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# Evaluation of the natural radioactivity ($^{238}U$,$^{232}Th$,$^{40}K$) in building materials used in Iraqi homes

*Roua* Mouaid Ali[1,*], *Ansam* Qassim Gadhban[2], *Yassir* A. Baqir[3], and *Shireen* N. Alebadi[4]

[1]College of Medicine, University of Iraq, Department of Physiology, Baghdad, Iraq
[2]Middle Technical university, Baghdad, Iraq
[3]Science department, College of Basic Education, Mustansiriyah University, Baghdad, Iraq.
[4]Al-Furat Al-Awsat Technical University, Engineering Technical College of Najaf, Department of Health Physics and Radiation Therapy Technical Engineering, Najaf, Iraq

**Abstract.** The purpose of this study is to quantify the amounts of natural radioactivity of the building materials employed in homes throughout Iraq due to three radioactive elements present: thorium-232 (232Th), potassium-40 (40K), and uranium-238 (238U). Radiation levels and specific activity of these elements in the materials were determined by gamma-ray spectroscopy. The specific activities (average value for each element) wereUranium-238 ($^{238}U$): 23.3633 ± 2.035 Bq/kg, $^{232}Th$: 10.1967 ± 1.482 Bq/kg, Potassium-40 ($^{40}K$): 217.4367 ± 25.815 Bq/kg.So, this means the rate of radiation emitted in Kg of building material in these naturally occurring radioactive elements. The research compares this data with international safety limits to look at whether the levels of natural radioactivity in the materials could have health implications for local people.

## 1 Introduction

Natural radioactivity and its possible effects on human health have been a topic of concern in recent years, especially in areas where there are rich natural resources of radionuclides. Here and there, the radioactive elements thorium-232 (232Th), potassium-40 (40K), and uranium-238 (238U) are found in the environment, including soils, rocks, and even in the building materials used in the homes we live in. These substances are dangerous for the environment and health when found in buildings or workplaces where humans stay for longer periods of time [1,2]. Therefore, the assessment of construction materials' inherent radioactive levels, particularly the materials that frequently used in Iraqi houses, is essential for evaluating of the possible radiological hazard and maintain of public health and safety [3]. Iraq, which is privileged with natural and geological resources, has crossed a more polluted stage due to wars, rapid urbanization and industrialization. The high levels of natural background radiation found in many areas of Iraq are due to the local soil and the rocks containing high concentrations of natural radionuclides [4]. The use of local construction materials in residential buildings, including limestone, gypsum and clay, can lead to different

* Corresponding author: roua.m.ali@aliraqia.edu.iq

levels of natural radioactivity [5]. These materials, when introduced to indoor environments, can result in cumulative radiation exposure, which could, over the long-term, pose an increased risk of health defects, including cancer [6]. Radioactivity is natural; earth crust contains trace amounts of isotopes of radioactivity. Thorium-232 (232Th), potassium-40 (40K), and uranium-238 (238U) are naturally" occurring isotopes found on earth which contribute to the background radiation. Uranium and thorium are heavy metals that occur in some rocks and soils, and potassium-40 is an ordinary occurrence isotope of potassium that is widely distributed in nature [7-9]. This study aims to assess the outdoor ionizing radiation arising from the building materials commonly used in Iraqi homes; this study accomplishes that by determining the potassium-40, thorium-232, and uranium-238 activity concentrations in a piety of building materials used in Iraqi homes, in addition to figuring out the radioactive risk indexes based upon the measured values and evaluating the possible negative health effects of prolonged radiation exposure generated from these materials. This latest research aims to present the radiological significance of building materials in Iraq, based on the data collected.

