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Research Article

Screening Level of Gross Alpha and Beta Activities in Building Materials

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The objective of the present study is the screening of the gross alpha and gross beta activity of some building materials commercialized in Saudi Arabia. The measurements were carried out using a gas flow proportional counter. The study has shown that the gross alpha activity ranged between 0.21 and 8.27 Bq/kg with an average activity of about 1.96 Bq/kg, whereas the gross beta activity ranged between 6.47 and 276.47 Bq/kg with an average activity of about 65.27 Bq/kg. The obtained values of gross alpha and beta activities are in the worldwide range and no significant activity was observed that accentuate the attention, which show that no radiation risks come from these building materials and, therefore, from their origin areas.

1. Introduction

In the environment, there are many natural and artificial sources of radioactivity [1]. The earth and atmosphere are the two principal natural sources. The natural radionuclides originate from uranium (^{238}U) and thorium (^{232}Th) series as well as potassium (^{40}K), whereas the artificial radionuclides, such as ^{137}Cs, generally come from a nuclear accident. These radionuclides are widely spread in the earth and it is present in various forms whose abundances differ significantly depending on the local geological features of each region [2, 3]. They can pass from the earth's crust to the surface, where they become natural sources of radiations. The radionuclides can be transferred to humans by different pathways such as by ingestion (radionuclides in food, water, or beverages), by inhalation of radon, which represents about50% of natural exposure of people [3], and also by dermal adsorption (radionuclides can enter the body through a wounded skin). However, monitoring of the radioactive elements in the environment and the determination of radioactivity level for different matrices, concerning the human, are very important and fundamental for human health maintenance [4]. According to the world organization UNSCEAR [5], humans are exposed to external radiations of 2.4 mSv/y, in which the terrestrial radiations pathway contributes to around 0.48 mSv/y, with 0.41 mSv/y related to indoor occupancy and 0.07 mSv/y to outdoor occupancy. However, the determination of the activity level of natural radioactive nuclides in soils, rocks, and therefore in building materials gives knowledge of the natural sources and the amount of radioactivity in a given region. All building materials contain radionuclides at different levels because of natural presence. These materials are used essentially for the construction of human dwellings, so they contribute to an additional radioactivity, which increases the radiation exposure [6] on human. Thereby, it is necessary to determine the amount of activity level in these materials and monitor them. Many methods are used to determine the activity level in many matrices such as soil, rocks, water, beverages, and building materials.

The gross alpha and beta measurement is one of the radioanalytical techniques which is widely used for screening radioactivity in many fields such as radioecology and environmental monitoring [7, 8], without regard to the identity of specific radionuclides. This technique gives direct information on overall radioactivity content, as all alpha and beta emissions are effectively measured.

As a result of this, several authors have used this technique to screen the radioactivity level in different matrices [8–13]. Due to the possible risks of background radiations on the human health and, in particular, their presence in building materials used to construct dwellings, it is so necessary to screen these materials and determine the order of magnitude of radioactivity level as well as the hazards, which is the main objective of the present study. We have also determined, in this work, the gross alpha and beta activities in many samples of different building materials commercialized in Saudi Arabia markets by using a gas flow proportional counter in order to give an order of magnitude of radioactivity in these materials.

2. Materials and Methods

2.1. Samples Preparation. Twenty-one samples of different building materials (cement, red bricks, ceramics, granular, marble, sand, and gypsum) were collected from Saudi Arabia markets. The origins of these samples are from different countries (Saudi Arabia, Italy, Turkey, and Oman). The type and the number of each sample are presented in Table 1. Some samples are powders such as cement, and the other samples were crushed and milled into powder in our laboratory.

2.2. Description of Equipment Used for the Analysis. The equipment used in the present work is the gas flow proportional detector type LB4200 manufactured by Canberra. It is a multidetector low background alpha/beta counting system. It is essentially designated for applications requiring high sample throughput with long counting times, or where a number of samples must be counted at the same time [14].

