World Bulletin of Public Health (WBPH)
Available Online at: https://www.scholarexpress.net
Volume-23, June 2023
ISSN: 2749-3644

MEASUREMENT OF RADON GAS CONCENTRATIONS IN THE BLOOD AND URINE OF RENAL FAILURE PATIENTS USING SOLID-STATE NUCLEAR TRACK DETECTORS (CR-39)

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Article history:
Received: April 11th 2023
Accepted: May 11th 2023
Published: June 20th 2023

Abstract:
The aim of the current study is to evaluate radon levels in patients with renal failure in serum and urine samples in Najaf province. and compare the measurements with those of healthy individuals. Contrary to results measured in healthy individuals, radon (222Rn), which is a common emitter of alpha particles. Kidney diseases, especially kidney failure, are becoming more common in Najaf Governorate. Especially after the Gulf War in 1991 and the events of 2003 and what followed. It is important to know the measurement of radon concentration in the serum and urine of patients with renal failure. The relationship between these cases and the effects of successive wars. The CR-39 detector was used for this investigation to measure radon-emitting alpha particles. Samples were collected from sick and healthy (20) patients, divided into (10) males and (10) females. (20) healthy individuals were collected, divided into (10) males and (10) females. These samples were obtained from Al-Sadr Teaching Hospital in Al-Najaf. Pathway intensities were calculated using the TASLIMAGE system after the 90-day exposure period. The results showed that patients with renal failure had an average concentration of radon in their serum 8.709 ± 7.639 Bq / m3, and in urine 6.4523 ± 0.77 Bq / m3. In addition to the above, people with kidney failure have much higher radon concentrations than healthy people. The results also revealed that all measured radon concentrations (both in patients and healthy subjects) were below recommended levels. Within the permissible limit (200Bq/m3) set by the International Atomic Energy Agency (IAEA) and the International Committee for Radiation Protection (ICRP), respectively.

Keywords: Radon gas - Renal failure – Radioactivity- Blood – Urine- CR-93

1. INTRODUCTION

The kidney is the first target organ of heavy metal toxicity due to its ability to reabsorb and accumulate divalent metals. Also, chronic kidney disease is a disease in which kidney function is gradually lost over a period of time, and it has a significant impact on the quality of life related to health and the use of medical services. [1] [2] [3]. CKD is a progressive disease that can be recognized by a diminished estimated glomerular filtration rate (less than 60 mL/min/1.73m2) that lasts for at least three months [4]. The main known causes of chronic kidney disease are diabetes, hypertension, hyperlipidemia, and skeletal disease. Although some studies reveal a possible association between CKD and heavy metals, it has not been demonstrated for low-level environmental exposures [5]. Thus, CKD of unknown etiology is termed CKDu, which has been considered as a matter of environmental selection. Health research and kidney disease research. Radon is a radioactive natural gas. The half-life is 3.85 days. This period is quite sufficient for radon to pass into the soil and atmosphere [6]. [7] I mentioned that radon gas has been identified as one of the health risks to humans, and it is one of the largest producers of this gas in closed areas. The decay of uranium that occurs naturally in soils and rocks is the source of radon, and thus people are exposed to this gas every day [8]. Inhalation of a high concentration of radon and its daughters for a long period of time can cause problems in respiratory functions or may cause lung and kidney cancer and failure [9]. The chain of decay of uranium-238U includes the formation of radon and ends with the formation of stable lead (206Pb). Both of these chemical elements (such as radon and 206 Pb) are heavy metals. Accordingly, exploring the relationship between radiation and heavy metals is crucial [10]. A high concentration of radon in an area under study is a sign of a high concentration of uranium, lead, and other heavy metals. Radioactive and toxic pollutants are one 2 of the environmental pollutants that can cause changes in human health and the living world in general such as kidney failure and cancers, and thus greatly

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Available Online at: https://www.scholarexpress.net
Volume-23, June 2023
ISSN: 2749-3644

affect changes in the environment [11] Measurements of radon concentrations and toxic elements in biological samples provide a clear picture of radioactive contamination And chemotherapy for exposed persons [12]. Due to the ability of the kidney to repair kidney injury, conventional tests are insensitive because they only show aberrations when a significant portion of the nephron mass has already been lost [13].Over the past few years, blood and tissue concentrations of TEs in patients with renal failure have been extensively studied [14].

