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Alpha Radioactivity in Various Brands of Rice in Iraqi Market

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Abstract

Natural radioactivity is wide spread in the earth's environment and it exists in various geological formations in soils, rocks, plants, water and air. The growing worldwide interest in natural radiation exposure has led to extensive surveys in many countries. The study was carried out to evaluate alpha radioactivity concentration in ten various brands of rice was collected from Iraqi market. Alpha sensitive CR-39 plastic track detectors commonly known as "Solid State Nuclear Track Detectors" were used to measure the radium and radon exhalation rate. The alpha particles emitted from the radon causes the radiation damaged tracks. The Chemical etching in NaOH at 70°C for about 8 h was done to reveal these latent tracks, which were then scanned and counted by an optical microscope of suitable magnification. The radon concentration and radium concentration in various brands of rice vary from 1.252 $\times 10^3$ Bq/m^3 to 23.110$\times 10^3$ Bq/m^3 with an average 6.940$\times 10^3$ Bq/m^3 and from 0.149 Bq/kg to 2.757 Bq/kg with an average 0.775 Bq/kg, respectively. The radon exhalation rates varied from 1.129 mBq/kg.h to 20.838 mBq/kg.h with an average 5.861 mBq/kg.h and surface exhalation rates from 20.268 mBq/m^2.h to 374.051 mBq/m^2.h with an average 105.212 mBq/m^2.h. Radium concentrations in the samples of this study were at higher concentrations of radium in grain products in the United States, China, Japan, Poland and Romania it were within the ranges of concentrations of radium in grain products in Germany and the United Kingdom. Excellent correlation has been observed between radium concentration and the radon exhalation rate in different rice samples.

Keywords

Alpha Radioactivity, Radon Concentration, Nuclear Tracks, Exhalation Rate, Rice

1. Introduction

Naturally occurring radioisotopes are the main sources of both external and internal radiation exposure in humans. Of the terrestrial radioisotopes thorium, uranium and potassium enter the human body primarily by ingestion of foods, while inhalation of these isotopes is limited [1]. The study of natural radioactivity is usually done in order to gain information about the present levels of harmful pollutants discharged to the environment itself or in the living creatures [2]. It is also important to understand the behavior of natural radionuclides in the environment because such information can be used as the associated parameter values for radiological assessment [3]. The release of radionuclides into environment contaminates food according to the type of soil, its chemical characteristics, and the physical and chemical forms of the radionuclides in the soil, radionuclide uptake by particular plant and finally the level of accumulation by particular foodstuffs [4].

Studies on the radioactivity of the consumable of rice assume importance as it is necessary to estimate the ingested dose to the public. ^{226}Ra is an α-emitter with a long half-life of 1600 y and closely follows calcium metabolism in the human body with eventual deposition in bones. This might lead to the buildup of ^{226}Ra and its daughters, causing potential health implications and high degree of radio-toxicity due to long exposure hazards.

Radon-222 is a radioactive gas with a half- life of 3.82 days. It is the immediate radioactive decay series products of radium (^{226}Ra), in the decay series of uranium (^{238}U) and thorium (^{232}Th). The process of the migration of radon is a

function of radioactivity concentration, and the porosity and permeability of the medium. Radon has long been known to contribute to risk of lung cancer. Radon is unstable and breaks down into radon progeny emitting highly ionizing alpha particles which is very harmful to humans when they are inhaled or swallowed [5].

The expose of population to high concentration of alpha radioactivity mainly of radon for a long period leads to pathological effects like the respiratory functional changes and the occurrence of lung cancer [6].

The alpha emitting radioactive substance is harmful to normal tissues of the human body because of their high attenuation power. Alpha emitters like uranium, thorium and their daughter are consumed in trace amounts by living species through their food chain and from the environment [7]. At present, rice is a very common item in our daily food menu and there are various kinds of rice in the market supplied by various countries. This rice contains a little amount of radioactive substance like alpha emitters that pose a great hazard by emitting alpha particles. These alpha particles may cause damage to normal tissues of various organs by their chemical and radioactive toxicity effects [8]. For this reason measurement of the concentrations of alpha emitters have been done in various rice samples, which are available in Iraqi market as well as other countries. So, the measurement of alpha emitter's concentration in rice is necessary to investigate the role of alpha emitting in causing various diseases, especially cancer.

2. Material and Methods

In this study, ten types of widely used rice samples which are available in Iraqi market were analyzed. For each sample about 27.27 g of rice was kept in a small cylindrical tube (6.5 cm height and 3.5 cm diameter) and marked with a proper number for identification.

