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Measurement of natural radioactivity in bread product samples available in Iraqi markets

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Abstract

Bread product is one of the main meals used by man for all age categories characterized as a cheap, quick, and therefore it must study the brad product in all scientific research, such as natural radioactivity. In this research, it is measured the natural radioactivity (^{40}k, ^{238}U, ^{232}Th) for ten samples of bread product that available in the Iraqi market, using gamma ray spectrometer NaI(Tl). Also, it was calculated the radium equivalent activity and internal hazard index. The results found that, the specific activity for potassium-40 were ranged from (14.91±0.89) Bq/kg to (112.45±2.99) Bq/kg with an average (50.64) Bq/kg, while the specific activity for uranium-238 ranged between (3.49±0.42) Bq/kg to (15.33±1.04) Bq/kg with an average (6.44) Bq/kg, but for thorium-232 were ranged from (0.64±0.11) Bq/kg to (5.44±0.31) Bq/kg with an average (2.29) Bq/kg. It also found that total average radium equivalent activity and internal hazard index were (13.61) Bq/kg and (0.054) respectively. The study has shown that the levels of radioactivity and radiological hazard index (radium equivalent activity and internal hazard index) in samples of bread product were less than the limit value of organization UNSCEAR and OECD. Finally, can be seed all samples under study are found to be safe.

Keywords: Gamma ray; NaI(Tl); Bread; Food; Iraqi markets.

1. Introduction

Background radiation surrounds us every time and everywhere. It is an integral part of our life, where all forms of life on earth have been exposed to ionizing radiation. Background radiation is emitted from both natural and human-made radionuclides. Naturally radionuclides come from the atmosphere as a result of radiation from outer space, earth's crust such as rocks mineral ores and soil, and our bodies as a result of radionuclides in the water and food. People are exposed to nuclear radiation every day in their lives. Some of this radiations are from natural sources and others are from artificial sources. Natural sources include cosmic radiation, terrestrial radiation and internal radiation. Artificial sources include medical procedures, commercial products that contain radioactive materials, and fallout from nuclear testing [1]. Terrestrial radiation is also called earth radiation source. The major Terrestrial radiations are uranium, thorium, potassium and any of their radioactive decay products, such as radium and radon [2, 3]. The basic component of our life support system is considered to be in the soil, water, air and vegetation, from which it is inhaled and ingested into the body. These environmental components contain measurable amount of radioactivity. The specific metabolic character of the plant species may lead to accumulation of radio -nuclides in their organs, which may further depend upon the physic -chemical characteristics of the soil [4]. Therefore, there may be increased risk to human population via food chain [5]. The radionuclides present in the environment are transferred to plants by two ways: first indirect method uptake from soil through roots. When food crops are grown in the contaminated soil, the activity is shifted from the soil to the roots and then in shoots. At the end, activity is transferred to the human diet [6]. These radio-nuclides can get transferred into plants along with the nutrients during mineral uptake and accumulate in various parts and even reach edible portions [7]. Second, it is a direct method absorption through aerial parts of the plants. Presence of radioactivity in plant organs has been reviewed by various workers [6]. The plants roots are naturally related to microorganisms, and these associations can have direct or indirect impacts on the mobility, availability and acquisition of elements by plants [7, 8]. Nowadays, agricultural chemical fertilizers are an essential component of the agricultural activities that help to increase crop production and improve the properties of the nutrient-deficient lands. However, a possible negative effect of chemical fertilizers is the contamination of cultivated lands by trace elements and some naturally occurring radioactive materials (NORM) [9]. Therefore, the agricultural usage of chemical fertilizers could be a potential source of radiation exposure to the farmers and general public [10]. Measurement of the natural radiation levels due to ^{238}U, ^{232}Th and ^{40}K in food product were investigated by several studies in countries around Iraq and other countries in the world [11-14]. Overall aim of this study is to measure the natural radioactivity levels in samples of bread product that are consumed in Najaf, Iraq using gamma spectroscopy (NaI(Tl)). Also, it calculated the radium equivalent and internal hazard index in all samples under study.

