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Determination of uranium concentrations in some building materials in Iraq

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Abstract. Eleven commonly used building construction materials were collected from several origins in Iraq and analyzed for uranium concentration using a fission track technique. The results of measurements of uranium concentration ranged between 0.22 ppm in ceramics and 1.86 ppm in marble. The obtained results were well below the allowed limit of 11.7 ppm.

Key words: uranium concentration • fission tracks • CR-39 track detectors • building materials

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Introduction

Natural radioactivity mainly comes from earth crust and cosmic rays and is present in all rocks and building materials in varying amounts depending on their concentration levels. Radioactive elements such as ^{235}U, ^{238}U and their decay products may be present with high concentration in building materials which are the main source of indoor gamma radiation, beside terrestrial and the cosmic radiation [9]. All building materials such as concrete, cement, brick, sand, aggregate, marble, granite, limestone, gypsum, etc. contain mainly natural radionuclides, including uranium (^{238}U) and thorium (^{232}Th) and their decay products and the radioactive isotope of potassium (^{40}K). In the ^{238}U series, the decay chain segment starting from radium (^{226}Ra) is radiologically the most important and therefore reference is often made to ^{226}Ra instead of ^{238}U. The naturally occurring radionuclides in the building materials contribute to radiation exposure which can be divided into external and internal exposure [13]. The uranium concentrations in some typical rocks, granite, which is relatively rich in uranium, has an average concentration of about 4.8 ppm and basalt, which is relatively uranium-poor, has an average of about 0.9 ppm [7]. The knowledge of the natural radioactivity of building materials is important for the assessment of population exposure to indoor radiation. The naturally occurring radionuclides present in building materials are ^{226}Ra, ^{232}Th and ^{40}K. Because these radionuclides are not uniformly distributed in materials, knowledge of this radioactivity is essential for the development of standards and guidelines for the use and management of these materials [8]. The purpose of this work is to estimate the uranium concentration for different building materials commonly used in construction of houses in Iraq.

Experimental techniques

Fission track technique was used for analysis of trace uranium in building materials [5]. Samples of different building materials were taken from Iraq and some countries as shown in Table 1.

The samples were crushed to fine powder using 200 mesh sieve. Powder samples of 0.5 g mixed with 100 mg of methyl cellulose (acts as binder), the mixture were pressed into a pellet of 1 cm diameter and 1 mm thickness. The geological uranium (density 19.3 g/cm^3) standards samples recommended by the International Atomic Energy Agency of 1, 4, 6, 8 ppm of ^{238}U were prepared and used to calibrate the system for low and high range analysis. The pellets covered with CR-39 track detectors on both sides and put in a plate of paraffin wax at a distance of 5 cm from Am-Be neutron source with thermal flux (5000 n·cm^{-2}·s^{-1}), as shown in Fig. 1 it emits fast neutrons by the α,n reaction $^{9}_{4}\mathrm{Be} + {}^{4}_{2}\mathrm{He} \rightarrow {}^{12}_{6}\mathrm{C} + {}^{1}_{0}\mathrm{n}_{\mathrm{fast}} + 5.71$ MeV. The irradiation time was seven days with a fluence of thermal neutron (3.02×10^9 n·cm^{-2}), the induced fission fragments were obtained according to the (n, f) reactions [5]

$$^{235}_{92}\mathrm{U} + {}^{1}_{0}\mathrm{n}_{\mathrm{thermal}} \rightarrow {}^{236}_{92}\mathrm{U}^{*} \rightarrow {}^{141}_{56}\mathrm{Br} + {}^{92}_{36}\mathrm{Kr} + 3^{1}_{0}\mathrm{n}$$

After irradiation, the CR-39 detectors were separated from the samples and etched in 6.25 N NaOH solution for 6 h at 60°C to reveal fission tracks. The developed fission tracks were counted using an optical microscope at a magnification of 400×. The uranium concentration in building material was determined using the formula [6].

$$C_{ux} = (T_x / T_s)(I_S / I_x)(R_s / R_x)\, C_{us}$$

where C_{ux} and C_{us} are the uranium contents in unknown and standard samples, respectively. T_x and T_s are the track densities in CR-39 for unknown and standard samples, respectively. T_s/Cu_s was the slope of Fig. 2.

I_x and I_S are the isotope abundance ratios of ^{235}U to ^{238}U in the unknown and standard samples, respectively. R_s and R_x are the ranges of fission fragments in the standard and unknown samples, respectively. The term I_S/I_x is taken as unity, assuming the isotope abundance ratio to be the same for unknown and standard samples [12]. The ratio R_s/R_x is also assumed to be unity.

