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STUDY OF NATURAL RADIOACTIVITY (^{238}U, ^{232}TH, ^{40}K) FOR CANNED RICE SAMPLES IN LOCAL MARKETS IN HILLA CITY

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Abstract

Food is indispensable to human life, thus an important parameter of environmental science. The presence of radionuclides in food grains poses a number of health hazards, especially when these radionuclides are deposited in the human body, through food. The main objective of this study is to determine the radioactivity concentration of gamma emitting radionuclides e.g. ^{238}U, ^{232}Th, ^{40}K activity in food grain sample. Nine samples of food grain were collected from the different market of Hilla city, have been measured by means of gamma ray spectroscopy with a NaI(Tl) detector. The average value of specific activities ^{238}U, ^{232}Th and ^{40}K were in the samples of rice (2.787±0.408) Bq.Kg^{-1} (6.058±0.58) Bq.Kg^{-1} (77.671±38.54) Bq.Kg^{-1}, respectively.

Also, it was found that, the average value of Radium Equivalent and the Internal Hazard Index were (17.380) Bq. kg^{-1},(0.051) Bq. kg^{-1}, respectively.

As were all the results It was found that the values of the specific radioactivity of the Uranium ^{238}U and the ^{232}Th and the ^{40}K Potassium were distributed in varying proportions for rice models and are within the internationally permissible range.

Key words : Radioactivity, canned rice, NaI(Tl) detector, gamma ray, radiation hazard.

Introduction

Through inhalation of contaminated air and ingestion of contaminated water and food. Other pathways for radionuclide penetration into human body, like for example through the skin, are irrelevant for the context of this study. It is well known that food can be a source of radiation, as it contains certain amounts of naturally occurring radionuclides (Olise *et al*., 2011). Their levels in food may be increased through a number of human activities such as nuclear fuel cycle and medical or other uses of radionuclides (Jannatul *et al.*, 2016).

Radioactive isotopes of elements (radionuclides) are naturally present in the environment, and that includes our bodies and our food and water. We are exposed to radiation (also known as background radiation) from these radionuclides on a daily basis. Radiation comes from space (*i.e.*, cosmic rays) as well as from naturally-occurring radioactive materials (radionuclides) found in the soil, water and air. Radioactivity can be detected in food and water and the concentration of naturally-occurring radionuclides varies depending on several factors such as local geology, climate and agricultural practices (Desideri *et al*., 2010). The naturally occurring radionuclides especially ^{40}K and the radionuclides of ^{238}U and ^{232}Th series are the major source of natural radiation exposure to the man. It has been estimated that at least one-eighth of the mean annual effective dose due to natural sources is caused by the consumption of foodstuff , People can also be exposed to radiation from man-made activities, including medical diagnostic intervention (Ali Abid Abojassim, 2017). Radioactivity can contaminate food after it has been discharged into the environment from industries that concentrate natural radionuclides and from civil or military nuclear operations (Marovic *et al*., 2006).

Open-air vegetables and plants can be affected by the atmospheric release of radionuclides, resulting in radioactive contamination. Thus, radionuclides tend to be detected from leafy vegetables especially the ones with large leafy parts in the early phase after a nuclear accident (Measurement of Radionuclides in Food, 1989). Over time, radioactivity can also build up with in food, as radionuclides are transferred through soil into crops or animals, or into rivers, lakes and the sea where fish and

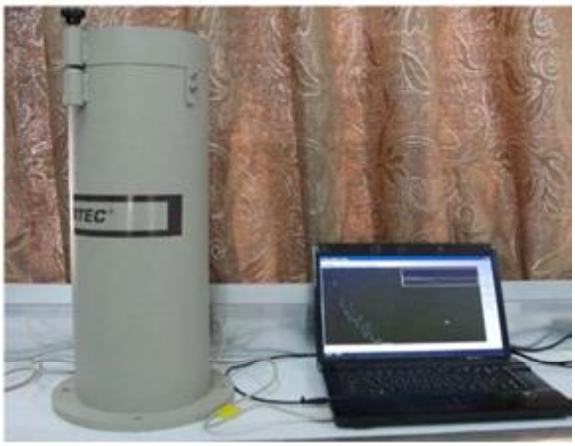

Fig. 1 : Experimental set-up.