2. MATERIALS AND METHODS

The research methodology deals with important aspects in this study, which is the field of study and the collection of samples consisting of two groups, including patients with renal failure, and a comparison with a healthy human group. Samples were collected from Al-Sadr Teaching Hospital in Najaf-Iraq. After that, blood and urine samples were collected for 20 patients (10 men and 10 women), and blood and urine samples were collected only for 20 healthy subjects. (10 men and 10 women) for comparison between patients and healthy subjects. These samples are intended for the determination of radon gas using different testing techniques. And the work of paper questionnaires for patients and healthy people. Results of the volunteers' baseline questionnaire, which asked about their age, gender, smoking or non-smoking and other chronic diseases, under Tab 1. All blood serum samples were prepared in the hospital laboratory.

Table 1. Statistical descriptions of the two groups

Classification	Healthy people	Renal failure Patients
Males no.	10	10
Females no.	10	10
Age range (years)	25-73	24,71
Males average age (years)	35.9	50.3
Females average age (years)	45.3	48
Average age total (years)	40.6	49.15

3 ml of blood was drawn from the patient via a 5 ml blood drawing syringe, and placed in a blood preservation type gel tube for radon measurement. From the same patient, a urine sample was taken and placed in a urine cup. Healthy subjects, the same method as the patients, also for 20 patients (10 men and 10 women) and 20 healthy subjects (10 men and 10 women). Leave the blood samples for 10 minutes at room temperature to clot. The blood sample was placed in a centrifuge that rotated at 6000 rpm for 5 minutes. Next, the separated serum is collected and placed into new disposable test tubes. Once the serum is collected, the test tubes are labeled so that each tube corresponds to a specific patient. After that, the blood samples are kept at 4 degrees Celsius using an ice box until they are stored in the laboratory refrigerator. Urine samples were also placed in a Jorn cup and stored in the laboratory refrigerator. They are awaiting analysis.. Detectors were placed to measure radon gas for a period of 90 days.

2.MEASUREMENT OF RADON

Solid Gas Nuclear Track Detectors (SSNTDs), CR-39, short for Columbia Resin-39 and most widely used, have been used to measure tracks of heavy charged particles, due to their sensitivity, efficiency, and preservation of tracks for long periods. The collision of these particles with the detector causes damage to their bonds along their path called latent pathways, and their image can be seen clearly under light microscopes. A plastic cup containing a serum and urine sample has a CR-39 detector attached to the top end to measure the amount of radon present. This detector has a thickness of 1 mm and a surface area of 2.5 x 2.5 cm2. According to Figure (1).

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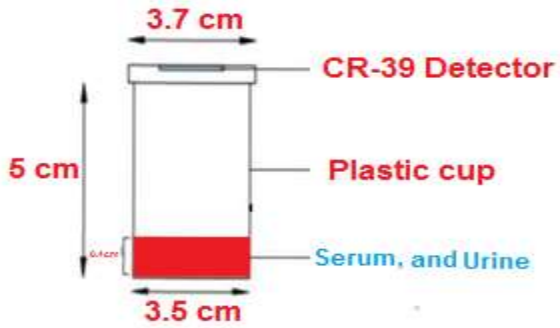

Figure 1. CR-39 Detector-Based Radon Gas Estimation

The plastic cup has a diameter of 3.5 cm and a length of 5 cm. The plastic cups contain the samples.After this time had passed, the detector was subjected to chemical etching by being placed in a beaker containing a chemical agent solution made by dissolving 100 gm of NaOH (6.25 N) in 400 ml of deionized water [15]. Alpha particles from the chemical solution have an impact on the damaged areas [16]. Equation (1), The beaker is heated in a water bath (type, HH-420, Germany) at a temperature of 85°C for 3 hours after the CR-39 detector has been submerged. To avoid any evaporation-related changes in NaOH concentrations, the beaker is tightly closed in this stage. The detectors are carefully rinsed with distilled water after the chemical etching procedure is complete, and they are then allowed to dry for 15 minutes. After that, distilled water was used to clean the detectors. TASLIMAGE system Fig(2). software (created by TASL) can scan the plastic at a greater magnification, differentiating between tracks and background characteristics with a high-quality image [17]. Track density as detected by CR-39 detector (track/cm2) was estimated using this system. system TASLIMAGE

Figure 2 shows the TASLIMAGE system.

