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Health Risk Assessment of Radioactive Contamination of Wheat Using the CR-39 Detector

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ABSTRACT

Since wheat is an important consumer commodity for humans, it was necessary to measure radiation, monitor the extent of its contamination, and ensure its suitability for consumption. This study aimed to determine the concentration of radon and uranium in (11) wheat crop samples grown in different locations in Iraq. The CR-39 tracer detector was used in this study. The highest concentration of radon and uranium (72.563(Bq/m³) ,11.258(ppb)) was found in a wheat sample from Basra Governorate, while the lowest values (38.126(Bq/m³), 5.915(ppb)) were found in Anbar Governorate. The study showed that the highest radiation concentration was in the southern governorates and the lowest in the central governorates. This is because crops have an impact on the ecosystem due to pollution from the outside world. In particular, all measured values were within the safety limits set by the World Health Organization and the International Commission on Radiological Protection (ICRP).

1. Introduction

The human body contains certain amounts of radionuclides. These include 40K, 14C, and 210Pb, which are either naturally occurring in the body from birth or brought on by ongoing exposure to man-made and natural radiation sources, such as radon, terrestrial sources, and cosmic rays [1]. There are several processes that nuclei might go through that cause them to emit radiation. Inhaling radon and its derivatives causes internal radiation exposure that affects the respiratory system [2]. The naturally occurring radioisotope 226Ra, which is a decay product of 238U, gives rise to radon. Since uranium and radium are frequently found in soil, rocks, and water, radon can escape from the substance it is created in and enter the atmosphere as a gas. Due to its widespread presence both indoors and outdoors, radon gas is regarded as a radiation health danger that contributes to excessive lung cancer[1] . The effects of radiation exposure on plants and animals have received more study than in the past. Uneven shape, poor growth or output, loss of reproductive capacity, wilting, and mortality (in cases of excessive exposure) are all signs of radiation damage in plants. When breathed, radionuclides are dispersed throughout the body according to the part's metabolism, which usually exhibits varying radiation sensitivity [3][4][5]. As irradiation is increasingly recognized and used as a sanitary food treatment in accordance with the World Trade Organization's Agreement on the Application of Sanitary Measures, it is crucial to use suitable dosimetry systems to guarantee that the trade in irradiated foodstuffs conforms with both national and international standards [6]. Consequently, the primary impact of charged particles on these detectors, like the CR-39, is their degradation; these

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effects indicate significant modifications to the polymer detector's characteristics. Radiation exposure causes these molecules to become irritated and ionized generally, breaking their connections and causing damage [7][8][9]
Some regions have been subjected to a variety of radioactive contamination sources, including industrial waste, fertilizers containing natural uranium, and even atmospheric deposition from far-off nuclear accidents. Radioactive isotopes can be stored in contaminated soil and then transferred to plants through their roots. Since wheat is a commodity that people depend on on a daily basis, contamination directly endangers public health. Alpha particles may raise the risk of cancer and disorders affecting the neurological, digestive, and bone systems when they enter the body through food. This has made it necessary to examine contamination and calculate radiation threats using precision measurement instruments like the 39-CR detector.

2. Experimental Method

Eleven wheat samples were collected from different regions of Iraq, including Baghdad, Mosul, Basra, and Najaf, among others. The samples were dried for a full day at 50°C. They were then finely ground to obtain an extremely fine powder. To reach radiological equilibrium, 5g of these materials were stored in special containers for 30 days. For a predetermined exposure period (usually 60 days), CR-39 detectors were placed 4 cm from the wheat samples As shown in the figure (1). To detect alpha particle signatures, the CR-39 films were chemically etched with sodium hydroxide (NaOH) solution at 6.25 N . The etching process lasted five hours at 70°C after exposure. A light microscope set to 400x magnification was used to count the tracks left by the etched tracers after they had been cleaned with distilled water.