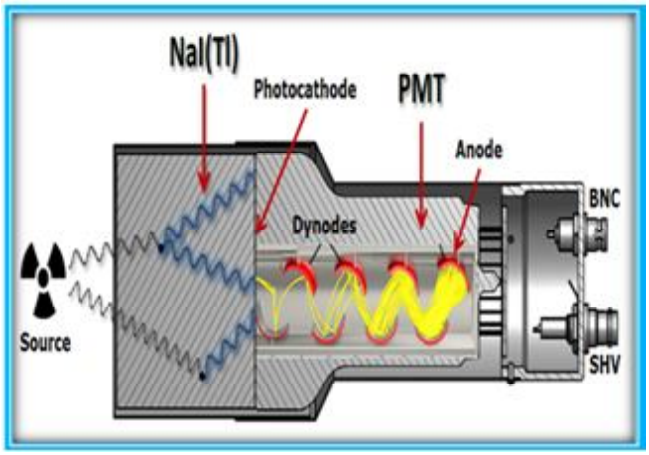

Fig. 2 : A schematic picture of the sodium iodide detector NaI(Tl) (Breur, 2013).

other seafood could take up the radionuclides (Tawalbeh *et al*., 2012).

The main health concern for consumers in the long term due to high radiation exposure is development of cancer. Cancer types and target organs depend on the radionuclides. IAEA estimates that on average, our radiation exposure due to all natural sources amounts to about 2.4 mSv a year - though this figure can vary, depending on the geographical location by several hundred percent (World Health Organiztion, 2011).

Materials and Methods

Samples were heated in the oven at 225-325^{0}C for 24h to remove moisture, put inside Marinalli beakers and then stored for 30 days to allow the equilibrium between ^{226}Ra and ^{222}Rn. The activity concentration of ^{226}Ra, ^{228}Ra, ^{238}U, ^{232}Th and ^{40}K was estimated from the gamma spectrum using Na(Tl) detector 3×3 inch (figs. 1 and 2) with a 1024 channel computer analyzer USX supplied by Spectrum Technique Company. The detector was employed with lead shielding, 4 cm thickness, which reduced the background.

The detector was calibrated using standard sources of 57Co (peak 122 keV), 137Cs (peak 662 keV) and 60Co (peaks 1173, 1333 keV). The detector resolution is about 8% at 662 keV of 137Cs. The efficiency calibration was achieved using eight standard sources include the calibration sources. The system was running freely, for 12 h live time, to evaluate the background spectrum. When γ-ray spectrometry was used for the measurement of natural radioactivity in environmental samples, the properly sealed samples must be allowed to remain undisturbed for at least three weeks to attain radioactive secular equilibrium. This is the radioactive equilibrium between ^{222}Rn gas, its progeny (^{214}Pb and ^{214}Bi) and ^{226}Ra, from the ^{238}U decay series. In the ^{232}Th decay series, the radon isotope ^{220}Rn poses no serious problem because of its short half-life of 55 seconds and in the ^{40}K decay series, no equilibrium is needed. For this reason the samples were allowed to stand for three weeks before the spectrum analysis was carried out (Breur, 2013).

The Marinalli beaker contains sample was placed over the detector for counting. Activity concentration Ai of any gamma-rays line taken to represent this parameter for the environmental radionuclides has been calculated using the relation (Amrani and Tahtat, 2001).

$$\left(A + \frac{N_{net}}{\varepsilon . I_\gamma . m . t} \pm \frac{\sqrt{N_{net}}}{\varepsilon . I_\gamma . m . t} \right) \left[Bq . kg^{-1} \right] \quad (1)$$

Where, ε is absolute gamma peak efficiency of the detector at this particular gamma-ray energy, $I\gamma$ decay intensity for the specific energy peak (including the decay branching ratio information), M the mass of the sample in kg and t is the counting time of the measurement in second (Nadir, 2015).