The background was eliminated from the measured track density because it has an impact on the density of the tracks.

$$W = Weq \times N \times V \quad \ldots\ldots\ldots (1)$$

where W is the weight of sodium hydroxide (NaOH) (100 gm), Weq is the equivalent mass of NaOH (40 gm/l), N is the normalcy of NaOH (6.25 N), and V is the volume of water (400 ml).

Incident Alpha particles on the detector generate circular etch pits. The bulk of etch pits will be elliptical, as a result of Alpha particles colliding with the detector surface at lesser dip angles .The widths and forms of etch pit "tracks" vary, of course: vertically . Then, any minor etch pits are continuously ignored, and any scratches are readily overlooked [18]. A microscopic treatment was used in this work to quantify radon concentrations in materials using the TASLIMAGE technology. The data will be statistically analyzed using the analysis of variance test and the Chi2 test to examine the incidences of the different studied variables for Radon levels using the computer software SPSSPC -version 22.

3.CALCULATIONS

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This study measures the level of radon (Alpha particles) in biological samples from both healthy individuals and patients with renal failure. This can be accomplished by capturing the particle trails on the CR-39 surface and using these relationships [19]. The first relationship is the track density (ρ), which is measured in track/cm2s. The tracks of Radon particles that are released when the Radon is subjected to the extracted biological samples are what make up the density. Equation is used to determine this word. (2):

$$\rho\left(\frac{track}{cm^2}\right) = \frac{\text{Number of Track}}{\text{Area of veiw}} \square \quad \ldots\ldots\ldots (2)$$

Equation (3) can be used to specify the alpha particle concentration (C_Rn, inBq/m3) in blood serum [20].

$$C_{Rn}^{\alpha}\left(\frac{Bq}{m^3}\right) = \frac{\rho}{Kt} \quad \square \ldots\ldots\ldots (3)$$

Where ρ is the sample exposure time, which is assumed to be (90 days), is the track density expressed in Tr/cm2, K is the diffusion constant, and t is also the sample exposure duration. This value is referred to as the calibration factor or sensitivity factor. using equ. (4), the following can be calculated numerically [21]:

$$k = 0.25\, r\left(2cos\theta_c - \frac{r}{r_a}\right) \quad \ldots\ldots\ldots (4)$$

where the tube radius is 1.75 cm, the detector critical angle is 35°, and the alpha particle range in air is assumed to be 4.15 cm [22]. As a result, the theoretical K value is 0.5733 cm. It is vital to remember that the experimental K is measured in Track.cm2 /Bqm3day, whereas K value has a unit of cm. Since 1Bq = Disintegration/second = track/second, 1day = 86,400 seconds, and 1m3 = 106 cm, it follows that 1cm = 0.0864 (Track.cm2/Bqm3day) [23]. Therefore, 0.049 Tr.cm2 /Bqm 3.d is the diffusion constant for CR-39 detectors.d.

4. RESULTS AND CONVERSATION

The concentration of radon in serum samples was determined using the CR-39 reagent for patients with renal failure and healthy subjects. Table 2 reveals the concentration of radon in serum samples from healthy males and females. The radon concentration value ranged (27.4376 - 0.9070Bq/m3, mean ± SD = 12.351 ± 0.896Bq/m3). The highest obtained value was 27.4376Bq/m3 for Hsb 7 and Hsb 11 males and females, 38 and 33 years old, from Diwaniyah and Najaf, and the lowest value obtained was 0.9070Bq/m3 for 14 Hisbi females, 26 years old, from Najaf .

