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Radon, Radium, and Uranium Concentrations in the Blood of Cigarette-Smoking Women and Lung Cancer Risk

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Abstract

Radon and its daughters are of the natural radioactive decay of the uranium series. Exposure to radon gas leads to lung cancer, so the risks are significantly higher for smokers than for non-smokers. Therefore, the risk of radon increases for both active and passive smokers. The radioactivity of alpha particles emitted by radium 226, the main source of radon 222, has become harmful because its prevalence and inhalation increase with increased smoking. In this study, a CR-39 detector was used to measure radon, radium, and uranium concentrations and then calculate risk parameters in seven cigarette-smoking females in vitro study of human blood samples, and three normal females with no actual and passive cigarette smoking. The radon concentrations in blood samples varied from 147.36±0.08 Bq/kg to 659.92±0.04 Bq/kg with an average of 316.83±150.42 Bq/kg, the radium concentration varied from 13.55±0.27 Bq/kg to 60.70±0.13 Bq/kg with an average value 29.05±13.84 Bq/kg, and uranium concentration varies from 11.89±0.29 ppm to 53.23±0.14 ppm with an average value 25.47±12.13 ppm. The annual effective dose ranged from 4.42±0.48 to 12.57±0.28 mSv/y with average value of 8.35±3.10 mSv/y. The annual risk cases of lung cancer varied from 79.50±.0.11 to 226.26±0.07 with an average value of 150.22±55.78 per million people. The results deal with the radioactive effect of female cigarette smokers as a risk factor for lung cancer. Most of the results exceed the permissible international limits. Hence, human health and their life are at risk of radioactivity resulting from cigarette smoking that is concentrated in the blood of female smokers examined in this work.

Keywords: Rn, Ra, and U concentration, female's blood, lung cancer, cigarette smokers, CR-39 detector

تراكيز الرادون والراديوم واليورانيوم في دم مدخنات السجائر ومخاطر الاصابة بسرطان الرئة

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الخلاصة

الرادون وبناته عناصر من عناصر التحلل الإشعاعي الطبيعي لسلسلة اليورانيوم. أن التعرض لغاز الرادون هو السبب الرئيسي لسرطان الرئة ، والمخاطر أعلى بشكل ملحوظ بالنسبة للمدخنين مقارنة بغير المدخنين. لذلك ، يزداد خطر غاز الرادون لكل من المدخنين النشطين والمدخنين السلبيين. أصبح النشاط الإشعاعي جسيمات ألفا المنبعثة من الراديوم 226 ، المصدر الرئيسي للرادون 222, ضارًا لأن انتشاره واستنشاقه يزدادان مع زيادة التدخين. في هذه الدراسة ، تم استخدام كاشف CR-39 لقياس تراكيز الرادون والراديوم واليورانيوم وحساب معايير المخاطر لسبع إناث مختلفة الاعمار من مدخنات السجائر في دراسة مختبرية لعينات دم بشرية ، وثلاث إناث عاديات مع عدم وجود مدخنين فعليين وغير فعليين للسجائر. تراوحت تراكيز الرادون في عينات الدم من 147.36 ± 0.08 بيكريل / كغم إلى 659.92 ± 0.04 بيكريل / كغم بمتوسط 316.83 ± 150.42 بيكريل / كغم، وتراوح تركيز الراديوم من 13.55 ± 0.27 بيكريل / كغم إلى 60.70 ± 0.13 بيكريل / كغم بمتوسط القيمة 29.05 ± 13.84 بيكريل / كغم ، ويتراوح تركيز اليورانيوم من 11.89 ± 0.29 جزء في المليون إلى 53.23 ± 0.14 جزء في المليون بمتوسط قيمة 25.47 ± 12.13 جزء في المليون. تتراوح الجرعة الفعالة السنوية من 4.42 ± 0.48 ملي سيفرت / سنة إلى 12.57 ± 0.28 ملي سيفرت / سنة بمتوسط قيمة 8.35 ± 3.10 ملي سيفرت / سنة. تراوحت حالات خطر الإصابة بسرطان الرئة سنويًا من 79.50 ± 0.11 إلى 226.26 ± 0.07 بمتوسط قيمة 150.22 ± 55.78 لكل مليون شخص. تتناول النتائج التأثير الإشعاعي لمدخنات السجائر كعامل خطر للإصابة بسرطان الرئة. معظم النتائج تتجاوز الحدود الدولية المسموح بها. ومن ثم ، فإن صحة الإنسان وحياتهم معرضة لخطر النشاط الإشعاعي في دم الإناث المدخنات السكائر التي تم فحصها في هذا العمل.