2. Materials and methods

2.1 Sample collection and preparation

Ten Samples from bread product were collected from the local markets in Najaf, Iraq for the period from 1/11/2018 to 1/1/2019 as shown in Table 1.

Table 1. Food categories of bread product samples in this study.

No.	Sample name	Sample code	Made
1	Loof	B1	Iraq
2	kb	B2	
3	Beirut	B3	Lebanon
4	Beirut Breeze	B4	
5	Karat Belady	B5	Syria
6	Soft Roll Brad	B6	
7	Lusine	B7	Saudi
8	Emad	B8	
9	Iranian Brad	B9	Iran
10	Rich Bake	B10	Egypt

The bread product samples were dried under the sun. After drying, each sample is placed in a plastic bag and labeled by name and country of origin. Then the samples were crushed electronically, using electric mill. For homogeneity, the samples were sieved (0.8mm-pore-size sieve); they were kept moisture-free in an oven, in order to reach a constant weight. Samples were packed in 1 -liter polyethylene plastic (Marinelli beakers) of constant volume (the containers before use, the containers have been washed with dilute hydrochloric acid and rinsed with distilled water and coded to the specific code in order to distinguish between samples, to achieve geometric homogeneity around the detector, and then the respective net weights were measured and recorded with a highly sensitive digital weighing (using a high sensitive digital weighting balance with a per cent of (±0.01%). Next, the marinelli beakers were sealed with PVC tape, and were stored for about 1 month before counting to reach secular equilibrium between the isotopes of natural decay series.

2.2 System of measurement used in this study

NaI(Tl) system, as shown in Figure 1, was used which consists of a scintillation detector NaI(Tl) of (3"×3") crystal dimension, supplied by (Alpha Spectra, Inc.-12I12/3), coupled with a multi-channel analyzer (MCA) (ORTEC –Digi Base) with range of 4096 channel joined with ADC (Analog to Digital Convertor) unit, through interface. Finally, the spectral data was converted directly to the PC of the laboratory introduced using (Maestro-32) software.

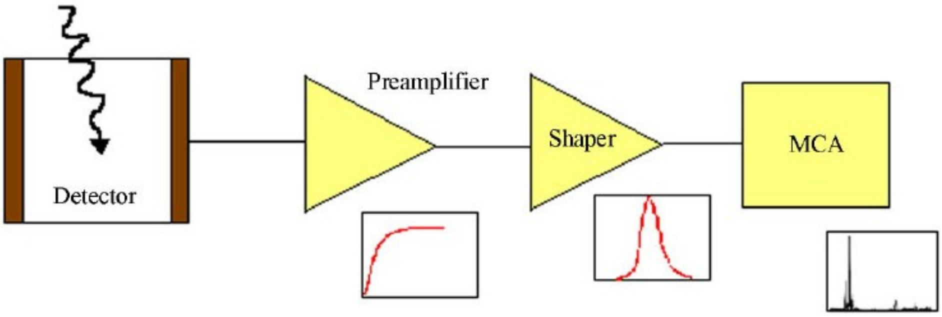

Figure 1. Block diagram of a spectroscopy system.

In order to reduce the background radiation, the detector is maintained in a vertical position and shielded by ORTEC cylindrical chamber. The shielding consists of two parts, the upper one is composed of lead 5cm thick and 20cm long surrounding the crystal with a cover that is 5cm thick and has a diameter of 22cm. The lower part forms the base. To minimize the effect of the scattered radiation from the shield, the detector is located at the center of the chamber. The high voltages necessary for the work is 775 volts and is within the range of stability of the operating voltage of the detector and was equipped with voltages of type classy. An energy calibration for this detector is performed with a set of standard γ-ray sources from USNRC and State License Expert Quantities, "Gamma Source Set", Model RSS–8. The variation in the absolute photo-peak detector efficiency with gamma-ray energy was calibrated using four sources; ^{22}Na, ^{54}Mn, ^{60}Co and ^{137}Cs. The calculated resolution is 7.9 % for energy of 661.66 keV of ^{137}Cs standard source, where is normally (5-10) % for NaI(Tl) detectors for the ^{137}Cs 0.662 MeV gamma [15, 16].