# 2 Materials and methods

## 2.1 Sample collection and preparation

The natural radio nuclides concentrations are reported in 30 Building materials Samples with an average of 15 imported and 15 local samples. These samples have been collected from various local markets of Bagdad and then sealed in plastic bags with labels and delivered to the radiation detection and measurement facility. A 1 L polyethylene Marinelli beaker serves as the sampling and measuring container for this project. Before being used, the containers are rinsed with distilled water and cleaned with diluted hydrochloric acid. Samples were placed in an oven to dry and remove moisture at 100Co for 24 hrs. for the analysis. The samples are then crushed mechanically to a degree of homogenization suitable for analysis, using a model FT102 micro soil attrition mill supplied by TAISITE; after homogenization, the samples were passed through a sieve of 0.8 mm pore size diameter. All samples were previously kept achieving secular equilibrium for four weeks before measurement. The light cap of the Marinelli breaker presses on the sample to ensure that all the air is removed. Each of the samples are then hermetically sealed and dry weighed in a standard Marinelli beaker within ±0.01% using a highly sensitive digital weighing balance, and no less than 1 kg of each sample is used. For a long-time measurement, the sample is coupled face-to-tail with the detector.

## 2.2 Measurements of system

In the current study, gamma-ray spectroscopy techniques were used to classify samples because of the considerable penetrating power of gamma rays in the structures. The multi-channel analyzer (MCA) (ORTEC-Digi Base) and a concern program (MAESTRO-32) are connected to the NaI(Tl) (3"×3") crystal dimension scintillation detector (purchased from Alpha Spectra, Inc.-12I12/3) in the lab PC for analysis (Fig.1). A spectrum from five common gamma radiation sources (22Na, 60Co, 54Mn, 137Cs, and 152Eu) was used to energy calibrate a NaI (Tl) detector. The energy calibration curve for these sources shows a linear relationship between energy and channel numbers. The energy resolution value for the 137Cs standard source at 662 keV was 8.6%. The secular equilibrium of 214Bi (1765 keV) and 208Tl (2614 keV) was used to determine the specific activities of each identified sample for

238U and 232Th, respectively, whereas the specific activity of 40K was directly calculated at phase position of 1460 keV.

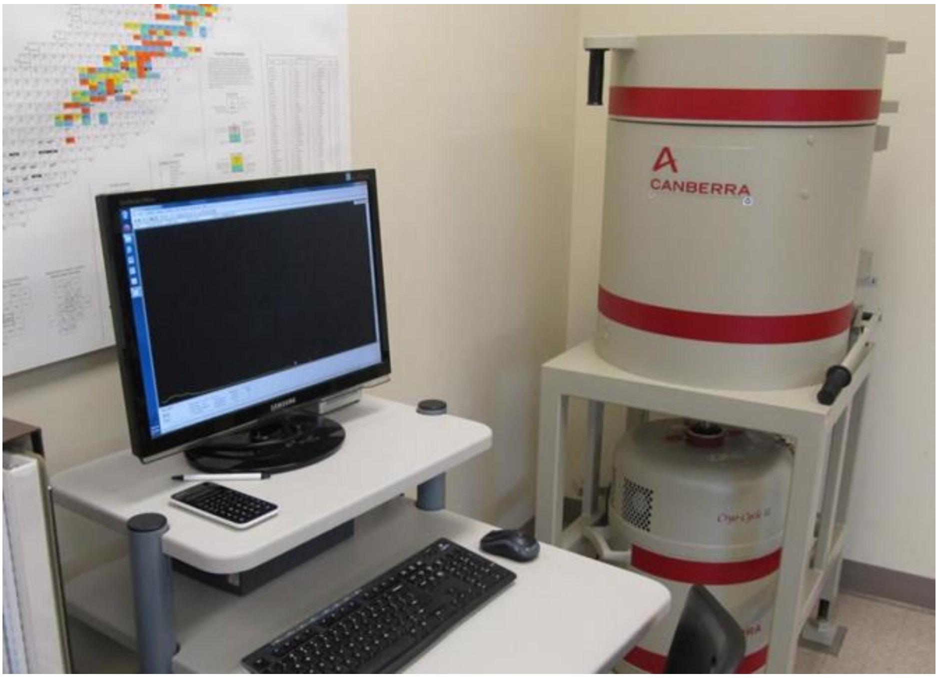


**Fig. 1**. Gamma-ray spectroscopy.

### 2.3 Calculations

Specific Activity (A)
The following formula was used to determine the specific activity of the radionuclides 238U, 232Th, and 40K (represented as AU, ATh, and Ak, respectively):

