Measurement of Radon Radiation Concentration in Imported and Local Powdered Milk using Nuclear Track Detector CR - 39

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Abstract. This study aims at measuring radon radiation in 35 different samples of local and imported powdered milk using nuclear track detector CR-39 to record the existence and impact of Alpha particles emitted from radon in the examined samples. Plastic pipes and tubes of the U type were used with the samples in radiating the detector. The study revealed that the highest concentration of radon was (1371.3) Bq.m⁻¹ in the sample M₄ (Dielac2-Dubai) and the lowest concentration is in sample M₃₂ (Lamsa- Jordan) with a radon level (151.8) Bq.m⁻¹. The levels of radon that were measured fall within the normal and natural concentration of the radiation that emit from the radionuclide in food and thus do not make any risk to the human life.

Key words: Radon gas, CR – 39 detector, radon in Milk.

1. Introduction

Human beings get exposed to radiation in an ongoing way from two main resources: natural resources as well as industrial resources that are made by man for different purposes and uses. The exposure to natural resources is the main type of radiation exposure such as the exposure to the cosmic rays and the rays from the radioactive elements in nature. The surrounding materials all have at least a minimal level of radiation. Thus, man gets exposed to a low level of radiation and that radiation has effect on the environment which lasts for many years and this radiation affects the gene recombination of man and animals and it could lead to genetic defects that appears in the next generations. Moreover, the effect of this pollution goes into water and soil and thus goes into the food chain of man and animals.

The high levels of radiation form rays and nuclear explosions resources lead to pollution in the environment and the resulting consequences affect the human beings. For example, falling down and detonating of nuclear bombs on Hiroshima and Nagasaki in 1945 was the beginning of the environmental pollution that was followed by nuclear explosions under the ground during 1955-1965. The Chernobyl disaster in the USSR in 1986 affected a huge land with radiation as well as the resulting operations from
the use of radioactive resources in the medical, industrial, agricultural sectors and other applications (1). Thus, the studies and radiation testing and inspection for the air, soil, rocks, water, heavy water, and food and other to measure the level of radiation doses that the human being gets exposed to. All these things led to the need to measure and study the effect of radiation and identifying the extent of environmental pollution and ways of dealing with it. Thus, different technologies have been developed such as revealing the impact of that was used in this study to measure the concentration of uranium in samples of powdered milk from local and global brands (2).

Radon is one of the elements in the periodical table and it is one of the noble and radioactive gases whose atomic number is 86 and it is found in nature in a gas form where it is considered one of the heaviest gases in nature. It was discovered in 1900 by Dorn in the radium salts (3). Radon is colorless and without smell and it is released from soil into the air through the spread of particles and it is composed of three isotopes:

1- Radon (Rn) and it is an isotope and belongs to the chain U238 and it is considered the longest among isotopes of radon where half-life is 3.825 days and this half-life gives it a capability to spread for long distances in the air and it spreads Alpha particles with an energy 5.4MeV

2- Thoron gas (Th) and it is the isotope (219Rn) and it belongs to the chain (235Ac) and its half-life is 55 seconds and it spreads and gives Alpha particles with an energy (2.6MeV).

3- Actinum (Ac) is an isotope (219Rn) and it belongs to (232Ac) and its half-life is four seconds and it is rarely found in nature because of the scarcity of (235U) and also because of its short half-life.

The exposure to radon is one of the risky health problems and there has been a proven relationship between the spread of Alpha particles and lung cancer where its inhalation into lungs with large amounts results in its absorption into the walls of the respiratory system. The studies and statistics have found that 200 death cases for every 105 people who get exposed to radon and its isotopes (5). The possibility of lung cancer from radon radiation is long-proved where it has been noted with miners workers where radon is spread (Ra226) which emits radioactive radon (6). It has been possible to prove that radon is one of the causes of lung cancer for mice which are exposed to it through experiments with a concentration of (10-3 μci/mm³) and it has been noted that lung cancer appears in mice (7).

2. The practical side
The samples were collected from powdered milk from local and global brands (35 samples) as in table (1). Five 5kg of each sample was then put into plastic plates with 3.8cm upper base and the lower base is 3.3cm and with a height. The detector (CR-39) was stuck into the plate cover and the Alpha particles resulting from the de-solution of radon was documented as in diagram (1) where the plate used for radiation to have radon concentration where the plate dimensions are ideal where there is a separation between radon and thoron gases on the basis of the half-life where radon is (3.8) days and thoron is (55) seconds and the emission from the milk sample into the detector lasts longer time than the half-life of thoron. After that, detectors were lifted after radiating for 60 days and then the chemical skimming was conducted as in diagram (2) after the process of radiating to reveal the effect of the spread particles resulting from Uranium (U238) that reacted to the detector. This process was conducted using sodium hydroxide (NaOH) skimming with weight (N6.25) and with a centigrade ℃(70) within (6 hours) as the most appropriate method where the solution was heated using water bath with noting the tight holding of the Erlenmeyer flask to prevent vaporizing of the solution in the process of skimming and changing its concentration in addition to the process of condensation in the skimming solution and at the required temperature where the detector is put into the skimming flask after hanging it by a wire. After skimming
the samples, the flasks are taken out of the skimming solution by tongs and washed by water and then dried (8).

