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Estimation of annual gonadal dose equivalent and cancer risk for the barley samples in Libya markets

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A B S T R A C T

Due to its important role in human safety, natural radioactivity has garnered a lot of attention worldwide. Barley is one of the basic and important for human beings. Therefore, the measurement of natural radioactivity is a critical because of its direct impact on human safety. In this research, quantification has been made of natural radionuclide concentrations using NaI(Tl) gamma-ray spectrometry. The analyses of samples reveal the mean activity concentrations of ^{226}Ra, ^{232}Th, ^{40}K% are found to (4.68) ppm, (17.14) ppm and (0.49) % respectively. Also estimated annual gonadal equivalent dose (AGED) resulting with an average (0.47) mSv.y^{-1} where was greater than globally limits, while the average value of cancer risk (ELCR) (0.29) equals the international permissible limits. The study can be considered as a basis for future studies on this basic substance in food.

1 Introduction

Environmental samples contain different concentrations of natural radionuclides due to geographic factors, which makes these nuclides scattered throughout the world, including soil, water and food**. [whicker ,1982]**. There are four main components of general radiation:
(1) Natural radioactivity in food and water and inhaled air.
(2) Natural terrestrial radiation from our immediate environment, including buildings.
(3) Natural cosmic radiation from Sun, stars and from galactic and intergalactic plasma.
(4) Medical and industrial applications.
The biological effect of ionizing radiation, such as gamma rays, X rays, and fast electrons is often nearly proportional to the absorbed radiation energy; that is, it is proportional to the radiation dose. The dose is measured in units of gray (Gy). The radioactivity present or transmitted through the soil or air may be present in agricultural crops and thus finds its way directly to the human body **[Oliver,1997]. Most** of the environmental radiation contribution comes from radionuclides which are members of the natural radioactive series and^{40}K**[Ackers et al,1984],[Mollah et al,1986].** In the last two decades, considerable attention has been focused on low level exposure arising from naturally occurring radionuclides, particularly^{226}Ra, ^{232}Th and^{40}K.The elements in food are responsible for building the human body, The large amounts of radionuclides deposited during food intake such as^{226}Ra accumulated in human kidneys, ^{232}Th in liver and skeletal tissues and ^{40}Kin muscle) lead to human health at risk**. [Njing et al,2016].**
Gonads were considered by the UNSCEAR as organs of interest for dosimeter purposes **[United,1988].** According to the Recommendations of the International Commission on Radiological Protections, the weighting factor for the gonads is 0.2**[International,1991].** This relatively high factor represents the radiation sensitivity of the gonads due to the risk of mutagenesis.

This work examines the natural radionuclides in barley which is considered one of the important foods of most of the world. A high-efficiency NaI (TI)gamma ray spectrometer was used to make the measurements after some samples of different barley were collected from local markets in Libya for The determination of the presence of natural radionuclides in some samples of was one of the most important goals in this study, as well as determining the natural concentrations per unit (parts

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per million) to estimate the radiation hazard indicators, and the annual gonadal equivalent dose in (AGED) and cancer risk (ELCR) in barley samples.

2 Materials and Methods

2.1 Sample Collection and Preparation

This study was conducted on six types of barley in most of the libya local markets, as shown in Table (1). To determine the concentration of radionuclides in the Barley samples were immediately brought to the laboratory for preparation and storage. Each sample was with weight (250 gm.), placing the samples in a tightly closed plastic container, then storing them separately for (30) day to allow a radioactive equilibrium between ^{226}Ra and then ^{232}Th and short-lived degradation products **[Maitham,2017].** Radionuclides of ^{226}Ra, ^{232} Th and ^{40}K were measured in Barley samples using NaI (Tl) gamma ray spectrometer detector.

Table1. List of Barley samples used in the present study

Samples No	Description
1	Patriotic barley [bright horizon company]
2	Imported barley [marai El-Morouj company]
3	Ukrainian barley [marai El-Morouj company]
4	Patriotic barley [marai El-Morouj company]
5	Barley from the south of sabha
6	Barley from sarir north field

2.2 Gamma spectrum analysis

The concentrations of radioactive isotopes (^{226}Ra, ^{232}Th and ^{40}K) present in the barley samples were calculated using gamma ray spectroscopy technique with a high penetrating ability of different materials. This spectrophotometer consists of a NaI (Tl) luster detector with crystalline dimensions (3" x 3"), fitted by Alpha Spectra, Inc.-12I12/3, and equipped with a multichannel analyzer (MCA) (ORTEC-Digi base) with a range of 4096 connected channels. With an ADC (analog to digital converter), through the interface. Using the MAESTRO-32 4365 program on the computer, which runs on the windows system, the measurements were calculated and the spectroscopic analysis was done. The aforementioned detector was calibrated using standard radioactive sources such as (^{22}Na,^{137}Cs and ^{60}Co).

