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Determination of Radionuclides and Their Radiological Risks in Different Brands of Cooking Oil Samples

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ABSTRACT

The concentration of radon-222 in different brands of cooking oil samples was evaluated using a passive technique. Besides, the concentration of radium-226 and uranium-238 was calculated. Radiation hazard indices, including the annual ingestion dose and excess cancer risk caused by the ingestion of radon were determined for all oil samples. The results demonstrated that the activity concentrations of ^{222}Rn, ^{226}Ra, and ^{238}U in all cooking oil samples were lower than the recommended values. A positive correlation was observed between radon concentrations and radium concentrations as well as radium concentrations and uranium concentrations in cooking oil samples. The maximum value of the annual ingestion dose calculated from the concentration of ^{222}Rn is 131.417±6.933 nSv/y. The results of the present investigation show that all the oil samples under this study do not create any cancer risk from ingestion of radon or other natural radionuclides through used cooking oil at these exposure levels and are safe for public health.

1. INTRODUCTION

Radionuclides such as uranium, radium, and the associated daughters are found in soil, air, water, and plant. Inhalation and ingestion of these radionuclides, beyond the allowable level, are a risk to human health [1]. One of the most important daughters of these radionuclides is radon-222 with a half-life of 3.82 days. It is the product of immediate radioactive decay series of radium (Ra-226), in the decay series of uranium (U-238). Rn-222 becomes an airborne gas before decaying. When airborne gas is inhaled or ingested, an alpha particle is emitted during its decay. Emitted alpha particles deposit all of their energy locally within a small thickness of adjacent tissue. So, Rn outside the body is much less harmful than if it were inhaled or ingested [2]. Radionuclides, in general, may enter the plants through water or air. Therefore, plants that will become substantial food for people are considered a route for radionuclides to travel from the environment to people [3], [4]. It has also been shown that exposure to radon produces lung cancer, while radium accumulation leads to bone tumor, the hazards related to uranium exposure caused by biochemical toxicity, as a heavy metal, are about six times higher than its radioactivity especially on the kidneys. In Saudi Arabia, many brands of oil derived from different plants are being used in cooking food. Therefore, measurement of the concentration of these radionuclides in cooking oils is very important in order to evaluate the ingested dose and to prevent the exposure of consumers to radiation.

The aim of the present work is to determine the concentration of natural radionuclides (U-238, Ra-226, and Rn-222) in different cooking oils derived from different manufacturers in Saudi Arabia by passive (CR-39) technique. In addition, radiological parameters such as the annual ingestion dose and risk of excess cancer per million persons are estimated.

2. MATERIALS AND METHODS

2.1 Samples collection

Eleven samples of different types of cooking oil derived from plants such as Corn, Sunflower and Olive were collected from different markets in Saudi Arabia for radiological analysis. The types of cooking oil samples are listed in Table 1. It was designated according to sample name, sample code, sample type, sample manufacture date, sample expiry date and sample density (Density of oil samples were measured by R.D bottle with a capacity of fifty cubic centimeters at an average temperature of 25 °C.). These types of oils were selected because most people use them.

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Table (1): Name, code, type, expiry, manufacture date, expiry date and density for different brands of Corn, Sunflower and Olive oil samples

Name	Code	Type	Manufacture date	Expiry date	Density(g/cm^3)
Haley	CH	Corn	16/10/2019	15/10/2020	0.833±0.022
Afia	CA	Corn	11/2019	10/2021	0.850±0.008
Panda	CP	Corn	9/2019	8/2021	0.881±0.006
Noor	SN	Sunflower	2/9/2019	1/9/2020	0.912±0.001
Shams	SS	Sunflower	5/2019	4/2021	0.913±0.001
Lite Life	SL	Sunflower	15/12/2019	16/12/2020	0.914±0.001
Abu Zahra	SA	Sunflower	2/12/2019	1/12/2021	0.918±0.001
Nadec	ON	Olive (EVOO)	3/1/2019	2/7/2020	0.907± 0.001
Panda	OP	Olive (EVOO)	30/11/2019	30/5/2021	0.908± 0.001
Almarai	OA	Olive (EVOO)	19/11/2019	16/11/2021	0.906± 0.002
Alwazir	OW	Olive (Refined)	5/2/2019	5/8/2020	0.909± 0.001