This work has been undertaken with the purpose of measuring Natural Radioactivity to ^{238}U(^{226}Ra), ^{232}Th and ^{40}K in rice samples and ^{222}Rn activity concentrations in rice samples that are available in the Iraqi markets. Also in this study, Radium Equivalent Activity, Internal Hazard, the Absorbed Dose Rates and annual Effective Dose for ^{238}U (^{226}Ra), ^{232}Th and ^{40}K .

Internal Hazard Index

In the international scientific community there is a general consensus that regarding the human internal exposure, due ingestion or inhalation, the introduction of a specific so-called Internal Hazard Index turns out to be very suitable to assess the radiation hazard. The

Internal Hazard iIndex (Hin) is given by the following expression (Afshari and Abbasisiar, 2009):

$$H_{in} = \frac{A_U}{185} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \quad (2)$$

a consequence radiation hazard can be considered negligible, if Hin turns out to be smaller than one. it turns out that a general agreement can be found on the statement that 370 Bq/kg (10 pCi/g) of ^{226}Ra, or 260 Bq/kg (7 pCi/g) of ^{232}Th or 4810 Bq/kg (130 pCi/g) of ^{40}K provide the same gamma ray doses [15-18]. Consequently, the following Radium Equivalent Activity (*Raeq*) of a sample in (Bq/kg) can be evaluated as Yu *et al*. (1992).

$$Ra_{eq}(Bq/kg) = A_U + 1.43A_{Th} + 0.077A_K \quad (3)$$

Where, Ra is the specific activity of ^{226}Ra, which is usually the same as that of ^{238}U(^{226}Ra), in (Bq/kg), A_{Th} is the specific activity of ^{232}Th, in (Bq/kg) and AK the specific activity of ^{40}K, in (Bq/kg) (Afshari and Abbasisiar, 2009).

Results and Discussion

Samples were collected from 9 concentrations in rice samples that are available in the Iraqi by using the NaI(Tl) detector. Table 1 shows the results were obtained in this study.

The measured specific activities of ^{238}U(^{226}Ra), ^{232}Th and ^{40}K detected in the samples of rice under study including their uncertainty are summarized in table 2. It can be noticed that the ^{238}U(^{226}Ra) activity concentrations detected in most of samples vary between (5.954±0.67) Bq/kg an average value of (2.787±0.408) Bq/kg. For ^{232}Th and ^{40}K the measured specific activity ranged from) 11.354±0.96) Bq/kg with an average value of (6.058±0.58) Bq/kg and from (109.720±2.55) Bq/kg with an average value of (77.671±38.54) Bq/kg, respectively. Also, the values of radiation hazard expressed by Raeq and Hin have been found to range from (0.093) Bq/kg to (0.011) Bq/kg with an average of (0.051) Bq/kg (table 3).

The results obtained in table 3 shows that for ^{238}U (^{226}Ra) the average measured specific activities and their average value appears to above the values reported in other countries; for ^{232}Th some values are greater and others lower. But for this two radioisotopes the results measured in Iraq turn out to be lower than the recommended reference limits by UNSCEAR (2000) (Nadir, 2015): 32 Bq/kg and 45 Bq/kg, respectively. For

Table 1 : Types and origins of the rice samples.