2.3 Calculation of concentration of Radionuclide

The activity concentration **(A)**, of naturally radionuclide in the samples was measured by the relation **[Tsoulfanidies,1983]**:

$$\mathbf{A} = \frac{\mathbf{N}}{\boldsymbol{\varepsilon}\, \mathbf{I_\gamma t\, m}} \quad \textbf{(1)}$$

Where:

ε : is the absolute efficiency at photopeak energy.

t: is the time of the sample spectrum collection in seconds.

$\mathbf{I_\gamma}$: is the gamma-ray emission probability corresponding to the peak energy.

m: is the mass **(Kg)** of the measured sample.

N: is the corrected net photo-peak area at energy peak, and given by:

$$\mathbf{N = N_s - N_B} \quad \textbf{(2)}$$

Where:

$\mathbf{N_s}$: is the net photo peak area in the sample.

$\mathbf{N_B}$: is the corresponding net photo peak area in the background spectrum **[Tsoulfanidies,1983]**.

N: is obtained from the peak interest analysis using an area of interest (**ROI**).

2.4 Hazard Indices

The relationship between natural radionuclides ^{226}Ra (parts per million), ^{232}Th (ppm) and ^{40}K% and the resulting risks was determined by a set of indicators, the refore; the lifetime risk of cancer (ELCR) and the annual dose were calculated. Gonad equivalent (AACD)

2.5 Representative level index (RLI)

The radiation level index **RLI** is used to assessment the hazard level of radionuclides ^{238}U,^{232}Th, and ^{40}K. The radiation level index calculated by using the relation:

$$\mathbf{RLI} = \frac{\mathbf{A_{Ra}}}{\mathbf{150}} + \frac{\mathbf{A_{Th}}}{\mathbf{100}} + \frac{\mathbf{A_K}}{\mathbf{1500}} \textbf{(3)}$$

Where, the A radioactivity of each of the three nuclides Ra, Th and K was measured in Bq/Kg unit. This index was used to calculate the risk arising from gamma radiation associated with the natural radioactive nucleus in the approved study samples and calculated from the equation on the activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K **[Hamza et al.,2019].** Its value should be less than one so as not to cause any danger to human health.

2.6 Representative Alpha index (Iα)

The excess Alpha radiation due to the Radon inhalation originating from the Barley samples were assessed through Alpha index, must be little than one. Alpha index (Iα) was calculated as follo**[Salih,2018]**

$$I_\alpha = \frac{A_{Ra}}{200} \qquad (4)$$

The recommended upper limit concentration of ^{226}Ra is 200 Bq.kg^{-1}, which gives Iα = 1

2.7 Annual Gonadal Equivalent Dose (AGED)

The gonads, the bone marrow and the bone surface cells are considered as organs of interest by UNSCEAR (1988) because they are the most sensitive parts of human body to radiation. An increase in **AGED** has been known to affect the bone marrow and destroys the red blood cells which are then replaced by white blood cells. This situation results in a blood cancer (leukemia). **AGED** is calculated with given activity concentration of ^{226}Ra, ^{232}Th and ^{40}K (in **Bq.Kg^{-1}**) using the relation **[Avwiri et al.,2014]**

$$\text{AGED } (\mu Sv.y^{-1}) = 3.09A_{Ra} + 4.18A_{Th} + 0.314A_K \quad (5)$$

Where, A_{Ra}, A_{Th}, and A_K are the radioactivity concentration of ^{226}Ra, ^{232}Th and ^{40}K (in Bq.Kg^{-1}).

2.8 Excess Lifetime Cancer Risk (ELCR)

To calculate the excess lifetime cancer risk due to gamma-ray radiation the following equation was used **1Loan et al.,2018], [Ife-Adediran et al., 2018]:**

$$ELCR = E_{out} \times D_L \times R_F \quad (6)$$

Where: D_L is the duration of lifetime (approximately 66 years) **[Valentin J,2007]** and R_F is the risk factor (Sv^{-1}) = 0.057 Sv^{-1}. **[P.Dorfman and A.Fucic,2013]**

3 Results

The concentration activity (^{226}Ra, ^{232}Th) in unit (ppm) and ^{40}K% was measured by gamma ray spectrometry (NaI (Tl)) for six samples of barley available in the Libya market as shown in Table (2), where the model contained (Patriotic barley [marai El-Morouj company]) had the highest activity concentration of nuclides ^{226}Ra(ppm), while the model (Patriotic barley [bright horizon company]) had the lowest activity concentration. As for the activity of the maximum concentration of ^{232}Th (ppm), it was the highest in the model (Barley from the south of sabha) and the lowest in (Ukrainian barley [marai El-Morouj company]). And according to what is recommended internationally, almost radionuclide concentration rates were within the permissible limit.

Table 2. Elemental Concentrations (ppm) in samples.

