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Health Assessment Based On the Exposure of Alpha Radioactivity in Narghile Smoking

Abdalsattar Kareem Hashim[1*]

1. Department Of Physics, Collage Of Science, Kerbala University, Iraq

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ABSTRACT

Introduction: Smokers and non-smokers are at the risk of developing lung cancer when exposed to alpha rays as a result of the relatively low levels of radium and radon that may be present in different tobacco species. There is a great interest in studies and research on the radionuclides in narghile tobacco emitting alpha particles to know the relationship between smoking narghile and cancer, especially lung cancer.
Material and Methods: This study was conducted to measure the alpha rays in 30 different narghile samples in the markets of Iraq. Radon concentrations were determined using time-tested passive radio doses containing CR-39 solid-state pathway detectors.
Results: The radon concentrations in samples varied from27.44±4.4 Bq/m^3 to 214.61±18.1 Bq/m^3 with the mean value of 65.60±41.04 Bq/m^3. The annual effective dose varies from 0.69±0.09 mSv/y to 5.41±2.20 mSv/y with the mean value of 1.64±1.03 mSv/y. The lung cancer risk cases per year vary from 12.46±2.11 to 97.45±7.34 with the mean value of 29.77±18.63 per million people. The effective radium content ranged between 0.054Bq/kg and 0.425Bq/kg with the mean value of 0.131 of Bq/kg, while the radon emission values for the mass and surface units ranged from 0.410 to 3.212 with the mean of 0.996 mBq/kg.h and 9.040 to 70.703 with the mean value of 21.943mBq/m^2.h, respectively.
Conclusion: The results of the study showed that alpha rays are within the internationally accepted limits and presently do not pose a threat to human health and life in terms of the radiation activity of the investigated narghile tobacco species in this study.

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Introduction

The phenomenon of waterpipe smoking (WPS) became widespread 400 years ago; however, there has been a revival of WPS in recent years, especially among young people [1]. This new challenge for adolescent health care providers reflects the impact of globalization on developed countries. Narghile was established in India, although there have been some theories indicating its first use in South Africa, Iran, and Ethiopia. Narghile is known with a number of different names, including Argyle, Banana, Shisha, Hearts, and Shisha [2, 3].

The spread of WPS in the world is a serious threat to the health of all members of society because it increases the incidence of lung cancer [4-6]. Despite the evidence that water pipe smoking has health risks at least similar to cigarette smoking, the general perception is exactly the opposite. Water pipe tobacco smokers generally believe that it is less harmful than cigarette smoking. Most smokers also believe that the water-filtration and extended hose serve as filters for harmful agents [7].

There has been a resurgence of WPS in the past several years. This phenomenon has been attributed to the perception that WPS is less dangerous than cigarette smoking, its easy availability, its low cost, and a number of other factors. It is usually a social activity, engaged in by peer groups and families, and often practiced in special cafes [3, 8]. The tobacco used in WPS typically weighs 10 to 20 g and has 3 main forms. “Mu’essel” or “maasel”(literally, “honeyed”) contains 30% tobacco and70% honey or molasses (treacle). “Tumbak” or Ajami” is a pure, dark paste of tobacco. “Jurak,”mainly of Indian origin, is an intermediate form that often contains fruits or oils but that may also be treacled and unflavored. “Muessel” is usually flavored with apple, mango, banana, strawberry, orange, grape, mint, cappuccino, or other additives. It is generally sold in cardboard boxes or plastic jars decorated with fruit illustrations. Drugs or alcohol is often added to the tobacco [2]

The nicotine content of tobacco in WPS was reported at 2-4%, compared with 1-3% of cigarettes. The tobacco composition used in the WPS system is not very uniform [9]. Both cigarette and shisha smokers have higher levels of the anion, and larger amounts of non-smoking white blood cells, which can cause lung tissue injury and chronic obstructive pulmonary disease due to surrounding blood muscles

**Corresponding Author:* Email: abdalsattarkareem@gmail.com

[10]. Regarding chromosomes, it was revealed that the genomic toxicity effects of shish on male smokers were an increase in schizophrenia, chromosomal abnormalities, morphological exchanges, and satellite associations, compared with nonsmokers [11].

