and sand) were lesser than the recommended value of (1) for the (H_{ex}) [9].

CONCLUSION: The obtained results confirm some conclusions as below:

- The maximum value of AU equal to (29.750 Bq/kg) was found in cement sample (Lebanon origin).
- The maximum value of ATh equal to (33.530 Bq/kg) was found in sand sample (Baghdad origin).
- The maximum value of AK equal to (223.270 Bq/kg) was found in brick sample (Najif origin).
- All results obtained in the present work have shown no significant radiological hazard when the studied building materials (Brick, cement, gypsum and sand) is used, for example, for construction of buildings.

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CONFLICT OF INTEREST: Nil

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