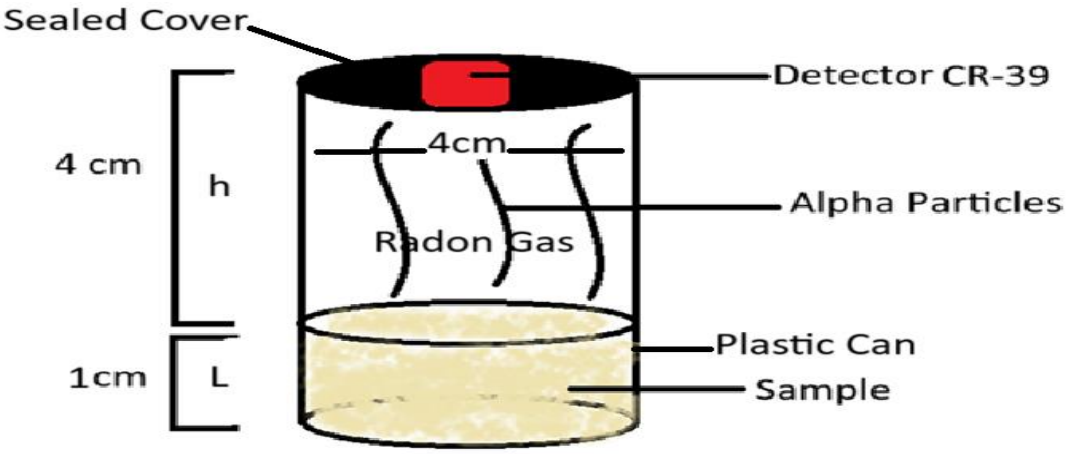

Fig.1. samples and detector storage within the tube.

2.1. Calculation of Radon and Uranium

The diffusion coefficient k, which is the basis for measuring the radon concentration, may be found for the propagation chamber utilized in this investigation using the relationship [14] that follows

$$\boldsymbol{\rho = KCT} \quad (1)$$

$\boldsymbol{\rho}$:Impact Intensity Track/cm2, K: Diffusion constant, C:Aerospace radon concentration Bq.^{m3} ,T irradiation time in seconds. The formula given by is used to calculate the density D of the track in the sample. [10],

$$D = \frac{\boldsymbol{\rho}}{\boldsymbol{T}} = \boldsymbol{K.C} \quad (2)$$

where D:the effects' density rate
It is possible to compute the radon concentration in the air space of the compartment enclosed between the detector's sample surface and the propagation chamber using the following Bq.m^{-3} units of the relationship[11]:

$$k = 1/4r(2Cos\theta_c - \frac{r}{R_\alpha}) \quad (3)$$

r is the radius of the storage tube (2 cm), θ_c is the critical angle of the CR-39 detector (35^o) [11], and R_α is the range of alpha particles in the air (4.14 cm). Equation (3) yielded a calibration factor K of 0.5776 (Tr/cm^2d^{-1} per Bq/m^3). Can be calculation radon concentration in samples of the relationship [12]

$$C_S = \frac{\lambda_{Rn} C_\alpha h t}{L} \tag{4}$$

Where: C_S Radon concentration in samples, C_α Radon concentration in air, λ_{Rn} Radon decay constant 0.1814, h upper atmosphere = 3 cm, L Sample thickness = approximately 1 cm, t Irradiation duration in days, valued at 60 days.The activity of Radon in grain samples A^S_{Rn} can be determined using the equation,[13]

$$A^S_{Rn}(Bq) = C^s_{Rn} V^S \tag{5}$$

whereA^S_{Rn} stands for the radon activity in the sample. The volume of the sample is (V = πr2 L) = $115.4\times10^{-6}m^3$, and the scan radius is r [14]. The following formula is used to determine the uranium content based on the radon activity and the number of radon atoms (N_{Rn}) [15]

$$A^S_{Rn} = N_{Rn}\lambda_{Rn} \tag{6}$$

The equation of secular equilibrium, which asserts that uranium activity is equal to radon activity, is used to determine the quantity of uranium atoms in the sample (NU).

$$N_U\lambda_U = N_{Rn}\lambda_{Rn} \tag{7}$$

Where λU ($4.883X10^{-18}$ sec^{-1}) is the uranium decay constant, the equation establishes the uranium weight within the sample

$$W_U = N_U At_U / N_{AVO} \tag{8}$$

Navo (6.02X1023 atom/mol) is the Avogadro number, while At_U is the symbol for uranium's mass number. One can compute the uranium concentration using the relation{Formatting Citation}

$$C_U = W_U / W_S \tag{9}$$

where C_U (ppm) is the uranium content and W_S (50 grams) is the sample mass [17].

3. Results

The concentration of radon and uranium gases was measured in different samples of dried wheat in the governorates of Iraq, and the results were shown in Table (1). It was found that the highest value of radon and uranium gas concentration in the dried wheat samples was 72.563(Bq/m^3) ,11.258 (ppb), and the lowest value was (38.126(Bq/m^3) ,5.915(ppb)) respectively.

Table 1. The concentration of radon and uranium and the activity in wheat samples.

