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Natural Radioactivity for Some Egyptian Building Materials

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ABSTRACT

Study of the radiation hazards for the building materials is interested in most international countries. Measurements of natural radioactivity was verified for some egyptian building materials to assess any possible radiological hazard to man by the use of such materials. The measurements for the level of natural radioactivity in the materials was determined by γ-ray spectrum using HPGe detector. A track detector "CR-39" was used to measure the radon exhalation rate from these materials. The radon exhalation rates were found to vary from 2.83±0.86 to 41.57 ± 8.38 mBqm^{-2} h^{-1} for Egyptian alabaster. The absorbed dose rate in air is lower than the international recommended value (55 nGy h^{-1}) for all test samples.

***Key Words**: CR-39 track detectors / HpGe detector / exhalation rate / Egyptian alabaster / absorbed dose*.

INTRODUCTION

The most sources of external and internal radiation exposure in homes are due to gamma ray emitted from members of uranium and thorium decay chains and ^{40}K and due to radon and its daughters which are exhaled from building materials. Knowledge of radioactivity present in building materials enables one to assess any possible radiological hazard to man by the use of such materials. This study has been satisfied in most countries[(1-4)].

A little data is known about the natural radioactivity of Egypt building materials[(5-8)], particularly that of alabaster, building limestone and different kinds of marbles which use in building and decoration. In the present work, measurements of the natural radioactivity and radon exhalation rates in Egyptian alabaster from eastern desert of Beni- Suef, Egypt, building limestone, marbles (four kinds) and raw of building bricks have been investigated. The measurements have been verified using a hyper pure germanium (HPGe) detector and etch track detector of type CR-39.

EXPERIMENTAL TECHNIQUE

Five types of alabaster and raw samples (sand, sand clay, yellow clay and cement) were collected from different Quarries and regions, from eastern dissert of Beni- Suef, Egypt. The other samples collected from different locations across Egyptian country. Galala sample from Zafarana and green marble from Qena. The black marble and Karara from outside the Egyptian country. The samples were dried at room temperature and crushed to 1 mm grain size.

ACTIVITY CONCENTRATION MEASUREMENTS

The volume of the prepared samples were weighed and sealed in plastic containers with a volume of 350 cm^3. The samples were sealed tightly for 4 weeks to reach secular equilibrium between ^{226}Ra and its daughters. The gamma-ray lines were measured directly using a hyper pure germanium (HPGe) detector. The detector has a resolution (FWHM) of 1.85 keV for the 1332.5 keV ^{60}Co γ-ray line.

The counting time was about 18,000 sec to obtain the γ -spectrum with good statistics. The gamma-ray transitions of energies 351.9 keV (^{214}Pb), 609.3 keV, 1120.3 keV (^{214}Bi) and 1764 keV (^{214}Bi) were used to determine the activity concentration of the ^{238}U series. The gamma-ray transitions of energies 338.4 keV (^{228}Ac), 583.3 keV (^{208}Tl), 2614 keV (^{208}Tl) and 911.1 keV (^{228}Ac) were used to determine the activity concentration of the (^{232}Th) series. The 1460 keV gamma-ray transition ^{40}K was used to determine the concentration of ^{40}K in different samples.

SURFACE EXHALATION RATE MEASUREMENTS

A 100 gm of each sample was placed at the base of a cylindrical glass cup. The cup has 6.5 cm diameter x 11 cm height. CR-39 detectors of area 1.5x1.0 cm^2 was fixed at the top center of the cup, to register alpha particles from the decay of radon and its plate out daughters. The cups were sealed for 60 days. The calibration factor of the can was 0.163 ± 0.028 tracks cm^{-2} $(Bq\ m^{-3}d)^{-1}$[9].

The surface exhalation rate E_S ($Bq\ m^{-2}h^{-1}$) of the rock sample was found from the following expression[10] :

$$E_S = \frac{CV\lambda}{A(T + \frac{(e^{-\lambda T} - 1)}{\lambda})} \qquad (1)$$

where C is the integrated radon concentration measured by CR-39 detector ($Bq\ m^{-3}h$), V is the volume of the emanation container (m^3), λ is the decay constant of radon (h^{-1}), A is the surface area emanates the radon (m^2) and T is the exposure time (days).

