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Measurement of Radon Exhalation Rate in some consuming Foodstuff in some Local Markets

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Abstract

This research aimed to evaluate the radon concentration for 11 different samples of consuming foodstuff collected from the markets. Alpha- CR-39 track detectors were used to analyze the radium concentration and radon exhalation rate. Al-Sayed coffee powder had the highest radon concentration of 99.7 Bq/m^3, while Al-Warda sugar had the lowest concentration of 56.5 Bq/m^3. The surface exhalation rate for the powdered milk samples varied from 2.3Bq/ m^2.h in Al-Marai sample to 3.5 Bq/m^2.h in sample Anchor. While the coffee powder samples ranged from 2.4 Bq/ m^2.h in sample Al-Rifai to 3.7 Bq/m^2.h in sample Al-Sayed. The sugar samples varied from 2.11 Bq/ m^2.h in sample Al-Warda to 2.3 Bq/m^2.h in sample Al-Usra. The lifetime cancer risk was found to be within the range of 28-44.8 people per million with a mean value of 36.5±0.5 for powdered milk, and within the range of 29.5-45.1 people per million with a mean value of 38±0.5 for coffee powder and the range of 25.5-28 people per million with a mean value of 26±0.07 for sugar sample. The samples measured are mainly used by consumers and do not contain harmful radioactivity.

Keywords: Radon concentration, Surface Exhalation, consuming Foodstuff, Alpha particle.

قياس معدل انبعاث غاز الرادون في بعض المواد الغذائية المستهلكة في الأسواق المحلية

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الخلاصة

تم تقييم تركيز غاز الرادون في احدى عشر عينة من المواد الغذائية المستهلكة بالاسواق المحلية، باستخدام كاشف الاثر النووي CR−39 . سجلت حبوب القهوة لعينة السيد أعلى تركيز للرادون 99.7Bq/m^3 ، بينما سجل في عينة سكر الزهرة أقل تركيز وبلغت قيمته 56.5Bq/m^3. في حين تراوح معدل الزفير السطحي لعينات الحليب المجفف من 2.3 Bq/ m^2.h في عينة المراعي إلى Bq/ m^2.h 3.5 في عينة حليب أنكور . بينما تراوحت معدل الزفير السطحي في عينات حبوب القهوة من Bq/ m^2.h 2.4 في عينة حبوب القهوة الرفاعي إلى Bq/ m^2.h 3.7 في عينة حبوب القهوة السيد. بينما تباينت القيم في عينات السكر من Bq/ m^2.h 2.11 في عينة سكر الزهرة إلى Bq/ m^2.h 2.3 في عينة سكر العائلة. وجد أن سرطان الرئة يتراوح بين 44.8−28 لكل مليون شخص بمتوسط قيم36±0.5 لعينات الحليب المجفف، وبنطاق 45.1−29.52 لكل مليون شخص بمتوسط قيمة 0.5± 38.6 لعينات حبوب

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القهوة. وتتراوح بين 28–25.5 لكل مليون شخص بمتوسط قيمة 26±0.07 لعينات السكر. تبين ان العينات التي تم دراستها امنة الاستخدام ولا تحتوي على نشاط إشعاعي ضار.

1. Introduction

The control of natural or artificial radiation levels, which are generally present in the environment and foodstuffs that are consumed on a continuous basis that humans are directly or indirectly exposed to necessitates precise measurements of radioactivity [1]. Several nuclear weapon tests and countless nuclear reactor accidents led to the introduction of a number of manufactured radioactive elements into the environment, which became a source of radioactive contamination [2,3]. Humans can be exposed to ionizing radiation via several routes, such as ingestion of food and inhalation Caused by radioactive contamination. Cancer, stomach disruption or death can be caused by prolonged exposure and the accumulation of radiation in the human body[4]. In order to evaluation radioactivity for in different foodstuff samples such as Milk, tea, coffee and sugar, It is necessary to know the level of radiation in it Because it is considered a source of consumption and most used [5]. Radium-226 is widely spread in the environment when humans consuming plants or drinking any fluids such as milk, tea, coffee, and water[6,7,8]. To ensure health safety, it is important to measure the concentrations of radon and radium in stuff food. Radon concentrations are determined from gamma emission after the decay of the radon offspring 214Pb and 214Bi, then achieving the secular equilibrium with 222Rn [9,10,11].

