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Determining radon concentration in blood samples of kidney failure patients in Salah al-Din governorate using nuclear track detectors

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Abstract:

In this study, the concentration of radioactive radon gas in blood samples of kidney failure patients and healthy people in Salah al-Din Governorate was evaluated, by analyzing blood samples of (33) kidney failure patients and (23) healthy people. The long-term nuclear trace detector technology was used using the CR-39 detector. Radon concentrations in blood samples from patients with kidney failure ranged from the highest value of (8.2892) Bq.m^{-3} to a 63-year-old Smoker male from Samarra city, and the lowest value of (1.3749) Bq.m^{-3} to a 22-year-old non-smoker male from Al-Diyum /Tikrit, with an average concentration of (3.3391) Bq.m^{-3}. While the results for the healthy group ranged from the highest value of (4.0891) Bq.m^{-3} to a 66-year-old male smoker from Al-Gharbiya /Al-Dour, and the lowest value of (0.7856) Bq.m^{-3} to a 28-year-old female non-smoker from Samarra, with an average concentration of (1.9253) Bq.m^{-3}. This study showed that radon concentrations in blood samples of patients are higher than in healthy people, and that all blood samples of patients and healthy people are within the permissible limits of 200 Bq/m^3 International Commission on Radiological Protection (ICRP).

Keywords: Radon gas, kidney failure,CR-39 detector, Blood.

تحديد تركيز غاز الرادون في عينات دم مرضى العجز الكلوي في محافظة صلاح الدين باستخدام أجهزة الكشف عن الآثار النووية

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الملخص

في هذه الدراسة، تم تقييم تركيز غاز الرادون المشع في عينات دم مرضى الفشل الكلوي والأشخاص الأصحاء في محافظة صلاح الدين، وذلك من خلال تحليل عينات دم (٣٣) مريضًا بالفشل الكلوي و(٢٣) شخصًا سليمًا. تم استخدام تقنية كاشف الأثر النووي طويل الأمد باستخدام كاشف .CR-39 تراوحت تراكيز الرادون في عينات الدم من مرضى الفشل الكلوي من أعلى قيمة (٨.٢٨٩٢) بيكريل.م-٣ لرجل مدخن يبلغ من العمر ٦٣ عامًا من مدينة سامراء، وأقل قيمة (١.٣٧٤٩) بيكريل.م-٣ لرجل غير مدخن يبلغ من العمر ٢٢ عامًا من الديوم/تكريت، بمتوسط تركيز (٣.٣٣٩١) بيكريل.م-٣. بينما تراوحت نتائج المجموعة السليمة من أعلى قيمة (٤.٠٨٩١) بيكريل.م-٣ لرجل مدخن يبلغ من العمر ٦٦ عامًا من الغربية/الدور، وأقل قيمة (٠.٧٨٥٦) بيكريل.م-٣ لامرأة غير مدخنة تبلغ من العمر ٢٨ عامًا من سامراء، بمتوسط تركيز (١.٩٢٥٣) بيكريل.م-٣. أظهرت هذه الدراسة أن تركيزات الرادون في عينات دم المرضى أعلى منها في الأشخاص الأصحاء، وأن جميع عينات دم المرضى والأصحاء تقع ضمن الحدود المسموح بها وهي ٢٠٠ بيكريل/م٣ وفقًا للجنة الدولية للحماية من الإشعاع .(ICRP)

الكلمات المفتاحية: (غاز الرادون، الفشل الكلوي، كاشف CR-39، الدم).

1.Introduction

Humanity is burdened with the problem of radioactive pollution and faces an existential threat because of it, because the sources of these pollutants have absorbed the planet's environment. Radioactive pollution is defined as an increase in environmental radiation resulting from human activity and the process of producing new fixed elements through the emission of matter in the form of matter or radiation, such as beta, gamma or alpha radiation [1]. Radiation has many harmful effects on living organisms, some of which are fatal, and some of them have an effect to the extent that humans suffer from their effects for long periods of time, especially after the expansion of the field of use of nuclear radiation to include various fields, including medicine, agriculture, industry, electricity generation and other important and various uses, in addition to wars in which depleted uranium and nuclear tests are used, which contributed to environmental pollution and helped increase the likelihood of living organisms being exposed to radiation [2]. The biological effects of ionizing radiation are divided into random effects, including genetic risks in offspring, and physical effects in directly exposed populations. And inevitable effects, including skin burns, damage to the lens of the eye, bleeding, vomiting, hair loss, anemia, bone marrow damage, digestive problems and brain damage [3].