1. Introduction

Radon-222 is a serious problem when inhaled. When cigarette smoke is present in the lung, the radon daughters are attached to the lung cells with radioactive particles causing lung function damage because of the increased alpha radiation [1]. The decay of naturally existing radium is regarded as a source from which radon is exhaled from the ground. Other radioactive elements in the earth, such as uranium, thorium, and potassium, emit alpha, beta, and gamma radiation [2]. Radon decays into several solid decay products, which achieve equilibrium within four days [3]. Most studies relate a significant association between radon exposure and lung cancer risk for its risk assessment. To investigate whether cigarette tobacco is a potential source of radon concentration in blood, the levels of radon, radium, and uranium from radioactive decay were measured in blood samples of ten cigarette-smoking women using CR-39 nuclear track detectors. When radon gas is inhaled into the lung, it travels to the rest of the body, where the blood is responsible for transporting it from the lung to the body's organs [4-6]. The high concentration of radon inhalation poses a great danger to human health and increases the incidence of lung cancer [7].

The aims of this study are to investigate the radon, radium, and uranium concentration levels, using CR-39 solid state nuclear track technique, in the blood of cigarette-smoking women. Also, to calculate the risk indices such as potential alpha energy concentration (PAEC), exposure to radon progeny (EP), annual effective dose (AED), and lung cancer cases per year per million person (CPPP) to reach conclusions regarding the hazardous effects of radioactivity on females due to cigarette smoking.

2. Materials and Methods

This study was conducted on seven selected cigarette-smoking females, whose age are 30-61 years old, as the donor group, and three non-smoking females as the control group of the age range 23-84 years. Ten millilitres of venous blood samples were drawn from donor and control subjects using a disposable syringe. The blood was transported into disposable test tubes containing an anticoagulant kind of sodium citrate (Partial-Thromboplastin-Time (PTT)). The tubes were labelled with a defined code. Subsequently, the blood samples were kept in an ice box (4°C) and then transferred to a laboratory for refrigeration until the start date of the analysis. The blood samples were transferred to a petri dish while keeping each code. Then they were placed in an electric oven (made in Germany, with serial number 412.2744 manufactured 2010) at a temperature of 70°C for 3 hours to dry, after which they were crushed in a melting pot (quartz crucible) and stored in sterilized plastic cans with dimensions of 7 cm height and 3.7 cm diameter. Each empty can was weighed before and after placing the powdered blood sample in it to know the weight of the sample. CR-39 detector with an area of $1 \times 1\ cm^2$ was pasted on the inside of the can cover. Then the can was tightly sealed with adhesive tape (type Para-film). The cans were left for two months. Alpha particles are received by the CR-39 detector after the decay of radon and its daughters. After the two months, the detectors were taken out and placed in NaOH solution with normality 6.25N and placed in a water bath at 60 °C for 5 hours to complete the etching process. The detectors were then taken out, rinsed with distilled water, and dried to be prepared for track reading under an optical microscope. The optical microscope (Pro.Way made in China) was equipped with a 5-megapixel camera developed with LED light instead of tungsten light, which has proven to be of high efficiency in terms of clarity of vision and track number [8, 9]. It is able to give magnification by an objective (4X, 10X, 40X, and 100X) and two eyepieces (40X) to count the number of tracks. Ten images were taken for each detector to increase the accuracy of the readings; the number of tracks in each image was counted, averaged and divided by the reading vision area to obtain the track density. The alpha particle track density recorded on the CR-39 is a ${}^{222}_{86}Rn$ component, so the ${}^{222}_{86}Rn$ concentration is directly proportional to the actual track density readings. The measured ${}^{222}_{86}Rn$ concentrations in the air above the sample inside the can are represented by $C(Bq/m^3)$ according to the equation [10]:

$$C(Bq/m^3) = \frac{Track\ Density\ (Track/cm^2)}{Calibration\ Factor\ (slope) \times Exposure\ Time} = \frac{\rho}{kt} \tag{1}$$

The track density ρ is the average number of total tracks per area of the field view of the ten images, t is the exposure time 60 days, k is the slope of the experimentally obtained calibration curve of CR-39 detector which was performed using ${}^{226}_{88}Ra$ standard source with a half-life of 1600y and activity 1.3μCi (48100 Bq), which decay to radon ${}^{222}_{86}Rn$. This activity was corrected up to the measurement time. The CR-39 detector and the standard source of ${}^{226}_{88}Ra$ were placed in a glass container. Thus, the radon activity within the container can be estimated after different exposure times of the detectors. Thus, the relationship between the track density of the standard source ρ_s (tracks/cm^2) and the radon exposure of the standard source E_s (Bq.day/m^3) gives the calibration curve from which the slope (k) can be obtained, as shown in Figure 1.