In this stage, the effects of the detection through zooming in with (400X) and then the number of size unit using a special lens divided into four squares with a rate of the number of effects and the calculation was put into a special gradual way on a glass slide in front of an objective lens where the length of side of the small or big square and then calculating the space and then dividing the number of effects (Nave) for each sample (x) on the calculated space unit (A) to reach the density of effects (ρx) and for the purpose of measuring the level of concentration of radon using the previous method through identifying the spread determiner of the system which differs from system to system on the basis of the dimensions of the system and its form. It needs to be considered that the concentration of the radioactive materials do not depend on the geometric dimensions of the system if the masses and sizes of the samples remain stable where the spread determiner of the used system in this study (K) was calculated using the following relation (9):

\[ K = \frac{1}{4} \times r \left( 2 \cos \theta c - \frac{r}{R \alpha} \right) \]  
(1) 

\[ C_{Rn} = \frac{\rho}{TK} \]  
(2) 

Where \((C_{Rn})\) refers to the concentration of the air vacuum and \((p)\) the density of the effects and \((T)\) is the time of the detector exposure to air and \((k)\) and Equilibrium Factor [11].

It is possible to find EEC that represent the concentration value of the balanced radon (concentration Equivalent Equilibrium) from the following relation (12):

\[ EEC = C_{Rn} \times K \]  
(3) 

And EEC is measured using \((\text{Bq.m}^{-3})\)

While \((D)\) represents Effective Annual Dose, and its unit is \((\text{mSv/y})\) and it can be calculated through the following relation [13]:

\[ D = C_{Rn} \times K \times H \times t \times Df \]  
(4) 

Where \((C_{Rn})\) represents radon concentration and the unit here \((\text{Bq.m}^{-3})\).

And \((H)\) is (occupancy factor) = 0.8

\((T)\) represents the number of hours in the year= 8760y/h

\(Df\) is (actor conversion d) = \(9 \times 10^{-6}\) (msv/Bq.m\(^{-3}\).h)
The microscope used in this study is a Germany-made and has objective lenses with enlargement and zooming power of (100x, 40x, 20x, 10x) and two optical lenses with the power (10x) to measure the density of effect.

![Diagram 1. Exposing the detector to radon using the plate method](image1)

![Diagram 2. Chemical skimming of the nuclear effect detector (CR-39)](image2)

Table 1. Represents symbols of the powdered milk samples (local and imported)

| Number of the sample | Name of the sample | Make          | Number of the sample | Name of the sample | Make  |
|----------------------|--------------------|---------------|----------------------|--------------------|-------|
| M₁                   | Dielac 1           | Dubai         | M₁₉                  | Like               | Jordan|
| M₂                   | Brimalc            | The Netherland| M₂₀                  | Kraft              | Jordan|
3. The findings and discussion

In this study, the concentrations of radon in the powdered milk were calculated as shown in table (2) and through measuring radon concentration in the samples, the findings show that the highest concentration is (1371.3) Bq.m⁻³ in sample (M₄) and the lowest concentration is (151.8) Bq.m⁻³ in sample (M₃₂) and that the average concentration of all samples is (577.5) Bq.m⁻³. The value of the concentration of the balanced radon was also measured and showed that the highest level is (726.8) Bq.m⁻³ in sample (M₃₂) and the lowest level is (80.4) Bq.m⁻³ in sample (M₄), and the average of samples is (306.1) Bq.m⁻³. Then, the annual active dose was calculated from the radon concentration values where the lowest value of equalized annual dose is (45.8) mSv.y⁻¹ in sample (M₄) and the average accumulated annual dose of samples is (19.3) mSv.y⁻¹ which remains within the allowed limits.