Sample	Region	C_S (Bq/m^3)	A_{Rn} (Bq)	C_U (ppb)
1	Wasit	47.966	0.0000923	7.442
2	Baghdad	51.04	0.0000982	7.918
3	Najaf	50.425	0.0000970	7.823
4	Karbala	46.121	0.0000887	7.155
5	Anbar	38.126	0.0000733	5.915
6	Mosul	55.345	0.0001064	8.586
7	Diyala	63.544	0.0001222	9.858
8	Basra	72.563	0.0001396	11.258
9	Dhi Qar	68.874	0.0001325	10.685
10	Qadisiyah	54.73	0.0001053	8.491
11	Maysan	67.644	0.0001301	10.494
	min	38.126	0.0000733	5.915
	max	72.563	0.0001396	11.258

Table 2. Radiation concentration rates in the central, northern and southern governorates of Iraq

	Region	C_S (Bq/m³)	A_{Rn} (Bq)	C_U (ppb)
Wasit, Baghdad, Najaf, Karbala, Anbar, Qadisiyah	Center	48.068	9.25E-05	7.457333
Mosul, Diyala	North	59.445	0.000114	9.222
Basra, Dhi Qar,Maysan	South	69.694	0.000134	10.81233

Table (2) shows that the highest radioactive concentration was in the southern governorates and relatively lower in the northern governorates, while the center had the lowest radioactive level. The reason for the variation in concentration between regions is due to many conditions that affect plants and increase their radiation levels. Many environmental, topographical, and agricultural factors affect the radon or uranium content in wheat. Soil is an important factor in increasing the radioactive content of food. Natural concentrations of uranium or radium are found in some areas [18]. Due to the high concentration of natural radioactive isotopes in soil, their concentrations are higher in Basra (as in Sample 8). Trace amounts of uranium or radon may be present in groundwater or well water. When this water is used to irrigate wheat, the grain absorbs more radiation. Locally, radioactive isotope concentrations also increase due to proximity to nuclear waste or industrial sites.
The uranium and radon concentrations found are less than those found in earlier research carried out in Iraq (Nineveh), where levels varied from (300-420)ppb, (59-128)Bq/m³[19].The results indicate that the uranium concentration is below the UNSCEAR-recommended allowable limit of 11.7 ppm. However, the results showed that there are no serious risks to human health, and the edible cereals are safe to eat[20].

4.Conclusion

Measuring the concentration of radioactivity (radon and uranium) in grains (wheat) is of great importance, as it is one of the most important components of household food samples in Iraq. This study describes the radioactivity in wheat samples. These measurements show that the concentration of radon and uranium in the northern, southern, and central regions falls within the global maximum limits for foodstuffs. However, there was a regional variation, with the southern region having the highest value, followed by the northern region and then the central region. Although the concentrations do not pose a danger, accumulations can lead to long-term effects, such as increased concentrations that can lead to risks in the lungs and digestive system.

References

[1] 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, no. 2, pp. 517–523, 2022, DOI: 10.24996/ijs.2022.63.2.9.

[2] 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, DOI: 10.30723/ijp.v15i32.164.

[3] A. A. Ridha, A. N. Jameel, and N. F. Kadhim, “Transfer factor of natural radionuclides from soil to silhouette plants using gamma spectroscopy,” in *AIP Conference Proceedings*, AIP Publishing LLC, 2020, Art. no. 020124, DOI: 10.1063/5.0000316.

[4] 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*, pp. 482–488, 2018.

[5] UNSCEAR, *Sources, Effects and Risks of Ionizing Radiation*, vol. I. United Nations Scientific Committee on the Effects of Atomic Radiation, 2017.

[6] S. Y. Y. Leung, D. Nikezic, J. K. C. Leung, and K. N. Yu, "Derivation of V function for LR 115 SSNTD from its sensitivity to 220Rn in a diffusion chamber," *Applied Radiation and Isotopes*, vol. 65, no. 3, pp. 313–317, 2007, DOI: 10.1016/j.apradiso.2006.08.006.

[7] A. A. Aziz, "Evaluation of radioactivity of cereals and legumes using a nuclear impact detector CN-85," *Iraqi Journal of Physics*, vol. 16, no. 38, pp. 139–146, 2018, DOI: 10.30723/ijp.v16i38.16.

[8] N. P. Singh, M. Singh, S. Singh, and H. S. Virk, "Uranium estimation in Siwalik vertebrate fossil bones using SSTD," *International Journal of Radiation Applications and Instrumentation Part D: Nuclear Tracks and Radiation Measurements*, vol. 12, no. 1–6, pp. 793–796, 1986, DOI: 10.1016/1359-0189(86)90704-1.

[9] K. N. Yu, V. S. Y. Koo, and Z. J. Guan, "A simple and versatile 222Rn/220Rn exposure chamber," *Nuclear Instruments and Methods in Physics Research Section A*, vol. 481, no. 1–3, pp. 749–755, 2002, DOI: 10.1016/S0168-9002(01)01418-8.

[10] Y. S. Mayya, K. P. Eappen, and K. S. V. Nambi, "Methodology for mixed field inhalation dosimetry in monazite areas using a twin-cup dosemeter with three track detectors," *Radiation Protection Dosimetry*, vol. 77, no. 3, pp. 177–184, 1998, DOI: 10.1093/oxfordjournals.rpd.a032308.

