International Journal of the Physical Sciences Vol. 5 (2), pp. 170-173, February, 2010
Available online at http://www.academicjournals.org/IJPS
ISSN 1992 - 1950 © 2010 Academic Journals

Full Length Research Paper

Natural radioactivity and dose rates in commercially-used marble from Afyonkarahisar - Turkey

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Accepted 14 January, 09

The gamma radiation has been measured to determine natural radioactivity of ^{238}U, ^{232}Th and ^{40}K in some marble materials produced in Afyonkarahisar region of Turkey. The absorbed dose rate and effective dose rate have been obtained from those activities. The measurement have been performed using a γ-ray spectrometer contains NaI(Tl) detector and Multi – Channel – Analyser (MCA). The activity of marbles has ranged from 38,883 - 195,726 Bq/kg for ^{238}U, from 32,165-47,814 Bq/kg for ^{232}Th, and from 106,264 - 351,755 Bq/kg for ^{40}K.

Key words : natural radioactivity, marble, NaI(Tl) spectrometer, Afyonkarahisar, Turkey.

INTRODUCTION

Gamma radiation has always been existed in environment since the big - bang occurred due to the long half-lives of the radionuclids from the ^{238}U and ^{232}Th series, and their decay products. These radionuclids are widely distributed and their concentrations depend on the local geological conditions. Therefore, it is important to measure the natural activity of all building materials collected from different places. This will help to assess the possible radiological risks to the human health.

A number of activity measurements have been performed for different types of materials in different places. Akkurt et al. (2009a) has measured activity of coal used in Turkey and some building materials (Akkurt et al., 2009b). The natural activity in building materials used in different countries has been measured and reported (Ahmed 2005; Ahmad et al., 1997; Armani et al., 2001; Bou - Rabee et al., 1996; Iqbal et al., 2000; Krstiica et al., 2007; Ngachina et al., 2007).In this paper, the gamma radiation has been measured in marble samples collected in Afyonkarahisar, Turkey to obtain activity of ^{238}U, ^{232}Th and ^{40}K activity. From those activities the absorbed dose rate and the effective dose rate have been obtained.

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EXPERIMENTAL DETAILS

In this study 5 different types of marbles have been collected in Afyonkarahisar region of Turkey. In Figure.1 the location of Afyonkarahisar in Turkey in which samples were collected has been shown. After collection of samples they have been dried until 100°C. The dried samples have been filled in a cup which is sealed tightly with a thick tape around its neck to limit any gas escape from it, and stored for four weeks to get secular equilibrium to be achieved between ^{238}U and its progeny (Yang Y.X, et al., 2005). Three marbles samples were collected from each location and averaged values have been used from the measurement.

The natural radioactivity of collected marbles have been measured using gamma spectrometer which contains a NaI(Tl) detector connected to MCA. As detailed in elsewhere (Akkurt et al., 2009a; Akkurt 2009b) the measurement has been based on recording natural radioactivity quantities of three natural long-live elements of ^{238}U, ^{232}Th and ^{40}K. The photopeaks related to those radioactive elements are considered at 1760, 2610, 1461 ke V respectively, in the natural γ-ray spectrum.

The activities for the natural radionuclides were calculated using the following relation:

$$A(Bq\ /\ kg) = \frac{N}{\varepsilon \cdot P \cdot M \cdot t} \quad (1)$$

Where; N is the net background subtracted counts recorded in the detector, ε is the detector efficiency of the specific γ-ray, P is the absolute transition probability of γ-decay, M is the mass of the sample (kg) and t is the counting time.

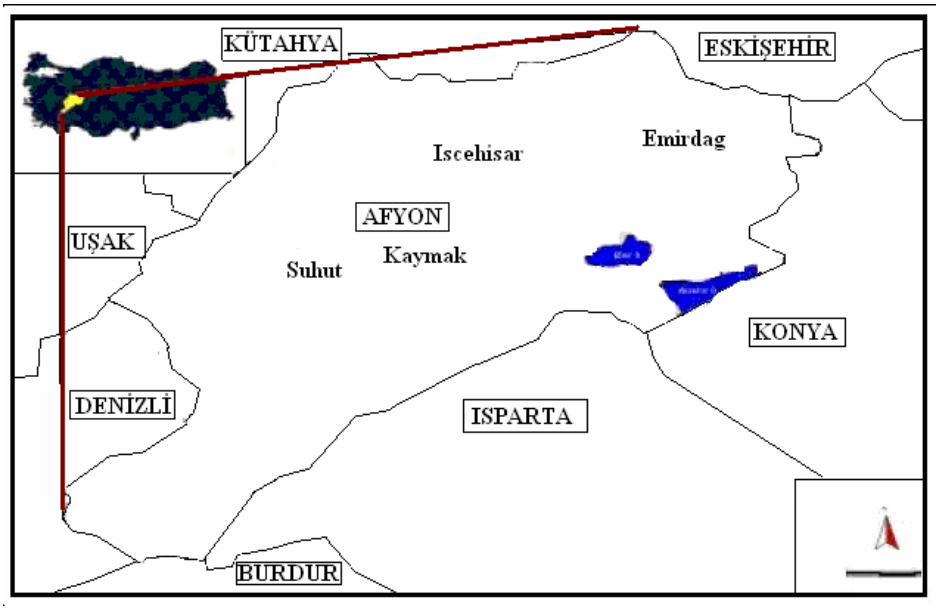

Figure 1. The places in Afyonkarahisar where samples were collected.