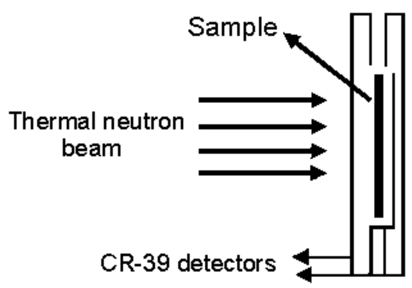

Fig. 1. The irradiation of the detector and sample in the neutron source.

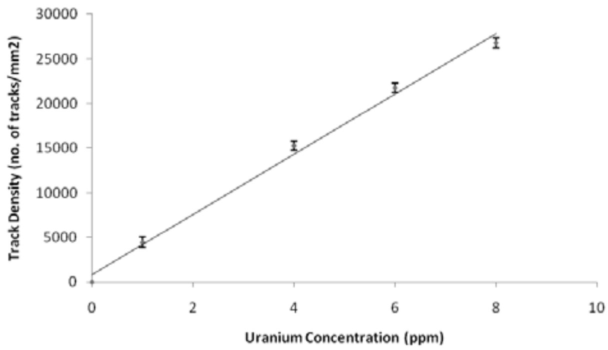

Fig. 2. Uranium concentration for standard samples.

Result and discussion

The standard deviation (SD) of the background measurements was then determined in terms of concentration, the calculation of the detection limit at the 99% confidence level using the formula of ($DL = 2.8 \times SD$). The obtained value of standard deviation was 0.0035 ppb with a detection limit of 0.01 ppb. The results of uranium concentration in the building materials are given in Table 1. The range of natural uranium concentrations may average as low as 0.22 ± 0.01 ppm (2.71 Bq/kg) in Egyptian ceramic building material to as high as 1.86 ± 0.03 ppm (22.94 Bq/kg) in Turkish white marble. The concentration was extremely low, except for three samples (Turkish white marble, Turkish ceramics stone and Turkish red granite) as shown in Fig. 3. The source of high activity concentration levels of the samples are chiefly the presence in radiogenic accessory minerals, uranium concentration of marble, ceramics stone and granite are intimately related to their mineral compositions and general petrologic features [2, 10, 15]. It seems that ceramic, concrete, block, bricks, stone and kashi produced from natural gypsum stone and the normal-weight aggregates made of sedimentary rocks have a small concentration of uranium.

Table 1. Uranium concentration in building materials samples

Sample kind	Average concentration of uranium (ppm)[a]
Iraqi thermston	0.68 ± 0.019
Iraqi block	0.41 ± 0.015
Iraqi kashi	0.49 ± 0.016
Chinese ceramics	0.54 ± 0.017
Iraqi bricks	0.56 ± 0.014
Egyptian ceramics	0.22 ± 0.01
Iraqi natural building stone	0.56 ± 0.017
Turkish white marble	1.86 ± 0.03
Turkish black marble	0.82 ± 0.02
Turkish ceramics stone	1.36 ± 0.01
Turkish red granite	1.01 ± 0.03

[a] ppm – it means part per million, this is the concentration of chemical or element in something like food or drink.

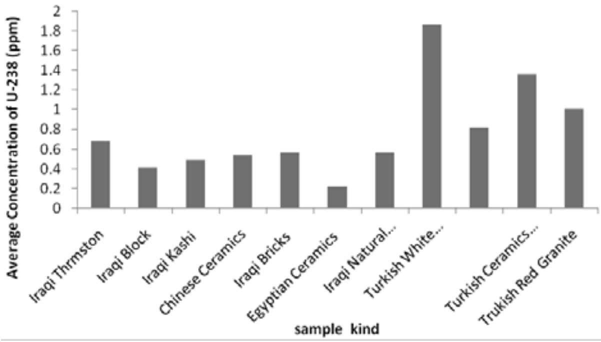

Fig. 3. Average concentration of uranium in building material samples.

The concentrations were within the recorded values in different countries, and the variation mainly depends on geological origins [3, 11].

When the results of this study are compared with other studies [1, 4] it is fair that to say that the obtained values from this study is similar to that of the commonly investigated samples. The uranium content in samples are less than the allowed limit 11.7 ppm from UNSCEAR [14].

Conclusions

In this work, ^{238}U concentrations were measured in a variety of commonly used building materials in Iraq using fission tracks technique. Eleven kinds of different building materials samples, which are the most common types in Iraq, were used in this study. The results indicate that the uranium concentration varies in the range 0.22 ppm in the Egyptian ceramics which recorded the lowest concentration while Turkish white marble measured the highest concentration of 1.86 ppm.

The concentrations of ^{238}U are found to be normal and within the average world ranges.

The results may not reflect the real situation in all types of building materials in the selected studied areas. For more accurate results that best represent the regions of the country, detailed studies can be carried out for all the different types of building materials used, using a higher number of samples. This study can also be used as a reference for more extensive studies and the results serve as a source of information to assist in the formulation of regulatory guidelines for decision-making in Iraq.

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