Solid State Nuclear Track Detectors (SSNTD) with sheet thickness 500µm are used in this study, which is usually known as CR-39 plastic detector [9, 10]. The detectors are small square pieces of size 1cm×1cm they are digging a certain number on the top right corner of the detector to facilitate the process of gathering information and distinguish between the detectors for each various samples, and prove this detector in the inner surface of the top of the tube by adhesive two-sided. We used a sensitive balance to measure the weights with a sensitivity (10^{-3}) of the type (VIC-303 US) equipped made by a company (Accul AB Sartorius group).

In order to study radioactivity of alpha in rice were collected 10 samples of domestic and imported rice from local Iraqi markets. After sampling, the samples were dried and then been grinding samples and screened using a standard sieve to get to the delicate powder samples and placed them in test tubes described as in Figure 1. The samples for a period of one month in order to reach the state of equilibrium between radium – radon members of the decay series, after which the detectors offered nuclear impact of rice samples used for a period of 57 days for the purpose of measuring the concentrations of alpha emitted from the samples. After the completion of the expose, these were etched in 6N NaOH solution at a temperature of 70±1°C for eight hours. To make a chemical etched process has been put detectors in a water bath of type (Memmert WNB22, German-made), in this process is an endorsement tracks resulting from the fall of the alpha particles emitted by radon and its derivatives. And after the end of the time period was taken out of the detectors and the water bath and then washed with distilled water. After drying, detectors were starting the process of counting the effects of nuclear detectors by an optical microscope.

Views microscopic process is the final stage after etched chemical process, where it was formed to calculate the number of tracks on detector using an optical microscope (A. KRÜSS - Optronic German-made) where it is at this stage. Disclosure of its nuclear effects of alpha emitted particles from the samples by selecting an appropriate magnification that amount (100X). After that, for calculating the number of impacts per unit area using special lens is divided into several boxes according to the average number of effects. For example, taken 20 readers each sample, because the distribution of relic detectors to be random, and calculates the area of the box a special status gradation exists on the glass slide in front of the objective lens is calculated as the side length of the small or large square and then see the viewing area calculation.

Calibration factor used was 0.0459 tracks/cm^2. day=1Bq/m^3 [11]. The dissolve radon concentration in rice was calculated using the following equation [12- 14]:

$$C_{Rn} = \frac{C_a \lambda h T}{L} \quad (1)$$

Where C_a =radon concentration in ambient air (Bq/m^3), λ= decay constant for radon (d^{-1}), h=the distance from the surface of rice to detector (m), T=time of exposing and L=the depth of the sample (m).

It is reasonable to assume that an effective equilibrium (about 98%) for radium-radon members of the decay series is reached in about one month. Once the radioactive equilibrium is established, one may use the radon alpha analysis for the determination of steady state activity concentration of radium. The activity concentration of radon begins to increase with time T, after the closing of the can,

Radium concentration of the rice samples can be calculated using the formula [15, 16]:

$$C_{Ra} = \frac{\rho h A}{K T_e M} \quad (2)$$

Where, T_e is the effective exposure time which is related to the actual exposure time t and decay constant λ for ^{222}Rn with the relation [17, 18].

$$T_e = T - \frac{1}{\lambda}(1 - e^{-\lambda T}) \quad (3)$$

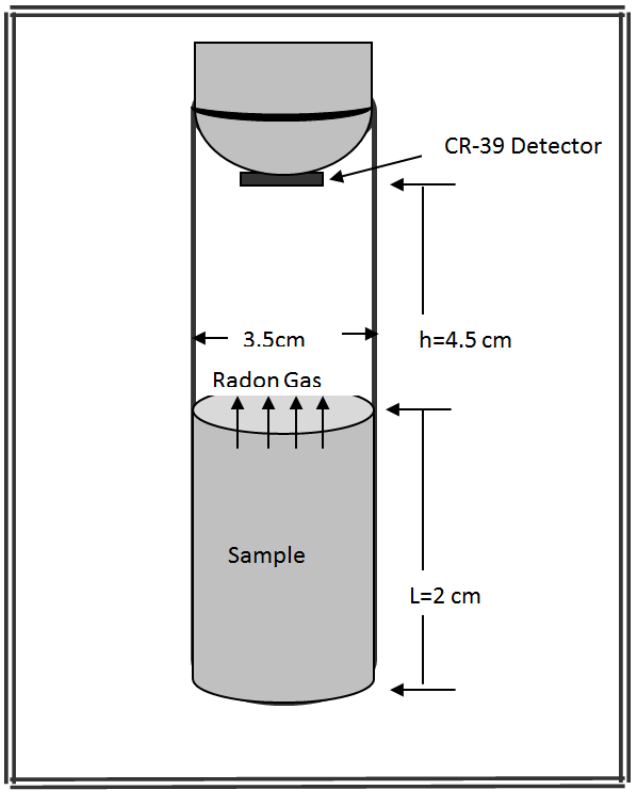

Figure 1. *Experimental setup for measurements of radium concentration and exhalation radon rates in rice samples.*

