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Research Article

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Determination of Radon and Thoron Concentrations in Different Kinds of Tobacco Samples Used in Palestine and Jordan

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Abstract samples used in Palestine and Jordan and then calculates the doses resulting from those samples for smoker peoples. To investigate whether the tobacco itself is a potential source of radon, the concentrations were measured in 49 different local tobacco, cigarettes and narghile tobacco samples using CR-39 solid-state nuclear track detectors (SSNTDs). The results showed that the total concentrations of radon and thoron in local tobacco and cigarettes used in Palestine ranged from 32.8 to 154.6 Bqm^{-3}, with an a total average value of 89.5 Bqm^{-3}, and from 56.9 to 150.9 Bqm^{-3}, with an a total average value of 100.0 Bqm^{-3}, respectively. The total concentrations of radon and thoron in cigarettes and narghile tobacco used in Jordan ranged from 53.6 to 200.1 Bqm^{-3}, with a total average value of 108.0 Bqm^{-3}, and from 38.3 to 194.7 Bqm^{-3}, with a total average value of 89.0 Bqm^{-3}, respectively. The annual effective dose and the lung cancer cases per year per million person were calculated for all samples. The results showed that the radon concentrations and the resulting doses emerged from several investigated samples were higher than the safe limits recommended by the World Health Organization in some aspects. Therefore, health risk due to radon is possible.

Keywords Radon, tobacco, health effects, risk of cancer, Palestine, Jordan

Introduction

Radon is a radioactive gas released from the normal decay of the elements uranium, thorium, and radium in rocks and soil. It is an invisible, odorless, and tasteless gas. When radon atoms spontaneously decay into other radioactive atoms (called radon progeny), they release potentially harmful radioactive particles in the process. When uranium decays in soil and rock, the resulting radon can seep up through the ground and diffuse into the air or dissolve into groundwater. The dissolved or free gas may also enter homes- basements in particular- through cracks and holes or simply by diffusing through most construction material [1].

Radon decays quickly, giving off tiny radioactive particles. When inhaled, these radioactive particles can damage the cells that line the lung. Long-term exposure to radon can lead to lung cancer, the only cancer proven to be associated with inhaling radon. There has been a suggestion of increased risk of leukemia associated with radon exposure in adults and children; however, the evidence is not conclusive.

Lung cancer is the leading cause of cancer - related deaths worldwide. Exposure to radon is the second leading cause of lung cancer, and the risk is significantly higher for smokers than for non-smokers. More than 85% of radon-induced lung cancer deaths are among smokers. The strong synergism between radon exposure and smoking as risk factors is a critical aspect of the relationship between radon and lung cancer. That is, the absolute magnitude of the lung cancer risk associated with radon exposure is significantly higher for ever-smokers than for never-smokers [2]. The available data suggest a strong interaction effect between radon exposure and smoking status in the determination of lung cancer risk, which means that smokers are at a much higher risk of dying from radon-induced lung cancer than are non-smokers [3].

Tobacco smoking is a risk factor for six out of eight main death causes all over the world; with lung cancer being one of the six causes, tobacco represents the most important one. Each year 1.35 million new cases are diagnosed, which represents more than 12% of all the new cancer cases [4]. It is estimated that more than 220,000 new cases of lung cancer were diagnosed and approximately 155,000 people died from this disease in the US in 2010. The Environmental Protection Agency (EPA) estimates that radon in the home is responsible for over 21000 lung cancer deaths annually among Americans, making radon the major cause of lung cancer after tobacco use [2,5,6].

When inhaled radon, the elements resulting from its decay give off alpha-radiation, which can severely damage the lungs and if the DNA is injured, this might lead to cancer. It is also possible that the heavy metal radon daughters (such as lead) can contribute to the overall increase in lung cancer risk through chemical impact. For its risk assessment, the EPA employed the prominent model that the Committee on Biological Effects of Ionizing Radiation (BEIR) VI of the National Academy of Sciences proposed [7]. The BEIR VI model purports a significant synergism between radon exposure and smoking in lung cancer risk. On the basis of BEIR VI, the EPA estimates that, at a radon level of 148 Bqm^{-3}, the lifetime risk of radon induced lung cancer death for never-smokers is 7 per 1000, compared with 62 per 1000 for ever-smokers [8].