3. Calculations

The measuring of the specific activity is possible at a good separated photo-peaks at high energies as that obtained in our results from the gamma rays emitted by the progenies of ^{238}U and ^{232}Th which were in secular equilibrium with them while, ^{40}K was estimated directly by its gamma-line of 1460 keV. Hence the specific activity of ^{238}U was determined using the gamma-lines 1764.5 keV (^{214}Bi). The corresponding results of ^{232}Th were determined using the gamma-ray lines 2614 keV(^{208}Tl). Since the counting rate is proportional to the amount of the radioactivity in a sample, the specific activity in (Bq/kg), is given by equation [11, 12]:

$$A_{rf}\left(\frac{Bq}{kg}\right)=\frac{N-N_o}{I_\gamma \times \varepsilon \times m \times t} \tag{1}$$

Where A_{rf} is the specific activity of the radionuclide in the sample given in Bq/kg, N is the net counts of a given peak for a sample, N_o is the background of the given peak, I_γ is the number of gamma photons per disintegration, ε is the detector efficiency at the specific γ-ray energy, m is the mass in kg of the measured sample and t is the counting time for the sample.

The radium equivalent activity is considered as the greatest commonly used radiation hazard index (Ra_{eq}). This factor is the weighted sum of activities of the three radionuclides which are the specific activity of ^{238}U (^{226}Ra), ^{232}Th and ^{40}K, Ra_{eq} activity is given by [11]:

$$R_{eq}\left(\frac{Bq}{kg}\right)= A_{Ra} + 1.43 A_{Th} + 0.077 A_K \tag{2}$$

The internal index (H_{in}) was also determined using the following equations [12]:

$$H_{in} = \frac{A_{Ra}}{180} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \tag{3}$$

4. Results and discussion

The natural radioactivity for gamma -ray natural radioactivity duo to long-lived gamma emitters in 10 samples from bread product commonly used in Najaf governorate, Iraq are analyzed. The results of arithmetic mean specific activity values ± standard error (S.E.) in Bq/kg for ^{238}U, ^{232}Th and ^{40}K in present samples compared with the worldwide median values reported by UNSCEAR (2000) are given in Table 2. This table shows that the highest value of specific activity for ^{238}U was (15.33±1.04 Bq/kg) in sample B6 (Soft Roll Brad, made in Syria), while the lowest value of specific activity in sample B8 (Emad, made in Saudi) was (3.49±0.42 Bq/kg), with an average (6.44±1.11 Bq/kg). Also, the same Table 2 shows that the highest value of specific activity for ^{232}Th was (5.44±0.31Bq/kg) in B5 (Karat Belady, made in Syria), but the lowest specific activity was (0.64±0.11Bq/kg) in B1 (Loof, made in Iraq), with an average (2.29±0.65 Bq/kg). The highest specific activity that it is displayed in Table 2 corresponds to radionuclide ^{40}K was (112.45±2.99 Bq/kg) in sample B6 (Soft Roll Brad, made in Syria), while the lowest value was (14.91±0.89 Bq/kg) in sample B3 (Beirut, made in Lebanon), with an average (50.63±10.75 Bq/kg).

Table 2. The specific activity of ^{238}U, ^{232}Th, and ^{40}K in bread samples under study.