After exposures, the detectors were etched chemically in 6.25 M NaOH solution at 70^0C for 6h. The tracks were counted with an optical microscope magnifying 400 times.

RESULTS AND DISCUSSION

Table 1 shows studying of radiation measurements (activity concentrations of ^{238}U, ^{232}Th and ^{40}K, radium equivalent in $Bqkg^{-1}$ and the absorbed dose rate in air (D) in ($nGyh^{-1}$) measured by (HPGe) detector beside CR-39 measurements for radon exhalation rate in $mBqm^{-2}\ h^{-1}$) for Egyptian alabaster . The average activity concentrations of ^{238}U, ^{232}Th , ^{40}K, radium equivalent and absorbed dose rate were found to be 15.47±0.78, 7.00±3.06, 62.41±5.01, 30.21±4.31 $Bqkg^{-1}$ and 13.90±2.02 $nGyh^{-1}$ in alabaster. While corresponding the average radon exhalation rate is 18.76±7.56 $mBqm^{-2}\ h^{-1}$.

Table 1 The Activity concentrations of ^{238}U, ^{232}Th and ^{40}K, radium equivalent in $Bqkg^{-1}$, absorbed dose rate ($nGyh^{-1}$) and the radon exhalation rate in $mBqm^{-2}\ h^{-1}$ of Egyptian alabaster

Sample	Activity concentration ($Bqkg^{-1}$)			Ra_{eq} ($Bqkg^{-1}$)	D($nGyh^{-1}$)	E_s ($mBqm^{-2}\ h^{-1}$)
	S_U	S_{Th}	S_K			
1	17.98±4.84	3.28±0.21	56.01±6.31	26.99±5.19	12.27±3.50	29.85±7.61
2	14.46±3.22	4.65±0.38	76.83±9.57	27.03±5.20	12.57±3.54	16.31±4.16
3	14.47±4.42	19.21±5.65	68.65±12.37	47.23±6.87	21.86±4.67	3.23±0.81
4	13.88±2.06	3.98±0.24	52.76±6.53	23.22±4.82	10.64±3.26	2.83±0.86
5	16.59±5.40	3.87±0.67	57.80±6.71	26.58±5.15	12.40±3.48	41.57±8.38
Average	15.47±0.78	7.00±3.06	62.41±5.01	30.21±4.31	13.90±2.02	18.76±7.56

Studying the variation of radon exhalation rate measured by CR-39 track detector with uranium concentration measured by (HPGe) detector for alabaster samples represented in Fig.1. It is noticed a linear dependence between uranium concentration and exhalation of radon with correlation factor, (R^2=0.67).