Table 2. Radon Concentration in blood serum samples for healthy individuals in Najaf governorate

SC	Age/Weight/Gende	ALocation	Smoking habit	C_{Rn}^{α} Bq/m^3
Hsb 1	25,70,male	Najaf	No	2.3425
Hsb 2	35,82,male	Najaf	Yes	5.8956
Hsb 3	44,79,male	Diwaniyah	No	16.0997
Hsb 4	31,72,male	Najaf	No	9.9773
Hsb 5	51,80, male	Najaf	No	10.8843
Hsb 6	35,69 male	Karbala	No	22.2222
Hsb 7	38,75 male	Diwaniyah	No	27.4376
Hsb 8	33,73,male	Najaf	Yes	8.6167
Hsb 9	43,95,male	Najaf	Yes	11.1111
Hsb 10	24,68,male	Najaf	No	16.0997
Hsb 11	33,82, female	Najaf	No	27.4376
Hsb 12	71,65, female	Najaf	No	2.2675
Hsb 13	41,83, female	Najaf	No	4.7619
Hsb 14	26,79, female	Najaf	No	0.9070
Hsb 15	32,85, female	Najaf	No	18.8208
Hsb 16	45,88, female	Najaf	No	2.0408
Hsb 17	53,75, female	Najaf	No	23.1292
Hsb 18	48,67, female	Najaf	No	11.1111
Hsb 19	44,80, female	Najaf	No	8.1632
Hsb 20	60,69, female	Najaf	No	17.6870
Permissibie limit				200
Mean				12.351
Min.				0.9070
Max				27.4376

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Table 3 shows the concentration of radon in urea samples from healthy males and females. The radon concentration value ranged (22.2222 - 0.2267Bq/m3, mean ± SD = 6.643 ± 0.981Bq/m3). The highest obtained value was 22.2222Bq/m3 for Hu 7, male, 38 years old, from Diwaniyah, and the lowest value obtained was 0.2267Bq/m3 for Hu 5, male, 51 years old. An old man from Najaf.

Table 3. Radon Concentration in urea samples for healthy individuals in Najaf governorate

SC	Age/Weight/Gende	ALocation	Smoking habit	C_{Rn}^{α} Bq/m^3
Hu 1	25,70,male	Najaf	No	5.3347
Hu 2	35,82,male	Najaf	Yes	4.1619
Hu 3	44,79,male	Diwaniyah	No	4.0816
Hu 4	31,72,male	Najaf	No	1.8140
Hu 5	51,80,male	Najaf	No	0.2267
Hu 6	35,69,male	Karbala	No	3.1756
Hu 7	38,75,male	Diwaniyah	No	22.2222
Hu 8	33,73,male	Najaf	Yes	12.0181
Hu 9	43,95,male	Najaf	No	13.6054
Hu 10	24,68,male	Najaf	No	2.4943
Hu 11	33,82, female	Najaf	No	6.5759
Hu 12	71,65, female	Najaf	No	10.2040
Hu 13	41,83, female	Najaf	No	1.5873
Hu 14	26,79, female	Najaf	No	7.7097
Hu 15	32,85, female	Najaf	No	4.5331
Hu 16	45,88, female	Najaf	No	8.1632
Hu 17	53,75, female	Najaf	No	6.3492
Hu 18	48,67, female	Najaf	No	9.977
Hu 19	44,80, female	Najaf	No	3.1746
Hu 20	60,69, female	Najaf	No	5.4421
Permissibie limit				200
Mean				6.643
Min.				0.2267
Max				22.2222

Table 4. shows the level of radon concentration in urea samples of male and female renal failure patients. The value of radon concentration in urea samples ranged from (22.2222 - 0.2267)Bq/m3, mean ± SD = 6.4523 ± 0.77Bq/m3. The highest value obtained was 22.2222Bq/m3 for (u7) male ages (62) years from Najaf and the lowest value obtained was 0.2267Bq/m3 for u5 male 32 years from Najaf.