Radon is a naturally occurring radioactive gas. It is colorless, odorless, and toxic. Radon has three isotopes, Rn^{220}, Rn^{219}, and Rn^{222}, which are produced by the decomposition of uranium (U^{238}), uranium (U^{235}), and thorium (Th^{232}), respectively. Of these, radon Rn^{222} is classified as the most potent isotope. This is mainly due to its longer half-life ($t_{1/2}$ 3.82 days) than other isotopes [4]. Radon travels easily over small distances in rocks and soil, where it can travel to the soil surface and into the air [5]. Scientists identified the hazards of radon, revealing that the fatalities of miners in 1980 resulted from their exposure to elevated radon levels, which may collect within homes and buildings at concentrations up to several times higher than those found outdoors[6]. The danger of radon gas depends on the amount and percentage of its concentration in the air, as well as the period of time during which a person is exposed to such gas [7]. CR-39 is one of the organic detectors that do not contain nitrogen, and CR-39 is an abbreviation for (Colombia Resins)[8]. Kidney disease is a serious and widespread health problem, and its symptoms include changes in the kidneys' ability to remove toxins, salt and water imbalance, and endocrine dysfunction[9]. Therefore, many researches and studies have been conducted to determine the level of radon concentration in various field[10-18].

2.Materials and Methods

2.1.Sample collection:

This research was carried out using 56 blood samples that were taken from two different groups. The initial group consisted of thirty-three samples taken from patients suffering from kidney failure who were receiving dialysis at the Tikrit Teaching Hospital located in the Salah al-Din governorate. The second group consisted of 23 samples taken from individuals who were in good health and lived in this governorate. As seen in figure 1, the cities that make up the Salah al-Din governorate.

Fig1: locations of the cities of Salah al-Din governorate.

2.2Experimental work

Radon concentrations were measured using the long-term method, where each blood sample was placed in sealed plastic cups with dimensions of (10 cm), as shown in fig (2), where comprehensive information was recorded for each sample and the storage date was fixed on papers that were glued to each cup. The cover of the test cups was quickly removed after reaching equilibrium to avoid air exchange inside the cup, and a piece of the CR-39 nuclear detector was fixed on the cover. The cups were left for (68) days to ensure recording the traces of alpha particles emitted from the samples as a result of radon decay[20-19]. After completing the required exposure process, the detectors were lifted to prepare them for the Chemical etching process. The detectors were etching by placing them in (6.25N) of sodium hydroxide (NaOH) solution at a temperature of (60˚C) for five hours to ensure the appearance of the traces.

Fig (2) Chemical etching process of the CR-39 detector.

Then the inspection process was carried out using a light microscope at a magnification of (40X). The density of traces in the samples was calculated using the equation[21].

$$\rho_{Rn} = N/A \qquad \text{……(1)}$$

Where **N**: Number of alpha particle tracks or effects and **A:** Lens area included.

Following that, the relationship was utilized in order to determine the amount of radon gas that was present in the air inside the tube [22]:

$$C_{Rn} = \rho_{Rn} / Kt \qquad \text{……(2)}$$

Where CRn denotes the radon concentration in the air pipe (Bq/m3), ρRn represents the density of tracks in blood samples (Tr./cm2), t signifies the exposure duration (68 days), and K refers to the calibration or sensitivity factor. (Tr/cm²·d / Bq/m³).

