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Measurement of Natural Radioactivity in Certain Types of Nut *Samples* in Iraq

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ABSTRACT

Introduction: The present study was conducted to measure the specific activities of ^{226}Ra,^{232}Th and ^{40}K, in some samples of nuts collected from the local markets in Iraq. In addition, this study sought to calculate the annual effective dose of gamma ray to children and adults.

Material and Methods: The quantification of radionuclides was accomplished by gamma spectrometry NaI (Tl) detector.

Results: According to the results, the specific activity of ^{226}Ra ranged from 1.39±0.53 to 13.33±1.19 Bq/kg with a mean value of 6.71±1.34 Bq/kg. However, regarding ^{232}Th and ^{40}K, their specific activities had the range values of 0.29±0.09 to 2.43±0.25 and 232.06±8.42 to 376.47±6.26 Bq/kg with the mean values of 1.68±0.50 and 308.57±17.76, respectively. Furthermore, the mean values of the total annual effective radioactive dose in 10-year-old children and adults were 7.43±0.86 and 54.48±6.32 µSv/y, respectively.

Conclusion: As the findings indicated, the values obtained for the specific activity of natural radionuclides samples under study were far below the world standard for the ingestion of naturally occurring radionuclide provided by the United Nations Scientific Committee on the Effects of Atomic Radiation (2000) report. The results indicated that the estimated total annual effective radioactive dose in all samples was lower than the value of annual dose limit of 1 mSv/y for public exposure, which is determined by the International Commission on Radiological Protection. Based on the results for each sample, it can be concluded that nut consumption do not expose the Iraqi population to any health risk.

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Introduction

The earth entails various levels of radioactivity due to natural radioactive decay series, such as uranium-238 (^{238}U) and thorium- 232 (^{232}Th), as well as singly occurring radionuclides, like potassium-40 (^{40}K). However, the radioactivity has the ability to transfer from the air or agricultural land into the crops, and then into the human bodies [1]. Human life is highly reliant upon many different resources; this includes water, soil, plants, and air which naturally had a certain level of radioactivity that is necessary to be investigated. . However, the radionuclides may accumulate inside the organs of plant species due to their metabolic character, which is determined by the physicochemical properties of the soil. Taking up a contaminated food is therefore expected to contribute to the amount of risk that human beings are subjected to. Air, water, and soil represent the primary sources through which radioactive contamination can transfer from environment to plants [2]. Occasionally, the radionuclides present in the environment can transfer into plants through two indirect and direct methods. In the indirect method, the radionuclides are transferred from the contaminated soil to the plant through root uptake. This process ends by the accumulation of these radionuclides in human's food chain [3]. These radionuclides have the ability to transfer to plants within the nutrients by mineral uptake and accumulate inside the plant parts [4,5]. Nuts are considered as a more healthy plant food, compared to other foods due to their healthy fat, protein, and fiber. However, potassium involves in the biochemical reactions in human body and is one of the agents accounting for the slight radioactivity of human body. Moreover, radium is accumulated in the ground; therefore, it is absorbed into the plants through their roots.

For instance, the Brazil nuts have the ability to emit around 6,600 pCi/kg of radiation. Occasionally, this radiation has no damage when passing through the body

This radiation level is considered to have no considerable effect on human body especially when

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consuming nuts that enriched with healthy selenium and other minerals

[6]. Furthermore, organic and chemical fertilizers are used in many countries to enhance the crop yield given the world population growth and the subsequent increase in their food demands.

The inherent radioactive elements in the soil and phosphate fertilizers can be transferred to human bodies through the food chain. Regarding this, it is necessary to assess radioactive doses in food and water samples [7]. Thallium-doped sodium iodide NaI(Tl) is the most popular spectroscopic scintillation material used in detectors (gamma ray). These detectors (NaI(Tl)) are inexpensive and easily available, and potentially of a large size. Moreover, they works at room temperature and do not need any cooling systems for operation [7]. These detectors have been used for the measurement and identification of the level of specific activity of "naturally occurring radioactive materials" in the food for a decade [6].

In many Arabic countries, such as Iraq, no investigation has examined radioactivity elements (e.g., gamma emitters) in nut samples, and there is no report on the baseline concentration of natural and anthropogenic radioisotopes. Consequently, the collection of data regarding the concentrations of radioisotopes would provide useful information and a suitable original baseline for population exposure. Nuts with high levels of natural radioactivity can lead to health problems because they are usually consumed for a long time. With this background in mind, the present study was conducted to determine the specific activities of ^{226}Ra, ^{232}Th, and ^{40}K, as well as their corresponding annual effective dose in nut samples consumed in Iraq.

