Radionuclide concentrations and Estimation of the Corresponding Annual Effective Dose due to gamma radioactivity in Powdered Milk in Babylon governments

Anfal Ali Shakir1, Mohsin Kadhim Muttaleb2

1 Department of biotechnology, Al–Qasim green university .College of biotechnology, Babil .Iraq
2 Department of Physics, University of Babylon ,College of Science, ,Babil Iraq

E-mail: anfal@biotech.uoqasim.edu.iq

Abstract

Natural radionuclides in ten of the most available types of milk powder among various brand names that collected from local markets in Babylon government have been analyzed by means of a gamma –ray spectrometry NaI(Tl) and estimated of the annual effective dose intake of the radionuclides .The concentration of 226 Ra, 232Th and 40K have been found to vary from (57.2645±1.853031) Bqkg\(^{-1}\) to(0.299814±0.1340 ) Bqkg\(^{-1}\) with an average  value of  (20.67518±0.134077) Bqkg\(^{-1}\),from (36.7284±1.422407 ) Bqkg\(^{-1}\) to (0.37037±0.066679) Bqkg\(^{-1}\) with an average value of.( 12.41975±0.65718 ) Bqkg\(^{-1}\)and from (481.521±5.65807) Bqkg\(^{-1}\) to (268.0537 ± 0.299814) with average value (377.5035±4.460395) Bqkg\(^{-1}\) respectively .the result showed that the concentration of radionuclides exceeded the result reported in the world wide. The dose due consumption of milk by public has also been determined and has been below the dose limit recommended by world health organization.

Keywords: radionuclide concentrations , radioactivity, Annual Effective Dose , Powdered Milk,

1. Introduction

Naturally occurring radionuclide materials (NORMs) are found in every constituent of the environment air ,water ,soil and food .Its transferred and cycled through natural processes and between the various environmental components entering into ecosystems and human food chains [1]. people have been exposed to both external and internal radiation. The most important radionuclide associated to internal radiation exposure (due to ingestion of contaminated water and food ) are 238U and 232Th decay series as well as 40K [2]. Plants obtain theses radionuclides via root and leaves while animals procure radionuclide by means of consumption of these plant food ingestion is a primary pathway for radioactive exposure. radiation pollution of the environmental is one of the most important problems of the modern age facing all living organisms on the surface of the earth [2],it is associated with many diseases such as cancer, glands, skin, bones and leukemia, also their direct impact on genetic traits and the ability to causes death of embryos and congenital malformation.

Milk and milk products such as ice cream,yogurt, chocolate , cookies and others human aliments are main constituents of human daily life [3] ,milk contains all the macronutrients such as carbohydrates ,protein , vitamins, fat and trace elements then is important vector of radionuclides , many studies and several international organizations have determined the concentration of natural radionuclides in milk and there radiological hazard [3,4,5],natural radioactivity measurements in milk sample have been carried out different countries to establish baseline of radioactivity exposure from different types of milk samples that available in Iraqi markets [6],the goal of this study was to measure NORMs levels and evaluate the radiological hazard in milk samples which is collected from Babylon governments markets which is located at (100 Km) south of Baghdad.
2. Materials and Methods

2.1 Sample collection

Ten samples of the most available types of milk powder among various brand names were collected from the local markets in Babylon governments. The samples were dried to remove moisture; after drying 500 gm were neatly packed in polyethylene bags and lightly sealed and stored for 28 days to reach equilibrium.

2.2 Experimental setup

Activity concentrations of $^{238}$U, $^{232}$Th and $^{40}$K were measured using NaI(Tl) γ-ray spectrometer of (3"×3") crystal dimension, supplied by (Alpha Spectra, Inc.-12112/3 coupled with a multiConvertor) unit. The energy calibration is a relationship between the number of channels and the energy absorbed in the detector. The energy calibration of the NaI(Tl) spectroscopy system is recognized by measuring the position of selected full-energy gamma-ray peaks with large peak-height to background ratios, and whose energies are known precisely.

3. Activity concentration and estimation doses

The specific activity can be determined as in eq (1) since the counting rate proportional to the amount of radioactivity in sample. The analytical model used in the calculated the activity in Bq.Kg$^{-1}$ as shown in equation [7]

$$A_s = \frac{N - N_0}{I*M*t*E}$$ \hspace{1cm} (1)

Where $A_s$: the specific activity of the radionuclide in the sample

$N$: net count of a given peak for a sample

$N_0$: the background of the given peak

$I$: number of gamma photons per disintegration

$E$: the detector efficiency at the specific gamma ray energy

$M$: mass of the measured sample (Kg)

$T$: measuring time for the sample (s)

Annual effective dose equivalent (AEDE): this quantity was considered to be among the most important due to the proportional relationship between its value and the induced health effects from the intake of radiation. is calculated as well in eq.(2)[8]

$$AEDE = C_i * C * IDCING$$ \hspace{1cm} (2)

Where

$C_i$: concentration (Bq Kg$^{-1}$) , $C$: consumption rate (Kg y$^{-1}$)