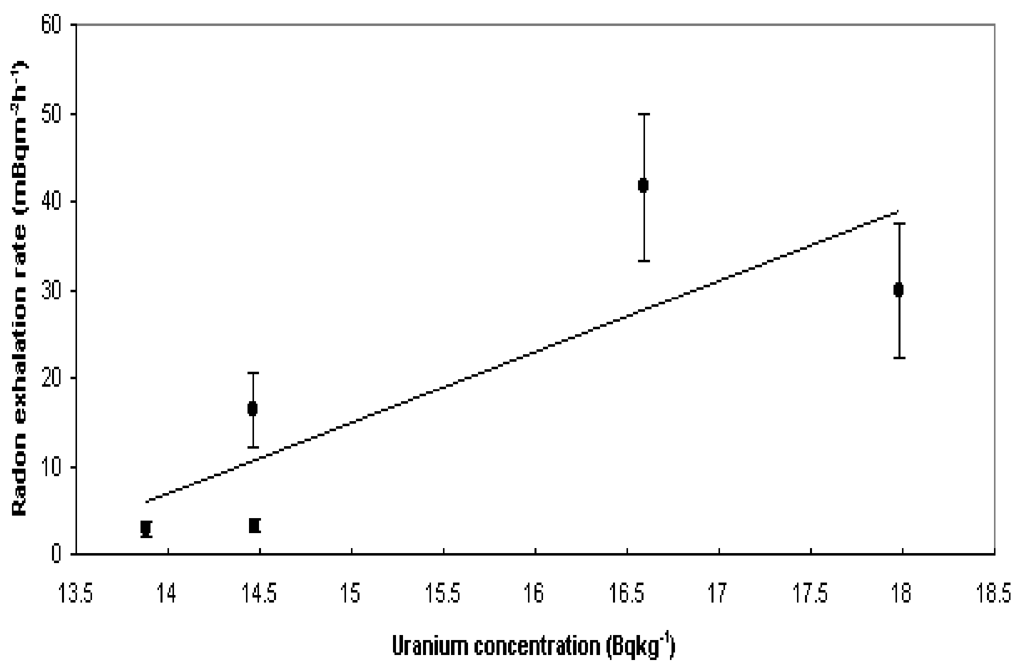

Fig. 1 Dependence of radon exhalation rate on the uranium concentration for alabaster samples.

The above radiation measurements have been investigated for building limestone, marbles and raw of building bricks as seen in Table 2 and 3. The raw of building bricks have highest average value of

^{238}U concentration (22.18±4.56 $Bqkg^{-1}$).The lowest value was found in building limestone, 1.15±0.33 $mBqm^{-2} h^{-1}$.

Table 2 Radiation measurements for building limestone and marble

Sample / Radiation parameters	Building limestone	Marble			
		Galala	Karara (white marble)	Black marble	Green marble
$S_U(Bqkg^{-1})$	13.41±4.05	9.81±2.59	15.38±3.94	26.71±6.59	------------
$S_{Th}(Bqkg^{-1})$	3.29±0.62	3.01±0.22	1.27±0.72	4.12±1.51	------------
$S_K(Bqkg^{-1})$	61.00±6.79	50.46±5.73	58.44±6.35	79.40±8.91	------------
$Ra_{eq}(Bqkg^{-1})$	22.81±4.77	18.00±4.24	21.71±4.66	38.71±6.22	------------
D ($nGyh^{-1}$)	10.54±3..24	8.36±2.89	9.94±3.15	17.56±4.19	
E_s ($mBqm^{-2} h^{-1}$)	1.15±0.33	54.11±11.11	76.21±21.79	1103.55±193.25	8.13±34.80

Table 3 Radiation measurements for raw of building bricks

Sample / Radiation parameters	Raw building bricks			
	Sand	Sand clay	Yellow clay	Cement
$S_U(Bqkg^{-1})$	9.26±3.28	29.74±10.49	27.22±5.60	22.51±3.23
$S_{Th}(Bqkg^{-1})$	2.91±0.10	16.86±4.72	19.36±2.48	3.99±1.02
$S_K(Bqkg^{-1})$	54.52±6.64	293.61±15.80	188.71±12.62	68.76±8.29
$Ra_{eq}(Bqkg^{-1})$	17.63±4.20	76.46±8.74	69.44±8.33	33.51±5.79
D ($nGyh^{-1}$)	8.24±2.87	36.54±6.04	32.59±5.70	15.22±3.90
E_s ($mBqm^{-2} h^{-1}$)	41.62±8.28	169.80±30.65	711.63±124.90	29.14±6.00

A non linear relationship between uranium concentration and radon exhalation rate for marble (three kinds) and raw of building bricks were observed in Fig. 2 and 3 respectively. The correlation factor for the raw of building bricks is small and equals to the value 0.247 compared with those for marble. That is due to the variations in the radium content of the sample and the porosity(11) .