Materials and Methods

Sampling and experimental treatments

This study was conducted on nine nut samples collected from the local markets across different regions of Al-Najaf city, Iraq (Table 1). These samples were coded, kept in plastic bags, and stored in the laboratory. In order to obtain a homogeneous material for the measurements, the nuts were ground in mills with titanium knives. Except for grinding, no other treatment was performed on the samples due to having high oil content.

Table 1. Samples of nuts under study

No.	Sample Name	Sample Code
1	Almonds	N1
2	Cashews	N2
3	Hazelnuts	N3
4	Peanuts	N4
5	Peanuts	N5
6	Pine Nuts	N6
7	Pistachios	N7
8	Walnuts	N8
9	Walnuts	N9

The grinded samples were placed in cylindrical plastics pots (1 L), and then sealed to prevent radon release. These sealed pots were kept for at least 30 days to reach an equilibrium condition with progeny nuclides of ^{226}Ra. Three important data, namely date of sealing, sample name, and sample weight, were recorded on every pot. The measurement of the specific activities of ^{226}Ra, ^{232}Th, and ^{40}K in nut samples were carried out in a gamma-ray spectrometer (ORTEC model Alpha Spectra Inc., -12I12/3, made in U.S.A.) equipped with an NaI(Tl) detector, coupled with a multi-channel analyzer (ORTEC-Digi Base) that contains a 4,096 channel connecting unit called 'analog to digital convertor' through interface.

The spectroscopic measurements were analyzed by the laboratory computer linked to the parts of the system measurements using MAESTRO-32 software (ORTEC, made in U.S.A.). The calibration of the energy was carried out by using the standard source of known energies obtained from various radiation sources, including sodium-22, cobalt-60 (^{60}Co), manganese-54, and ^{137}Cs. The applied detector had the resolutions (full width at half maximum) of 6.8% and 7.9% for 662 keV gamma rays of ^{137}Cs and 1,332 keV gamma rays of ^{60}Co, respectively. The counting time for samples and background was 5 h. All measurements were carried out with the samples placed in contact with the detector.

Calculation of specific activities and annual effective doses of ^{226}Ra, ^{232}Th, and ^{40}K radionuclides

The specific activity of a sample is the activity per unit mass (Bq/kg). In the current study, the specific activity of each sample was estimated using the following equation [8-10]:

$$A = \frac{(N - B)}{t \times \varepsilon \times I_\gamma \times m} \qquad (1)$$

Where *B* represents the background counts, *N* is the gross counts (sample plus background), *t* signifies the counting time (sec), $I\gamma$ is the probability of gamma emission, *m* is the sample weight (kg) , and ε is the absolute efficiency of the detector at a particular gamma energy.

Annual effective dose

The annual effective dose due to the intake of ^{226}Ra, ^{233}Th, and ^{40}K in any of the food samples was calculated using the following formula [11, 12]:

$$D = A \times I \times E \qquad (2)$$

where *D* is the annual effective dose (Sv/y), *A* is the specific activity of radionuclides in the ingested sample (Bq/kg), *I* is the annual intake of nut samples (kg/y), assuming the consumption of 1.5 and 11 kg/y nuts per year for each of the 10-year-old children and adults, respectively [13]. In addition, while *E* is the effective dose conversion factor that was equal to 0.28, 0.69, and 6.2×10^{-3} µSv/Bq for the ingestion of ^{226}Ra, , ^{232}Th, and ^{40}K, respectively [11].

Results

Figures 1, 2, and 3 depict the specific activities of ^{226}Ra, ^{232}Th, and ^{40}K in different types of nut samples, respectively. The values of specific activity for ^{226}Ra ranged from 1.39±0.53 to 13.33±1.19 Bq/kg, respectively, with a mean value of 6.71±1.34 Bq/kg. Regarding ^{232}Th, the specific activity values had a range of 0.29±0.09 to 5.01±0.42 Bq/kg with a mean value of 1.68±0.50 Bq/kg. Furthermore, ^{40}K had a specific activity range of 232.06±8.42 to 376.47±6.26 Bq/kg and a mean value of 308.57±17.76 Bq/kg.