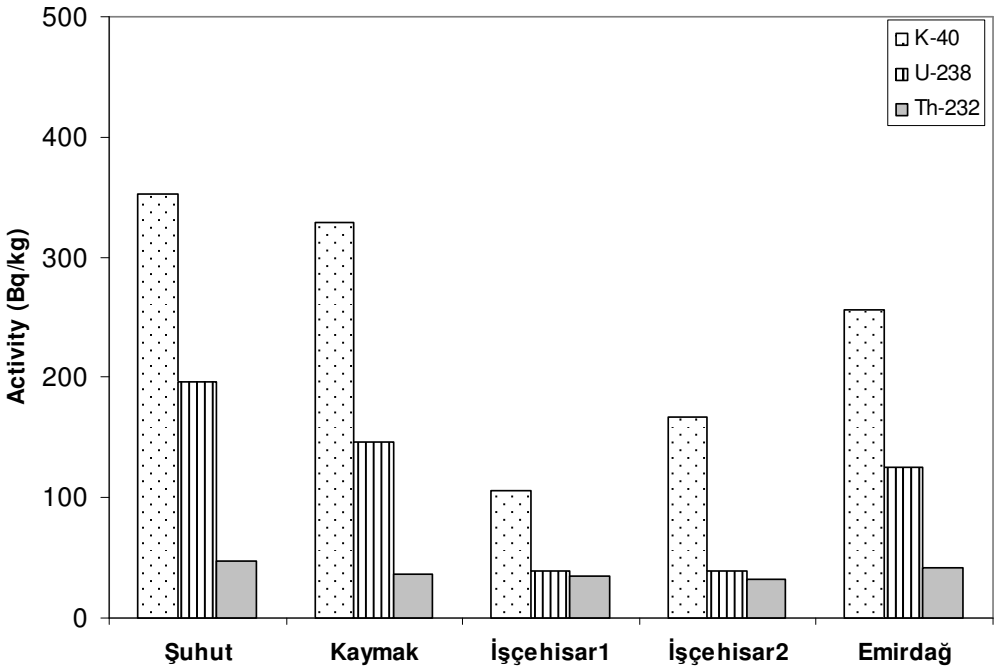

Figure 2. Activity of marbles samples collected from 5 different place.

RESULTS AND DISCUSSIONS

The natural activity of some rocks has been measured and the results have ranged from 38,883 - 195,726Bq/kg for ^{238}U, from 32,165-47,814 Bq/kg for ^{232}Th, and from 106,264 - 351,755 Bq/kg for ^{40}K. The obtained results have been displayed in Figure 2. It can be seen from this figure that the lowest values for all radionuclids have been obtained in iscwhisar1 and the highest values obtained in Suhut. In Figure 3 the activities have been displayed as a function of radionuclids. It can be clearly seen from this figure that the highest value obtained for ^{40}K and the lowest value obtained for ^{232}Th from all samples. The absorbed dose rate (D) in air at 1 m above the ground is calculated to provide a characteristic of the external terrestrial γ-ray (Veiga et al., 2006; UNSCEAR 2000):

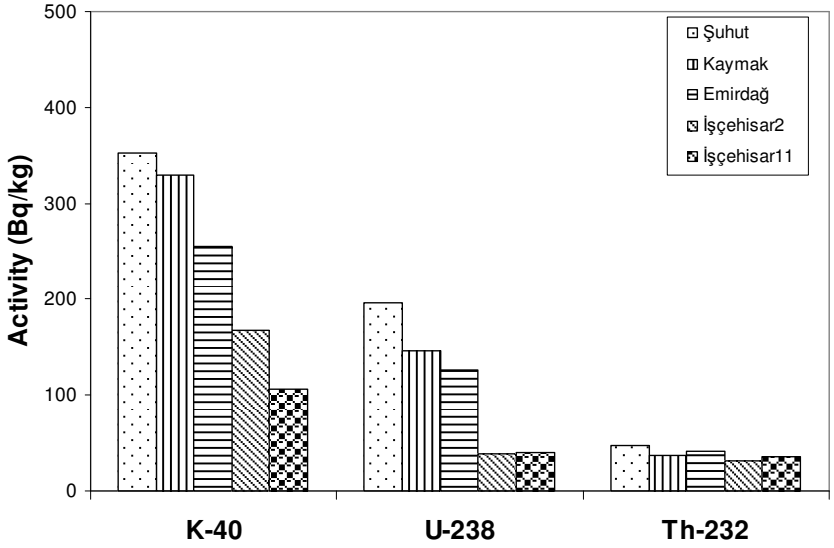

Figure 3. Comparison of each activities for samples.