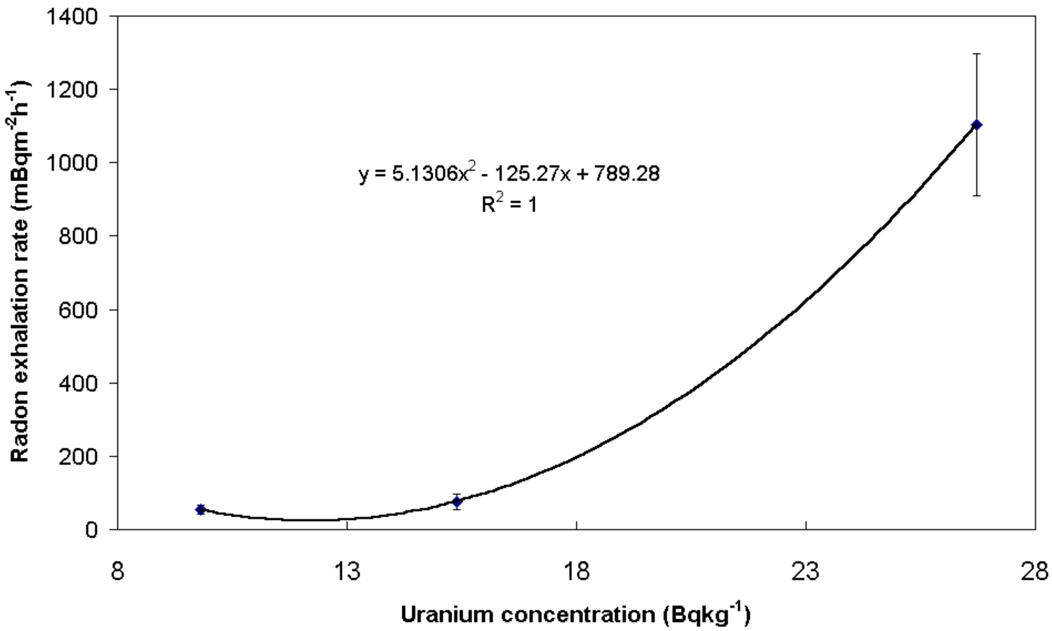

Fig. 2 Dependence of radon exhalation rate on the uranium concentration for marble

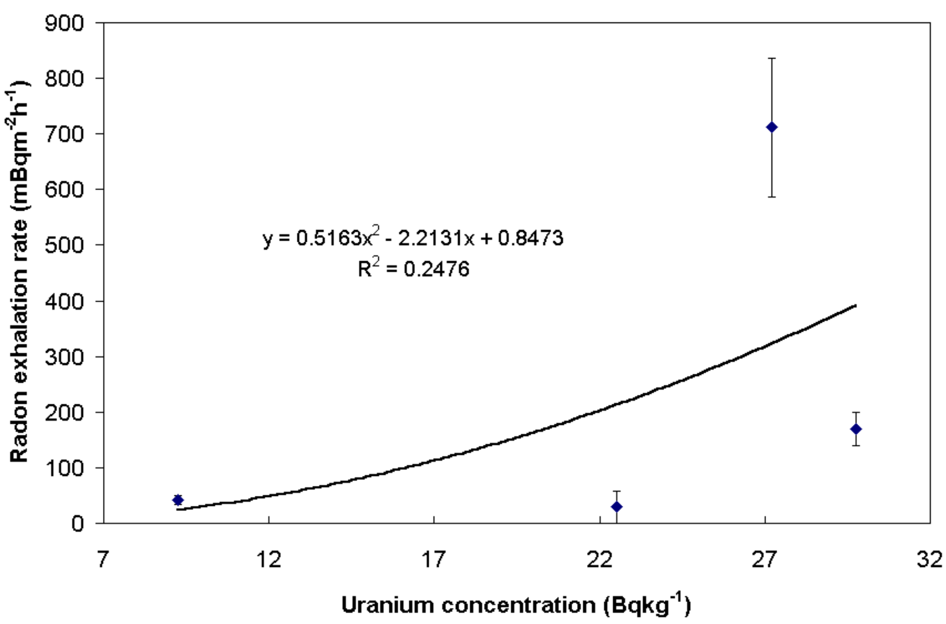

Fig. 3 Dependence of radon exhalation rate on the uranium concentration for raw of building bricks.