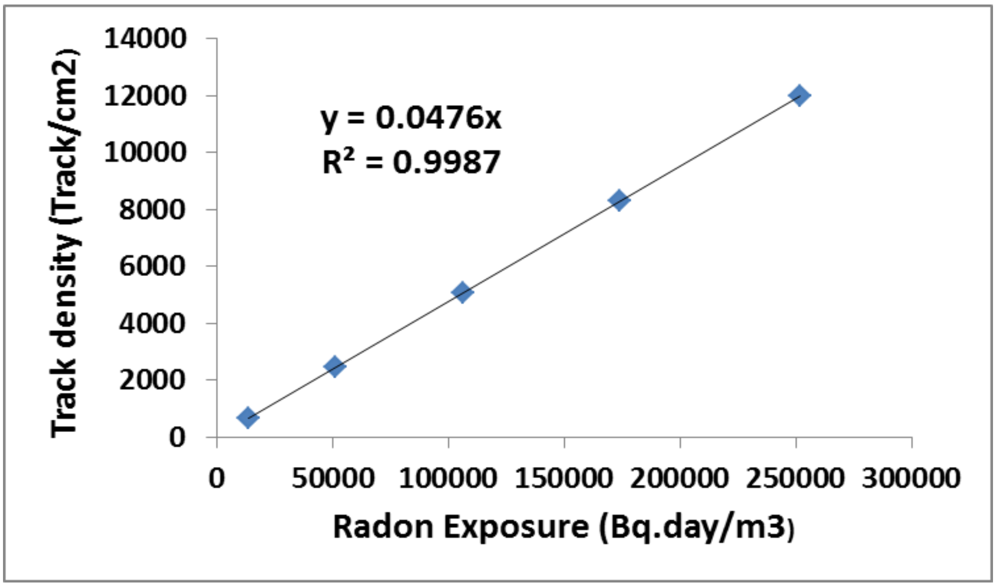

Figure 1: Calibration curve for Radon exposure.

2.1 Radon Concentration in Sample

The concentration of radon ${}^{222}_{86}Rn$ in the studied female blood samples C_{Rn} can be calculated according to the proposal given by Somogyi et al. [11], in terms of radon concentration C in the air above the sample, which can be expressed as in the equation:

$$C_{Rn}(Bq/m^3) = \frac{C\,\lambda_{Rn}\,h\,t}{L} \tag{2}$$

Where: λ_{Rn} is the decay constant for ${}^{222}_{86}Rn$ $(0.1814\ day^{-1})$, h is the height above the blood surface up to the detector in cm., t is the exposure time 60 days, L is the thickness of the blood powder inside the can in cm.

2.2 Activity Concentration of Radon in Sample

The activity concentration of ${}^{222}_{86}Rn$, $C_{Rn}\left(\frac{Bq}{kg}\right)$, in the blood samples was estimated using Equation (3) [12]:

$$C_{Rn}(Bq/kg) = \frac{C_{Rn}(Bq/m^3)\,L\,A}{m} \tag{3}$$

Where: A is surface area of the sample (cm^2) and m is the mass of the sample (kg).

2.3 Radium Concentration in Sample

The radium ${}^{226}_{88}Ra$ concentration in the blood samples can be estimated in terms of radon concentration in the air inside the can as in Equation (4) [12]:

$$C_{Ra}(Bq/kg) = \frac{C\,h\,A}{m} \tag{4}$$

2.4 Radon Progeny Concentration

The estimation of the concentration of radon progeny ${}^{214}_{84}Po$ and ${}^{218}_{84}Po$ emitting alpha particles which were deposited on the walls of the can Po_{Wall} and on the face of the detector Po_{Face} can be calculated using the following equations [13, 14]:

$$C_{{}^{218}Po\ wall} = C_{{}^{214}Po\ wall} = \frac{C}{4}\,r\left(\frac{h}{r+h}\right)cos\theta_c \tag{5}$$

$$C_{{}^{218}Po\ face} = C_{{}^{214}Po\ face} = \frac{C}{4}\,r\left(\frac{h}{r+h}\right)\left(cos\theta_c\,\frac{r}{R_\alpha}\right) \tag{6}$$

Where: r is the radius of the can, θ_c is the critical angle (35°) of the CR-39 detector, and R_α is the average range of alpha particles in the air (4.15 cm).