Lung cancer risk is greater at higher levels of radon exposure. For example, with a lifetime exposure of 370 Bqm^{-3}, the risk of radon-induced lung cancer is 18 per 1000 for never-smokers and 150 per 1000 for ever-smokers. Several community case-control studies confirm the BEIR VI model results [9].The literature demonstrates clearly that the public health problem of radon is, for the most part, a problem of radon and smoking. Because cigarette smoking greatly increases the risk of radon-induced lung cancer, the majority of radon-related deaths are among smokers [2,7].

Tobacco smoke contains more than 4000 different chemicals, most of which are generated during the combustion process. More than 40 compounds are carcinogenic, which include some radionuclides such as polonium (^{210}Po) and lead (^{210}Pb). Radioactivity in cigarette smoke was measured by several authors, and it was suggested that ionizing radiation from cigarette smoke could originate a meaningful exposure of lung tissues. Smokers are 10 times at greater risk of developing lung cancer than that of non-smokers [10-12].

Narghile, one of the names for water pipe, that is used to smoke specially made tobacco that is usually flavoured, it has become a trend among the youth in the world. Many narghile smokers believe that smoking of it carries less risk of tobacco- related disease than cigarette smoking which wrong. Narghile smoking has become fashionable worldwide. Its tobacco pastes generally contain 30–70% tobacco.

The aims of the present study are to determine radon and thoron concentration in different kinds of local tobacco, cigarettes, and narghile tobacco samples used in Palestine and Jordan and then calculate annual effective dose (*AED*), and lung cancer cases per year per million person (*LCC*).

Materials and Methods

Forty nine samples for different types of local and imported cigarette and narghile tobacco were collected from the Palestinian and Jordanian markets, which the cigarettes were isolated from their papers and filters, each weighted about (10 g) tobacco. These tobaccos put in the bottom of a plastic cup equipped with a solid state nuclear track detector SSNTDs. The CR-39 detectors have been used in this work were supplied by Pershore Mouldings, UK, in the form of large sheets that were cut into 1cm × 1cm.A fixed amount of tobacco sample was placed in the bottom of plastic cups. The cup was 7 cm in height and 5.2 cm in diameter. A piece of CR-39 detector was embedded in the sample in each cup, at the same time a second piece of CR-39 detector was held at the top of the cup(See Figure 1). The lower detector recorded alpha particles from radon, thoron and their daughter products present in the cigarette samples. The upper detector, however records only the ^{222}Rn component [13].

The cups were left at room temperature for 75 day exposure time. During this time alpha particles from the decay of radon, thoron, and their daughters bombarded the CR-39 nuclear track detectors in the air volume of the cup. After exposures time, the CR-39 detectors were collected and chemically etched in a 6.25 NaOH solution using a water bath at 70 °C for 6hours. The etched films were washed with distilled water and after that got dried [14]. Alpha-particle track measurements per cm^2 produced by the decay of ^{222}Rn, ^{220}Rn and their daughters were conducted using an optical microscope of 160 × magnification power. The track density was converted into radon concentration in Bqm^{-3} using the calibration factor.

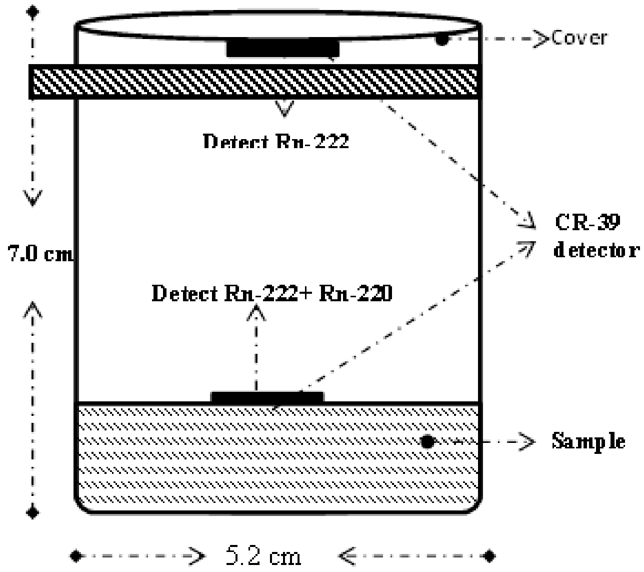

Figure 1: A schematic diagram of the sealed-cup technique

Theoretical Calculations

The Activity Concentration of Radon

The concentration of ^{222}Rn in the tobacco samples (C_{Rn}) will be calculated in (Bqm^{-3}) unit from the following relation [15, 16]:

$$C_{Rn}\,(Bq/m^3) = \frac{\rho}{k\,\eta\,t} = c_0\,(\frac{\rho}{t}) \qquad (1)$$

Where ρ is the track density recorded on the detector, k is attenuation factor of ^{222}Rn, η is the calibration coefficient of measuring system in terms of $cm^2\ d^{-1}\ Bqm^{-3}$, and t is the exposure time.