No.	Sample code	Specific activity (Bq/kg)		
		^{238}U	^{232}Th	^{40}K
1	B1	3.50±0.42	0.64±0.11	16.44±0.96
2	B2	6.07±0.52	1.76±0.18	25.05±1.12
3	B3	4.13±0.42	0.94±0.14	14.91±0.89
4	B4	6.77±0.52	3.09±0.23	89.15±2.03
5	B5	6.19±0.51	5.44±0.31	67.18±1.79
6	B6	15.33±1.04	5.43±0.40	112.45±2.99
7	B7	5.36±0.49	1.18±0.15	34.44±1.31
8	B8	3.49±0.42	1.44±0.17	77.84±2.11
9	B9	4.83±0.53	1.03±0.16	24.11±1.26
10	B10	8.73±0.61	1.95±0.19	44.81±1.47
Average ± S.E		6.44±1.11	2.29±0.65	50.63±10.75
Worldwide median value		32	30	400

The differences are significant in all samples in these values of specific activities in bead product samples due to geochemical composition and origin of soil cultivation kinds in these location. Also, it can be seen in the Table 2 and Figure 2, the average value of specific activity for uranium-238 level is higher than thorium-232 in all samples. It is also noticed that the specific activity of ^{40}K exceeds markedly the values of each ^{238}U and ^{232}Th, as it is that the most abundant radioactive element among other element. Furthermore, the excessive use of potassium containing fertilizers in the adjacent to the sampling sites might contribute to the upper values of ^{40}K activity. The results of specific activity in natural radioactivity for the collected bread product samples under study were lower than the world median according to UNSCEAR 2000 [17] which are 32, 30 and 400 Bq/kg for ^{238}U, ^{232}Th and ^{40}K respectively.

Figures 4 and Figure 5 show the spectrums of sample B1 (Loof, made in Iraq) and sample B6 (Soft Roll Brad, made in Syria) respectively.

Table 3 illustrates the value of radium equivalent activity (Ra_{eq}) and internal hazard index (H_{in}) duo to ^{238}U, ^{232}Th and ^{40}K in samples under study. From Table 3, the lowest value of Ra_{eq} was (5.68 Bq/kg) in sample B1 (Loof, made in Iraq), while the highest value was (31.75 Bq/kg) in sample B6 (Soft Roll Brad, made in Syria), with an average (13.61±2.74 Bq/kg). The values of H_{in} has been determined for various samples of bread production which ranged from (0.02) in sample B1 (Loof, made in Iraq) to (0.13) in sample B6 (Soft Roll Brad, made in Syria), with an average (0.054±0.009). The values obtained for radium equivalent activity (Ra_{eq}) and internal hazard index (H_{in}) in All samples under study are lower than 370 Bq/kg and unity which is the maximum value of the permissible safety limit recommended [18, 19]. It may be concluded that the high activity concentration of Ra_{aq} is still in the range of the permissible level.

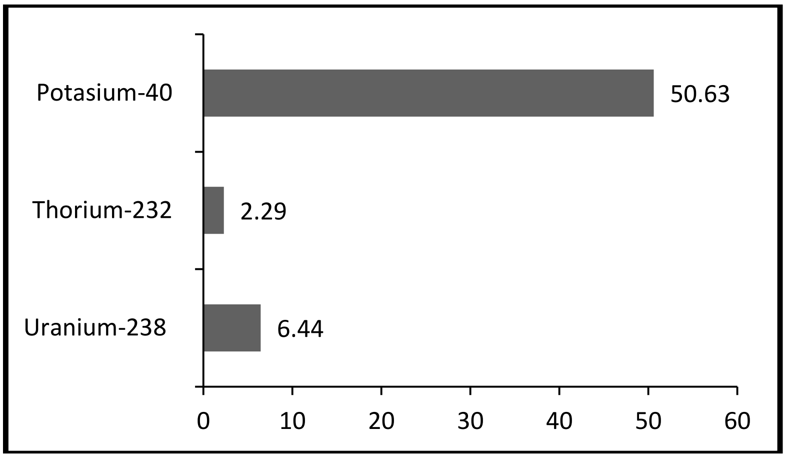

Figure 2. Average of the specific activity (Bq/kg) in samples under study.