The radon exhalation rate in terms of area is calculated from the next equation [15, 19]:

$$E_A = \frac{CV\lambda}{AT_e} \quad (4)$$

Where, E_A is the radon exhalation rate expressed in $Bq/m^2.h$, C represents the integrated radon exposure ($Bq.m^{-3}.h$), V is the effective volume of the can in (4.3295×10^{-5} m^3), T_e is the exposure time (57 day), λ is the decay constant for radon and A is the area of the tube ($9.6211\times10^{-4}m^2$). The radon exhalation rate in terms of mass is calculated by using equation [15, 19]:

$$E_M = \frac{CV\lambda}{MT_e} \quad (5)$$

Here E_M is the radon exhalation rate in terms of mass (Bq/kg.h) and M is the mass of the rice sample.

3. Results and Discussion

The can technique proposed by Alter and Price [20] and later developed by Somogyi [21] was used to calculate the radium concentration and exhalation rates of radon in ten different of rice samples.

Where these samples were collected from the Iraqi market by three samples of rice product Iraqis and seven productive samples from different countries and set out in Table 1.

The results of radon, radium and exhalation rates of radon in terms mass and area for different of rice samples are presented in Table 1. The radon concentration in various brands of rice varies from 1.252×10^3 Bq/m^3 to 23.110×10^3 Bq/m^3 with an average 6.940×10^3 Bq/m^3.

From table 1, it found the highest concentration of radium in the Iraqi Mashkhab rice by 2.757 Bq/kg and less concentration in the Indian rice (Golden Mark) 0.149 Bq/kg with mean value 0.775 Bq/kg.

The concentration of radium found in a sample of the Iraqi rice (Mashkhab) concentrations is high compared to the radium concentrations in other types of imported rice as well as its concentration in the sample rice Mashkhab about four times the concentration in Alyasameen and Shamia samples of rice.

From figure 2, it has seen observed that there is variation in the values of radium concentrations and radon exhalation rate among the rice samples. This variation may be arising due to the difference in the nature of the sample and nuclei content of this sample.

Other reasons for the disparity radium concentrations in the samples of this study is the type and nature of this soil for rice-producing countries as well as the type and quantity of chemical fertilizers used in agriculture and rice production in those countries.

In addition to the above reasons, the use of insecticides to deal with pests and diseases, and type of the quantities used are influential factors in increased concentrations of radioactive nuclei in all agricultural plants.

The concentrations of radium in this study are higher than the concentrations of radium in grain-producing countries, especially in the United States, China, Japan, Poland and Romania. These concentrations were comparable to the concentrations of radium in Germany and the United Kingdom for the same products [22].

According to reported of the United Nations Scientific Committee on the effects of atomic radiation to the general report for the prevention of radiation in grain products may report it showed that the concentrations of radium in the United States ranged from 0.0007 to 0.1 Bq/kg, while in China and Japan were 0.017 and 0.014 Bq/kg, respectively. In Europe radium concentrations ranged from 0.020 to 2.9 Bq/kg in Germany and between 0.0007 to 5.2 Bq/kg in the United Kingdom, while the concentration between (0.008 to 0.110) Bq/kg in Boland and between (0.030 to 0.090) Bq/kg in Romania [22].

The concentrations of radium in this study are higher than the concentrations of radium in grain-producing countries, especially in the United States, China, Japan, Poland and Romania. but these concentrations were comparable to the concentrations of radium in Germany and the United Kingdom for the same products [22].

The radon exhalation rate measured in terms of mass and area of rice samples are found to vary from (1.129 to 20.268) mBq/kg.h with mean 5.861mBq/kg.h and (20.838 to 374.051) $mBq/m^2.h$ with mean 105.212 $mBq/m^2.h$, respectively.

Through our findings in this study, we find that the concentrations of radium in rice rate equal to twice the concentration of radium in the rice of the findings of some researchers in Egypt [23] and less about four times the

concentration of radium in the rice to the findings of some researchers in India [24].

Excellent correlation has been observed between radium content and the radon exhalation rate in terms mass and area in different rice samples shown in figures 3 and 4 respectively.