The purpose of this study was to knowledge into the radon gas concentrations and estimate the annual internal dose from the consumption of natural isotopes in powdered milk and coffee powder, tea, and sugar in Iraq. These readings can be used as a basis for estimating rates of radiation exposures and essential to ensure health safety.

2. Samples Preparation

Eleven samples were collected, 4 samples of milk powdered, and coffee powder and 3 samples of sugar from Al- Mansour region as shown in table 1. After being sieved, these samples were put inside cans. The can's dimensions were 8 cm in diameter and 13 cm in height. A 500μm-thick square piece of CR-39 detectors. The samples were positioned within the cans at a height of three centimeters, and the inner surface of the can covers held the NaOH that was used to prepare the solution. which were subsequently sealed for two months in order to attain the radioactive balance. Following this period, the CR-39 detectors were etched for four hours at 60˚C in a 6.25N NaOH solution in order to reveal the tracks of alpha particles. Following this period. Figure 1 displays what was used can's dimensions.

Table 1 : The studied foodstuffs

No	Sample	Code	Name of sample	production country	Date of manufacture
1	**Powdered milk**	P1	Al-Tunsa	Emirates	2021
2		P2	Gard	New Zeeland	2020
3		P3	Al-Marai	New Zeeland	2019
4		P4	Anchor	UK	2021
5	**Coffee powder**	C1	Al- Fajer	Jordan	2019
6		C2	A l –Sahara	New Zeeland	2020
7		C3	Al-Rifai	Turkey	2021
8		C4	Al-Sayed	Jordan	2019
9	**Sugar**	S1	Al-Usra	Saudi Arabia	2020
10		S2	Al- Frashaa	Iraq	2021
11		S3	Al-Warda	Iraq	2020

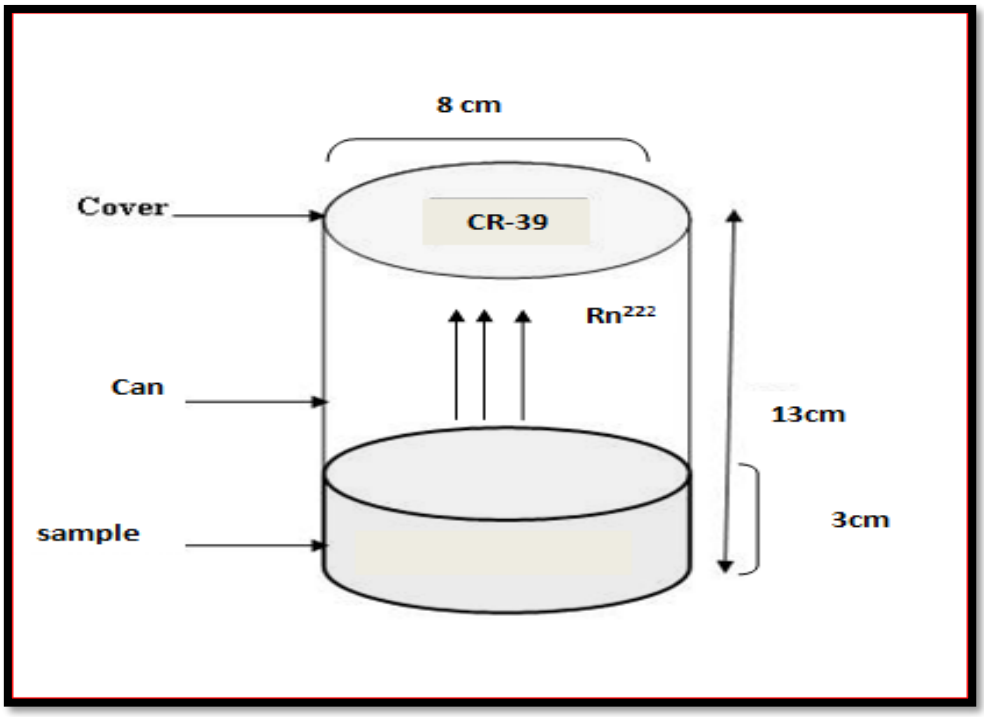

Figure 1: shows the cans' measurements

3.Caculation

3.1 Density of the tracks

The formula for calculating the density (ρ) of the tracks on the CR detector was as follows. [11,12].