Table 4. Radon levels in blood serum samples from patients with renal failure at Al-Sadr Teaching Hospital in the governorate of Najaf

Sc	Age/Weight/Gende	ALocation	Smoking habit	C_{Rn}^{α} Bq /m^3
u1	48,77,male	Babylon	Yes	4.7619
u2	55,80,male	Najaf	Yes	8.6167
u3	48,72,male	Nazareth	Yes	23.8095
u4	45,98,male	Basra	No	0.9070
u5	32,70,male	Najaf	Yes	11.5646
u6	56,72,male	Najaf	Yes	5.8956
u7	62,88,male	Najaf	No	14.5124
u8	63,75,male	Najaf	Yes	0.9370
u9	68,72,male	Najaf	Yes	12.2449
u10	26,68,male	Babylon	No	29.7052
u11	41,85, female	Najaf	No	8.1632
u12	24,68, female	Najaf	No	13.1519
u13	73,60, female	Najaf	Yes	2.2675

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u14	44,74, female	Diwaniyah	No	1.8140
u15	38,80, female	Diwaniyah	No	5.6689
u16	25,63, female	Najaf	No	4.7619
u17	63,66, female	Najaf	Yes	4.0816
u18	60,73, female	Najaf	No	1.3605
u19	65,70, female	Najaf	Yes	7.02947
u20	47,90, female	Najaf	No	18.8208
Permissibie limit				200[]
Mean				8.709
Min.				0.9070
Max				29.7052

Table 5. shows the level of radon concentration in stone samples of patients with and without renal failure. The value of radon concentration in urea samples ranged from (16.3265 - 0)Bq/m3, mean ± SD = 5.751 ± 0.77Bq/m3. The highest value obt highest measurement made ained was 16.3265Bq/m3 for males (63 and 45) years old Najaf and Basra, and the result with the lowest value was 0Bq/m3.m3 for s12 24-year- female from Najaf.

Table 5 .Radon concentration in urea samples taken from patients with renal failure at Al-Sadr teaching hospital in the governorate of Najaf

SC	Age/Weight/Gende	ALocation	Smoking habit	C_{Rn}^{α} Bq /m^3
s1	48,77,male	Babylon	Yes	0.9070
s2	55,80,male	Najaf	Yes	4.7619
s3	48,72,male	Nazareth	Yes	4.0816
s4	45,98,male	Basra	No	1.8140
s5	32,70,male	Najaf	Yes	0.2267
s6	56,72,male	Najaf	Yes	3.1746
s7	62,88,male	Najaf	No	22.2222
s8	63,75,male	Najaf	Yes	12.01814
s9	68,72,male	Najaf	Yes	13.6054
s10	26,68,male	Babylon	No	2.4943
s11	41,85, female	Najaf	No	6.5759
s12	24,68, female	Najaf	No	10.2267
s13	73,60, female	Najaf	Yes	1.5873
s14	44,74, female	Diwaniyah	No	7.7097
s15	38,80, female	Diwaniyah	No	4.5351
s16	25,63, female	Najaf	No	8.1632
s17	63,66, female	Najaf	Yes	6.3492
s18	60,73, female	Najaf	No	9.9773
s19	65,70, female	Najaf	Yes	3.1746
s20	47,90, female	Najaf	No	5.4421
Permissible limit				200
Mean				6.4523
Min.				0.2267
Max				22.2222

Figure 3 It shows a comparison of the mean radon concentration of four different groups of patients and healthy subjects with serum (serum) and urea (u) samples of patients and serum (hs) and urea (hu) healthy samples. The average radon concentration in the s, u, hs and hu groups is below the limit at 200Bq/m3. [24]

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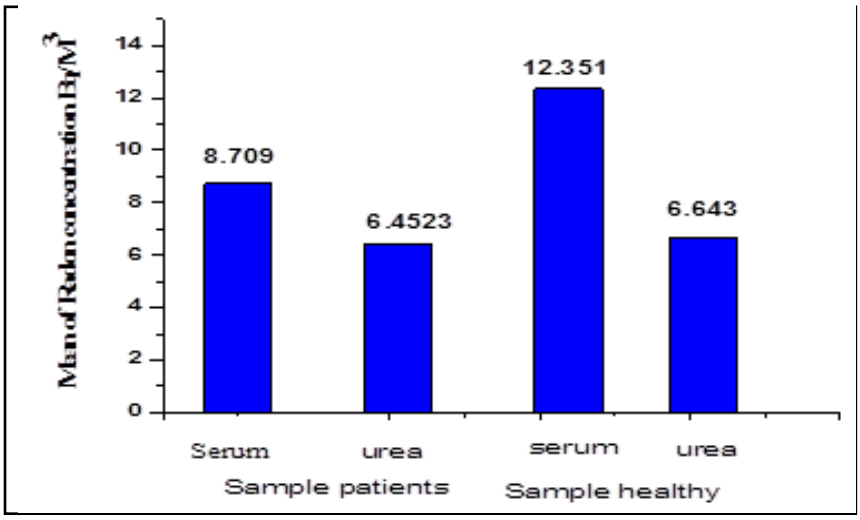