2.5 Uranium Concentration in Sample

Radon activity in the blood samples can be calculated in terms of radon concentration $C_{Rn}(Bq/m^3)$ in the sample, as in Equation (7) [12]:

$$A_{Rn}(Bq) = C_{Rn}(Bq/m^3) \times V \tag{7}$$

Where: V is the sample volume $(m^3) = \pi\, L\, r^2$, r is the radius of the can.
The number of uranium atoms $^{238}_{92}U$ in the sample at secular equilibrium can be obtained according to Equation (8) [15]:

$$N_U = \frac{A_{Rn}(Bq)}{\lambda_U} \tag{8}$$

Where: λ_U is uranium decay constant $(4.9 \times 10^{-18}/s)$. Therefore, uranium weight (g) in the sample is given by Equation (9) [16]:

$$M_U(g) = \frac{N_U\, A_U}{N_A} \tag{9}$$

Where: A_U is the mass number of $^{238}_{92}U$, N_A is Avogadro's number. Therefore, the uranium concentration can be calculated from Equation (10):

$$C_U(ppm) = \frac{M_U(g)}{m} \tag{10}$$

2.6 Potential Alpha Energy Concentration

The Potential Alpha Energy Concentration ($PAEC$), in unit of working level (WL) of $^{222}_{86}Rn$ and $^{222}_{86}Rn$ daughters, 3700 is the working level conversion factor. However, most countries have professional guidelines for the effects of radon exposure from prolonged exposure to radon [17, 18]. It can be calculated by Equation (11) [19, 20]:

$$PAEC\ (WL) = \frac{F \times C}{3700} \tag{11}$$

Where: F is the equilibrium factor = 0.4, as recommended by UNSCEAR [21].

2.7 Exposures to Radon Progeny

The exposures to radon progeny EP in terms of radon concentration C is indicated in Equation (12) [22]:

$$EP\ (WLM/y) = 8760 \times 0.80 \times \frac{F \times C}{170 \times 3700} \tag{12}$$

Where: 8760 is the number of $hours/year$, 80% is the house occupancy factor i.e. the fraction of time spent indoors, and 170 is the number of $hours/working\ month$.

2.8 Annual Effective Dose

The annual effective dose $AED\ (mSv/y)$ was also calculated using Equation (13) [21]:

$$AED\ (mSv/y) = F \times C \times 0.80\ \times 8760 \times D \tag{13}$$

Where: D is the ICRP dose conversion factor 9×10^{-6} $(mSv/Bq.h.m^{-3})$ [22].

2.9 Lung Cancer Cases

The number of lung cancer cases per year per million people $CPPP$, can be calculated using the following expression[21]:

$$CPPP = AED \times (18 \times 10^{-6}\ y/mSv) \tag{14}$$

3. Results and Discussion

In this work, CR-39 detector was used because it has good sensibility to register low energy alpha particles. Also, it possesses good stability to resist environmental variables sensitive to alpha particles [23]. The aim of this work is to find out if the concentration levels of radioactive elements present in the blood samples of cigarette-smoking women are in excess of the permissible levels in order to quit smoking or at least reduce it.

Table 1 shows the measurement results of radon, radium, and uranium concentrations in blood samples of cigarette-smoking women in Baghdad Governorate, capital of Iraq. It can be seen that the radon concentration varied from 175.07±0.08 Bq/m^3 in the 7FC sample to a maximum value 498.25±0.05 Bq/m^3 in the 4FC sample. All results were higher than the recommended limit given by EPA of 16.24±6.13 Bq/m^3 (1.49±0.56 Bq/kg) [19] and WHO[24] while the 1FC, 3FC, 4FC, 5FC, and 6FC exceeds these limits in addition to the limits recommended by the International Commission on Radiological Protection (ICRP, 2009) [25] and the European Union (EU, 1990) [26]. Compared to the control group with a minimum value 13.66±0.27 Bq/m^3 and a maximum value 30.81±0.18 Bq/m^3. Table 1 also shows the variation of radon and radium concentration in blood samples from 147.36±0.08 Bq/m^3 (13.55±0.27 Bq/kg) in 7FC sample to a maximum value 659.92±0.04 Bq/m^3 (60.70±0.13 Bq/kg) in 4FC sample. The maximum value of radium exceeded the recommended limit 30 Bq/kg recorded by UNSCEAR [21], while its average value of 29.05±13.84 Bq/kg is nearly the same. Compared to the control group with an average value of 16.24±6.13 Bq/m^3 (1.49±0.56 Bq/kg) is weakly related with recommended limit. The Uranium concentrations in the blood of cigarette-smoking females ranged from 11.89±0.29 ppm in 7FC sample to 53.23±0.14 ppm in 4FC sample with an average value of 25.47±12.13 ppm. While the control group average value was 1.31±0.49 ppm, which is higher than the recommended value 0.115 ppm reported by ICRP [25]. The high concentration of uranium in the samples depends strongly on the concentration of radon in the samples and on the mass of the material, so this was observed in the increase in the concentration of uranium.