Table 2. The concentrations of radon in the local and imported powdered milk samples

| Symbol | Name          | Origin      | Symbol | Name          | Origin   | Symbol | Name          | Origin      | Symbol | Name          | Origin      | Symbol | Name          | Origin      |
|--------|---------------|-------------|--------|---------------|----------|--------|---------------|-------------|--------|---------------|-------------|--------|---------------|-------------|
| M₃     | Celia         | France      | M₂₁    | Diana         | Iraq     |        |               |             |        |               |             |        |               |             |
| M₄     | Dielac 2      | Dubai       | M₂₂    | Mofeed        | Jordan   |        |               |             |        |               |             |        |               |             |
| M₅     | Nactalia      | France      | M₂₃    | Marai         | Jordan   |        |               |             |        |               |             |        |               |             |
| M₆     | Dovielac      | France      | M₂₄    | Sayadat Al Haleeb | UAE |        |               |             |        |               |             |        |               |             |
| M₇     | Miedo         | Jordan      | M₂₅    | Hana          | Iraq     |        |               |             |        |               |             |        |               |             |
| M₈     | Moniash       | Iraq        | M₂₆    | Tama Al Keery | Jordan   |        |               |             |        |               |             |        |               |             |
| M₉     | Dielac        | New Zealand | M₂₇    | Hana 2        | Iraq     |        |               |             |        |               |             |        |               |             |
| M₁₀    | Altun Sa      | Dubai       | M₂₈    | Rawa          | New Zealand |        |               |             |        |               |             |        |               |             |
| M₁₁    | Rawa Al Modheesh | New Zealand | M₂₉    | The amazing Batal | Iraq |        |               |             |        |               |             |        |               |             |
| M₁₂    | Moniash       | Oman        | M₃₀    | Celeka        | New Zealand |        |               |             |        |               |             |        |               |             |
| M₁₃    | Noosh         | Iraq        | M₃₁    | The Amazing boy | Iraq |        |               |             |        |               |             |        |               |             |
| M₁₄    | Mielac        | Jordan      | M₃₂    | Lamsa         | Jordan   |        |               |             |        |               |             |        |               |             |
| M₁₅    | Ancor         | New Zealand | M₃₃    | Sunny         | France   |        |               |             |        |               |             |        |               |             |
| M₁₆    | Halibana      | New Zealand | M₃₄    | Baby Liah     | Jordan   |        |               |             |        |               |             |        |               |             |
| M₁₇    | Tam Al Hana   | Jordan      | M₃₅    | Novielac 2    | Germany  |        |               |             |        |               |             |        |               |             |
| M₁₈    | Gold Gazal    | Jordan      |        |               |             |        |               |             |        |               |             |        |               |             |
|   | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 |
|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 38.9 | 216.4 | 12.0 | 190.6 | 359.6 | 39.4 | M_1 | .1 |
| 116.9 | 650.7 | 36.2 | 573.2 | 1081.5 | 92.2 | M_2 | .2 |
| 37.7 | 209.8 | 11.7 | 184.8 | 348.6 | 38.6 | M_3 | .3 |
| 148.3 | 825.1 | 45.8 | 726.8 | 1371.3 | 113.4 | M_4 | .4 |
| 89.1 | 496.1 | 27.6 | 437.0 | 824.4 | 73.4 | M_5 | .5 |
| 76.4 | 425.3 | 23.6 | 374.6 | 706.9 | 64.8 | M_6 | .6 |
| 46.3 | 257.5 | 14.3 | 226.8 | 427.9 | 44.4 | M_7 | .7 |
| 54.2 | 301.9 | 16.8 | 265.9 | 501.8 | 49.8 | M_8 | .8 |
| 63.7 | 354.6 | 19.7 | 312.3 | 589.3 | 56.2 | M_9 | .9 |
| 92.4 | 514.2 | 28.6 | 452.9 | 854.5 | 75.6 | M_{10} | 1.0 |
| 63.7 | 354.6 | 19.7 | 312.3 | 589.3 | 56.2 | M_{11} | 1.1 |
| 76.1 | 423.7 | 23.5 | 373.2 | 704.1 | 64.6 | M_{12} | 1.2 |
| 23.8 | 132.5 | 7.4 | 116.7 | 220.1 | 29.2 | M_{13} | 1.3 |
| 99.2 | 552.0 | 30.7 | 486.2 | 917.4 | 80.2 | M_{14} | 1.4 |
| 39.8 | 221.3 | 12.3 | 194.9 | 367.8 | 40.0 | M_{15} | 1.5 |
| 98.0 | 545.4 | 30.3 | 480.4 | 906.5 | 79.4 | M_{16} | 1.6 |
| 22.0 | 122.6 | 6.8 | 108.0 | 203.7 | 28.0 | M_{17} | 1.7 |
| 38.0 | 211.4 | 11.7 | 186.2 | 351.4 | 38.8 | M_{18} | 1.8 |
| 65.8 | 366.1 | 20.3 | 322.5 | 608.4 | 57.6 | M_{19} | 1.9 |
| 27.0 | 150.6 | 8.4 | 132.6 | 250.2 | 31.4 | M_{20} | 2.0 |
| 30.9 | 171.9 | 9.6 | 151.4 | 285.8 | 34.0 | M_{21} | 2.1 |
| 73.8 | 410.5 | 22.8 | 361.6 | 682.3 | 63.0 | M_{22} | 2.2 |
| 52.5 | 292.1 | 16.2 | 257.2 | 485.4 | 48.6 | M_{23} | 2.3 |
| 42.4 | 236.1 | 13.1 | 208.0 | 392.4 | 41.8 | M_{24} | 2.4 |
| 99.2 | 552.0 | 30.7 | 486.2 | 917.4 | 80.2 | M_{25} | 2.5 |
| 93.3 | 519.1 | 28.8 | 457.2 | 862.7 | 76.2 | M_{26} | 2.6 |
| 99.8 | 555.3 | 30.9 | 489.1 | 922.9 | 80.6 | M_{27} | 2.7 |
| 69.9 | 389.1 | 21.6 | 342.8 | 646.7 | 60.4 | M_{28} | 2.8 |
| 41.2 | 229.5 | 12.8 | 202.2 | 381.5 | 41.0 | M_{29} | 2.9 |
| 80.0 | 445.1 | 24.7 | 392.0 | 739.7 | 67.2 | M_{30} | 3.0 |
| 49.2 | 274.0 | 15.2 | 241.3 | 455.3 | 46.4 | M_{31} | 3.1 |
| 16.4 | 91.3 | 5.1 | 80.4 | 151.8 | 24.2 | M_{32} | 3.2 |
| 35.9 | 199.9 | 11.1 | 176.1 | 332.2 | 37.4 | M_{33} | 3.3 |
| 52.2 | 290.4 | 16.1 | 255.8 | 482.6 | 48.4 | M_{34} | 3.4 |
| 31.5 | 175.2 | 9.7 | 154.3 | 291.2 | 34.0 | M_{35} | 3.5 |
| 16.4 | 91.3 | 5.1 | 80.4 | 151.8 | 24.2 | Min | 3.6 |
| 148.3 | 825.1 | 45.8 | 726.8 | 1371.3 | 113.4 | Max | 3.7 |
| 62.4 | 347.5 | 19.3 | 306.1 | 577.5 | 55.3 | Average | 3.8 |