Figure 3: Mean value of Radon Concentration of four different Groups of patients and healthy people with serum (s) , urea(u) for patients, urea (U), serum (S) for healthy people

Figure 4 compares the radon concentration emission from serum samples taken from healthy and sick people. The mean radon emission in healthy people (12.351 B/m^3) is slightly more than the mean radon emission in patients people (8.709 B/m^3) . This may be due to enriched food intake, type of food and lifestyle.

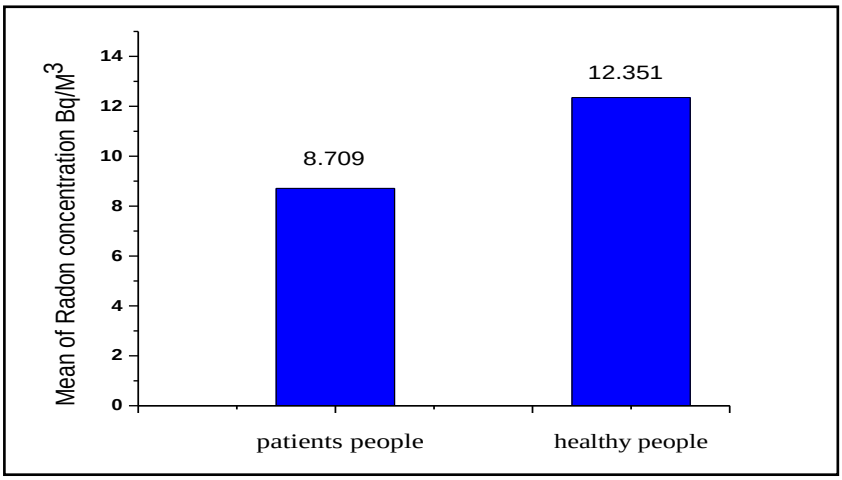

Figure 4: Comparison of the mean radon levels in serum samples from healthy and unwell patients

Figure 5. Compares average radon concentration. Male and female samples of serum and urea for patients, and serum and urea for healthy subjects. The level of radon gas concentration in male patients was higher than in females in the case of urea samples. The results in patients' serum samples showed that the average concentration of radon gas in males is higher than in females, and the reason for this may be attributed to the relatively continuous work. of men compared to females. As for healthy people, men had higher concentrations of radon in their serum and urea samples than women. The results of the mean concentration of radon gas in blood serum samples of patients and healthy subjects indicated that the patients' samples were higher than the healthy samples.