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Defined by equation[23]:

$$K = \frac{1}{4} r \left(2\cos\theta_c - \frac{r}{R\alpha}\right) \qquad \dots\dots(3)$$

Where r represents the radius of the cylinder, which is 1.65 centimeters, and θ represents the critical angle for the CR-39 detector, which is 35 degrees. The symbol Rα is used to represent the range of alpha particles in air, which is 4.14 centimeters.

The calibration factor (K) was determined to be 0.0443 ($Tr/cm^2 \cdot d/Bq/m^3$). Consequently, the radon concentration in blood samples can be determined using the equation [22]:

$$C_{SRn} = \frac{ht\lambda C_{Rn}}{\ell} \qquad \dots\dots(4)$$

Where CRn represents the radon concentration in the air space, measured in Bq/m3, and h represents the distance between the sample and the detector, which is 5.3 cm. Additionally, λ represents the decay constant, which is 0.1814 d-1, and t represents the time. l: The sample thickness was approximately one centimeter, and the exposure duration was 68 days.

Table (1) and fig (3) show the radon concentrations of these samples in units ($Bq.m^{-3}$). The results showed that the highest radon concentration in the air space Ca_{Rn} (8.2892)$Bq.m^{-3}$ was for a 63-year-old Smoker male from Samarra city who was a smoker, while in second place was the radon concentration in the air space (6.7570)$Bq.m^{-3}$ for another 67-year-old male from Al-Zawiya district who was also a smoker. The lowest radon concentration was for a 22-year-old non-smoker male from Al-Diyum /Tikrit in the air space (1.3749)$Bq.m^{-3}$, and thus the average radon concentration in the air space was (3.3391) $Bq.m^{-3}$.

Table (1): Radon concentrations in blood samples of the group of patients with kidney failure.

Code.no	Age(years)	Gender	Region	State smoking	Ca_{Rn} ($Bq.m^{-3}$)	C_{SRn} ($Bq.m^{-3}$)
1	24	F	Samaraa	Non	1.5714	102.73
2	63	M	Samaraa	Smoker	8.2892	541.91
3	55	F	Tikirit	Non	4.8713	318.46
4	52	F	Samaraa	Smoker	3.1035	202.89
5	60	M	Samaraa	Smoker	4.4785	292.78
6	47	M	Al-Dhuluiya	Smoker	6.0499	395.52

7	53	M	Makhul-Baiji	Smoker	5.1070	333.87
8	32	M	Albuajil	Smoker	4.9499	323.60
9	50	M	Alhumrat-Al-Alam	Non	1.8464	120.71
10	22	M	Al-Dium-Tikirit	Non	1.3749	89.88
11	64	M	Baiji	Smoker	4.5963	300.49
12	32	F	Al-Dour	Non	1.4142	92.45
13	34	M	Samaraa	Non	1.6892	110.73
14	38	M	Al-Sherqat	Smoker	3.1428	205.46
15	29	F	Samaraa	Non	1.5714	102.73
16	63	F	Samaraa	Non	3.8499	251.69
17	44	F	Baiji	Non	1.6499	107.86
18	34	M	Tikirit	Smoker	3.4178	223.44
19	48	M	Al-Abbasiya-Samaraa	Non	4.3213	282.51
20	42	M	Mushak-Baiji	Smoker	5.6570	367.83
21	58	M	Baiji	Non	3.6535	238.85
22	60	F	Al-Mazoua-Baiji	Non	3.2213	184.91
23	61	M	Al-Sherqat	Non	1.9642	210.59
24	38	F	Balad	Non	1.6106	105.29
25	48	F	Tikirit	Non	2.9463	192.61
26	41	M	Baiji	Non	2.4356	159.23
27	43	M	Baiji	Non	2.6713	174.64
28	66	F	Al-Naaeima-Tikrit	Non	3.0249	197.75
29	40	M	Samaraa	Non	2.8285	128.41
30	50	M	Dujail	Non	2.3570	154.09
31	57	M	Hamrin	Non	2.0428	127.65
32	35	F	Samaraa	Non	1.7285	113.00
33	67	M	Al-Zaawia	Smoker	6.7570	411.74
Average					3.3391	207.82