ID(code of sample)	Elemental Concentrations (ppm)		
	^{226}Ra	^{232}Th	^{40}K%
1	2.56	13.12	0.23
2	4.94	18.64	0.28
3	4.33	11.95	1.53
4	7.67	23.31	0.09
5	2.88	23.69	0.43
6	3.00	12.14	0.38

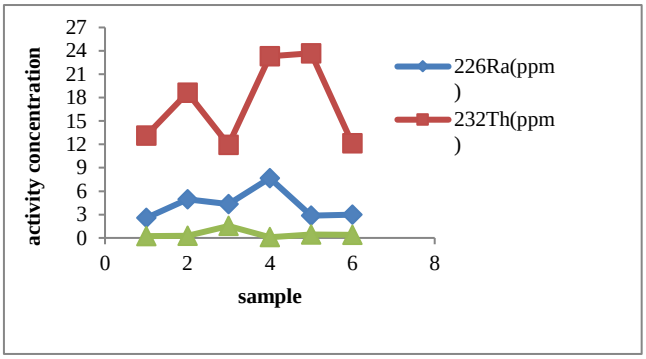

Figure 1. Comparison of elemental concentration of Radionuclides in barley Samples

Table 3. Radiological hazard Indices (Representative gamma index, Representative Alpha index, Annual Gonadal Equivalent Dose and Excess life-time Cancer risk in the studied Barley samples

ID	RLI	Iα	AGED (mSv/y)	ELCR
1	0.79	0.16	0.33	0.2
2	1.22	0.31	0.52	0.31
3	1.16	0.27	0.43	0.3
4	1.59	0.47	0.69	0.41
5	1.29	0.18	0.53	0.32
6	0.82	0.19	0.34	0.21
P.L	1	1	0.3	0.29

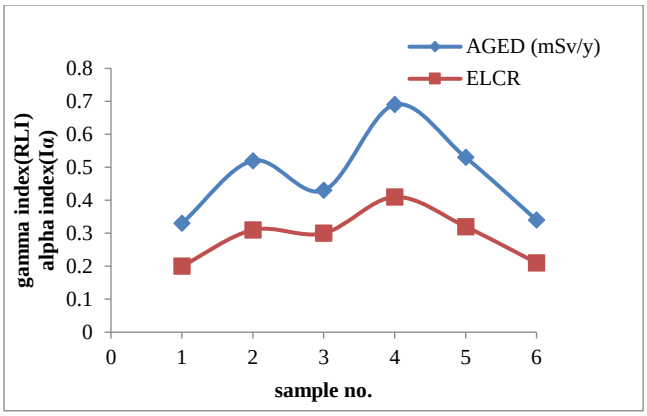

Figure2. Representative gamma index, Representative Alpha index in Barley Samples

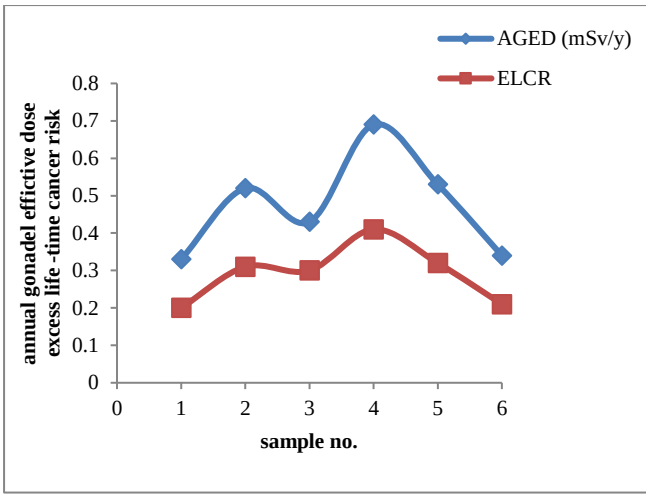

Figure3. Annual Gonadal Equivalent Dose and Excess life-time Cancer risk in the studied Barley samples

4 Discussion

In Table 2, the values are also compared graphically in Figure 1, to make it clear Results when compared, where we note that the concentration of thorium was the highest among the results, the activity concentration of radium are higher than the permissible level for all samples and the activity concentration of the studied barley samples are lower than the permissible level for potassium except (Patriotic barley [marai El-Morouj company]).

From table (3), we find that the highest values RLI, Iα, Annual Gonadal Equivalent Dose (AGED) and cancer risk (ELCR) in Sample (Patriotic barley (no.4) and with values 1.59, 0.47 , 0.69 and 0.41 successively, they are higher than what is permitted worldwide except Iα. The representative gamma index and excess life-time cancer risk in the studied barley samples are higher than the permissible level except samples no.(1and 6), all values of representative alpha index of samples are lower than the recommended level by **[Unscear,2010]**, annual gonadal equivalent dose for all samples are higher than the permissible level.

The values are also compared graphically in Figure 2, to make it clear Results when compared, where we note that the representative gamma index was the higher than representative alpha index.

The values are also compared graphically in Figure 3, where we note that the annual gonadal equivalent dose was the higher than excess life-time cancer risk.

5 Conclusions

The values of annual gonadal equivalent dose for all samples are higher than the permissible level (0.3) and excess life-time cancer risk in the studied barley samples are higher than the permissible level (0.29) **[Unscear,2010],** except samples no. (1and 6).

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