Country of origin	Sample name	Sample code	No
USA	American	R1	1
Iraq	Nabiaa AL- Euphrates	R2	2
Pakistan	Ngoom Al-Thymania	R3	3
Kuwait	Al- Doraa	R4	4
India	Al-Effia	R5	5
India	Abo-Alarabaa	R6	6
India	Mahmood	R7	7
India	Kalbhar	R8	8
Iraq	Nafis	R9	9

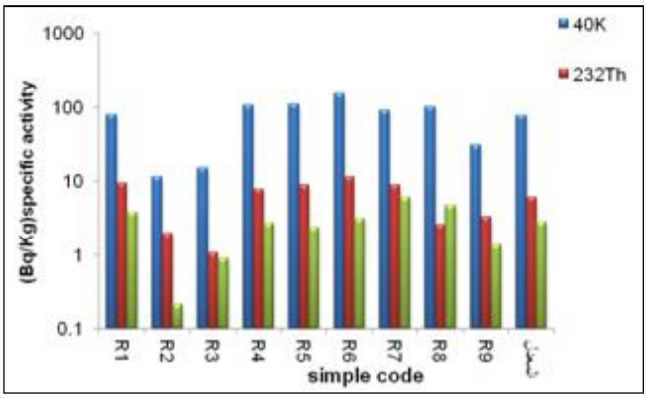

Fig. 3 : shows the results of the specific efficacy of rice simple.

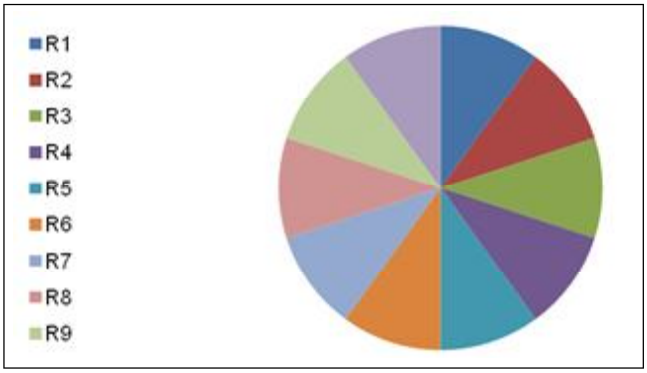

Fig. 4 : shows the radium equivalent for rice simple.

Table 2 : Specific Activity (Bq/kg) in rice sample.

Specific activity (Bq/kg)			Sample Code
^{40}K	^{232}Th	^{238}U(^{226}Ra)	
79.371±2.15	9.181±0.72	3.757±0.43	**R1**
11.155±0.87	1.920±0.13	0.217±0.13	**R2**
14.695±0.83	1.056±0.22	0.907±0.20	**R3**
107.329±329	7.744±0.83	2.681±0.47	**R4**
109.720±2.55	8.747±0.71	2.344±0.36	**R5**
153.525±3.57	11.354±0.96	3.130±0.48	**R6**
90.241±2.74	8.678±0.60	5.954±0.67	**R7**
102.099±3.50	2.590±0.55	4.733±0.60	**R8**
30.901±1.64	3.255±0.52	1.358±0.33	**R9**
77.671±38.54	**6.058±0.58**	**2.787±0.408**	**Average**

Table 3 : Radiation hazard in Rice samples.

Internal Hazard Index H_{in}	Raeq (Bq/kg)	Sample Code
0.072	22.997	**R1**
0.011	3.822	**R2**
0.012	3.549	**R3**
0.067	22.019	**R4**
0.069	23.301	**R5**
0.093	31.188	**R6**
0.084	25.312	**R7**
0.026	15.886	**R8**
0.026	8.349	**R9**
0.051	**17.380**	**Average**

what it concerns the specific activity of ^{40}K the comparison with other outcomes shows the same behaviour like for ^{232}Th, but, nevertheless, the results from this study have been found to be lower than the recommended reference limit by UNSCEAR(2000): 412 Bq/kg (UNSCEAR, 2003).

Radium Equivalent Activities and Internal Hazard Index (Hin) values for all the samples are below the recommended value of 370 Bq/kg and one, respectively (UNSCEAR, 2003).

Conclusion

- It was found that the values of the specific radioactivity of the Uranium ^{238}U and the ^{232}Th and the ^{40}K Potassium were distributed in varying proportions for rice models and are within the internationally permissible range.
- All the results of the radium equivalent and the internal risk factor of the models were within the global limit.
- All rice models are considered to be radically safe because there is no increase in the concentrations of natural radionuclides from the internationally permissible limits.

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