A study conducted in Saudi Arabia on 595 smokers indicated that the average bioenergy, forced exhalation volume in one second, and forced coercive capacity were lower among nonsmokers, and these values declined with age. The lung function was more likely to decrease in Pipe smokers than cigarette smokers. The WPS was associated with non-sarcoma morbidity and physiological pathology in the respiratory system [12]. In a study on 203 Turkish men, a reduction in excretion rate was found among heavy smokers [13]. In another study on 54 Turkish people, no association was found between lung function and WPS [14]. A third study of 397 Turkish men reported a detrimental effect on pulmonary function, specifically on the peak expiratory flow rate, although the decrease was smaller than with cigarette smoking [9].

Tobacco is used in many ways (e.g., cigarettes, cigars, pipes, and shisha) and health consequences vary accordingly. Tobacco consumption and the number of smokers continue to increase globally [15]. Water pipe users believe it is less harmful than smoking cigarettes because smoking through water pipes removes toxins from tobacco. Shisha smoking increases the risk of lung cancer and respiratory diseases through a recent systematic review of the health effects of narghile smoking. The more the years of smoking, the higher the chance of lung cancer development.

The risk of lung cancer among cigarette smokers is comparable to the risk of smoking narghile, according to an Indian study by Gupta et al. [4]. In a study performed in the USA, narghile smokers are five times more likely to develop lung cancer than non-smokers [5]. The risk of lung cancer among smokers is six times higher than that of non-smokers, according to a study conducted in Kashmir (India) by Koul et al. [6].

Various US agencies have classified radon as a human carcinogen, including the National Toxicology Program, the International Agency for Research on Cancer, and the Agency for Toxic Substances and Diseases [16].

Radioactive uranium is found throughout the earth's crust. Radon-222 is a product of radioactive gas generated by natural uranium-238 decay and spreads as a relatively harmless gas. This gas is inhaled in a small fraction along with other gases daily. On the other hand, solid particles in the respiratory tract are easily breathed out and result in the disintegration of radon. However, some solid particles, such as polonium-214 and polonium-218, may remain in the lungs and undergo radioactive decay, which causes infection and corrosion as a result of alpha particles. Although the penetration distance of alpha particles is low, they are classified as high linear energy transfer alphas because they transfer more energy to the target and cause more severe ionizing events. This process has the most serious damage in the cell. In support of this concept, a study found that the effective dose of inhaled radon gas was doubled in smokers over the long term due to poor ventilation and mucus [17]. The damage to the DNA caused by alpha particles is 100 times greater than that other types of radiation [18]. The reason is that radiated polonium is one of the daughter of radon-emitting alpha radiation, which can cause cancer at least 10-20 times more than the other forms of radiation. Some scientists estimate that its danger can even be 100 times more because the higher produced intensity of radiation damage increases the relative biological impact on DNA leading to fractures and translocations of chromosomes. Alpha radiation is also known for easily causing cancer with low doses [19].

Due to the widespread prevalence of narghile smoking and the absence of field studies associated with this subject, this study aimed to investigate natural radioactivity using CR-39 to determine the levels of radioactivity in 30 different narghile tobacco samples available in Iraqi markets. The objectives of the present study were to determine the activity of the radon level for the various types of commercial narghile tobacco available in the Iraqi market, as well as the calculation of possible potential concentration on alpha energy (PAEC) concentrations, exposure to radon (EP), effective annual dose (AED), and lung cancer per year per million people (CPPP). In addition, the effective radium content and radon exhalation rates were determined for the study samples.

Materials and Methods

Water pipes vary in size, shape, and installation as these factors affect the combustion of coal and the tobacco on the coal, which can affect the inhalation of smoke resulting from the combustion of tobacco and diffusion of air pressure in the water pipes.