$$Density\ of\ track\ (\text{tracks/mm}^2) = \frac{number\ of\ total\ pits\ (track)}{Area\ of\ filed} \quad (1)$$

3.2 Radon Exposure

The following relationship was used to calculate the amount of radon gas present in food buff samples [13,14].

$$C_{Rn}(sample) / \rho_{Rn}(sample) = C_s(standard) / \rho_s(standard) \quad (2)$$

Where:

C_{Rn}:The unknown sample's radon gas concentration.

C_S: The standard sample's radon gas concentration.

p_{Rn}: The unidentified sample's track density.

p_S : The unknown sample's track density.

Fig. 2 shows the calibration curve of radon gas concentration and track density for standard sources. The slope of the resulted straight line is track density/ radon gas concentration for a standard sample, from which the radon concentration of a sample can be calculated knowing its track density.

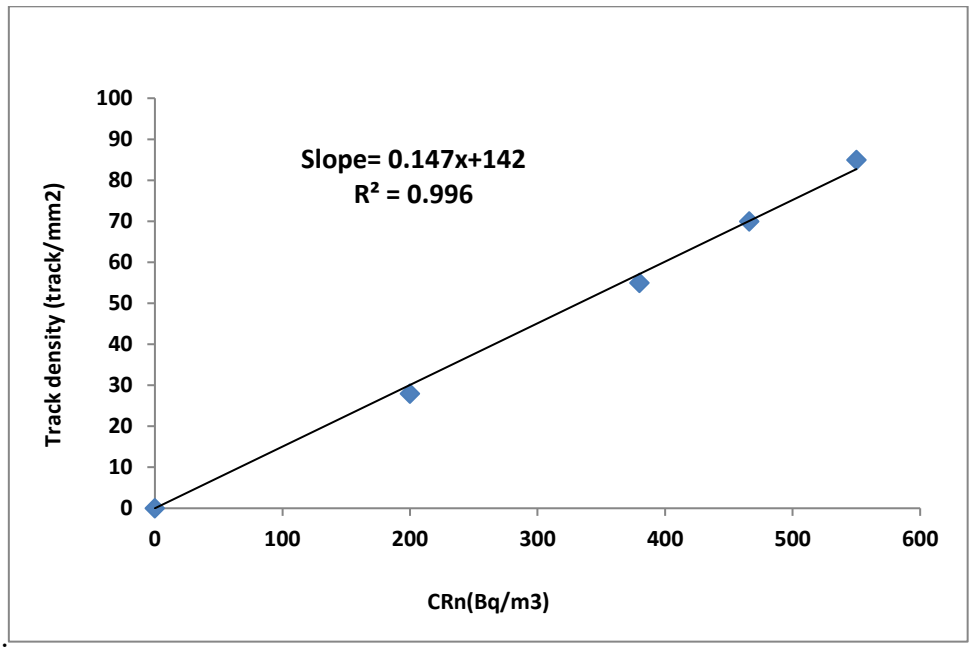

Figure 2: Relation of radon gas concentration and track density of the food buff samples

3.3 Radon Exhalation Rate :

The formula that follows can be used to determine the Radon Exhalation Rate [15,16]:

$$E_A = \frac{C\,V\,\lambda}{A\,(T+\lambda^{-1}\,(e^{-\lambda T}-1)} \quad (3)$$

Where: C is radon emission as measured by the detector, V is the volume of air in the cans (m^3) =452.16 cm^3= 0.000452 m^3, λ is the decay constant for ^{222}Rn (h^{-1}) = 0.1812 day^{-1} =0.00755 h^{-1},

A is the surface area of a sample (m^2) = $2.5^2 \times 3.14$=19.62 cm^2=0.001962 m^2, T is the exposure time (h) = 30day =720 h.