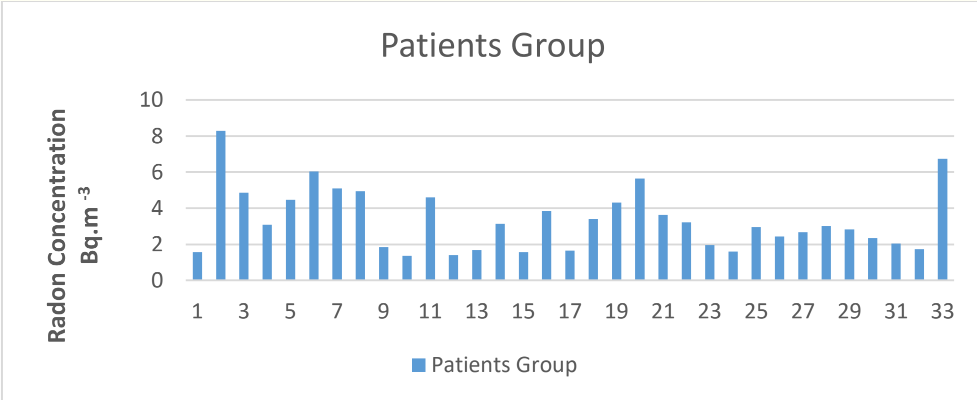

Fig (3): Radon concentration in blood samples of patients with kidney failure Ca_{Rn}.

Table (2) shows the concentrations of radon in blood samples of healthy people. The study was conducted on (23) healthy people with kidney failure. The highest value of radon concentration in the air space was (4.0891) $Bq.m^{-3}$ for a smoking male aged (66 years from Al-Gharbia/Al-Dour) and its value in the sample was (267.33) $Bq.m^{-3}$, while the lowest value of radon concentration in the air space was (0.7856 $Bq.m^{-3}$) for a non-smoking female aged (28 years from Samaraa) and its concentration in the samples was (51.35) $Bq.m^{-3}$, and at a rate of (1.9253) $Bq.m^{-3}$ for its concentration in the air space and samples (125.90) $Bq.m^{-3}$. fig (4).

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Table (2): Radon concentrations in blood samples of healthy individuals.

Code. no	Age (years)	Gender	Region	State smoking	C_{Rn} ($Bq.m^{-3}$)	C_{SRn} ($Bq.m^{-3}$)
1	63	M	Al-Qadisiyah-Al-dour	Non	2.5535	166 .933
2	28	F	Samarra	Non	0.7856	51.35
3	33	M	Albuajil	Non	1.1791	77.08
4	27	F	Aleayth-Al-Dour	Non	1.3749	89.88
5	35	F	Hay-AlKhadhra-Al-Dour	Smoker	1.1249	73.54
6	24	F	Hay-Al-gharbia	Non	1.2963	84.74
7	18	M	Hay-Al-gharbia	Smoker	1.4035	91.75
8	55	F	Aljalam-Al-Dour	Smoker	1.3570	88.71
9	35	M	Hay-Al-gharbia/Al-Dour	Smoker	1.7321	113.23
10	25	F	Hay-Al-gharbia	Non	1.4999	98.05
11	62	F	Aljalam-Al-Dour	Smoker	3.1428	205.46
12	25	F	Al-Obour / Al-Dour	Non	1.6463	107.62
13	29	F	Hamrin	Non	0.5714	37.35
14	51	M	Hay-Al-gharbia	Smoker	2.1249	138.91
15	40	F	Hay-Al-gharbia	Non	1.5177	99.22
16	40	M	Aljalam-Al-Dour	Non	1.7499	114.40
17	35	F	Aljalam-Al-Dour	Non	1.8362	120.04
18	61	M	Hay-Al-gharbia	Non	3.6963	241.65
19	36	F	Alsharqia-Hay	Non	0.9642	63.03
20	67	M	Alsharqia-Hay	Non	3.5710	233.45
21	51	M	Al-Dour	Non	2.1070	137.74
22	45	F	Al-Majame / Al-Dour	Non	2.9587	193.42
23	66	M	Hay-Al-gharbia	Smoker	4.0891	267.33
Average					1.9253	125.90