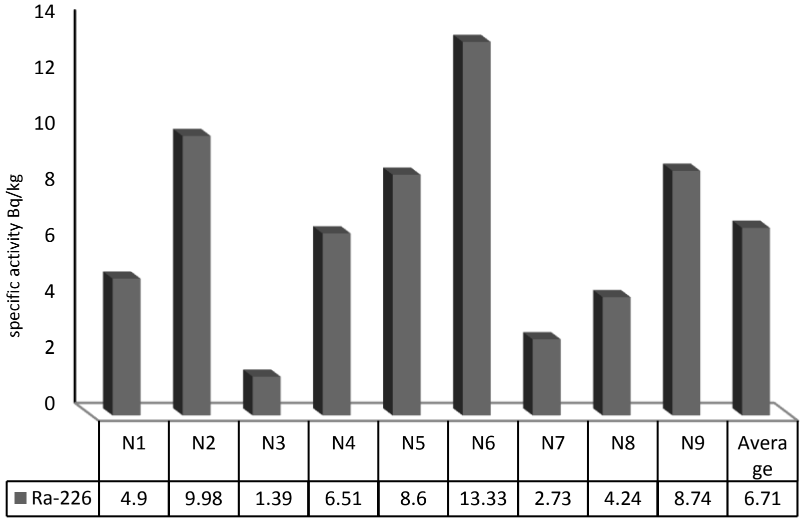


Figure 1. Specific activity of radium-226 in samples under study

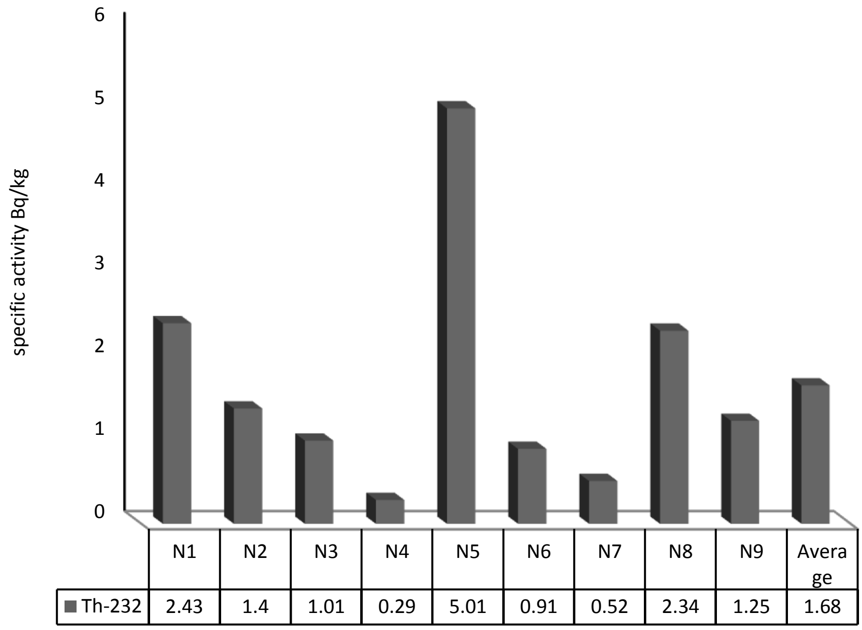
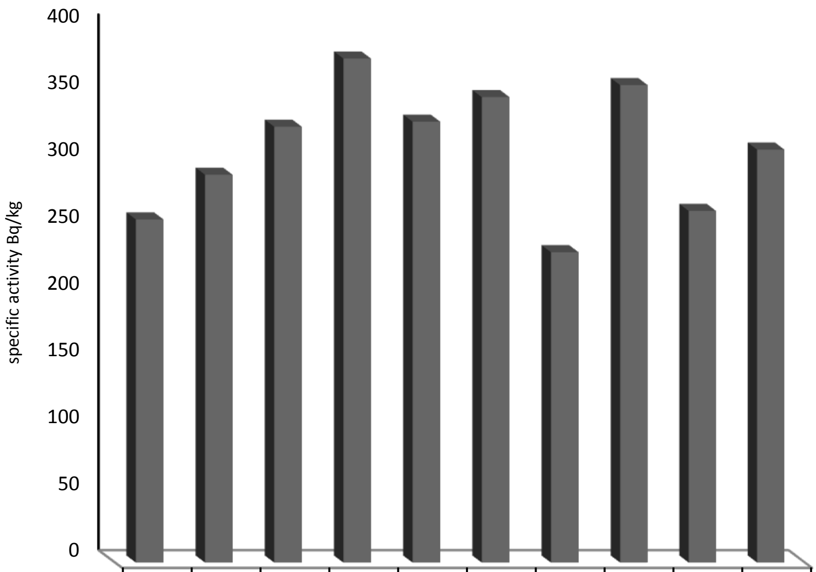
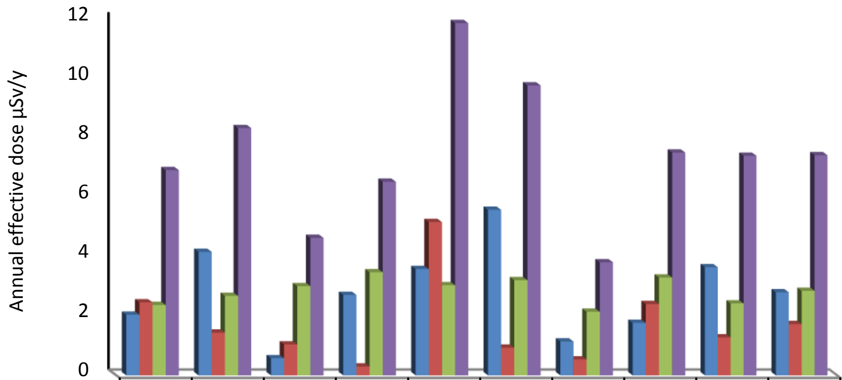