The LB 4200 system can be configured from one to four counting drawers. The maximum detector capacity is sixteen 5.7 cm or 3.1 cm detectors, or four 12.7 cm detectors.

The LB 4200 counter has an electronic gas monitoring system that automatically delivers optimal gas pressure to the detectors. Usually such types of detectors are filled with a noble gas since they have the lowest ionization voltages and do not degrade chemically. Often the main gas is mixed with a quenching additive. In our case, the detector was filled with P-10 (mixture of 90% argon and 10% methane).

Concerning the calibration, the detector is calibrated using the standard sources of ^{90}Sr and ^{210}Po. The efficiency is about 38% for alpha and 45% for beta particles, respectively [14].

To control and analysis the counting data, the LB4200 system incorporated the Apex-Alpha/Beta software [15], which is the software used for most gas flow alpha/beta counters.

The following equation was used to determine the gross alpha/beta specific activity (Bq/kg) [16]:

$$A_{\alpha,\beta} = \frac{N_{\text{net}}}{m \times \varepsilon_{\alpha,\beta} \times 60}, \quad (1)$$

where m (kg) is the mass sample, $\varepsilon_{\alpha,\beta}$ is the total alpha/beta efficiency, and N_{net} is the net alpha/beta counts measured by counts per minute (cpm), and 60 is to convert cpm to counts per second (cps). Note that the counting time for each sample is 500 minutes.

3. Results and Discussion

Table 1 shows the obtained results in net counts per minute (cpm) and the specific activities for both alpha and beta particles. The average gross alpha activity varies from 0.21 ± 0.09 to 8.27 ± 0.58 Bq/kg for ceramic and red brick samples, respectively, whereas it varies from about ≤6.47 to 276.27 ± 3.83 Bq/kg for gross beta in both granite and red brick samples, respectively. The highest activity for alpha and beta particles obtained in the red bricks show that it contains high natural radionuclides level in comparison with the other building materials studied.

The average value of activity for all building material samples is about $1.96 \pm 0.21$and 65.27 ± 3.72 Bq/kg for both alpha and beta activities, respectively, which gives a total average alpha and beta activities about 67.23 ± 3.93 Bq/kg.

The natural radioactivity in the soil and rocks and in building materials is generally due to the presence of ^{210}Pb (^{238}U) and ^{228}Ra (^{232}Th), which are the major contributors of beta activity [16] as well as ^{40}K, whereas the alpha activity is essentially due to the heavy radionuclides such as radium (the major contributor) [16], actinium, and thorium as well as their progenies.

Given that there is no nuclear accident in the origin area of the used building materials, the contribution of the artificial radionuclides is very low and will be negligible relative to that of natural radionuclides. However, it is concluded that the activity concentration of the building materials is essentially due to the presence of natural radionuclides, which is an expected result.

From the obtained results, the gross alpha activity is found to be less than gross beta activity in all samples, which is in good agreement with the published results such as References [2, 17, 18]. This result is expected since the intensity of alpha particles decreases rapidly with the distance and they lose their energy due to the interaction with air before interact with gas and, therefore, not registered in the counter.

Inversely, beta particles can travel longer distances in air and can lose their energy into absorption materials, so the number of beta particles reaching the gas is more than that of alpha particles. The highest average activity for alpha and beta particles was obtained in the red bricks such as mentioned above, whereas the lowest is in ceramics for alpha particles and in granite for beta particles. Figure 1 depicts a relatively good correlation ($R^2 = 0.74$) between the gross alpha and beta activities in all samples.

The obtained activity results are compared with those in building materials as well as in the soil or rocks which are the origin of the building materials. The present values of alpha and beta activities are comparable to the values obtained in references [2, 8, 17], whereas they are lower than those reported elsewhere [18–21].

However, the lowest values of alpha and beta activities obtained in the present work are expected because no nuclear accident occurred in the origin area of the used building materials.