The popular water pipe (Figure 1) consists of a head, a metal object, a glass bottle, and a flexible connecting tube with a tongue. Wet tobacco along with charcoal is placed on the top of the water pipe. After the combustion process, the smoke passes through the water in the tube body. Tobacco combustion begins on the top of the water pipe, where wet tobacco is placed with burning charcoal. After the combustion of tobacco, the smoke passes through the water in the body of the tube to be diluted and cooled and dissolve soluble compounds. Next, it passes through the contact tube and is inhaled by the smoker. The smoker requires continuous inhalation of smoke to maintain the combustion of tobacco.

Due to the lack of environmental studies on the production of shisha in Iraq, 30 different kinds of narghile tobacco have been collected among those which are widely used in Iraqi markets. Table 1 shows the types, flavors, and companies of the producing countries and the sample used in this study. The samples were placed in sealed box technique (Figure 2) for four weeks to reach the radiation balance between radium and radon. The CR-39 nuclear track detectors were then mounted on the top of the sample lid in the double-sided adhesive.

The CR-39 nuclear track detectors, which were cut in square forms (1.5cm × 1.5cm), used were from a US company, charleswater.co.uk, and vermason.co.uk. The use of these detectors is an appropriate way to measure the radiation activity of alpha particles due to their low cost, simple application, high sensitivity to record the effects of alpha, and the possibility of using it for a long time anywhere. The CR-39 reagent is very useful in detecting alpha particles emitted from radon and its analogs [20-23]. The 35 grams of narghile tobacco was placed on the inner lower base of the plastic containers, where the samples were stored. The container was 7 cm in length and 4.5 cm in diameter. The samples were stored for 67 days.

After the sample storage process, the nuclear detectors were removed from the samples for electricity in the nuclear physics laboratory in the Physics Department of the Faculty of Science at Kerbala University, Karbala, Iraq. In the electrochemistry process, the researchers employed a German-made water bath using sodium hydroxide solution and a 6 molar concentration for 8 h to enhance the nuclear alpha pathways on the detector surface. In the next step, all the nuclear detectors were removed after the electrochemical abrasion process for washing the water well with the distilled water. Accordingly, remove all the sediments were removed from the surface of the detectors, which could indicate the effects of the alpha particles on the surface of the detectors. The detectors were then dried, and at the last stage, their microscopic trace on all detectors was counted using an optical microscope with 100x magnification.

Figure 1. Popular water pipe used in Iraq

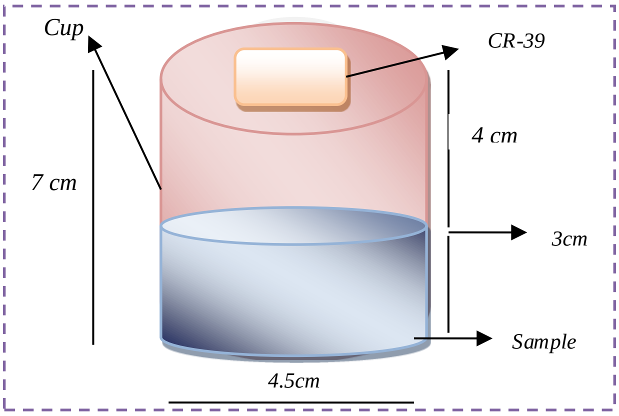

Figure 2. Sealed can technique

Radon Concentration and Annual Effective Dose

In order to calculate radon concentration levels (^{222}Rn) in different narghile tobacco samples from the fumigation layer, the concentration of radon (C) in the air above the samples was determined by measuring the line density on the detector according to the *Equation 1* [24, 25].

$$C\ (Bq/m^3) = \frac{\rho}{K.t} \quad (1)$$

Where, *C* is the concentration of ^{222}Rn in the test tube above the measured sample ($Bq\ /\ m^3$), ρ denotes the surface density of the tracks on the exposed detectors ($Tr\ /\ cm^2$), t refers to the exposure time, and *K* signifies the calibration factor that has been experimentally found to be equal (0.223±0.011 track.cm^{-2}/ Bq.d.m^{-3}) [26].

The PAEC in terms of units (WL) was obtained by using [27-29] the following equation:

$$PAEC\ (WL) = F \times C\ /\ 3700 \quad (2)$$

Where, *F* is the equilibrium factor between radon and its progeny and is equal to 0.4 as proposed (UNSCEAR, 2000) [30].