The Annual Effective Dose

According to the UNSCEAR (2000) report, the annual effective dose (*AED*) in terms of ($mSvy^{-1}$) to the smokers due to ^{222}Rn and its progeny is estimated using the following equation [12,17]:

$$AED(mSvy^{-1}) = C_{Rn} \times \mathrm{F_R} \times \mathrm{H} \times \mathrm{T} \times \mathrm{D} \qquad (2)$$

Where F_R is the equilibrium factor between radon and its progeny and it is equal to (0.4) as suggested by UNSCEAR report [17], H is the occupancy factor (0.8), T is hours in a year (8760 $hy^{-1)}$ and D is the dose conversion factor (9.0×10^{-6} mSv/ Bqm^{-3}. h), which is the effective dose received by adults per unit ^{222}Rn activity per unit of air volume [17].

The Lung Cancer Cases

Radon decays quickly, giving off tiny radioactive particles. When inhaled, these radioactive particles can damage the cells that line the lung. Long-term exposure to radon can lead to lung cancer, the only cancer proven to be associated with inhaling radon. The lung cancer cases per year per million person (LCC) is estimated by using the risk factor lung cancer induction $18\times10^{-6}\ mSv^{-1}$, and obtained using the relation [18,19].

$$LCC = AED\ \ (mSvy^{-1}) \times 18 \times 10^{-6}\,(\mathrm{mSv})^{-1} \qquad (3)$$

Results and Discussions

The Activity Concentration of Radon

A total of 49 different cigarette and tobacco samples were taken from Palestine and Jordan, to measure the Radon (^{222}Rn and ^{220}Rn) concentrations. Ten local tobacco samples (coded T_{P1}–T_{P10}) and fourteen of different cigarette samples (coded C_{P1}–C_{P14}) which are used by smokers in Palestine; and seventeen of different cigarette samples (coded C_{J1}–C_{J17}) and eight of different narghile tobacco samples (coded N_{J1}–N_{J8}) which are used by smokers in Jordan.

Radon and thoron concentration in all local tobacco, cigarette and narghile tobacco samples have been recorded in the tables 1 - 4. The results showed that the concentrations in local tobacco and cigarettes used in Palestine ranged from 26.3 Bqm^{-3} (T_{P5} sample, Shami medium) to 122.7 Bqm^{-3} (T_{P8} sample, Mashareeb/ Hot), with an average value of 75.9 Bqm^{-3}; and from 40.6 Bqm^{-3} (C_{P6} sample, LM/ red) to 125.8 Bqm^{-3} (C_{P14} sample, LM/white), with an average value of 82.0 Bqm^{-3} respectively, for ^{222}Rn; and ranged from 1.2 Bqm^{-3} (T_{P9} sample, Brazilian) to 31.9 Bqm^{-3} (T_{P8} sample, Mashareeb/ Hot), with an average value of 13.6 Bqm^{-3}; and from 4.3 Bqm^{-3} (C_{P10} sample, Marlboro) to 28.9 Bqm^{-3} (C_{P13} sample, More/green), with an average value of 18.0 Bqm^{-3} respectively, for ^{220}Rn. The total concentrations of radon and thoron in local tobacco and cigarettes ranged from 32.8 to 154.6 Bqm^{-3}, with an a total average value of 89.5 Bqm^{-3}, and from 56.9 to 150.9 Bqm^{-3}, with an a total average value of 100.0 Bqm^{-3}, respectively.

The concentrations in cigarettes and narghile tobacco used in Jordan ranged from 43.8 Bqm^{-3}(C_{J3} sample, Karena/red (strawberry)) to 194.7 Bqm^{-3} (C_{J5} sample, Rothmans/white), with an average value of 89.4 Bqm^{-3};and from 35.0 Bqm^{-3} (N_{J8} sample, Unknown /yellow), to 164.7 Bqm^{-3} (N_{J5} sample, Alfakher (mint)), with an average value of 75.4 Bqm^{-3} respectively, for ^{222}Rn; and ranged from 4.4 Bqm^{-3} (C_{J9} sample, Kent/blue) to 31.7 Bqm^{-3}(C_{J2} sample, Marlboro/white), with an average value of 18.6 Bqm^{-3};and from 3.3Bqm^{-3}(N_{J6} sample, Mazaya (lemon)), to 30.0 Bqm^{-3}(N_{J5} sample, Alfakher (mint)), with an average value of 13.6 Bqm^{-3} respectively, for ^{220}Rn.