3.4 Annual effective dose

The Annual Effective Dose (AED) was calculated using the (mSv/y) unit[17,18].

$$AEDE = C_{Rn} \times F \times H \times T \times D \quad (4)$$

Where: C is radon emission as measured by the detector, V is the volume of air in the cans (m^3) =452.16 cm^3= 0.000452 m^3, λ is the decay constant for ^{222}Rn (h^{-1}) = 0.1812 day^{-1} =0.00755 h^{-1},

A is the surface area of a sample (m^2) = $2.5^2 \times 3.14$=19.62 cm^2=0.001962 m^2, T is the exposure time (h) = 30day =720 h.

3.5 The Cancer of Lung

The following relationship estimate the Excess Lifetime Cancer Risk (ELCR) values and the lifetime cancer risk [19,20].

$$ELCR = AED \times DL \times RF \quad (5)$$

$$LCR = AED \times 18 \times 10^{-6} \quad (6)$$

DL is the average lifespan of the population (70 years), RF is the risk of fatal cancer in per sieverts. the RF factor equal 18×10^{-6} Sv^{-1} and indicate the probability of developing cancer.

4. Results and Discussion

In this study, 11different food samples were analyzed 4 samples of milk powdered, 4 samples of coffee powder and 3 samples of sugar for a closed cans approach. Table 2 shows the values of the radon activity, surface exhalation rates, annual effective dose and The lung cancer. As the findings of the current study indicated the values of radon activity in collected samples were with a mean value of 81.7 ± 11.6 Bq/m^3 for powdered milk, and with a mean value of 85±12.7 Bq/m^3 for coffee powder and with a mean value of 59.3±1.3 Bq/m^3 for sugar sample. The Al-Sayed coffee bean had the highest radon concentration at 99.7 Bq/m^3, while the Al-Warda sugar samples from Iraq had the lowest concentration at 56.5 Bq/m^3. The radon gas concentration in the Powdered milk samples were compared and found to be in agreement with Abass, K etal., 2017. results [21].

Figure (3) illustrates the distribution of radium activity in the different food buff samples of Iraq.

Table 2: The concentration radon and exhalation rate, Annual effective and Lung Cancer of the foodstuff samples

No.	*Sample*	*C_{Rn} (Bq/m^3)*	*E_A (Bq/m^2.h)*	*AEDE (μSv/y)*	*ELCR/10^6*
Powder milk					
1	Al-Tunsa	79.15	2.9	1.99	35.8
2	Gardo	87	3.2	2.21	39.7
3	Al-Marai	62.1	2.3	1.56	28
4	Anchor	98.8	3.5	2.49	44.8
Mean ±S.D		**81.7±11.6**	**2.9 ±0.03**	**1.05± 0.21**	**36±0.5**
Coffee powder					
5	Al- Fajer	90.4	3.3	2.282	41
6	Al-Sahara	84.8	3.1	2.13	38.3
7	Al-Sayed	99.7	3.7	2.51	45.1
8	Al-Rifai	65.1	2.4	1.64	29.5
Mean ±S.D		**85±12.7**	**3.1 ±0.04**	**2.1±0.3**	**38±0.5**
Sugar					
9	Al-Usra	62.1	2.3	1.5690	28
10	Al- Frashaa	59.3	2.2	1.497	27
11	Al-Warda	56.5	2.11	1.42	25.5
Mean ±S.D		**59.3±1.3**	**2.2±0.02**	**1.4±0.03**	**26±0.07**
Limit ICRP, 2009 [22]		**300-400**			