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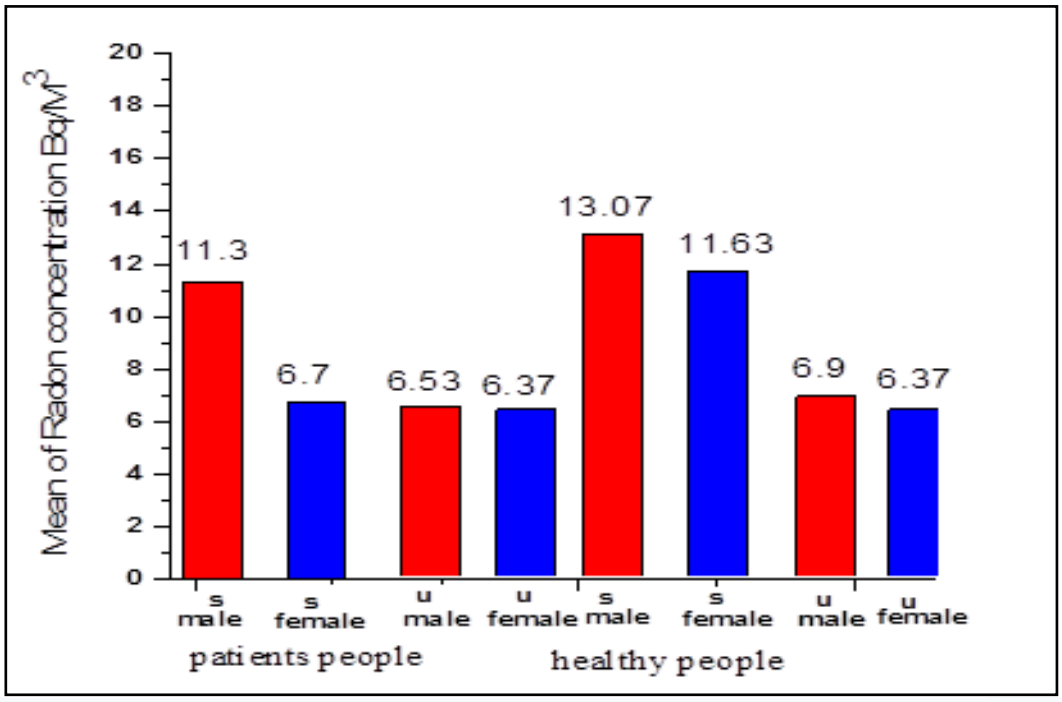

Figure 5: Comparison of average radon concentration levels between males and females from serum and urea of patients and serum and urea samples of healthy subjects

Table 7 demonstrates how (Rn, Age, and Weight) relate to one another in healthy individuals. Weak inverse correlation between age and weight and radon levels. A person correlation test conducted on the study's results revealed that weight has a greater impact on Rn than age.

Table 7. shows the Pearson association between weight, age, and radon in healthy individuals..

correlation between people N =20	Rn	Weight	Age
Rn	1	-0.179	-0.15
Weight	-0.179	1	-0.401
Age	-0.15	-0.401	1

Table 8 displays the Relationship between(Age, Weight, and Rn) in patients' individual cases. Age and weight have just a minimal relationship with radon. The analysis of these study's results revealed that age affects Rn more so than weight, according to a person correlation test. .

Table 8 shows the Pearson association between weight, age, and radon in patient populations.

Correlation of individuals N=20	Rn	Weight	Age
Rn	1	0.019	0.11
Weight	0.019	1	0.321
Age	0.11	0.321	1

Table 9. Alpha particles concentrations in different places in Iraq and other countries reported in the relevant literature.

PLACE	Concentration of alpha particles (Bq/m3)	Reference
UNSCEAR	200	[25]
Malaysia	734.50	[26]

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Karbala, Iraq	64.3	[27]
Iraq/ Babylon	19.2234	[28]
Iraq/ Najaf	8.709 , 6.4523	Present study

5. CONCLUSIONS

In this study, samples of blood, urine, and gravel are taken from both healthy volunteers and patients with renal failure .Governorate of Najaf. Utilizing a CR-39 detector, the concentrations of alpha particles in these samples are determined. According to the findings, renal failure patients had a higher concentration of alpha-V particles related to health, The mean concentrations were 6643 and 12531 and 8.709, and 6.4523, respectively. additional, ,According to the findings, radon concentrations in men were often greater than in women. Consider both the healthy and the patient-based measured samples. Last but not least, the data (average focus) with data published in the pertinent literature. In the province of Najaf, the concentration was less than 200Bq/m3. The limit exists. Described by the International Commission on Radiation Protection (ICRP) as well as the International Atomic Organization Energy Agency (IAEA).

ACKNOWLEDGEMENT.

The authors thank Al-Sadr Teaching Hospital in Najaf. Special thanks to Prof. Dr. Haider Hamza, Prof. Dr. Samah O. Al-Rammahi, from the College of Science. Kufa University for their support for finishing this research.

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World Bulletin of Public Health (WBPH)
Available Online at: https://www.scholarexpress.net
Volume-23, June 2023
ISSN: 2749-3644

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