The total concentrations of radon and thoron incigarettes and narghile tobacco ranged from 53.6 to 200.1 Bqm^{-3}, with an a total average value of 108.0 Bqm^{-3}, and from 38.3 to 194.7 Bqm^{-3}, with an a total average value of 89.0 Bqm^{-3}, respectively.

Table 1 : The Radon concentrations, C_{Rn}; the annual effective dose, *AED;* andthe lung cancer cases ,*LCC*; for different local tobacco samples used in Palestine

Code	Type	**The radon concentrations (Bqm^{-3})**			***AED* ($mSvy^{-1}$)**			***LCC* ($\times10^{-6}$)**		
		C_{Rn-222}	C_{Rn-220}	*Total*	*Rn-222*	*Rn-220*	*Total*	*Rn-222*	*Rn-220*	*Total*
T_{P1}	Hishi	53.6	9.8	63.4	1.35	0.25	1.60	24.3	4.5	28.8
T_{P2}	Mixed Shami medium	101.7	8.8	110.5	2.56	0.22	2.78	46.1	4.0	50.1
T_{P3}	Golf/ Israelian	107.2	26.1	133.3	2.70	0.66	3.36	48.6	11.9	60.5
T_{P4}	Hawa	68.5	20.1	88.6	1.73	0.51	2.24	31.1	9.2	40.3
T_{P5}	Shami medium	26.3	6.5	32.8	0.66	0.16	0.82	11.9	2.9	14.8
T_{P6}	Shami Mashareeb	110.5	6.5	117.0	2.78	0.16	2.94	50.0	2.9	52.9
T_{P7}	Yaabadrubbed	56.9	16.4	73.3	1.43	0.41	1.84	25.7	7.4	33.1
T_{P8}	Mashareeb/ Hot	122.7	31.9	154.6	3.09	0.80	3.89	55.6	14.4	70.0
T_{P9}	Brazilian	60.5	1.2	61.7	1.52	0.03	1.55	27.4	0.5	27.9
T_{P10}	Qashet light water	51.4	8.8	60.2	1.30	0.22	1.52	23.4	4.0	27.4
	Average	**75.9**	**13.6**	**89.5**	**1.91**	**0.34**	**2.25**	**34.4**	**6.2**	**40.6**

Table 2: The Radon concentrations, C_{Rn}; the annual effective dose, *AED;* andthe lung cancer cases, *LCC*; for different cigarette samples used in Palestine

Code	Type	**The radon concentrations (Bqm^{-3})**			***AED* ($mSvy^{-1}$)**			***LCC* ($\times10^{-6}$)**		
		C_{Rn-222}	C_{Rn-220}	*Total*	*Rn-222*	*Rn-220*	*Total*	*Rn-222*	*Rn-220*	*Total*
C_{P1}	King	45.9	16.4	62.3	1.16	0.41	1.57	20.9	7.4	28.3
C_{P2}	LM Hilal/ red	98.0	25.4	123.4	2.47	0.64	3.11	44.5	11.5	56.0
C_{P3}	West	99.5	17.5	117.0	2.51	0.44	2.95	45.2	7.9	53.1
C_{P4}	Gem	96.4	23.9	120.3	2.43	0.60	3.03	43.7	10.8	54.5

C_{P5}	Dunhill/red	58.5	25.7	84.2	1.47	0.65	2.12	26.5	11.7	38.2
C_{P6}	LM/ red	40.6	18.5	59.1	1.02	0.47	1.49	18.4	8.5	26.9
C_{P7}	Dunhill/green	90.8	14.2	105.0	2.29	0.36	2.65	41.2	6.5	47.7
C_{P8}	Chocolate	43.8	13.1	56.9	1.10	0.33	1.43	19.8	5.9	25.7
C_{P9}	Manchester	84.2	18.6	102.8	2.12	0.47	2.59	38.2	8.5	46.7
C_{P10}	Marlboro	56.9	4.3	61.2	1.43	0.11	1.54	25.7	2.0	27.7
CP11	President /P king size	67.8	6.6	74.4	1.71	0.17	1.88	30.8	3.1	33.9
C_{P12}	Elegance green	122.7	28.2	150.9	3.09	0.71	3.80	55.6	12.8	68.4
C_{P13}	More/green	117.7	28.9	146.6	2.97	0.73	3.70	53.5	13.1	66.6
C_{P14}	LM/white	125.8	10.9	136.7	3.17	0.28	3.45	57.1	5.0	62.1
	Average	**82.0**	**18.0**	**100.0**	**2.07**	**0.46**	**2.53**	**37.3**	**8.2**	**45.5**

Table 3: The Radon concentrations, C_{Rn}; the annual effective dose, *AED;* and the lung cancer cases, *LCC*; for different cigarette samples used in Jordan.