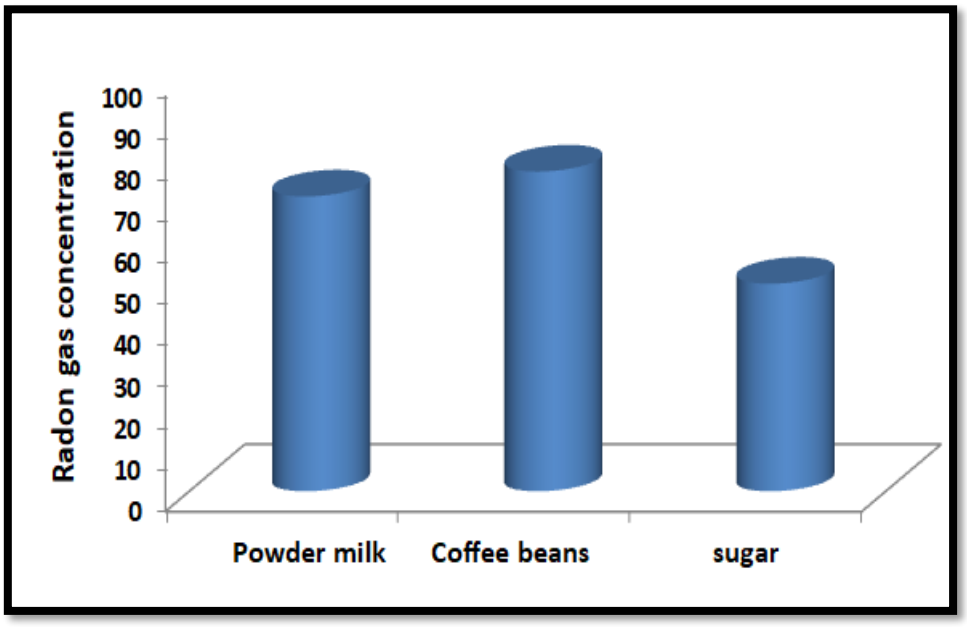

Figure 3: Average concentration of radon in the foodstuff samples

The exhalation rate of radon and were calculated and indicated in Table (2) and Figures (4) and (5). The surface exhalation rate for the powdered milk samples varied from 2.3Bq/ m^2.h in sample Al-Marai to 3.5 Bq/m^2.h in sample Anchor. Whereas the coffee bean samples' surface exhalation rates ranged from 2.4 Bq/m^2.h in sample Al-Rifai to 3.7 Bq/m^2.h in sample Al-Sayed. And While for the sugar samples ranged from 2.11 Bq/ m^2.h in sample Al-Warda to 2.3 Bq/m^2.h in sample Al-Usra.

The Lung Cancer were found to be with the range of 28-44.8 people per million with a mean value of 36±0.5 for powdered milk, and with the range of 29.5-45.1 people per million with a mean value of 38±0.5 for coffee beans and the range of 25.5-28 people per million with a mean value of 26±0.07 for sugar samples.