Table 1: Gross alpha/beta counts (cpm) and activities (Bq/kg).

Type and number of samples	Average net alpha counts (cpm)	Average net beta counts (cpm)	Average gross alpha activity (Bq/kg)	Average gross beta activity (Bq/kg)
Cement (5)	0.04 ± 0.008	2.33 ± 0.31	0.78 ± 0.16	34.67 ± 4.58
Marble (3)	≤0.09	0.67 ± 0.19	≤2	10.04 ± 2.87
Ceramics (3)	0.01 ± 0.004	7.83 ± 0.35	0.21 ± 0.09	115.53 ± 5.24
Sand (2)	≤0.12	4.02 ± 0.21	≤2.56	60.43 ± 3.20
Red bricks (2)	0.40 ± 0.03	18.4 ± 0.25	8.27 ± 0.58	276.27 ± 3.83
Granite (2)	0.016 ± 0.005	≤0.44	0.34 ± 0.10	≤6.47
Gypsum (2)	0.05 ± 0.01	0.77 ± 0.17	1.14 ± 0.21	11.71 ± 2.62
Granular (2)	0.02 ± 0.006	≤0.49	0.40 ± 0.13	≤7.26
Average activity for all samples (Bq/kg)			1.96 ± 0.21	65.27 ± 3.72

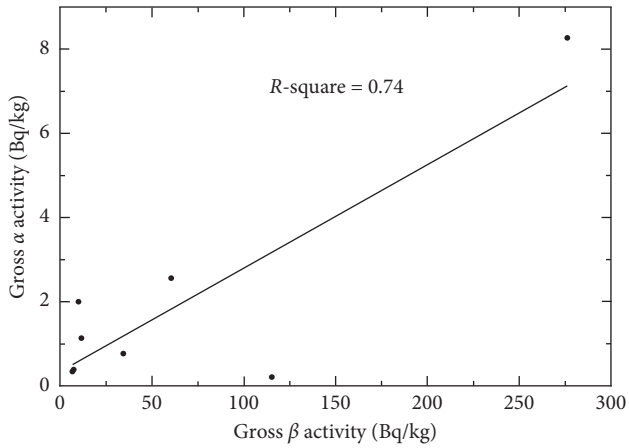

Figure 1: Correlation between gross alpha and beta activities.

Concerning the radiological risk on the human health, the alpha particles are heavily charged particles and a layer of paper or human skin is sufficient to stop them, but they can easily enter into the human body either by ingestion (by ingestion of water or food) or by inhalation of air (radon) and, therefore, become hazardous. In the same way, beta emitters are also more hazardous when they enter into the body by the same ways. However, the alpha and beta particles become dangerous if they enter into the body by ingestion (food or water) or by inhalation (radon in air), and the radiological risk on people health increases.

In contrary of ingestion or inhalation, people living in dwellings are not in direct contact with the house walls, and so they are not exposed directly to these radiations. The alpha and beta particles emitted by the radionuclides present in the building materials are not dangerous because usually they can be stopped in the air before reaching the body.

The exposure of alpha/beta radiations by humans, from construction materials and in particular from dwelling houses, is very little, and so the absorbed dose will be very small or negligible compared to that comes from ingestion or inhalation.

Finally, the external exposure due to alpha or beta radiations, emitted by radionuclides present in building materials, carries little radiological risk to the human health [22] and in particular people living in dwellings or the workers in the building material companies.

4. Conclusions

The gross alpha and beta activity concentrations in building materials commercialized in Saudi Arabia markets have been determined by the using alpha/beta counter. The obtained result shows a relatively good correlation between our values and other published data. The obtained lowest activity levels show no radiations risk, and so it does not cause immediate human health effects.

The advantage of the studied gross alpha and beta data is that it is creating a baseline of radioactivity level for further studies in the origin areas of the used building materials. Finally, this work can serve and give a general idea on the screening level of radioactivity in some building materials for researchers doing similar work.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest regarding the publication of this paper.

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