Code	**Type**	**The radon concentrations (Bqm^{-3})**			***AED* (mSvy^{-1})**			***LCC* (×10^{-6})**		
		C_{Rn-222}	C_{Rn-220}	*Total*	*Rn-222*	*Rn-220*	*Total*	*Rn-222*	*Rn-220*	*Total*
C_{J1}	Kingdom/black	51.4	8.8	59.2	1.30	0.22	1.52	23.4	4.0	27.4
C_{J2}	Marlboro/white	100.6	31.7	132.3	2.54	0.80	3.34	45.7	14.4	60.1
C_{J3}	Karena/red (strawberry	43.8	25.1	68.9	1.10	0.63	1.73	19.8	11.3	31.2
C_{J4}	Karena (Menthol)	108.1	28.6	136.7	2.72	0.72	3.44	49.0	13.0	62.0
C_{J5}	Rothmans/white	194.7	5.4	200.1	4.91	0.14	5.05	88.4	2.5	90.9
C_{J6}	Savanna (peach)	84.7	24.7	109.4	2.13	0.62	2.75	38.3	11.2	49.5
C_{J7}	Karenna (cherry)	89.7	23.0	112.7	2.26	0.58	2.84	40.7	10.4	51.1
C_{J8}	Romens/ white	121.4	9.8	131.2	3.06	0.25	3.31	55.1	4.5	59.6
C_{J9}	Kent/blue	49.2	4.4	53.6	1.24	0.11	1.35	22.3	2.0	24.3
C_{J10}	Winston/blue	120.4	27.2	147.6	3.03	0.69	3.72	54.5	12.4	66.9
C_{J11}	Real/red	48.1	20.8	68.9	1.21	0.52	1.73	21.8	9.4	31.2
C_{J12}	Mind (light)	148.7	11.1	159.8	3.75	0.28	4.03	67.5	5.0	72.5
C_{J13}	Gauloises/red	87.7	16.2	103.9	2.21	0.41	2.62	39.8	7.4	47.2
C_{J14}	Target	59.4	15.0	74.4	1.50	0.38	1.88	27.0	6.8	33.8
C_{J15}	Savanna (strawberry)	45.9	12.1	58.0	1.16	0.31	1.47	20.9	5.6	26.5
C_{J16}	Kingdom (Menthol)	64.5	24.1	88.6	1.63	0.61	2.24	29.3	11.0	40.3
C_{J17}	Kingdom/gold	99.4	27.5	126.9	2.50	0.48	2.98	45.0	8.6	53.6
	Average	**89.4**	**18.6**	**108.0**	**2.25**	**0.46**	**2.71**	**40.5**	**8.3**	**48.8**

Table 4: The Radon concentrations, C_{Rn}; the annual effective dose, *AED;* and the lung cancer cases, *LCC*; for different tobacco samples used in narghile / Jordan

Code	**Type**	**The radon concentrations (Bqm^{-3})**			***AED* (mSvy^{-1})**			***LCC* (×10^{-6})**		
		C_{Rn-222}	C_{Rn-220}	*Total*	*Rn-222*	*Rn-220*	*Total*	*Rn-222*	*Rn-220*	*Total*
N_{J1}	AL sultan (Honey)	89.7	18.6	108.5	2.26	0.47	2.73	40.7	8.5	49.2
N_{J2}	Mazaya (gam with mint)	58.0	16.4	74.4	1.46	0.41	1.87	26.3	7.4	33.7