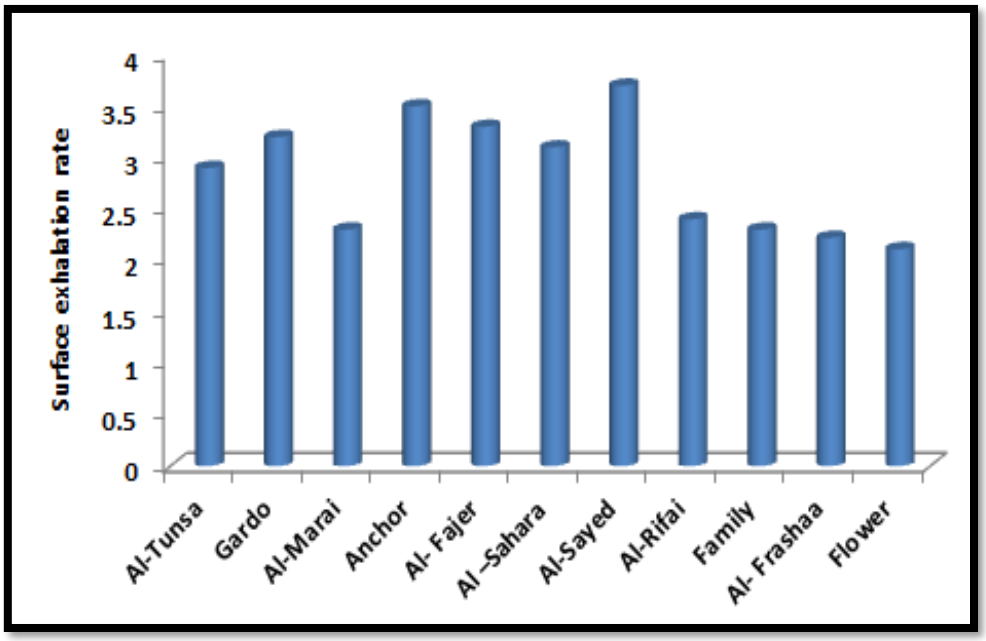

Figure 4: Surface exhalation rate in the foodstuff samples

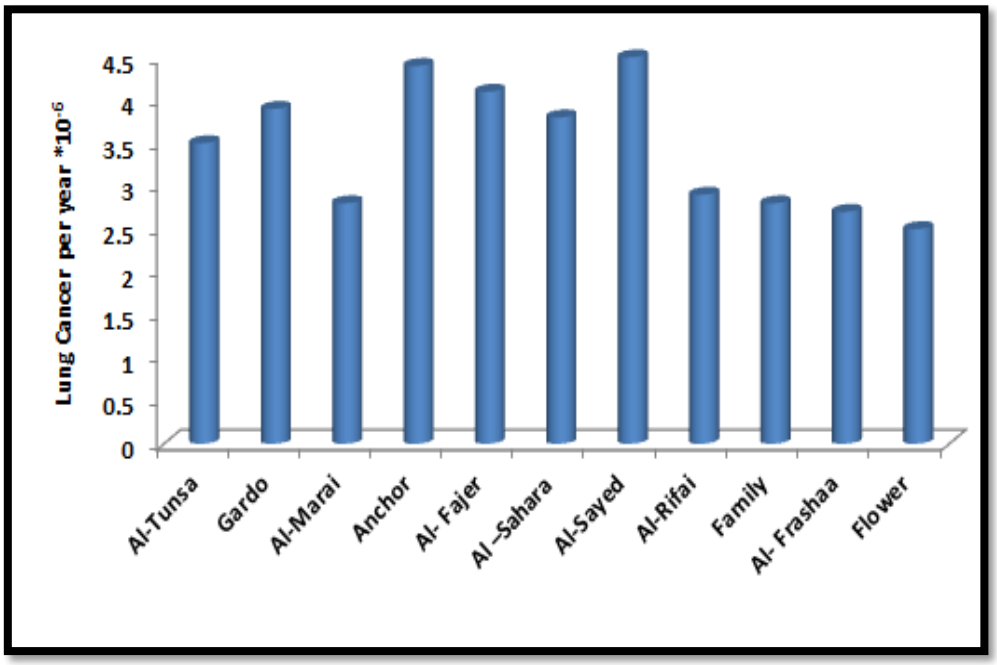

Figure 5: Cancer of the lung for Foodstuff

5. Conclusion

The Al-Marai milk powdered among, The Al-Rifai coffee powder and Al-Usra sugar among the samples from the food buff had the least amount of radon gas in them. They also displayed the lowest rate of surface exhalation and LCR. The findings showed that all the radon gas concentration in the food buff samples within the ICRP's acceptable global limit. Al-Mansour Markets in Baghdad is regarded as a shopping destination by many people. They are foodstuffs that are suitable for eating and there is no harm in their possession.

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Reference

[1] **[1]** F.L. Melquiades, and C.R. Appoloni, "40K, 137Cs and 232Th activities Brazilian milk samples measured by gamma-ray spectrometry," *Ind. J. Pure. Appl. Phys*. vol.40, pp. 5-11, 2002.

[2] G. Arnoux, S. Devaux, D. Alves, I. Balboa, C. Balorin, and N. Balshaw, JET-EFDA Contributors "A protection system for the JET ITER-like wall based on imaging diagnostics, " *review of scientific instruments*, vol. 83, no. 10, p.10D727,2012.

[3] E.M. Rasheed, "Determination the concentrations of radon gas and exhalation rate in some phosphate fertilizer using CR-39 track detector, "*Iraqi Journal of Physics*, vol.15, no.32, pp.136-144,2017.

[4] OECD, "Exposure to radiation from natural radioactivity in building materials. Nuclear Energy Agency (NEA) Report by NEA Group of Experts OECD," Paris. 1979.

[5] O. Abollino, M. Acet, M.C. Bruzzoniti, E. Mentasti, & C. Sarzanini, "Speciation of copper and manganese in milk by solid-phase extraction/inductively coupled plasma- atomic emission spectrometry, "*Annals Chim Acta*, vol. 375, pp. 299–306,1998.