Table 1: Radon, Radium, and Uranium concentrations in the blood samples of female's cigarettes smokers

Sample Code	**Smoking Period (year)**	**Daily Smoking Amount (Cigarette/day)**	ρ $(Track/cm^2)$	**Radon-222**		**Radium-226**	**Uranium-238**
				C (Bq/m^3)	C_{Rn} (Bq/kg)	C_{Ra} (Bq/kg)	C_U (ppm)
1FC	20	30	1270	444.68±0.05	314.09±0.06	28.89±0.19	25.33±0.20
2FC	5	15	544	190.48±0.07	244.09±0.06	22.45±0.21	19.69±0.23
3FC	8	20	720	252.10±0.06	237.77±0.07	21.87±0.21	19.18±0.23
4FC	15	20	1281	448.53±0.05	659.92±0.04	60.70±0.13	53.23±0.14
5FC	24	25	1423	498.25±0.05	297.84±0.06	27.40±0.19	24.02±0.20
6FC	9	20	875	306.37±0.06	309.77±0.06	28.49±0.19	24.98±0.20
7FC	4	15	500	175.07±0.08	147.36±0.08	13.55±0.27	11.89±0.29
Max.	24	30	1423	498.25±0.05	659.92±0.04	60.70±0.13	53.23±0.14
Min.	4	15	500	175.07±0.08	147.36±0.08	13.55±0.27	11.89±0.29
Average	12.14	20.71	945	330.78	316.83	29.05	25.47
	Standard Deviation		±350.79	±122.82	±150.42	±13.84	±12.13
	Normal (No actual and passive females cigarettes smokers)						
1FN	zero	zero	88	30.81±0.18	21.96±0.21	2.02±0.70	1.77±0.75
2FN	zero	zero	39	13.66±0.27	7.74±0.36	0.71±1.19	0.63±1.27
3FN	zero	zero	58	20.31±0.22	19.01±.23	1.75±0.76	1.53±0.81
Max.	zero	zero	88	30.81±0.18	21.96±0.21	2.02±0.70	1.77±0.75
Min.	zero	zero	39	13.66±0.27	7.74±0.36	0.71±1.19	0.63±1.27
Average	zero	zero	62	21.59	16.24	1.49	1.31
Standard Deviation			±20.17	±7.06	±6.13	± 0.56	±0.49
Recommended Limit				200-300 ICRP, 2009 [25] 200 EU, 1990[26] 148 EPA, 2009 [19] 100 WHO, 2009 [24]		30 UNSCEAR, 2000 [21]	0.115 ICRP, 2009 [25]

Figure 2 shows a comparison between the different concentrations of cigarette-smoking females with the control group concentrations. It can be seen that the variation of radon concentration in the blood samples depends mainly on the uranium concentration in the blood samples, which it decays to different radioactive elements including radon. Among individuals who never smoked, the statistically significant P value was <0.05 in the activity concentration of radon, in the selected female group.

The ICRP [25] recommended the permissible limit the of radon concentration to be 200-300 Bq/m^3, and that for uranium concentration 0.115 ppm. While the US EPA [19] estimated that

26% of lung cancer deaths were radon-related. Because of the lognormal distribution of radon, the majority of radon-induced lung cancers for many countries occur below the radon action or reference levels adopted by that country [27]. Hence, this committee estimated that two-thirds of the radon-related deaths in the United States occur below the EPA's action level of 148 Bq/m^3.