Exposure to the radon (EP) is then linked to the mean concentration of radon C by *Equation 3* [31]:

$$EP\ (WLM\ Y^{-1}) = 8760 \times n \times F \times C\ /\ 170 \times 3700 \quad (3)$$

Where, *C* is in Bq/m^3, *n* is the time spent inside, which equals to 0.8, the number of h per year is 8760, and 170 is the number of worked h per month.

The annual effective dose (mSv/y) was obtained using *Equation 4* [32-34]:

$$AED\ (m\ Sv/y) = C \times F \times H \times T \times D \quad (4)$$

Where, *H* is the occupancy factor of 0.8, (i.e. the fraction of time the indoor are occupied by the residents), T is the time in hours in a year, (T=8760 h/y), and *D* is the dose conversion factor of $[9\times10^{-6}\ (m\ Sv)/(Bq.h.m^{-3})]$.

The CPPP of lung cancer was through *Equation 5* [27, 35, 36]:

$$CPPP = AED\ (mSv/y) \times (18\times10^{-6}\ mSv^{-1}.y) \quad (5)$$

Table 1. Types, flavors, and companies of the producing countries of the studied samples.

No.	Code	Narghile tobacco Samples	Flavor	Country	Company
١	N1	Molasses Alamasi	Lemon Menthol Fusion	Jourdan	Middle East
2	N2		Lemon and Mint Fusion		Middle East
3	N3		Gum Fusion		
4	N4		Gum and Iced Cinnamon		
5	N5		Menthol Fusion		
6	N6		Orange Fusion		
7	N7		Bounty Fusion		
8	N8	AL sultan	Lemon	Jourdan	Eastern Tombac and tobacco East
9	N9		Gum		
10	N10		Mint		
11	N11	Al Fakher	Strawberry Flavor	United Arab Emirates	Al Fakher Tobacco Trading
12	N12		Mint Flavor		
13	N13		Orange Flavor		
14	N14		Grenadine Flavor		
15	N15		Gum Flavour		
16	N16		Grape Flavour		
17	N17		Tow Apples Flavor		
18	N18		Cherry Flavor		
19	N19		Gum and Mint Flavor		
20	N20		Lemon Flavor		
21	N21	Mazaya	Natural two Apples Molasses	Iraq	Industrial Alzawraa company
22	N22		Lemon Flavor		
23	N23		Natural Lemon with Mint Molasses		
24	N24		Natural Gum with Mint molasses		
25	N25		Natural Orange Molasses		
26	N26		Natural Lemon Molasses		
27	N27		Natural Gum molasses		
28	N28		Heavenly Fruit Molasses		
29	N29		Natural Mint Molasses		
30	N30		Natural Orange with Mint Molasses		

Effective radium content

The effective radium content of the narghile tobacco sample can be calculated by *Equation 6* [37-39]:

$$C_{Ra}(Bq.\text{kg}^{-1}) = \left(\frac{\rho}{KT_e}\right)\left(\frac{hA}{M}\right) \quad (6)$$

Where, *M* represents the mass of tobacco in kilograms, *A* indicates the area of the cross section of the can in m^2; the distance (h) is between the detector and the top surface of tobacco samples in meters.

The T_e can be expressed to the effective exposure period provided by [40]:

$$T_e = [T - \lambda_{Rn}^{-1}(1 - e^{-\lambda_{Rn}T})] \quad (7)$$

Where, *T* is the hourly exposure of time, λ_{Rn} is the decay constant for ^{222}Rn radon (h^{-1})

Radon exhalation rates

The radon exhalation rate in terms of area (E_A) can be expressed using *Equation 8* [41, 42]:

$$E_A(mBq\ m^{-2}h^{-1}) = \frac{CV\lambda}{A[T+\lambda^{-1}(e^{-\lambda T}-1)]} \quad (8)$$

Where, *C* is the integrated radon exposure expressed in Bq m^{-3}h, *V* refers to the effective volume of the cup in m^3.

