Evaluating Radon Level in Imported Milk Using CR-39 Detector

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Abstract

The current study aims to measure the concentration of radon gas in four milk samples (NIDO, Anchor, MAHMOOD and RAINBOW) collected from the local markets in Baghdad city, which are imported from various countries. Analysis of milk is important because milk is an indicator of environmental pollution, and is a significant pathway for radionuclide intake. The results show that the highest average value of was found in RAINBOW milk (Oman) and was equal to 44.045. While the lowest value of the average is found in the sample of Anchor milk (New Zealand) was equal to 24.70133. Also, Results indicate that the concentrations of the in all studied samples are less than the recommended value. While Annual effective dose (AED), surface exhalation rate and effective Radon content for all samples were below the global limits, therefore these kinds of milk are Therefore, these types of milk can be considered safe to use as it relates to concentration of the radon.

Key Words: Radon Concentration, CR-39 Detector, Powder Milk.

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Introduction

It is necessary to know the levels of radiation in the ambience for the purpose of estimation the effects of radiation exposure that results from various sources [1]. About 80% of the radiation dose that the human body acquires from natural sources. The usual dose of gamma rays is around 2.4 mSv / year [2]. Terrestrial radiation from different radioactive elements that are present in soil, water, air and their abundance changes based on the geological and geographical characteristics of the region, natural radionuclides such as $^{232}_{90}Th_{142}$, $^{238}_{92}U_{146}$, $^{40}_{19}K_{21}$ present in soil considered the background of radiation [3]. The largest part of exposure to natural radiation comes from Radon gas. Radon is an inert element of uranium when it decomposes to form a stable lead [4]. Radon is one of the most common sources of radiation to which a person is exposed [4]. Studies show that the radionuclides in water are absorbed more easily than radionuclides incorporated in food [5]. The nuclear weapon experimentations and a few nuclear reactor accidents caused a large release of radionuclides to the atmosphere and dispersed in the biosphere, besides natural radionuclide. One more fact is that on account of a nuclear accident anyplace in the world, through the importation of contaminated foods, the health of people in any place can be indirectly affected. There are two main sources of radiation exposure to people are the external source of radionuclides on the surface of the earth and the internal source as a result of ingestion of food. The importance of measuring the level of radiation in the environment and foodstuffs lies in controlling radiation exposure levels. [6]. The detector used in this study is one of the types of organic detectors called CR-39 and is used in the detection of alpha particles because it has a high sensitivity [7].

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Materials and Methods

Twelve samples of four brands of powdered milk which imported from different countries were collected from the Iraqi local markets. As shown in the Table (1).

Table 1. Commercial names, codes and country of origin for the milk samples.

Samples	Samples cod	Country of origin
NIDO	N1	Franca
	N2	
	N3	
Anchor	A1	New Zealand
	A2	
	A3	
MAHMOOD	M1	Dubai
	M2	
	M3	
RAINBOW	R1	Oman
	R2	
	R3	

Methods and Materials

The CR-39 detector is one type of the Solid State Nuclear Detectors, with 500μm thickness, the UK issued [8]. The detector was segmentation into small parts with an area (1cm×1cm), fixed in the bottom of the dosimeter, as shown in figure (1), and left around 40days for irradiation by alpha particles. After completing the process of etching and washing the detectors with distilled water, the tracks in each detector were counted visually using an optical microscope with the power being off (400X).

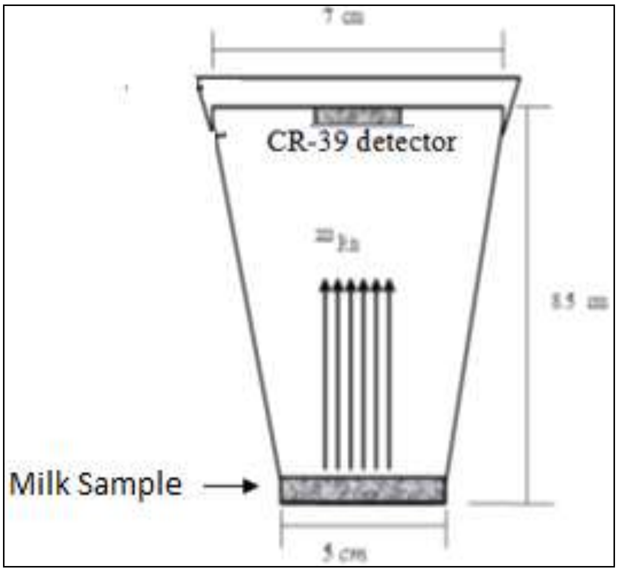

Figure 1. A schematic picture of the tight-cup techniques in milk samples [9]

To measure the tracks density in detector, the following equation can be used [10]:

$$\rho = \frac{N}{A} \qquad (1)$$

Where:

ρ: Density of track, N: Total of average tracks , and A: Field view area .

The radon concentration was measured by using the relation (2) [11]:

$$C_{Ra}\left(\frac{Bq}{m^3}\right) = \frac{C_0\left(\frac{Bq.day}{m^3}\right)\,\rho\left(\frac{track}{cm^2}\right)}{\rho_0\left(\frac{track}{cm^2}\right)\,t(day)} \qquad (2)$$

C_{Ra}, C_0 = Radon concentration in (Bq/m^3) for unknown and standard sample respectively.

ρ , ρ_0 = track density (tracks/cm^2), for unknown and standard sample respectively

t = exposure time (days) of distributed detectors.