N_{J3}	AL sultan/orange	34.8	18.6	53.4	0.87	0.47	1.34	15.7	8.5	24.2
N_{J4}	Alwaha/orange	103.9	12.0	115.9	2.62	0.30	2.92	47.2	5.4	52.6
N_{J5}	Alfakher (mint)	164.7	30.0	194.7	4.15	0.76	4.91	74.7	13.7	88.4
N_{J6}	Mazaya (lemon)	78.7	3.3	82.0	1.98	0.83	2.81	35.6	14.9	50.5
N_{J7}	Unknown/red	38.3	6.5	44.8	0.97	0.16	1.13	17.5	2.9	20.4
N_{J8}	Unknown /yellow	35.0	3.3	38.3	0.88	0.83	1.71	15.8	14.9	30.7
	Average	**75.4**	**13.6**	**89.0**	**1.90**	**0.53**	**2.43**	**34.2**	**9.5**	**43.7**

Figures 2 and 3, shows the concentration of ^{222}Rn and ^{220}Rn in the different tobacco samples

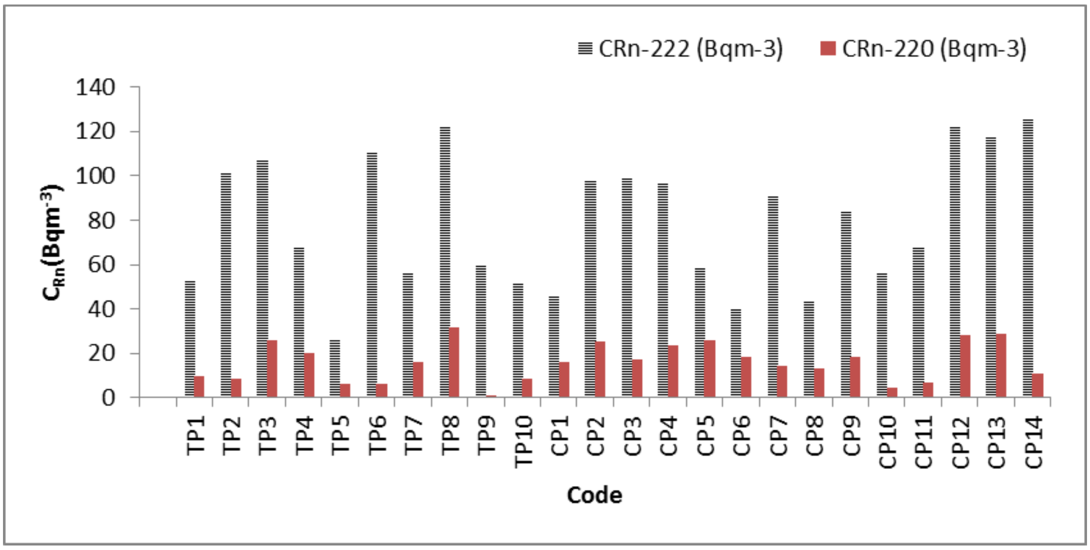

Figure 2: Radon and thoron concentrations in different local tobacco and cigarettes samples used in Palestine

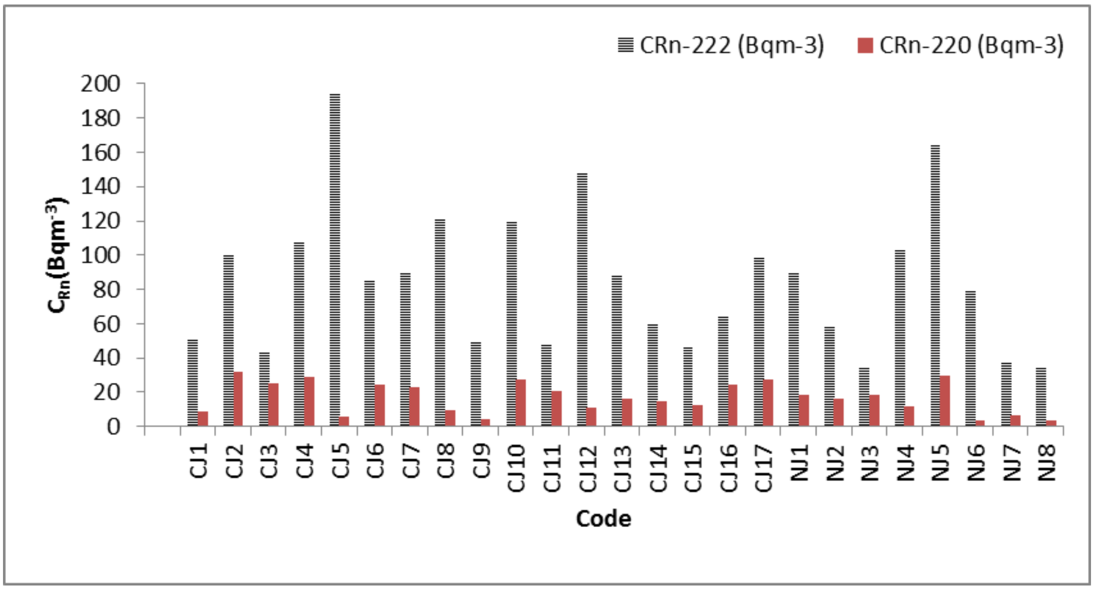

Figure 3: Radon and thoron concentrations in different cigarettes and tobacco samples used in 3 narghile / Jordan