Figure 2. Specific activity of thorium-232 in samples under study



	N1	N2	N3	N4	N5	N6	N7	N8	N9	Average
K-40	256.5	289.81	325.62	376.47	329.39	347.73	232.06	356.68	262.87	308.57

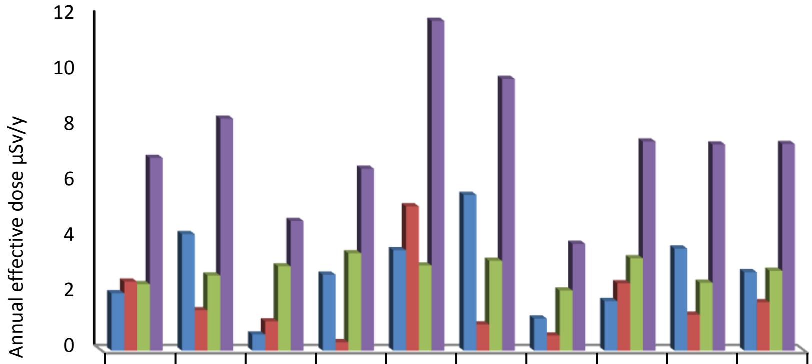
Figure 3. Specific activity of potassium-40 in samples under study



	N1	N2	N3	N4	N5	N6	N7	N8	N9	Average
Ra-226	2.06	4.19	0.58	2.73	3.61	5.6	1.15	1.78	3.67	2.82
Th-232	2.48	1.45	1.05	0.3	5.19	0.94	0.54	2.42	1.29	1.74
K-40	2.39	2.7	3.03	3.5	3.06	3.23	2.16	3.32	2.44	2.87
Total	6.93	8.34	4.66	6.54	11.86	9.77	3.84	7.52	7.41	7.43

Figure 4. Annual effective dose in samples under study for 10-year-old children

The annual effective doses due to ^{226}Ra, ^{232}Th, and ^{40}K for 10-year-old children and adults were calculated in all samples as shown in figures 4 and 5, respectively. The mean values of annual effective dose were 2.82±0.56, 1.74±0.52, and 2.87±0.16 µSv/y for ^{226}Ra, ^{232}Th, and ^{40}K, respectively. Furthermore, the mean values of annual effective dose were 20.68±4.14, 12.76±3.86, and 21.04±1.21 µSv/y for ^{226}Ra, ^{232}Th, and ^{40}K, respectively.



	N1	N2	N3	N4	N5	N6	N7	N8	N9	Average
Ra-226	2.06	4.19	0.58	2.73	3.61	5.6	1.15	1.78	3.67	2.82
Th-232	2.48	1.45	1.05	0.3	5.19	0.94	0.54	2.42	1.29	1.74
K-40	2.39	2.7	3.03	3.5	3.06	3.23	2.16	3.32	2.44	2.87
Total	6.93	8.34	4.66	6.54	11.86	9.77	3.84	7.52	7.41	7.43

Figure 5. Annual effective dose in samples under study for adults

Discussion

The comparison of the obtained results with the worldwide average values recommended by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR; 2000) [11] revealed that the values obtained for ^{226}Ra, ^{232}Th, and ^{40}K were lower than the corresponding values of 33, 32, and 400 Bq/kg, respectively.

The variation exists in the obtained specific activity can be attributed to the geological factors of the agricultural soil together with the existence of the phosphate fertilizers that already rich of the potassium (^{40}k). Additionally, the values of the total annual effective dose for two age groups in this study were found to be within the world limit. In this regard, the estimated annual effective doses due to the ingestion of nut samples sold in Iraqi markets were obtained as 7.43±0.86 and 54.48±6.32 µSv/y for 10-year-old children and adults, respectively. This dose is lower than the annual dose limit of 1 mSv/y for public exposure determined by the International Commission on Radiological Protection (ICRP) [14]. Therefore, the consumption of nuts under study had no health risk.

Conclusion

As the findings of the present study indicated, the specific activities of ^{226}Ra, ^{232}Th, and ^{40}K and the total values of annual effective dose due to these radionuclides were much lower than the regulatory standard recommended by UNSCEAR and ICRP. Consequently, nut samples investigated in this study contained no potential hazards.

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