The radon exhalation rate in terms of mass *(E_M)* can be calculated by using *Equation 9* [41, 42]:

$$E_M(mBq\ kg^{-1}h^{-1}) = \frac{CV\lambda}{M[T+\lambda^{-1}(e^{-\lambda T}-1)]} \quad (9)$$

Results

Radon concentration and annual effective dose

Table 2 summarizes the obtained results of track density on detectors, radon concentrations, PAEC, EP, AED, and lung cancer CPPP of various tobacco hookah. The highest track density and concentration of radon was found in the N1 tobacco narghile smoking, which was (32.06±4.2)×10^2 track/cm^2 and 214.61±18.1Bq/m^3). On the other hand, the lowest track density and concentration of radon was found in the N7 tobacco narghile smoking, which was 4.10±1.8 track/cm^2 and 27.44±4.4 with the mean value of (9.61±2.58)×10^2 track/cm^2 and 65.60±41.04 Bq/m^3, respectively. This value was less than even the lower limit of the recommended range (200-300 Bq/m^3)(ICPR,2009)[43].

The highest concentration of PAEC was found in N1 (23.2±3.3mWL), while the lowest alpha-potential energy concentration in N7 (2.9±0.9 mWL), with mean value of 6.3±3.8 mWL, This results were less than the recommended (53.33 mWL) reported (UNSCEAR, 1993) [44].

The highest exposure value for EP was found in area N1, which was equal to 0.95±0.03$WLMY^{-1}$, while the lowest EP value was found in area N7 (0.12±0.01$WLMY^{-1}$) with the mean value of 0.28±0.18$WLMY^{-1}$. All EP results in air internal closed can technique were below the recommended minimum range (1-2 $WLMY^{-1}$) (NCRP, 1989) [27].

Moreover, as can be observed in Table 2, the AED received by the study population varies from 0.69±0.09 mSv/y (N7) to 5.41±2.20 mSv/y (N1) with the mean value of 1.64±1.03mSv/y. In all tobacco narghile smoking investigated in the current study, the annual effective internal dose was less than the minimum range modified (3-10$mSv/$) (ICRP, 1993) [45].

The risk of lung cancer at specific in tobacco narghile smoking ranged from 12.46±2.11 (N7) to 97.45±7.34 (N1) with a total value of 29.77±18.63 per million people. These values are lower than the recommended minimum range per million people (170-230) (ICRP, 1993) [45].

Effective radium content and radon exhalation rates

Table 3 summarizes the obtained results of effective radium content and radon exhalation rates for 30 different tobacco narghile smoking in the Iraqi market. The values of the effective radium content were found to vary from 0.054 Bq/kg to 0.425 Bq/kg with a mean value of 0.131 Bq/kg. The radon exhalation rate of both mass and surface in different narghile tobacco smoking sample varies from 0.410 to 3.212 mBq/kg.h, with the mean value of 0.996 mBq/kg.h and 9.040 to 70.703 mBq/m^2.h, with the mean value of 21.943 mBq/m^2.h, respectively.

Table 2. The tabulation of Radon gas concentration(C), potential alpha energy concentrations(PAEC), exposure to radon progeny(EP), annual effective dose(AED), and lung cancer cases per year per million(CPPP).