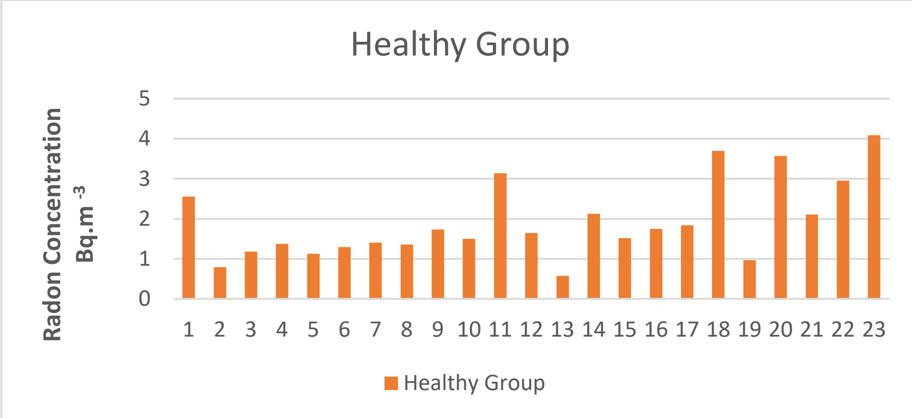

Fig (4): Radon concentration in blood samples of healthy people Ca_{Rn}.

Table (3) shows the average radon concentrations in blood samples of infected individuals of both sexes, males and females. The table shows that the average radon concentration in males is higher than in females among those with kidney failure. This is equally applicable to healthy individuals. The mean radon concentration in male blood samples exceeds that of females. The disparity arises from the fact that males are exposed to a higher percentage of pollution than females, as the blood volume in females is approximately 4-5 liters, but in males it ranges from 5-6 liters. This may also be attributable to the nature of male employment in industrial facilities or their involvement in prior conflicts[24]. As shown in fig(5).

Table (3): Average radon concentration as a function of gender (male and female).

Classification	Gander	No of Subject	Mean($Bq.m^{-3}$)
Patients Group	Male	21	3.6966
	Female	12	2.5469
Healthy Group	Male	10	2.4206
	Female	13	1.5443

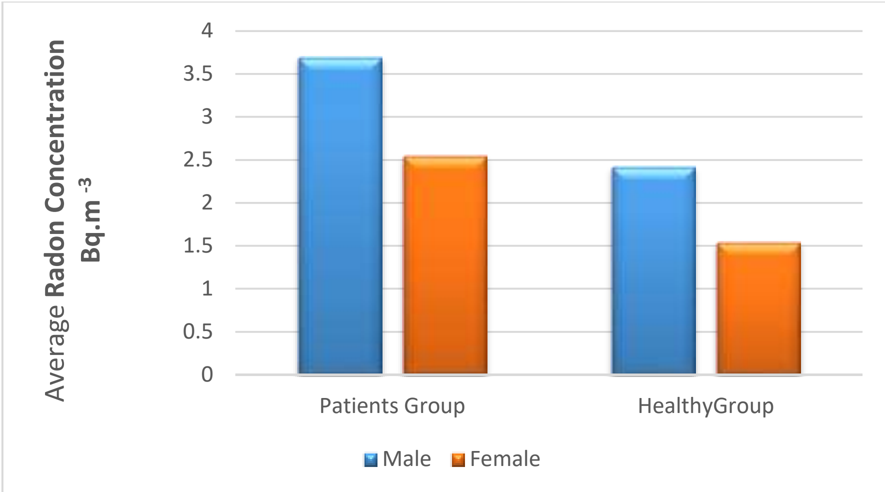

Fig (5) shows a graph of the average radon concentration as a function of gender (male and female).

4.Conclusions

This study showed that the radon concentration in patients with kidney failure is higher than the radon concentration in healthy people. This study also showed that the radon concentration in males is higher than the radon concentration in females.

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