$$\mathbf{A}\left(\frac{\mathbf{Bq}}{\mathbf{kg}}\right) = \frac{\mathbf{N}}{\mathbf{I_\gamma\ \varepsilon\ M\ T}} \tag{1}$$

where N represents the net area beneath the photopeak, Iγ denotes the likelihood of gamma decay, ε signifies the detector's effectiveness, M indicates the mass of the sample, and the measurement pertains to time.

## 3 Results

The activities and ratios of the radionuclides 238U, 232Th, and 40K in 30 samples of construction materials are presented in Table 1. The specific activity 238U, 232Th, and 40K, were 23.3633 ±2.035 Bq/kg; 10.1967 ±1.482 Bq/kg and the average were the; 217.4367 ±25.815 Bq/kg respectively. A comparison with the average global activity is shown in Fig. 2-4.

**Table 1**. Results of particular activity for 40K, 238U, and 232Th in current samples.

| No. | Sample code | Specific activity in Bq/kg | | | | | |
|---|---|---|---|---|---|---|---|
| | | $^{238}$U | | $^{232}$Th | | $^{40}$K | |
| | | Average | S.E | Average | S.E | Average | S.E |
| 1 | p1 | 12.0 | 0.7 | 25.5 | 0.7 | 476.7 | 4.3 |
| 2 | p2 | 31.0 | 1.2 | 8.5 | 0.3 | 167.6 | 2.5 |
| 3 | p3 | 26.8 | 1.4 | 19.6 | 0.6 | 486.1 | 4.3 |
| 4 | p4 | 22.5 | 1.3 | 0.8 | 0.1 | 173.2 | 2.6 |
| 5 | p5 | 30.1 | 1.6 | 12.0 | 0.6 | 141.2 | 2.3 |
| 6 | p6 | 33.4 | 1.2 | 6.8 | 0.5 | 120.7 | 2.2 |
| 7 | p7 | 40.6 | 1.3 | 11.3 | 0.4 | 510.9 | 4.4 |
| 8 | p8 | 29.7 | 1.6 | 20.2 | 0.6 | 465.8 | 4.2 |
| 9 | p9 | 25.1 | 1.8 | 27.5 | 0.9 | 352.0 | 3.7 |
| 10 | p10 | 20.6 | 0.9 | 25.6 | 0.8 | 315.9 | 3.5 |
| 11 | p11 | 18.8 | 1.1 | 13.3 | 0.5 | 410.8 | 4.0 |
| 12 | p12 | 33.2 | 1.4 | 5.5 | 0.4 | 57.1 | 1.5 |
| 13 | p13 | 26.9 | 1.3 | 8.3 | 0.4 | 161.5 | 2.5 |
| 14 | p14 | 26.3 | 1.3 | 6.9 | 0.4 | 125.4 | 2.2 |
| 15 | p15 | 24.0 | 1.4 | 4.0 | 0.3 | 84.4 | 1.8 |
| 16 | p16 | 26.2 | 1.2 | 3.7 | 0.3 | 147.1 | 2.4 |
| 17 | p17 | 29.1 | 1.2 | 6.4 | 0.4 | 125.4 | 2.2 |
| 18 | p18 | 12.5 | 0.7 | 22.8 | 0.6 | 260.8 | 3.2 |
| 19 | p19 | 6.3 | 0.6 | 4.2 | 0.2 | 90.6 | 1.9 |
| 20 | p20 | 5.2 | 0.4 | 8.2 | 0.4 | 149.5 | 2.4 |
| 21 | p21 | 10.7 | 0.6 | 2.1 | 0.2 | 91.6 | 1.9 |
| 22 | p22 | 16.4 | 1.0 | 3.5 | 0.2 | 140.4 | 2.3 |
| 23 | p23 | 31.3 | 1.3 | 5.3 | 0.3 | 150.3 | 2.4 |
| 24 | p24 | 40.3 | 1.4 | -1.6 | 0.4 | 100.1 | 2.0 |
| 25 | p25 | 18.6 | 0.8 | 6.5 | 0.3 | 117.7 | 2.1 |
| 26 | p26 | 22.3 | 1.1 | 23.7 | 0.6 | 100.6 | 2.0 |
| 27 | p27 | 7.0 | 0.5 | 11.1 | 0.5 | 166.4 | 2.5 |
| 28 | p28 | 12.6 | 0.8 | 2.8 | 0.2 | 189.0 | 2.7 |
| 29 | p29 | 19.4 | 1.0 | 4.4 | 0.3 | 476.7 | 4.3 |
| 30 | p30 | 12.0 | 0.7 | 7.0 | 0.4 | 167.6 | 2.5 |
| **Aveage±S.E** | | 23.3633 ±2.035 | | 10.1967 ±1.482 | | 217.4367 ±25.815 | |
| **Worldwide** | | **33** | | **45** | | **420** | |