The results shown that the total concentrations of 51% in studying samples are above threshold average of radon concentration (100 Bqm^{-3}) [20], therefore, health risk due to radon is possible. Darby *et al*., [21], provided compelling evidences that indoor ^{222}Rn is an important contributor to the risk of lung cancer. However, the derived estimates of ^{222}Rn-attributable lung cancers may have a low bias. The authors estimated an increase in the lung cancer risk of 16% for each incremental 100 Bqm^{-3} of ^{222}Rn from a pooling of the European residential case-control studies. Although a huge amount of data is available about the biological effect of tobacco smoking [4], here we have investigated the possible involvement of ^{222}Rn derived from tobacco as a risk factor for lung cancer.

The Annual Effective Dose

By using equation (2) and Tables (1-4), the results of total annual effective dose received from ^{222}Rn and ^{220}Rn are as follows: from 0.82 to 3.89 mSv y^{-1} with an average value of 2.25 mSv y^{-1} in local tobacco samples/ Palestine; from 1.43 to 3.80 mSv y^{-1} with an average value of 2.53 mSv y^{-1} in cigarette samples/ Palestine; from 1.35 to 5.05 mSv y^{-1} with an average value of 2.71 mSv y^{-1} in cigarette samples/ Jordan; and from 1.13 to 4.91 mSv y^{-1} with an average value of 2.43 mSv y^{-1} in tobacco samples used in narghile/ Jordan.

The radiation dose received from of ^{222}Rn, ^{220}Rn, and their daughters have been presented in Figures 4 and 5.

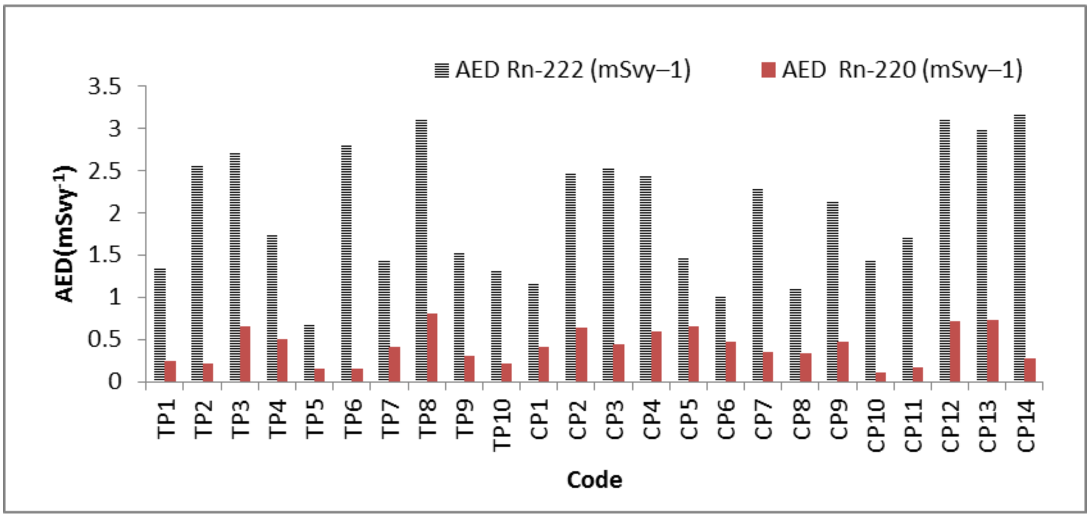

Figure 4: Resulting dose due to radon and thorone in local tobacco and cigarette samples used in Palestine