Table 1. *Values of radium and radon exhalation rate in terms of mass (E_M) and area (E_A) in different rice samples of Iraqi market.*

Code	Country	P (Track/cm^2)	C (Bq/m^3)	$C_{Rn} \times 10^3$ (Bq/m^3)	C_{Ra} (Bq/Kg)	E_M mBq/kg.h	E_A mBq/m^2.h
AR	Argentina	416.864	159.028	3.700	0.441	3.336	59.884
NI	Nicaragua	285.393	108.874	2.533	0.302	2.284	40.998
UR	Uruguay	436.106	166.369	3.870	0.462	3.490	62.648
TH	Thailand	378.384	144.349	3.358	0.401	3.028	54.356
IN	India (Mahmood)	798.459	304.602	7.086	0.845	6.390	114.702
IG	India (Golden)	141.093	53.825	1.252	0.149	1.129	20.268
IE	India (EVA)	846.561	322.952	7.513	0.896	6.775	121.612
IY	Iraq (Alyasmeen)	724.706	276.466	6.432	0.767	5.799	104.107
IM	Iraq (Mashkhab)	2603.813	993.323	23.110	2.757	20.838	374.051
IS	Iraq (Shamia)	692.638	264.233	6.147	0.733	5.543	99.501
Maximum		2603.813	993.323	23.110	2.757	20.838	374.051
Minimum		141.093	53.825	1.252	0.149	1.129	20.268
Mean		732.401	279.4021	6.940	0.775	5.861	105.212

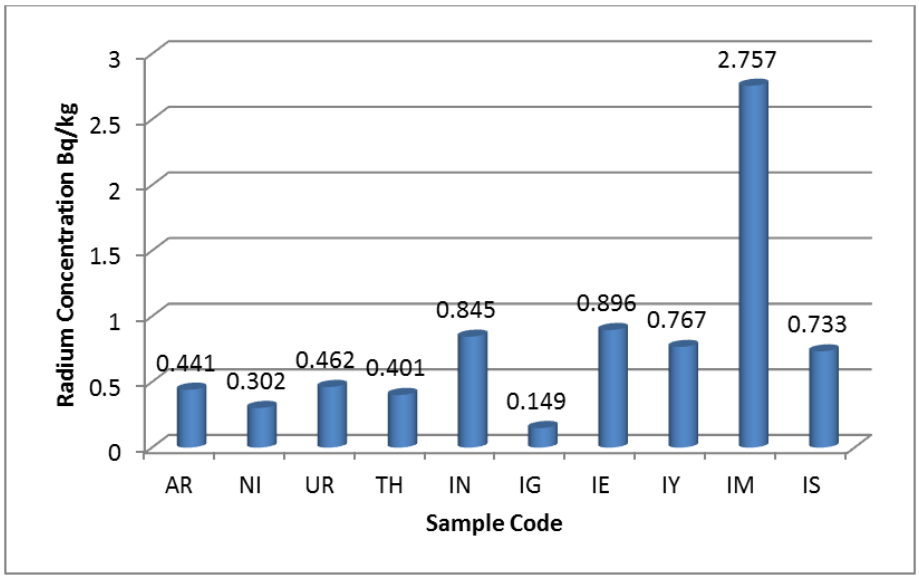

Figure 2. *Radium concentration in different rice samples.*

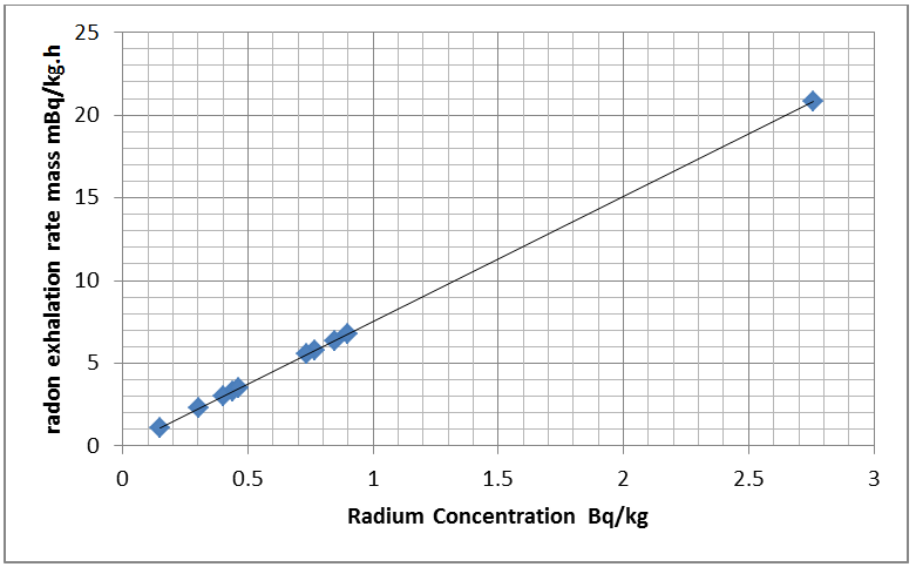

Figure 3. *Correlation between radium concentration and radon exhalation rate of mass.*