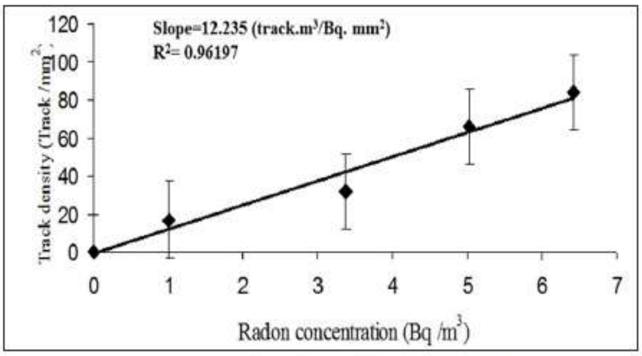

Figure 2. Relation between Radon Gas Concentration and Track Density for Standard Samples

1. Effective radon content in milk sample (C_d *):*

Using equation (3), the effective radon content in milk sample was calculated [12]:

$$C_d\left(\frac{Bq}{kg}\right) = (C_{Rn} \times \lambda \times h \times t)/L \qquad (3)$$

Where:

C_{Rn}: The concentration of radon inside the swallowed water in (Bq/kg), λ: The decay constant of ^{222}Ra, h: The space from the sample surface to the detector (m)= 0.09m, t: The exposure time (h) = 60 day = 960 h, L: The deepness of the sample (m) = 0.05m.

Radon Exhalation Rate

Radon exhalation rate values were calculated by relation (4) [13]:

$$E_x = \frac{C \times V \times \lambda}{A\left[T + 1/\lambda\left(e^{-\lambda t} - 1\right)\right]} \qquad (4)$$

Where:

E_x: The radon exhalation rate (Bq $m^{-2}h^{-1}$), C: The Radon concentration (Bq.$m^{-3}d^{-1}$), V: The volume of air in cup (cm^3) =452.16cm^3 =452.16*$10^{-3}cm^3$, λ: The decay constant for ^{222}Rn

(h^{-1}) = 0.1812 day^{-1} =0.00755h^{-1}, A: The surface area of the sample (m^2) =4^2×3.14= 50.24cm^2= 0.005024m^2, T: The exposure time (h) = 40day = 960h.

The Annual Effective Dose (AED)

The annual effective dose was calculated by fowling equation [12]:

$$AED\ (mSvy^{-1}) = C \times F \times T \times D \quad (5)$$

Where:

C: is the concentration of radon, F: is the factor of indoor equilibrium, T: is time, D: Dose conversion factor.

Results and Dissection

The results in the table (2) show that the radon concentrations show that the radon concentrations Table show the Radon concentrations which have been measured by the CR-39 detector and other related parameters. From Table (2), it can be observed that the maximum average value of radon concentration was 44.045 Bq/kg in RAINBOW milk, and the minimum average value of radon concentration was 24.701 Bq/kg in Anchor milk. Current results showed that the radon concentrations in the studied samples were below the recommended level by (ICRP). Effective annual dose values were from 0.779 mSv /y to 1.389 mSv /y, with an average of 1,373 mSv /y.

Table 2. Radon concentration, Annual effective dose (AED), surface exhalation rate E_x, and effective Radon content C_s, for the milk sample

Samples cod	ρ $(Track/mm^2)$	Radon Gas Concentratio (Bq/kg)	AED (mSv/y)	E_x $(Bq/m^2 h)$	Effective Radon content in the milk sample C_s	
					(Bq/kg)	(pCi/kg)
N1	250	20.433	0.644	1.943	266.577	7197.581
N2	533.333	43.591	1.3747	4.146	568.706	15355.05
N3	593.333	48.495	1.529	4.612	632.685	17082.5
Avg.	**458.8887**	**37.506**	**1.183**	**3.567**	**489.323**	**13211.71**
A1	106.667	8.718	0.275	0.829	113.739	3070.94
A2	333.333	27.244	0.859	2.591	355.436	9596.775
A3	466.667	38.142	1.203	3.627	497.616	13435.63
Avg.	**302.2223**	**24.701**	**0.779**	**2.349**	**322.263**	**8701.113**
M1	536.667	43.863	1.383	4.171	572.254	15450.86
M2	490	40.050	1.263	3.809	522.508	14107.72
M3	366.667	29.969	0.945	2.850	390.988	10556.66
Avg.	**464.4447**	**37.961**	**1.197**	**3.610**	**495.250**	**13371.75**
R1	670	54.761	1.727	5.208	714.434	19289.72
R2	603.333	49.312	1.555	4.689	643.344	17370.29
R3	343.333	28.062	0.885	2.669	366.108	9884.918
Avg.	**538.8887**	**44.045**	**1.389**	**4.1887**	**574.629**	**15514.97**

As for the values of effective radon content in the studied samples, they were less than the permissible value recommended by the Organization for Economic Cooperation and Development. Values of the Radon exhalation rate E_A varied from 2.349$(Bq/m^2.h)$ to 4.1887$(Bq/m^2.h)$. It was found that the Rainbow sample manufactured in Oman recorded the highest average exhalation value for radon.

Conclusion

Activity concentrations of ^{222}Rn were determined for only 4 brands of powdered milk consumed. The mean values of activity concentrations become range from 24.701 Bq/kg to 44.045Bq/kg are normally orders lower than the ICRP values mentioned (1-1000) Bq/kg [14]. The current results indicated that the annual effective doses in milk samples are lower than the global value 1mSv/y, therefore, the milk samples are safe as the radon concentration being concerned. Many of the analyzed milk samples, the brand from New Zealand (Anchor) confirmed a low degree of radioactivity.

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