Araştırma Makalesi / Research Article

Calculation of Radiogenic Heat Productions from Marble and Glazed Tiles Used as Covering Building Materials in Turkey

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Abstract
In this study, radiogenic heat productions of marble and glazed tiles samples are calculated based on the elemental concentrations of uranium (in terms of mg/kg), thorium (in terms of mg/kg) and potassium (in terms of %) in the samples collected from various provinces in Turkey. The radiogenic heat productions from the marble tile samples varied from 0.05 to 2.17 µW/m3 with an average of 0.26 µW/m3. The average of the radiogenic heat production of the marble tile samples is approximately four times lower than the average continental crust of 0.9 µW/m3.

Keywords: Marble, Radiogenic heat production, Building materials.

Türkiye'de kaplama yapı malzemesi olarak kullanılan mermer ve sırlı karolardan radyojenik ısı üretiminin hesaplanması

Öz
Bu çalışmada, Türkiye'nin çeşitli illerinden toplanan mermer ve sırlı karo örneklerinin radyojenik ısı üretimi, uranyumun (mg/kg cinsinden), toryumun (mg/kg cinsinden) ve potasyumun (% cinsinden) temel konsantrasyonlarına göre hesaplanmıştır. Mermer karo örneklerinden elde edilen radyojenik ısı üretimi, ortalama 0.26 µW/m3 olam üzere 0.05 ile 2.17 µW/m3 arasında değişmektedir. Mermer karo örneklerinin radyojenik ısı üretiminin ortalaması, 0.9 µW/m3 ortalama kıtasal kabuk değerindenyaklaşık dört kat daha düşüktür.

Anahtar kelimeler: Mermer, Radyojenik ısı üretimi, Yapı malzemeleri.

1. Introduction

The radioactive elements that cause this are divided into two groups as short and long half-life isotopes. Long half-life radionuclides such as the member of natural radioactive series of uranium †(^{238}U), thorium (^{232}Th), actinium (^{235}U), and radioactive potassium (^{40}K). The two main radionuclides, ^{238}U (half-life of 4.5 x10^{9} y) and ^{235}U (half-life of 0.7 x10^{9} y), decay into lead, ^{206}Pb and ^{207}Pb, respectively.

In this study, radiogenic heat productions of marble tiles are calculated based on the elemental concentrations of uranium (in terms of mg/kg), thorium (in terms of mg/kg) and potassium (in terms of %) in the samples collected from various provinces in Turkey.

2. Material and Method

The elemental concentrations (EC) using the following formula:

$$EC = \frac{W \times A_C \times F}{\lambda_E \times N_{Av.} \times IA_E} \quad (1)$$

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The elemental concentration of ^{238}U was calculated. The radioactive heat production (H in µW/m^3) of given rocks or building materials can be calculated by using the equation [2]:

$$H = \rho \times (9.52 \times C_U + 2.56 \times C_{Th} + 3.48 \times C_K) \times 10^{-5} \quad (2)$$

where ρ is the bulk density of the rock or building material (in kg/m^3), C_U, C_{Th} and C_K is elemental concentration of U (in terms of mg/kg), Th (in terms of mg/kg) and K (in terms of %), respectively.

3. Results and Discussion

The values of elemental concentrations of U, Th and K in marble tile samples, and radiogenic heat productions calculated for marble tile samples are given in Table 1. It is seen from Table 1 that the elemental concentrations of U, Th and K varied from 0.1 to 4.6 mg/kg with an average of 0.7 mg/kg, 0.2 to 20.4 mg/kg with an average of 1.5 mg/kg and 0.04 to 2.4% with an average of 0.2%, respectively. The highest concentration of ^{238}U was measured in marble tile sample coded of MRB5 while the lowest concentration of ^{238}U was measured in marble tile samples coded of MRB17 and MRB25. The highest concentration of ^{232}Th and ^{40}K was measured in marble tile sample coded of MRB4 while the lowest concentration of ^{232}Th and $^{40}K$was measured in marble tile samples coded of MRB13 and MRB12, respectively. The value of H from marble samples varied from 0.05 to 2.17 µW/m^3 with an average of 0.26 µW/m^3. The highest value of radiogenic heat production was calculated in marble tile sample coded of MRB4. Comparison of the average value of the H calculated for the marble samples studied with those calculated for different rocks types is given in Table 2. From Table 2, the average value of the marble H is lower than those of rock types.

4. Conclusions

The average of concentration of U, Th and K in marble samples is lower than the average value of earth's crust of 2.5, 13 and 25000 mg/kg, respectively [6]. The average of the radiogenic heat production of the marble tile samples is approximately four times lower than the average continental crust of 0.9 µW/m^3. The contribution of ^{238}U, ^{232}Th and ^{40}K to total radiogenic heat production is estimated as 60%, 34% and 6%, respectively. The results revealed that radiogenic heat production by the marble samples varies according to the geological structure of the region.

Table 1. The values of radiogenic heat production of the marble samples

Sample code	^{238}U	^{232}Th	^{40}K	H (µW/m^3)
	mg/kg	mg/kg	(%)	
MRB1	0.3	0.8	0.2	0.13
MRB2	0.9	1.1	0.2	0.30
MRB3	0.6	1.0	0.2	0.21
MRB4	3.3	20.2	2.4	2.17
MRB5	4.6	0.8	0.1	1.08
MRB6	0.3	0.8	0.1	0.11
MRB7	2.4	0.6	0.1	0.58
MRB8	0.2	0.8	0.0	0.09
MRB9	1.9	2.3	0.3	0.59
MRB10	0.2	0.3	0.0	0.06
MRB11	0.2	0.3	0.0	0.06
MRB12	0.2	0.3	0.0	0.06
MRB13	0.5	0.2	0.1	0.13
MRB14	0.6	0.8	0.0	0.18
MRB15	0.3	0.6	0.1	0.11
MRB16	0.1	0.3	0.1	0.05
MRB17	0.1	0.3	0.1	0.05
MRB18	0.2	0.5	0.1	0.08
MRB19	0.4	0.6	0.0	0.14
MRB20	0.2	0.4	0.1	0.07
MRB21	0.1	0.5	0.1	0.06
MRB22	0.2	0.6	0.1	0.09

MRB23	0.3	0.8	0.1	0.12
MRB24	1.2	3.0	1.2	0.55
MRB25	0.1	0.3	0.1	0.05
MRB26	0.4	2.5	0.1	0.25
MRB27	0.5	1.1	0.1	0.19
MRB28	0.2	0.8	0.0	0.10
MRB29	0.2	0.6	0.1	0.08
MRB30	0.3	0.6	0.1	0.10
Average	0.7	1.5	0.2	0.26
Standard deviation	1.0	3.6	0.5	0.42
Standard error	0.2	0.7	0.1	0.08
Min	0.1	0.2	0.04	0.05
Max	4.6	20.2	2.4	2.17

Table 2. Comparison of the marble H with those calculated for different rocks [7]

Type of Rock	H ($\mu W/m^3$)
Granite (Egypt)	9.53
Granite (South Africa)	3.51
Quartz diorite (Egypt)	1.76
Quartz diorite (California)	0.40
Acidic rocks	2.38
Acidic rocks	2.84
Lamprophyre (Egypt)	1.74
Swiss Alps	1.12
Basalt (Egypt)	0.11
Basalt (Japan)	0.80
Basalt (Former USSR)	0.39
Metamorphic (Marble-Turkey)	0.26

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