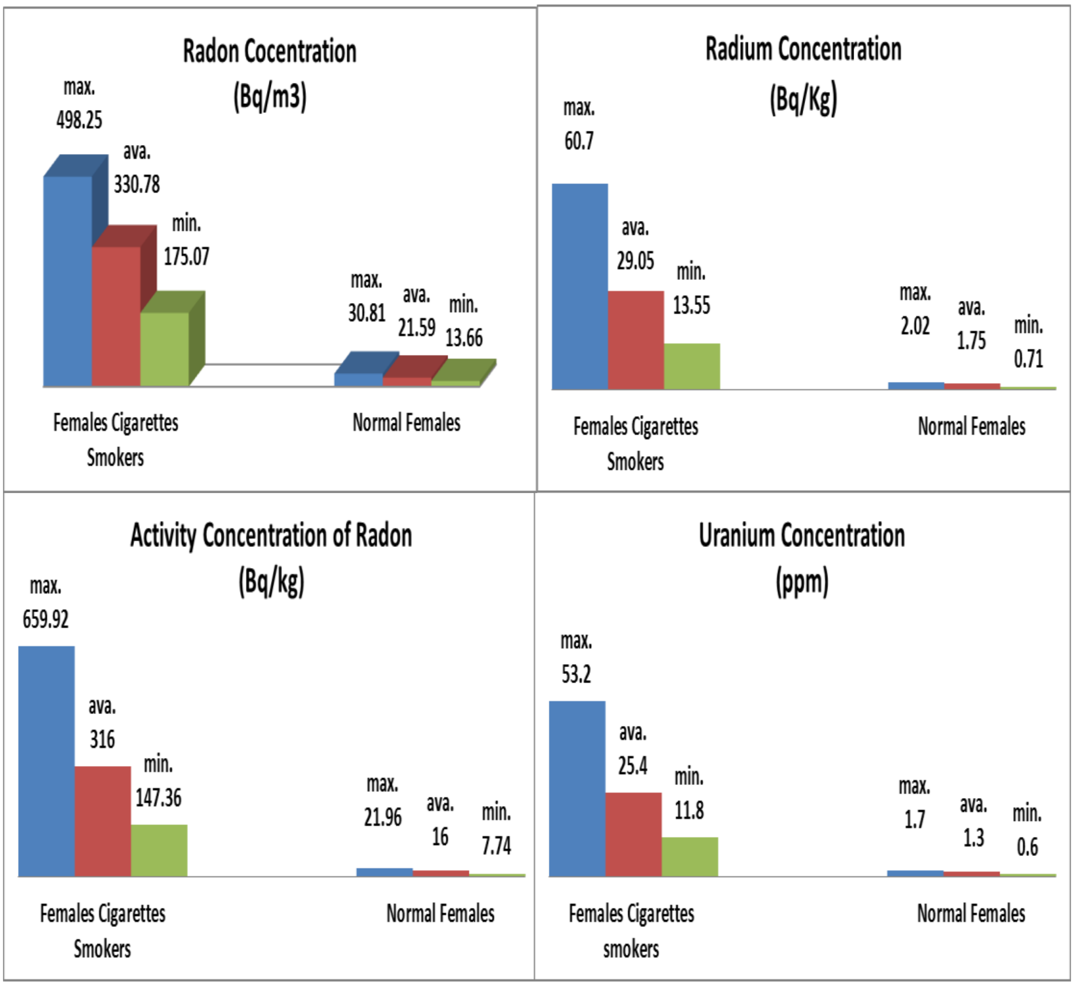

Figure 2: Comparisons of radon, radium, radon activity, and uranium concentrations for women smokers with normal group concentrations

Table 2: displays the calculated values of potential alpha energy concentration (PAEC), exposure to radon progeny (EP), annual effective dose (AED), and lung cancer cases per year per million persons ($CPPP$). The maximum value of potential alpha energy concentration was 53.87±0.14 mWL in the 5FC sample and the minimum value was 18.93±0.22 mWL in the 7FC sample with an average value 35.76 mWL. The results were lower than the recommended value of 53.33 mWL reported by the UNSCEAR committee [28], even that for the control group except for those in the 5FC sample which is slightly higher. The exposure values for radon progeny EP varied between 0.78±1.13 WLM/y in the 7FC sample and 2.22±0.67 WLM/y in the 5FC sample with an average value 1.47 WLM/y . All EP results were less than the recommended 1-2 WLM/y value reported by NCRP [29] except for the 4FC and 5FC samples which were 2.00±0.71 WLM/y and 2.22±0.67 WLM/y, respectively. When compared with the results obtained for the control group with that of cigarette-smoking females blood samples, the average exposure value for radon progeny was 0.10±0.03 WLM/y which is less than the recommended limit.

Table 2: potential alpha energy concentration ($PAEC$), exposure to radon progeny (EP), annual effective dose (AED), and lung cancer cases per year per million person ($CPPP$) in the blood for nonsmoker females and cigarette's smokers.