No.	Code	$\rho\times10^2$ Trac/cm^2	C Bq/m^3	PAEC mWL	EP WLM Y^{-1}	AED m Sv/y	CPPP$\times10^{-6}$
1	N1	32.06±4.2	214.61±18.1	23.2±3.3	0.95±0.03	5.41±2.20	97.45±7.34
2	N2	6.13±1.6	41.04±6.7	4.4±0.8	0.18±0.01	1.03±0.51	18.63±3.65
3	N3	10.73±2.3	71.83±8.2	7.7±1.2	0.32±0.01	1.81±0.62	32.16±5.23
4	N4	7.73±2.1	51.75±5.7	5.6±1.1	0.23±0.01	1.30±0.65	23.50±4.21
5	N5	13.43±3.4	89.90±9.3	9.7±1.7	0.40±0.02	2.26±1.10	40.82±5.68
6	N6	8.73±2.6	58.45±6.1	6.1±1.3	0.26±0.01	1.47±0.59	26.54±4.77
7	N7	4.10±1.8	27.44±4.4	2.9±0.9	0.12±0.01	0.69±0.09	12.46±2.11
8	N8	7.63±1.9	51.08±6.2	5.5±1.1	0.22±0.02	1.28±0.43	23.19±3.17
9	N9	6.74±1.7	45.11±6.3	4.8±0.7	0.20±0.01	1.13±0.54	20.48±1.18
10	N10	7.00±1.3	46.85±5.4	5.0±0.6	0.20±0.01	1.18±0.55	21.27±2.33
11	N11	7.16±1.6	47.96±5.1	5.1±0.8	0.21±0.01	1.20±0.57	21.77±3.15
12	N12	8.30±2.2	55.55±4.6	6.0±1.1	0.24±0.01	1.40±0.71	25.22±2.99
13	N13	6.36±2.3	42.60±4.1	4.60±1.2	0.18±0.00	1.07±0.41	19.34±1.89
14	N14	13.06±4.6	87.45±9.6	9.4±2.3	0.38±0.02	2.20±1.21	39.71±5.67
15	N15	4.46±1.7	29.89±5.5	3.2±0.7	0.13±0.01	0.75±0.33	13.57±2.69
16	N16	9.90±3.1	66.26±7.7	7.1±1.6	0.29±0.01	1.67±0.63	30.08±3.88
17	N17	13.73±3.2	91.91±8.9	9.9±1.5	0.40±0.02	2.31±1.02	41.73±3.98
18	N18	7.56±2.1	50.63±7.1	5.4±1.2	0.22±0.01	1.27±0.88	22.99±2.66
19	N19	23.13±4.5	154.82±14.8	6.7±1.9	0.68±0.03	3.90±1.02	70.30±7.67
20	N20	6.60±1.2	44.17±6.6	4.7±0.7	0.19±0.01	1.11±0.45	20.05±1.89
21	N21	5.20±1.3	4.80±1.9	0.5±0.02	0.02±0.00	0.12±0.01	2.17±1.55
22	N22	4.90±0. 9	32.79±5.1	3.5±0.6	0.14±0.01	0.82±0.03	14.89±1.23
23	N23	11.96±3.3	80.08±10.2	8.6±2.2	0.35±0.02	2.02±0.98	36.36±3.78
24	N24	10.20±2.5	68.26±4.9	7.3±2.0	0.30±0.01	1.72±0.65	30.99±3.46
25	N25	10.86±3.1	72.72±6.1	7.8±2.1	0.32±0.02	1.83±0.67	33.02±3.24
26	N26	9.36±2.2	129.61±12.6	4.0±1.2	0.57±0.03	3.26±1.11	58.85±6.34
27	N27	10.46±3.3	70.04±7.3	7.5±2.3	0.31±0.01	1.67±0.44	31.80±4.22
28	N28	9.26±2.6	62.01±7.1	6.7±1.2	0.27±0.01	1.56±0.32	28.15±2.12
29	N29	4.56±1.1	30.56±3.3	3.3±0.7	0.13±0.01	0.77±0.15	13.87±1.64
30	N30	7.16±2.4	47.96±4.9	5.1±1.9	0.21±0.01	1.20±0.63	21.77±3.13
Mean		9.61±2.58	65.60±41.04	6.3±3.8	0.28±0.18	1.64±1.03	29.77±18.63
Maximum		32.06±4.2	214.61±18.1	23.2±3.3	0.95±0.03	5.41±2.20	97.45±7.34
Minimum		4.10±1.8	27.44±4.4	2.9±0.9	0.12±0.01	0.69±0.09	12.46±2.11