$IDC_{ING}$ : ingestion dose coefficient

4. Results and Discussion

Table 1. show the results of the gamma-ray analysis of the ten powdered milk samples analyzed.

| Milk trademark | Production Country | $^{238}$U (Bqkg$^{-1}$) | $^{232}$Th(Bqkg$^{-1}$) | $^{40}$K(Bqkg$^{-1}$) |
|----------------|--------------------|-------------------------|-------------------------|-------------------------|
| Dielac         | New Zealand        | 23.145 ± 1.178          | 0.493 ±0.174            | 281.964 ±4.311          |
| Rawat Almudhish| Iraq               | 6.715 ±0.634            | 7.345 ±0.673            | 377.688 ±4.989          |

Table 1. Natural Radionuclide level in the powdered milk samples(Bqkg$^{-1}$)
The radionuclides observed with reliable regularity in the samples belonged to the decay series chain of $^{226}$Ra, $^{232}$Th and the non-series $^{40}$K. The activity concentrations of $^{226}$Ra in the samples ranged from (57.2645 ± 1.853031) Bq kg$^{-1}$ to (0.299814 ± 0.1340) Bq kg$^{-1}$ with an average value of (20.67518 ± 0.134077) Bq kg$^{-1}$; the highest activity concentration of $^{238}$U was recorded for *puck* whilst *almaraei cow* had the lowest activity concentration. For the activity concentration of $^{232}$Th in all the samples have value range between (36.7284 ± 1.422407) Bq kg$^{-1}$ (0.37037 ± 0.066679) Bq kg$^{-1}$ with an average value of (12.41975 ± 0.65718) Bq kg$^{-1}$, the highest and lowest activity concentration was recorded for *kiri taste* and *puck* respectively. $^{40}$K record the highest activity concentration in all milk sample compared to the activity of $^{238}$U and $^{232}$Th observed. The activity concentration of $^{40}$K in the milk samples varied from (481.521 ± 5.65807) Bq kg$^{-1}$ to (268.0537 ± 0.299814) Bq kg$^{-1}$ with average value (377.5035 ± 4.460395) Bq kg$^{-1}$, *altunsa* recorded the highest activity concentration whilst the lowest activity concentration was record in *kiri taste*.

The variation of the activity concentration of natural radionuclide in the different milk samples may due to the variation of the natural radionuclide content of the environments which is being transferred to the milk through the grass–cow–milk pathway. Since the passage of radionuclides to organisms is through the food chain and the production of soy and processing to make good formula may enhance the activity level, published work in the same field had involved other powdered milk other than those considered for this study, however, comparing the result form this study with published data from some countries indicates that the average concentration for all radionuclide under this study are higher than other published work with exception of Brazil[9,10] and Iran[11] as show in the table below.

### Table 2. Comparison of Mean/Range of the Activity Concentration (Bq/kg$^{-1}$) Of $^{238}$U, $^{232}$Th and $^{40}$K with the Literature

| Country     | $^{238}$U | $^{232}$Th | $^{40}$K | References |
|-------------|----------|-----------|---------|------------|
| Iraq        | 9.64     | 6.77      | 74.5    | Present study |
| Saudi Arabia| 0.25–0.85| 0.09–0.76 | 210–257 | [12]        |
| Iran        | 0.05–0.186| 0.094–0.166| 434.1–610| [11]        |
| Jordan      | BDL, 2.14| BDL, 1.28 | 296.8–392.9| [3]         |
| Brazil      | —        | 1.6–3.6, 1.7–3.7| 475–489 | [9,10]      |
| Malaysia    | 3.05 – 1.84 | 2.55 – 2.48 | 99.1 – 69.5 | [13]        |

BDL, below detection limit; —, not reported.

### Table 3. Annual effective ingestion dose due to the intake of $^{226}$Ra, $^{232}$Th and $^{40}$K in the powered milk samples.
Annual effective ingestion dose due to milk consumption is strongly dependent on the milk consumption. In this study, the average mass of the milk consumed by the adults is taken as 13 Kg y\(^{-1}\) according to [14]. Annual effective dose (\(\mu\text{Sv}y\text{y}^{-1}\)) was calculated using eq.(2). In the calculation of the total dose, the sum of the contributions from each radioisotope in the samples Table 1 with the recommended conversion factors for adults.