[11] R. Barillon, D. Klein, A. Chambaudet, and C. Devillard, "Comparison of effectiveness of three radon detectors (LR115, CR39 and silicon diode pin) placed in a cylindrical device, theory and experimental techniques," *Nuclear Tracks and Radiation Measurements*, vol. 22, no. 1–4, pp. 281–282, 1993, DOI: 10.1016/0969-8078(93)90067-E.

[12] M. H. Kheder and H. N. Azeez, "Measurement of uranium concentrations in the soil samples of Nineveh Province, Iraq using CR-39 detector," *Proceedings of the Pakistan Academy of Sciences A: Physical and Computational Sciences*, vol. 61, no. 4, pp. 317–323, 2024, DOI: 10.53560/PPASA(61-4)677.

[13] G. Somogyi, A.-F. Hafez, I. Hunyadi, and M. Toth-Szilagyi, "Measurement of exhalation and diffusion parameters of radon in solids by plastic track detectors," *International Journal of Radiation Applications and Instrumentation Part D: Nuclear Tracks and Radiation Measurements*, vol. 12, no. 1–6, pp. 701–704, 1986, DOI: 10.1016/1359-0189(86)90683-7.

[14] M. H. Kheder, A. M. Ahmad, H. N. Azeez, and I. F. Mustafa, "Radium and uranium concentrations of powder juice in the Iraq markets using CR-39 detector," *Journal of University of Babylon for Pure and Applied Sciences*, pp. 341–349, 2019.

[15] M. F. L'Annunziata, *Radioactivity: Introduction and History, from the Quantum to Quarks*. Elsevier, 2016.

[16] M. H. Kheder, L. A. Najam, and H. N. Azeez, "Long-lived alpha emitters concentrations in the spices consumed in Iraq using CR-39 detector," *Journal of University of Babylon for Pure and Applied Sciences*, pp. 274–283, 2020.

[17] M. H. Kheder, A. M. Ahmad, H. N. Azeez, M. Y. Slewa, B. A. Badr, and S. Y. Sleeman, "Radon and uranium concentration in groundwater of Nineveh plain region in Iraq," *Journal of Physics: Conference Series*, vol. 1234, no. 1, Art. no. 012033, 2019, DOI: 10.1088/1742-6596/1234/1/012033.

[18] E. H. Abdelfadeel et al., "Relationship between radioactivity and toxicity in some medicinal plants," *Scientific Reports*, vol. 13, Art. no. 10952, 2023, DOI: 10.1038/s41598-023-37403-7.

[19] M. H. Kheder et al., “Radioactivity concentrations in barley and wheat crops in Nineveh plain region in Iraq,” *International Journal of Nuclear Energy Science and Technology*, vol. 14, no. 1, pp. 50–60, 2020, DOI: 10.1504/IJNEST.2020.108804.
[20] A. Y. Kadhim, K. H. Al-Ataya, and M. Sh. Aswood, “Distribution and uptake of uranium in rice and wheat from soil samples collected from Al-Diwaniyah, Iraq,” *Journal of Physics: Conference Series*, vol. 1897, no. 1, Art. no. 012065, 2021, DOI: 10.1088/1742-6596/1897/1/012065.

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التقييم الصحي لمخاطر التلوث الإشعاعي في القمح باستخدام كاشف CR-39

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الملخص

نظرًا لأن القمح سلعة استهلاكية مهمة للبشر، فقد كان من الضروري قياس الإشعاع ومراقبة مدى تلوثه والتأكد من ملاءمته للاستهلاك. هدفت هذه الدراسة إلى تحديد تركيز الرادون واليورانيوم في (11) عينة من محصول القمح المزروع في مواقع مختلفة في العراق. تم استخدام كاشف التتبع CR-39 في هذه الدراسة. تم العثور على أعلى تركيز للرادون واليورانيوم (72.563) (Bq / m^3)و 11.258 ((ppb)في عينة قمح من محافظة البصرة، بينما تم العثور على أقل القيم (38.126 ((ppb)) ($5.915\ Bq / m^3$)في محافظة الأنبار. أظهرت الدراسة أن أعلى تركيز للإشعاع كان في المحافظات الجنوبية وأدنى تركيز في المحافظات الوسطى. وذلك لأن المحاصيل لها تأثير على النظام البيئي بسبب التلوث من العالم الخارجي. وعلى وجه الخصوص، كانت جميع القيم المقاسة ضمن حدود السلامة التي وضعتها منظمة الصحة العالمية واللجنة الدولية للحماية من الإشعاع (.ICRP)

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