Sample Code	Age (year)	Weight (kg)	$PAEC$ (mWL)	EP (WLm/y)	AED (mS/y)	$CPPP$ $Lung\ Cancer/10^6\ Person$
1FC	53	65	48.07±0.14	1.98±0.71	11.22±0.30	201.94±0.07
2FC	41	110	20.59±0.22	0.85±1.09	4.81±0.46	86.50±0.11
3FC	36	68	27.25±0.19	1.12±0.94	6.36±0.40	114.48±0.09
4FC	43	72	48.49±0.14	2.00±0.71	11.32±0.30	203.69±0.07
5FC	61	65	53.87±0.14	2.22±0.67	12.57±0.28	226.26±0.07
6FC	30	76	33.12±0.17	1.37±0.86	7.73±0.36	139.13±0.09
7FC	48	82	18.93±0.22	0.78±1.13	4.42±0.48	79.50±.0.11
Max.	61	110	53.87±0.14	2.22±0.67	12.57±0.28	226.26±0.07
Min.	30	65	18.93±0.22	0.78±1.13	4.42±0.48	79.50±.0.11
Average	44.6	76.9	35.76	1.47	8.35	150.22
Standard Deviation			±13.28	±0.55	±3.10	±55.78
Normal (No actual and passive females cigarettes smokers)						
1FN	84	50	3.33±0.55	0.14±2.70	0.78±1.13	13.99±0.27
2FN	23	60	1.48±1.48	0.06±4.05	0.35±1.70	6.20±0.40
3FN	46	100	2.20±0.68	0.09±3.32	0.51±1.40	9.22±0.33
Max.	84	100	3.33±0.55	0.14±2.70	0.78±1.13	13.99±0.27
Min.	23	50	1.48±1.48	0.06±4.05	0.35±1.70	6.20±0.40
Average	51	70	2.33	0.10	0.55	9.81
Standard Deviation			±0.76	±0.03	±0.18	±3.21
Recommended Limit			53.33 UNSCEAR,1993 [28]	1-2 NCRP, 1989 [29]	3-10 ICRP, 1993 [30]	170-230 ICRP, 1993 [30]

Figure 3 shows the relationship between percentages of dose absorbed and periods of cigarette smoking for female blood samples. It can be seen from the present results that the absorbed dose clearly depends on the smoking period. Hence, the absorbed dose ranged from 5% for the 7FC woman blood sample whose smoking period was four years, to 28% for the 5FC woman blood sample whose smoking period was 24 years. The annual effective dose depends on the smoking period, therefore when the period of smoking increases the annual effective dose also increases. Figure 4 confirms and clarifies a positive strong correlation coefficient between absorbed dose rate and the period of smoking to be 92.57%. While the correlation coefficient with the number of cigarettes smoking per day is less strong 65.99%, it showed a weak correlation with the age of cigarette-smoker women of 0.82%.

The lung cancer cases per year per million people in the blood for cigarette-smoking females varied between 79.50±.0.11 per million people in 7FC sample to 226.26±0.07 per million people in 5FC sample, with average value 150.22±55.78 per million people. The results in 1FC, 4FC, and 5FC samples exceed the permissible limit of 170 recommended by ICRP [30]. While the average control group value was 9.81±3.21 per million people. Not all control values exceeded this limit. Figure 5 shows that there is a strong correlation between lung cancer cases per million people with radon concentration.

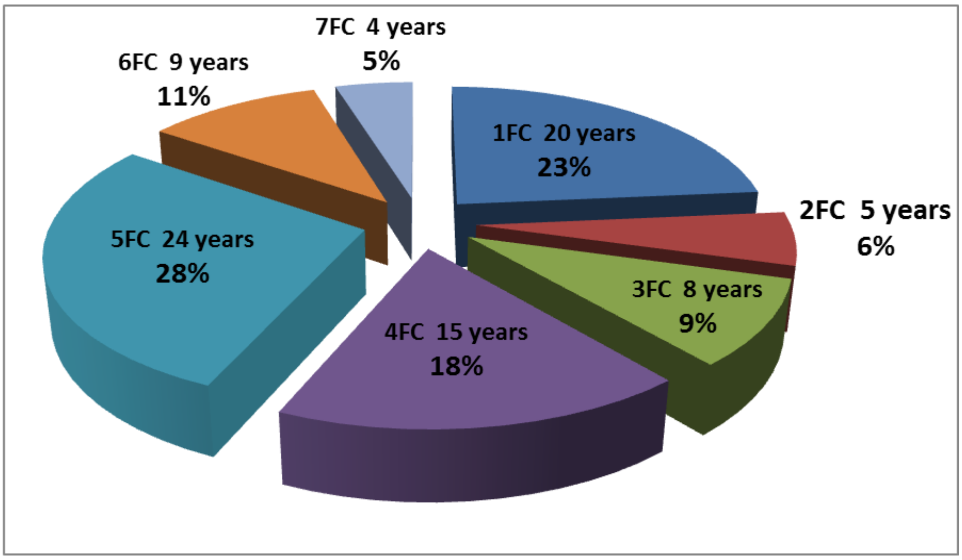

Figure 3: Absorbed dose percentages various periods of female's smoking.