[6] A. N. Jameel, "Measurements of Radon Concentrations in Some Dried Fruit and Grain Samples by (CR-39) Nuclear Track Detector, " *Iraqi Journal of Science*, vol. 63, 517-523, 2022.

[7] H. Samavat, M. R. D. Seaward, S. M. R. Aghamiri, & F. Reza-Nejad, "Radionuclide concentrations in the diet of residents in a high level natural radiation area in Iran. *Radiation and environmental biophysics*, " vol.*45*, pp.301-306, 2006.

[8] IV. BEIR, Report of the Committee on the Biological Effects of Ionizing Radiation. "The health effects of exposure to indoor radon," National Research Council, *National Academy of Science*, Washington, DC. 1999.

[9] H. N. Azeez, M. H. Kheder, M. Y. Slewa. and S. Y. Sleeman, " Radon Concentration Measurement in Ainkawa Region Using Solid State Nuclear Track Detector," *Iraqi Journal of Science*,vol.59, 482-488,2018.

[10] M. Singh, M.Kumar, R.K. Jain, and R.P. Chatrath," Radon in groundwater related to seismic events, " *Radiation Measurements*, Vol. 30, No.4, pp. 465-469, 1999.

[11] N. Ai. Khan, E.U. Akhter, P. Khan, F. and A. Waheed, "Estimation of Mean annual Effective Dose through Radon Concentration in the Water and Indoor air of Islamabad and Murree," *Radiation Protection Dosimetry*, Vol. 141, pp.183-191, 2010.

[12] J. Chen, N. M. Rahman, and IA. Atiya, "Radon Exhalation from Building Materials for Decorative Use," *Environmental Radioactivity*, vol.101, no.4, pp.317-322,2010.

[13] A.B. Tanner, "*Radon migration in the ground: a supplementary review*, " No. CONF-780422,vol. 1,1980.

[14] M. M. Al-KofahiKhader, B. R. Lehlooh, A. D. Kullab, M. K. Abumurad, & B. A. Al-Bataina,"Measurement of radon 222 in Jordanian dwellings," *International Journal of Radiation Applications and Instrumentation,* "*Part D. Nuclear Tracks and Radiation Measurements*, vol. 20,no. 2,pp.377-382 ,1992.

[15] A. N. Jameel, "Measurement of Radon Concentration in Drink and Well Water Samples for Selected Regions in Baghdad City," *Ibn Al-Haitham Journal for Pure and Applied Sciences*, vol. 36, no.3,pp.100-108,2023.

[16] M. N. Alam, M.I. Chowdhry, M. Kamal, S.Ghose, M. N. Islam, M. Awaruddin, "Radiological assessment of drinking water of the Chittagong region of Bangladesh," *Radiat. Prot. Dosim*. vol. 82, pp.207–214,1999.

[17] A.O. Ferreira, B.R. Pecequilo, and R.R. Aquino,"Application of a Sealed Can Technique and CR-39 detectors for measuring radon emanation from undamaged granitic ornamental building materials," *Radioprotection Journal*, vol.46,no.6,pp.49-54, 2011.

[18] A. Jarad, F. Fremlin, and R. Bull, "A study of radon emitted from building materials using plastic α-track detectors," *Physics in Medicine & Biology*, vol.25,no.4, pp.683-694,1980.

[19] A. A. Abdullah, "*Internal and external radiation exposure evaluation amongst selected workers and locations in Iraq,*"*Diss. Universiti Sains Malaysia*, 2013.

[20] B. Lindell, H. J. Dunster, J. Valentin, "The International Commission on Radiological Protection at 90," *Ann. ICRP*, 47, pp.343–345, 2018.

[21] K. H. Abass, A. O .Muhsen, A. Mayyali, B. Y. Mohammed, and J. M. Hussien, "Measurement the concentration of radon gas emitted from infant powdered milk consumed in Iraq using nuclear track detector CR-39. *J. Chem. Pharm. Sci*, *10*(2), pp.906-909, 2017.

[22] ICRP, "International Commission on Radiological Protection, Statement on Radon," ICRP,2009.