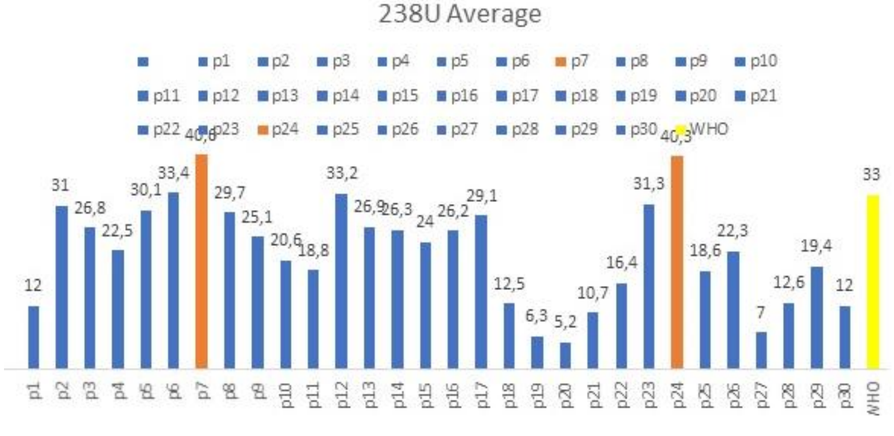


**Fig. 2**. A comparison of the particular activity for 238U with the average global activity, by UNSCEAR 2008.

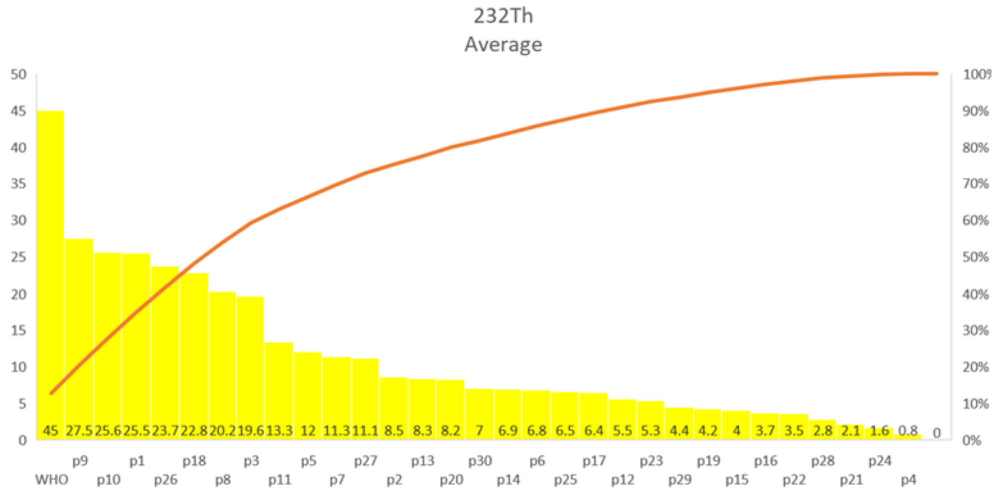


**Fig. 3**. A comparison of the particular activity for 232Th with the average global activity, by UNSCEAR 2008.

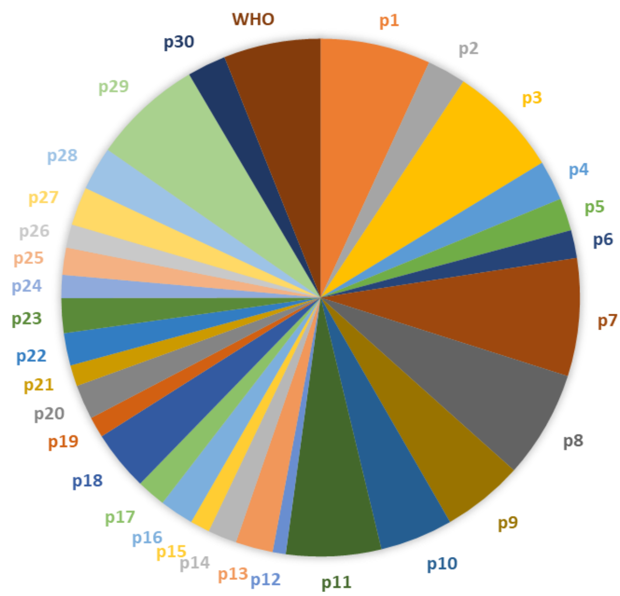


**Fig. 4**. A comparison of the particular activity for 40K with the average global activity, by UNSCEAR 2008.

## 4 Discussions

Among the radioactive elements, uranium ( $^{8}$U), thorium ($^{32}$Th), and potassium ($^{40}$K) are among the most examples occur naturally in trace amounts in the crust of the earth. These are found naturally in a variety of materials found in the environment. These radioactive elements are often found in building materials like stone, granite, sand, concrete, and bricks but in low concentrations. Sources of Radioactivity: The three naturally occurring isotopes are Potassium-40 ($^{40}$K), uranium ($^{238}$U), and thorium ($^{232}$Th) will be discussed. Being in the Earth's crust, raw materials used in common construction, such as stones, sands or clays, can be contaminated with these isotopes. Variation in Concentrations: These radioactive elements may vary in concentration depending on geography and which raw materials you are using. For instance, the radioactivity of materials may be slightly greater if the earth is naturally rich in uranium or thorium. Specific Building Materials: Both of these natural stones are used for construction and countertops. Because of the geological conditions in which they are formed, they are also typically more enriched in uranium and thorium than other materials. Concrete and Bricks These building supplies are created using mixtures, including sand and aggregates, which can contain potassium. Potassium itself naturally contains the radioactive isotope potassium-40. Moreover, small amounts of uranium and thorium may also be present in concrete and bricks depending on basic ingredients that are utilized in the production of each item. Cement-like concrete and bricks are commonly produced by mixing together several raw ingredients, such as limestone, clay and other additives. These materials may contain trace amounts of uranium and thorium. In addition, if the cement contains any of these raw materials, like fly ash or slag, which may contain natural radioactive substances, the level of radioactivity in the cement varies.

## 5 Conclusion

This study would provide an estimate of natural radioactivity levels from ($^{238}U$), thorium ($^{232}Th$), and potassium ($^{40}K$) in the building materials normally used in the homes of Iraqi families. While radionuclide concentrations in the materials are within acceptable levels of safety, such radionuclides merit concern about the potential health effects they may pose on human health, particularly in poorly ventilated or high-density settlements. Ongoing monitoring of these products is important and if, based on its results, necessary regulations should be developed and implemented to prevent exposure to residential areas from ionizing radiation. Moreover, by raising knowledge of the risks of natural radioactivity through preventive action such as ensuring safer building materials are used and proper ventilation of houses, the associated risks could be minimized.

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