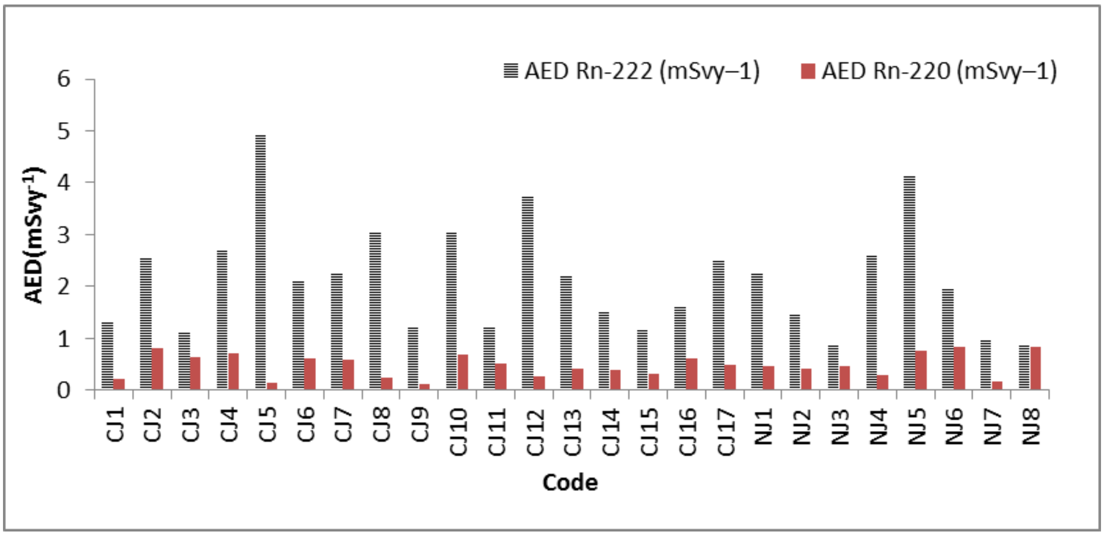

Figure 5: Resulting dose due to radon and thoron in cigarette samples and tobacco samples 3 used in narghile / Jordan

In its recent reports of ICRP (1994) and WHO (2015) [20,22], it has recommended that the action levels of radon should be set around of 1.3 and 2.5 mSv y^{-1}, respectively. On the basis of these recommendations, it has been observed that many samples for annual effective dose show higher values than the action levels. Therefore, it is possible that there will be a health risk to the people, which inhalation of radon resulting from smoking.

The Lung Cancer Cases

According to this study, the radon induces lung cancer risks, we found that the total *LCC* resulted from ^{222}Rn and ^{220}Rn areas follows: from 14.8 to 70.0 per million person per year resulting from local tobacco samples/ Palestine; from 25.7 to 68.4 per million person per year resulting from cigarette samples/ Palestine; from 24.3 to 90.9 per million person per year resulting from cigarette samples/ Jordan and from 20.4 to 88.4 per million person per year resulting from tobacco samples used in narghile/ Jordan. The total average values of (*LLC*) in all studied tobacco types are: 40.6, 45.5, 48.8 and 43.7 per million persons per year, respectively.

Therefore, a public health priority should be essential to develop countermeasures for the banning of all forms of smoking wherever possible in public areas. Radon mitigation should accompany smoking cessation measures in lung cancer prevention efforts.

The values of Lung Cancer Cases (*LLC*) are less than the lower limit of the range (170-230) per million person recommended by the ICRP (1993) [23].

Conclusions

Tobacco smoking is fatal in many ways and has severe health, economic, and social consequences. The main aim of this study was to determine the radon concentration in the different kinds of tobacco samples used in Palestine and Jordan by using the closed can technique and solid state nuclear track detectors. The results of this study indicate that the total radon concentrations of 51% in studying samples are above the world average radon concentration as recommended by WHO reports (100 Bqm^{-3}).

To estimate the health effects of radon and its progeny, many of the radiological effects in the studied tobacco samples were calculated. The annual effective dose has been calculated to carry out the assessment of the variability of expected radon exposure of the people inhaled radon and its progeny. The lung cancer cases per year per million persons have been calculated where the values are less than the lower limit of the range (170-230) per million persons recommended by the ICRP (1993). The results of the present work provide an additional database on the effect of radon to the population.

Through the results of the study it can be argued that high radon concentration in many tobacco samples poses a risk to human health, leading to increased risk for lung cancer and thus may lead to increased deaths due to high doses of radon.

Finally, a public health priority should be essential to develop countermeasures for the banning of all forms of smoking wherever possible in public areas. Radon mitigation should accompany smoking cessation measures in lung cancer prevention efforts. And because the people fear everything that is radioactive, the proper authority should take immediate steps for the placement of a clear indication about the radioactivity content on cigarette packets.

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