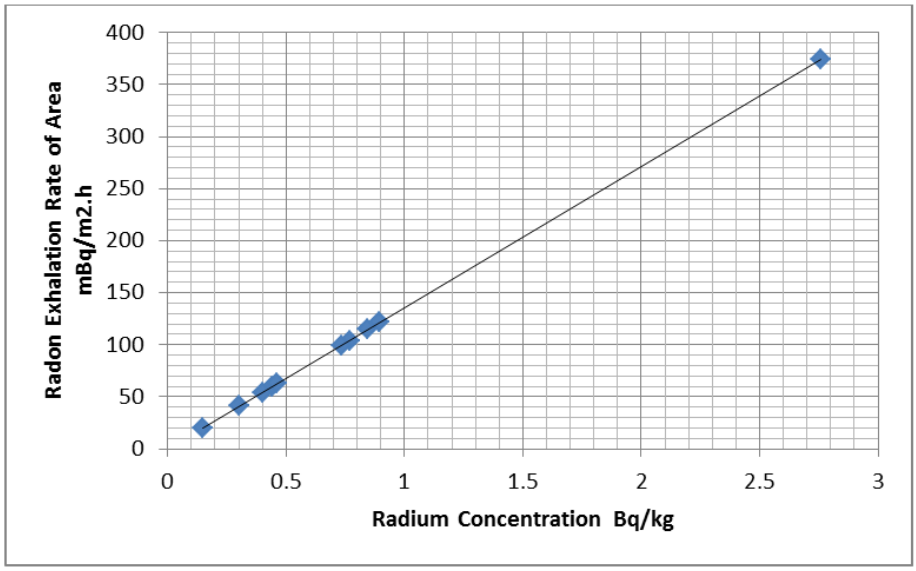

Figure 4. *Correlation between radium concentration and radon exhalation rate of area.*

4. Recommendations

Given the great importance of rice as the main staple and daily to humans and as a result to contain the different types of radioactive nuclei to him naturally, especially nuclei emitting alpha particles, which cause various diseases, especially cancer.

To reduce radioactivity and its effects on the health of people in grain products, especially rice, we recommend the following:

1. Creating the ground and plowed before planting rice season for the evaporation of some nuclei in the soil, especially radon gas.
2. Use chemical fertilizer that contains a few percentages of nuclei that cause cancerous diseases.
3. Check the soil before planting to make sure they are free of radioactive nuclei.
4. The use of modern techniques and methods in agriculture.
5. The use of modern techniques and methods in agriculture and community awareness of the health risks resulting from radioactive contamination.
6. Move away from the use of chemical fertilizers and pesticides on which contain high levels of radioactive nuclei to reduce the radiation danger posed to humans.
7. Non-use of anabolic substances to increase the rapid growth of plants because it leads to adverse effects on human and animal health together.
8. Accuracy in the importation of rice-producing countries of this crop is important to stay away from the countries where radioactive contamination is more than the permitted globally border.

5. Conclusion

The concentrations of radium and exhalation rates of radon in terms mass and area have been measured by "Sealed Can Technique" containing CR-39 solid state nuclear track detectors which are very sensitive for alpha particles. The results showed that the radium concentration in rice samples were ranged between (0.149 – 2.757) Bq/kg with a mean value 0.775Bq/kg. Also, the radon exhalation rate measured in terms of mass and area of rice samples were ranged between (1.129 - 20.268) mBk/kg. h with mean 5.861 mBq/kg. h and (20.838 - 374.051) mBq/m^2. h with mean 105.212 mBq/m^2.h, respectively. Excellent correlation has been observed between radium concentration and the radon exhalation rate in various brands of rice in Iraqi market.

When comparing the results obtained in this study with concentrations of radium in the United States and some European and Asian countries, it could be argued that the concentration of radium in samples of rice is higher than the concentrations of radium in grain products in the United States, China, Japan, Poland and Romania. But the results of the study were comparable to the concentrations of radium in Germany, the United Kingdom and in certain levels in grain products in these countries, noting that the highest concentration of radium in the dormitory Mashkhab Iraqi sample is less than the concentration of radium in grain products in these two countries.

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