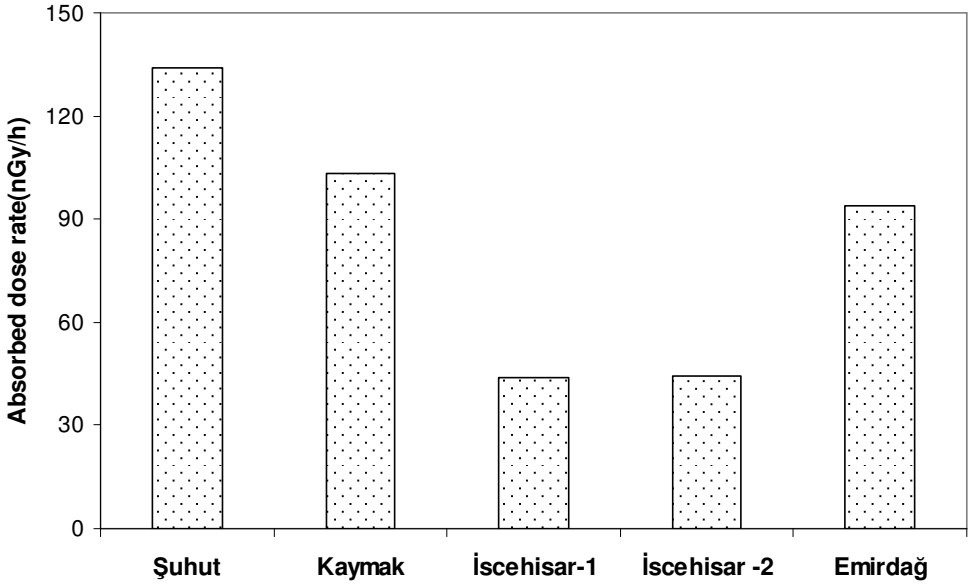

Figure 4. Absorbed dose rate for all samples.

$$D(nGy \cdot h^{-1}) = 0.462A_{Ra} + 0.604A_{Th} + 0.0417A_K \quad (4)$$

Where; A_{Ra}, A_{Th}, A_K represent the activity of ^{238}U, ^{232}Th and ^{40}K in Bq/kg. The absorbed dose rate is displayed in Figure 4 where it can be seen that three of the values obtained for marble is higher than the global average value of absorbed dose rate is 55 nGy/h (UNSCEAR 2000). This could be due to the geological differences of places where marbles are produced. The annual effective dose rates (EDR) is an important parameter in order to judge the health effects of the absorbed dose. By using the conversion coefficient from the absorbed dose in air to the effective dose (0.7 Sv/Gy) and the outdoor occupancy factor (0.2) proposed in ref. (Veiga et al., 2006), EDR has been obtained:

$$EDR(mSv\,y^{-1}) = D(nGy\,h^{-1}) \times 8760(h \cdot y^{-1}) \times 0.2 \times 0.7(SvGy^{-1}) \times 10^{-6} \quad (5)$$

The obtained results due to the marbles ranged 0.054 to0.1643 mSv.y^{-1}. The EDR results have been displayed in Figure 5. It is clear that none of the results are higher than the UNSCEAR limit where the average EDR from the terrestrial radionuclids is 0.460 mSv y^{-1} in areas with the normal background radiation (UNSCEAR, 2000). It

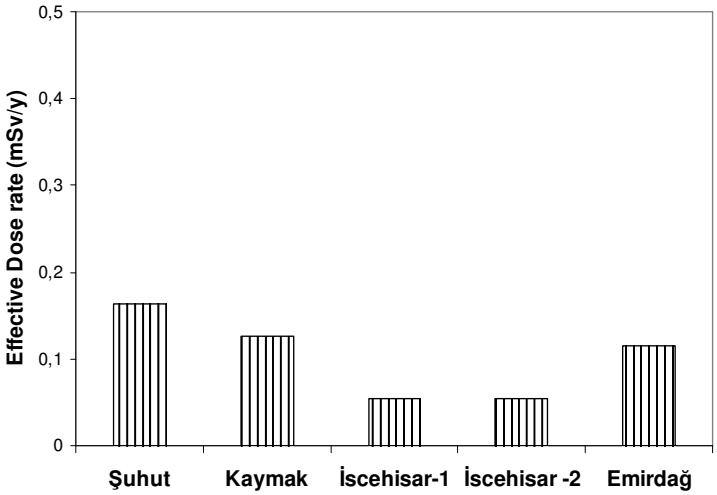

Figure 5. Effective dose rate for all samples.

can be concluded from this work that marble is an important material used in building construction and thus radiation dose due to the natural radioactivity of marble produced in Afyonkarahisar is between acceptable limits.

ACKNOWLEDGEMENTS

This work has been supported by the Research foundation of Afyon Kocatepe Üniversitesi with the project number of 06.FENED.19.

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