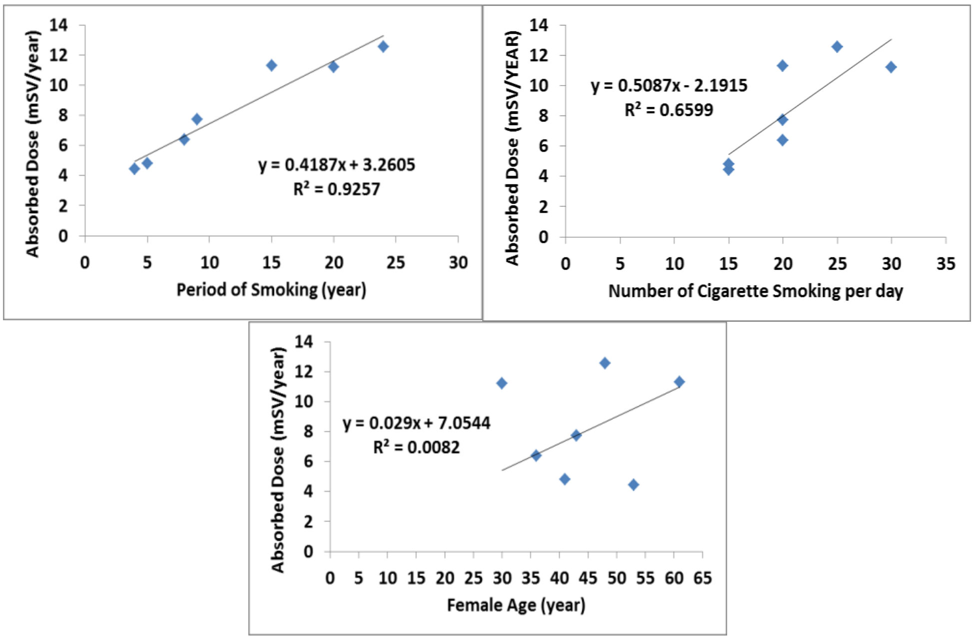

Figure 4: Correlation between absorbed dose rate and period of smoking, number of cigarette smoked daily, and the female's age.

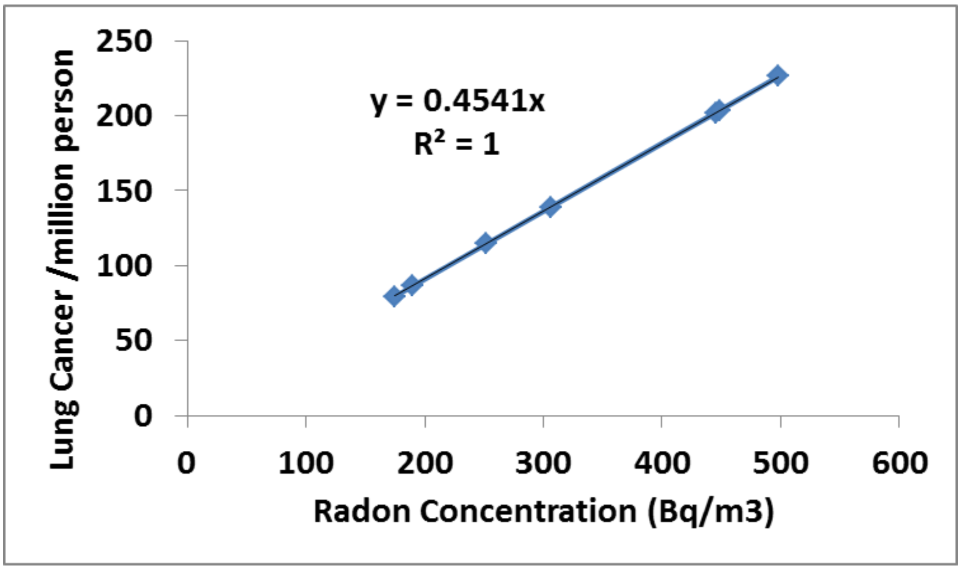

Figure 5: Lung cancer cases versus radon concentrations for cigarette-smoking females.

4. Conclusions

Concentrations of radon, radium, and uranium in female blood are noteworthy because they give a significant indicator of smoking and lung cancer risk. This research found that the maximum concentration of radon in female blood samples was higher than the 200 Bq/m^3 limit allowed by ICRP. The minimum concentration of radon was higher than the recommended limit of 148 Bq/m^3 given by the Environmental Protection Agency and higher than the reported limit of 100 Bq/m^3 given by WHO. From the results, it can be observed that the lung cancer cases varied with radon concentration; a significantly strong positive correlation was found. Hence, there is a close relationship between radon and cigarette smokers and its impact on increasing lung cancer rates. The distribution of radium and uranium concentrations also gave a similar strong correlation. The increase of the percentage of annual effective dose was noticeable with the increase of the period of smoking years poses clear with correlation 93%. While the correlation of the absorbed dose rate with the number of cigarette smoked per day was 0.66%. The results of this study will help women smokers whose rate of concentration of radioactive elements in their blood exceeded the permissible scientific limits to take one of two decisions either to quit or reduce smoking, to prevent the transportation of these harmful radiation elements into the human organs.

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