To compare the materials which containing different ^{238}U, ^{232}Th and ^{40}K, use radium equivalent activity Ra_{eq} ($Bqkg^{-1}$) formula(12) as follows

$$Ra_{eq} = S_U + 1.43 S_{Th} + 0.077 S_k \qquad (2)$$

The average value of Ra_{eq} in the measured samples were found 34.56 ± 5.26 $Bqkg^{-1}$. This value was smaller than the recommended maximum value 370 Bq kg^{-1}(12) .

The absorbed dose rate in air (D) in nGy h^{-1}, resulting from the activity concentration of ^{238}U, ^{232}Th and ^{40}K in Bq kg^{-1}, at a height of 1 m above the ground was calculated using the following formula(13):

$$\mathbf{D = 0.427 S_U + 0.662 S_{Th} + 0.0432 S_K} \qquad \mathbf{(3)}$$

Fig. 4 shows the variations of D values for all investigated samples. The maximum value was found for the sand clay sample. This value is lower than the international recommended value (55 nGy h^{-1}) (13)

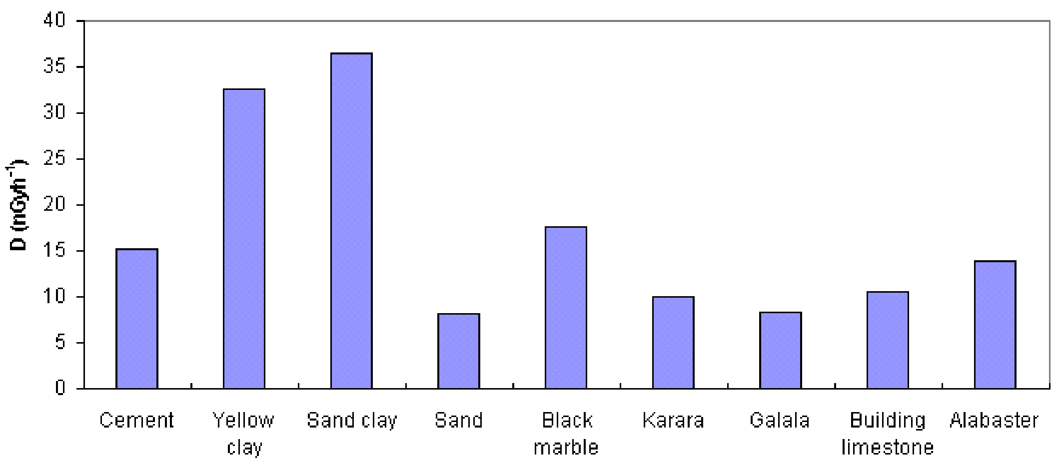

Fig. 4 The variations of absorbed dose rate in air (D) in nGy h^{-1} for alabaster, marble, raw building bricks and building limestone

The activity concentrations for some Egyptian building materials and comparison with other reported previous data are listed in Table 4.It is obvious from this table that there is an agreement between the present data and the reported data.

Table 4. Comparison of Activity concentrations in $Bqkg^{-1}$ of different Egyptian building material with the corresponding values reported previously

Type of building material	Activity concentrations			Reference
	^{226}Ra	^{232}Th	^{40}K	
Sand	9.2±2.5 9.26±3.28	3.3±1.3 2.91 ±0.1	47.3±9.0 54.52±6.64	7 Present
Cement	37.6±6.0 31.3±3.6 22.51±3.23	11.8±3.0 11.1±1.1 3.99±1.02	178.6±15 48.6±4.0 68.76±8.29	8 7 Present
Limestone	13.4±4.05 31.5±5.0 20.4±2.8	3.29±0.62 10.0±2.0 4.4±0.8	61±6.79 --------- 19.3±2.0	Present 8 7
Yellow clay	27.22±5.60 25.6±2.4	19.36±2.48 23.5±3.5	188.71±12.62 282±15	Present 7

CONCLUSION

From the present study, concluded that :-
1- The measurement of radon exhalation rate is considered an indicator for the uranium present in the alabaster, marble and raw of building bricks samples.
2-Using the Egyptian alabaster as a building material is very safe from radiation hazards of gamma rays and exhalation of radon gas.
3- The absorbed dose rate in air at a height of 1 m above the ground is lower than the international recommended value (55 nGy h^{-1}) for all test samples.

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