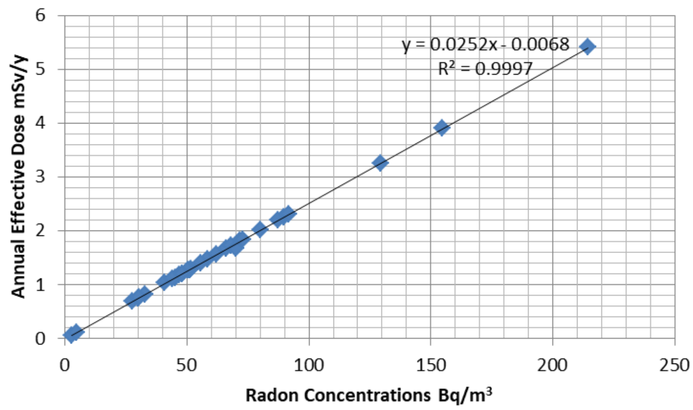

Figure 3. Relationship between annual effective dose and radon concentration.

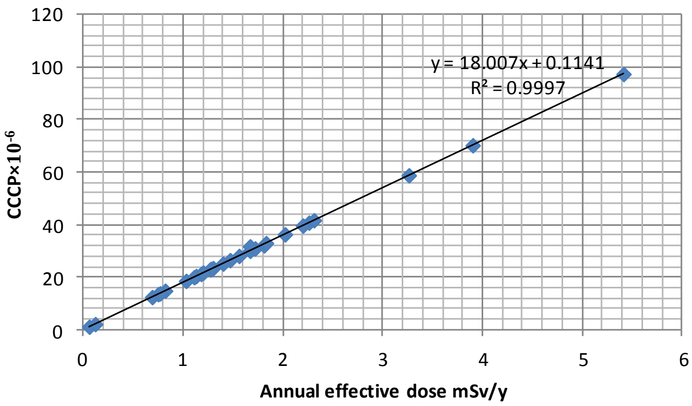

Figure 4. Relationship between lung cancer cases obtained per year per million people and annual effective dose.

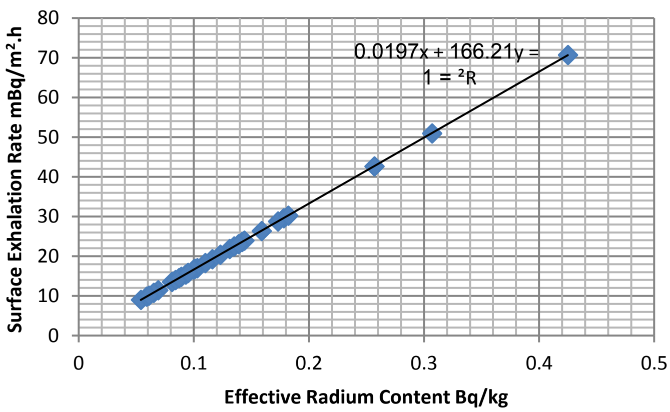

Figure 5. Relationship between surface exhalation rate and effective radium content.

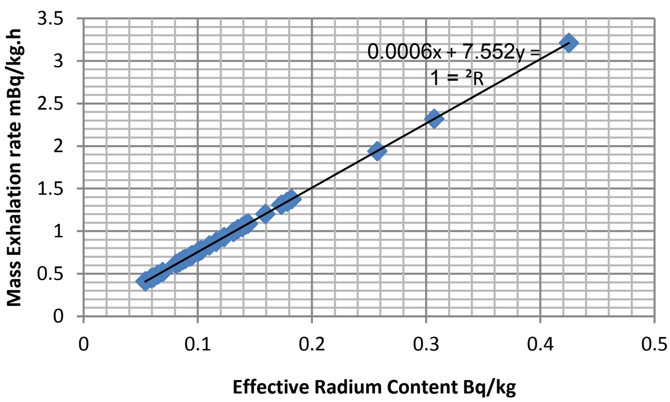

Figure 6. Relationship between mass exhalation rate and effective radium content.

Table 3. Effective radium content and radon exhalation rates for 30 different tobacco narghile smoking.