The estimated annual effective due to ingestion of powdered milk are presented in Table (3). The annual effective ingestion doses due to intake of \(^{238}\text{U}\) varied from (148.8877±4.8178) \(\mu\text{Sv}y\text{y}^{-1}\) in puck which is have a maximum value to minumum value (0.779517±0.3486) \(\mu\text{Sv}y\text{y}^{-1}\) in Al marai cow. the dose received from \(^{232}\text{Th}\) due to consumption of food spices varied from (109.8179±0.1993) \(\mu\text{Sv}y\text{y}^{-1}\) in Kiri taste to (1.107407±2.0302) \(\mu\text{Sv}y\text{y}^{-1}\) in puck. the values of effective dose from ingestion \(^{40}\text{K}\) ranged from (43192.44±507.528) \(\mu\text{Sv}y\text{y}^{-1}\) in Altunsa to (24044.42±377.076) \(\mu\text{Sv}y\text{y}^{-1}\) in Kiri taste. the mean annual effective dose from \(^{238}\text{U},^{232}\text{Th}\) and \(^{40}\text{K}\) in milk were estimated to be (53.755, 34.835 and 33.862) \(\mu\text{Sv}y\text{y}^{-1}\) respectively. The highest mean annual dose was \(^{238}\text{U}\) and all their mean doses are less than annual dose limit of 1 \(\mu\text{Sv}y\text{y}^{-1}\) for general public[14]. The total annual effective dose ranged from (187.463±6.862) \(\mu\text{Sv}y\text{y}^{-1}\) in puck to (44.190±3.376) \(\mu\text{Sv}y\text{y}^{-1}\) in Al marai cow with an mean value (122.453±4.933) \(\mu\text{Sv}y\text{y}^{-1}\). These results are within the typical worldwide range of annual dose (200–800) \(\mu\text{Sv}y\text{y}^{-1}\) due to the ingestion of all natural radiation sources reported by [14].

### Conclusion

The present study is the important at national level to estimate the natural radionuclides of \(^{232}\text{Th}\), \(^{226}\text{Ra}\) and \(^{40}\text{K}\) by means of gama ray spectrometry in different samples of powder milk that are available in Iraqi market which is frequently consumed by the population of Iraq, the concentration are found to be greater than those reported of the countries in the literature, this data will provide base line radiometric values for NORMs in milk that in Iraqi markets and help to develop future guidelines in Iraqi for radiological protection for the population.

### References

[1] E F Salman, M K Muttelab and Manii 2019 "Assessment of radioactivity levels and its associated radiological hazards in soil of Babylon governorate middle of Iraq", IOP Conf. Series: Journal of Physics: Conf. Series.

[2] Mohsin K.Muttaleb,Inaam H.Kadhim,Anfal A.Shakir and zaid A.Abed, 2018 "study of radioactivity of selected samples of soil in Amarah city. Maysan province,Iraq",engineering and technology journal,36(2).

[3] Zaid Q. Ababneh, Abdalmajeid M. Alyassin, Khaled M. Aljarrah and Anas M. Ababneh 2010 "measurement of natural and artificial radioactivity in powdered milk consumed in jordan and estimates of the corresponding annual effective dose, Radiation Protection Dosimetry, 138(3), pp. 278–283.
[4] N. Sarayegord Afshari, F. Abbasisiar, P. Abdolmaleki and M. Ghiassi Nejad1 2009 "Determination of 40K concentration in milk samples consumed in Tehran-Iran and estimation of its annual effective dose", Iran. J. Radiat. Res., 7 (3): 159-164.
[5] Zain M. Alamoudi 2013 "Assessment of Natural radionuclides in Powdered milk Consumed in Saudi Arabia and Estimates of the Corresponding annual Effective Dose", Journal of American Science;9(6) .
[6] Sahar A., Amin Mohammed S. M. AL-kafaje and Rana R. Al-Ani1 2016 "Assessment of Natural Radionuclides in Powdered Milk Consumed in Iraq", Journal of Natural Sciences Research,, 6(13).
[7] Knoll GF 2010 radiation detection and measurement ,wiley Hoboken.
[8] Murtadha Sh. Aswood, Anees A. Al-Hamzawi and Abdulhussain A. Khadayeir 2010 "Natural radionuclides in six selected fish consumed in south Iraq and their committed effective doses", SN Applied Sciences,1(21).
[9] Melquiades.F.L.and Appoloni.C.R. 2001 "Radiationof powdered milk produced at Londrina, PR", Brazil. Radiat, Phys. Chem. 61,691–692.
[10] Melquiades.F.L.and Appoloni.C.R. 2002 "40K,137Cs and 232Th activities razilian milk samples measured by gamma-ray spectrometry",Ind.J.Pure.Appl.Phys.40,5–11.
[11] Hosseini.T.,Fathivand.A.A.,Barati.H.and Karimi,M 2006 "Assessmentof Radionuclides in Imported Foodstuffs in Iran", J. Radiat ., 4(3) , 149 -153.
[12] Alzahrani J.H. 2012 "Natural Radioactivity and Heavy Metals in Milk Consumed in Saudi Arabia and Population Dose Rate Estimates ", Life Science Journal, 9(2):651 - 656.
[13] Alasri.M.S.,Mukallati.H.,AlHamwi.A.,Khalili.H.,Hassan.M.,Assaf.H.,Amin.Y.,Nashaw-ati,A. 2004 " Natural radionuclides in Syrian diet and their daily intake " Journal of Radioanalytical and Nuclear Chemistry, 260(2).
[14] UNSCEAR 2000 united nations scientific committee on the effect of atomic radiation source ,effect and risks of ionizing radiation.report to the general assembly ,with scientific annexes.United Nations,New York.