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**References**
[1] ALDulaimi B K 2018 Calculation of radon concentrations in the buildings of Tikrit University for the years 2017-2018 and radiation indicators using the nuclear track detector CR-39 and RAD-7. M.Sc. Thesis, Physics Department, College of Science, Tikrit University, Iraq.

[2] Rejah B Kh 2011 Measurement of Background Radioactivity in Sewage Sludge for Baghdad City Treatment Stations. Baghdad Science Journal. 8(2):439 – 443.

[3] Ghassan A 1999 Radon and its effects on man and environment. Atom and Development Quarterly, vol. 11, no. 33.

[4] Ammar A 1999 Radon: Risks and benefits. Atom and Development Quarterly, vol. 11, no. 2.

[5] Archer V E, Wagoner G K, Lundin F E Health Phys., Vol.25, P.351 (1973).

[6] Jasimuddin U A 1994 Radon in the human environment Assessing the picture Quarterly Journal of the international atomic energy Agency, Vol.36, No.2, Vienna, Austria.

[7] Maroof B H 1989 The protection of ionized radiations. Publications of Atomic Energy.

[8] Al Sudani Z 2016 concentrations of natural and industrial radionuclides in different environmental samples in Amar city- Missan, Iraq. Unpublished PhD dissertation, College of Sciences for women, Baghdad University.

[9] Azam A, Naqvi A H and Srivastava D S 1995 Radium Concentration and Radon Exhalation Measurements Using LR – 115 Type II Plastic Track Detectors. Nucl. Geophys., 9(6): 653 – 657.

[10] Tawfiq N F Nasir H M and Khalid R 2012 Determination of Radon Concentrations in AL-NAJAF Governorate by Using Nuclear Track Detector CR-39. Journal of AlNahrain University, 15 (1): 83-87.

[11] UNSCEAR 2008 United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). UNSCEAR 2006 Report. Annex E. Sources-to-Effects Assessment for Radon in Homes and Workplaces. New York: United Nations.

[12] UNSCEAR 2010 United National Scientific Committee on the Effects of Atomic Radiation. Report to the General Assembly, United Nations, New York.

[13] UNSCEAR 2000 Exposures from Natural Sources, Report to General Assembly, Annex B, New York.