No.	Code sample	C_{Ra} Bq/kg	E_M $mBqkg^{-1}h^{-1}$	E_A $mBqm^{-2}h^{-1}$
1	N1	0.425	3.212	70.703
2	N2	0.081	0.614	13.52
3	N3	0.142	1.075	23.665
4	N4	0.103	0.774	17.050
5	N5	0.178	1.345	29.618
6	N6	0.116	0.874	19.255
7	N7	0.054	0.410	9.040
8	N8	0.101	0.764	16.830
9	N9	0.089	0.675	14.863
10	N10	0.093	0.701	15.434
11	N11	0.095	0.717	15.800
12	N12	0.110	0.831	18.300
13	N13	0.084	0.637	14.036
14	N14	0.173	1.309	28.809
15	N15	0.059	0.447	9.847
16	N16	0.131	0.991	21.828
17	N17	0.182	1.375	30.280
18	N18	0.100	0.758	16.682
19	N19	0.307	2.317	51.006
20	N20	0.087	0.661	14.552
21	N21	0.069	0.521	11.466
22	N22	0.065	0.491	10.804
23	N23	0.159	1.199	26.384
24	N24	0.135	1.022	22.490
25	N25	0.144	1.089	23.959
26	N26	0.257	1.940	42.701
27	N27	0.139	1.049	23.077
28	N28	0.123	0.928	20.431
29	N29	0.061	0.457	10.068
30	N30	0.095	0.718	15.801
Mean		0.131	0.996	21.943
Maximum		0.425	3.212	70.703
Minimum		0.054	0.410	9.040

Discussion

All the obtained values for the radon concentrations in the current study were less than those of previous studies which included different types of tobacco cigarettes available in Iraqi markets [46, 47]. Figure 3 shows the strong positive linear correlation between radon concentrations and the effective annual dose of 30 samples of narghile tobacco smoke(R^2=0.9997). The increased concentration of radon increases the annual dose of smokers and thus increases the health risks of these people, which leads to an increased risk of lung cancer. Figure 4 shows the strong correlation between the effective annual dose and the number of people who are likely to have lung cancer (R^2=0.9997). The increase in the annual dose of radon increases the risk of lung cancer.

Furthermore, effective radium content and radon exhalation rates were higher than the results of two previous studies of a researcher in Saudi Arabia, including cigarette tobacco and tobacco used in Narghile smoking [48,49]. However, the obtained values in the current study were less than those of a study conducted in India [50]. The difference was due to the different geological nature of the soil of India than Iraq and other producing countries of tobacco, as well as chemical fertilizers used in agriculture. Figures 5 and 6 show the strong positive correlation between radium efficiency and radon emission rate for both the area and mass units (R^2=1), respectively. In other words, increasing radium efficiency increases the radon emission rate for the samples used in the study.

Despite many risks of smoking on human life and health, the obtained results of the current study revealed that the radioactivity of the studies samples was within the limits allowed internationally and was not a danger to human health in terms of radioactivity of radon and radium.

Conclusion

Many researchers around the world are interested in studying the natural and industrial radiation activity and its health effects on the life of living organisms, especially humans, and the possibility of being infected with many serious diseases, especially cancer [51-54].

Many health risks to human health can result from narghile smoking, including lung cancer. In comparison to smoking cigarettes, there is a limited number of studies on smoking narghile. The objective of this study was to shed more light on the concentrations of radon and radium in the tobacco used for shisha smoking. The results of this study indicated a wide range of variations in the contents of ^{222}Rn in moassel tobacco which could be due to non-standard manufacturing procedures and/or variation in tobacco-producing species. The highest concentrations of ^{222}Rn, ^{226}Ra content, surface, and mass exhalation rate were observed in N1 sample, while the lowest concentrations of the same nucleus in sample N7.

The reason for this variation is mainly due to soil and fertilizer, which is the source of radioisotopes. The use of soil chemical fertilizers to increase yields of crops will enhance and improve the concentration of radioactivity of radon, radium concentration, and radon exhalation rates. Therefore, maximum efforts should be made at the national and international levels to reduce the activity of Ra-226 in fertilizers used in agriculture. For instance, extracting uranium from phosphoric acid in solvent extraction can lead to more environmentally friendly fertilizers. The analysis of the results indicated that tobacco does not currently pose a danger to the health and life of people in terms of radiation, which is within the international limits.

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