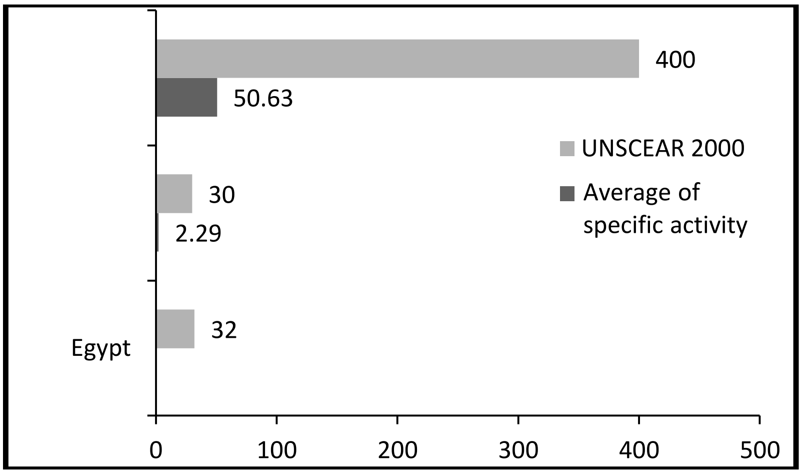

Figure 3. Compare between averages of the specific activity in samples under study with UNSCEAR 2000.

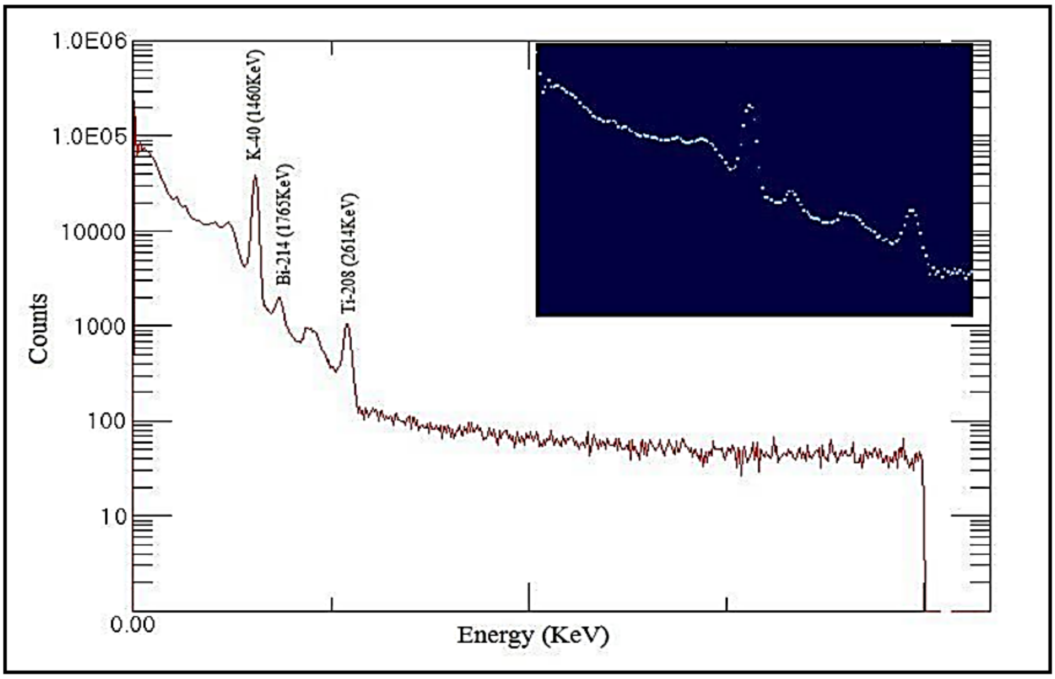

Figure 4. The spectrum of sample B1 (Loof, made in Iraq) in Maestro-32.

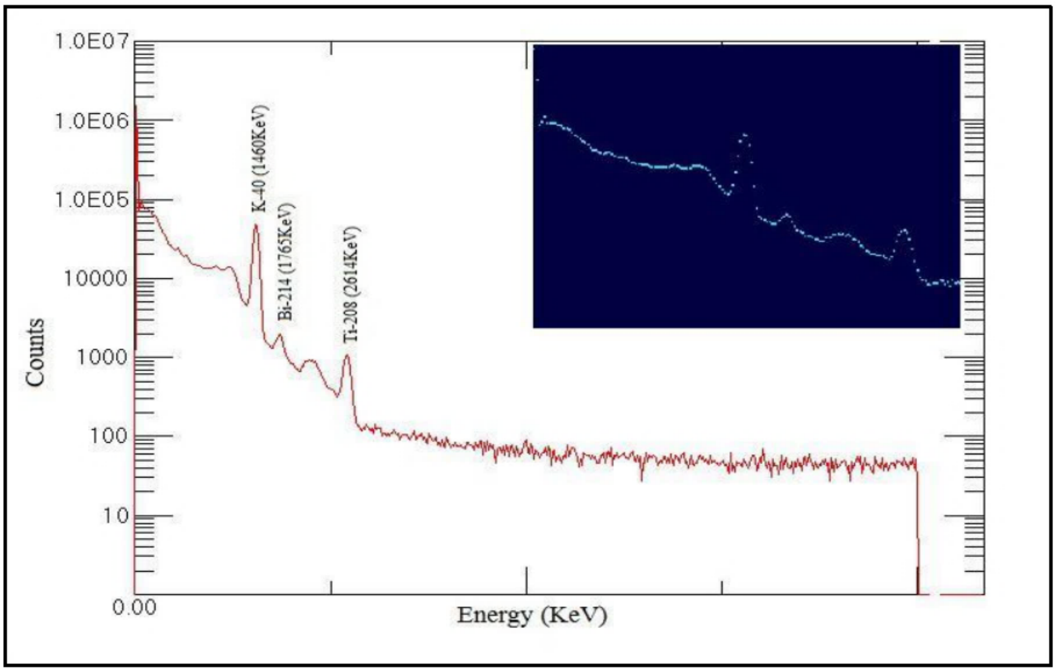

Figure 5. The spectrum of sample B6 (Soft Roll Brad, made in Syria) in Maestro-32.

Table 3. The Ra_{eq} and H_{in} due to ^{238}U, ^{232}Th, and ^{40}K in bread samples under study.

No.	Sample code	Raeq (Bq/kg)	Hin
1	B1	5.68	0.02
2	B2	10.52	0.04
3	B3	6.62	0.03
4	B4	18.05	0.07
5	B5	19.14	0.07
6	B6	31.75	0.13
7	B7	9.70	0.04
8	B8	11.54	0.04
9	B9	8.16	0.04
10	B10	14.97	0.06
Average ± S.E		13.61±2.74	0.054±0.009
Worldwide median value		370	<1

When we compare the results of the average specific activity for ^{238}U ,^{232}Th and ^{40}k which obtained from the current study at different countries as shown in Table 4., it is found that the average of the specific activities for ^{238}U are higher than Syria, but lower than the values recorded in Saudi. The average value of the specific activities for ^{232}Th in Iran are less than other counties. The average of the specific activities for ^{40}K in Iraq were lower than other countries.

Table 4. Compare the average value of specific activity for bread product samples at different counties.

County	Specific activity (Bq/kg)		
	Uranium-238	Thorium-232	Potasium-40
Iraq	4.785	1.2	20.745
Lebanon	5.45	2.015	52.03
Syria	10.76	5.435	89.815
Saudi	4.425	1.31	56.14
Iran	4.83	1.03	24.11
Egypt	8.73	1.95	44.81

5. Conclusion

The results from this study show that the, specific activity in food (Bread product) samples for natural radionuclides such as (^{238}U, ^{232}Th and ^{40}K) have been found to be lower than worldwide median value (32, 30 and 400) data from the recommended reference UNSCEAR 2000. The values of radium equivalent activity and internal hazard index from bread product consumption by human in all samples was lower than the permissible limit according to report that it recommended by OECD and UNSCEAR 2000. At last, there are no health hazards when eating of the samples bread samples under this study.

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