2.2 Passive technique

Passive technique, CR-39 polymer detectors type TASTRAK (Track Analysis System, Ltd, UK)) of area 1 cm^2 were used for measuring alpha particles levels in this study. Each detector was pasted at the bottom of the cover per plastic flask at a distance 10 cm from the surface of the oil sample, and then sealed at room temperature for 90 days exposure time as shown in Fig.(1). One flask was left without oil sample to calculate the background alpha radiation. After 90 days CR-39 detectors were collected from each plastic flask and etched by NaOH solution of concentration 6.25 N for 7 hours at 70 ^oC with an accuracy of ±1 ^oC using water bath technique. Next, the detectors were removed from the etching solution and washed and dried. The numbers of alpha tracks were observed by using an optical microscope of magnification 400 X.

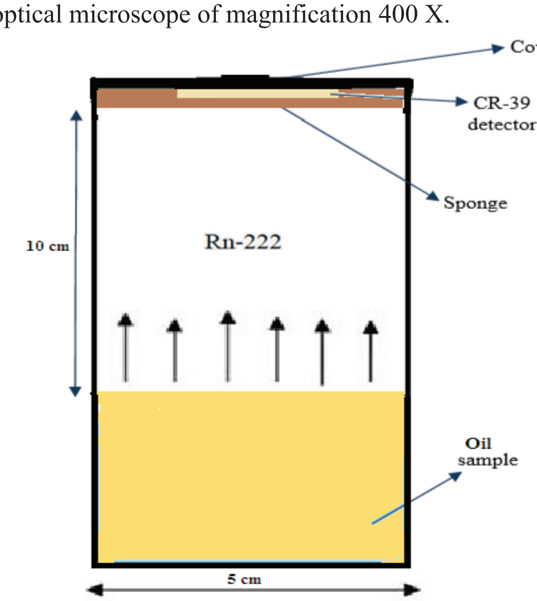

Fig. (1): Sealed-can technique of radon measurements

The radon concentration, C_{Rn} (Bq/m^3), in airspace of flask was calculated using the following equation [5],[6]:

$$C_{Rn} = \frac{\rho}{Fxt} \quad \textbf{(1)}$$

where ρ is the track density ($tracks.cm^{-2}$), t is the exposure time of distributed CR-39 detector in (days) and *F* is the calibration factor which calculated and equal to 0.18±0.002 ($tracks.cm^{-2}.d/Bqm^{-3}$) [5]. The effective radium content C_{Ra} (Bq/L) can be calculated from the relation [5], [7]:

$$C_{Ra} = \frac{\rho h A}{F T_e M} \quad \textbf{(2)}$$

where h is the distance between the detector and the surface of the oil sample (in m), A is the area of cross section of the flask (in m^2), M is the amount of the oil sample (in L) and T_e is the effective exposure time (in hour) which can be determined using the following equation:

$$T_e = t - \frac{(1-e^{-\lambda_{Rn} t})}{\lambda_{Rn}} \quad \textbf{(3)}$$

where *t* is the exposure time, and λ_{Rn} (in h^{-1}) is the decay constant for radon. Uranium concentrations C_U (in ppm) of oil samples has been calculated using the following equation [8]:

$$C_u(ppm) = \frac{W_u}{W_s} \quad \textbf{(4)}$$

where W_U is uranium weight in oil sample and W_S *is* the weight of oil sample.

2.3 Radiological risk parameters

2.3.1 Annual ingestion dose

The annual dose for ingestion (AED_{ig}) was calculated from the experimentally determined value of activity of radon concentration (C^{a}_{Rn}) in (Bq/Kg) by using eq. (5) given by [9]:

$$AED_{ig} = C^{a}_{Rn} x A_O x EDC \quad \textbf{(5)}$$

where, A_O is the amount of oil consumed by one person in one year [10] and EDC is the effective dose coefficient of radon ingestion (3.5 nSv/Bq) [11].

2.3.2 Excess lifetime cancer risk

The excess lifetime cancer risk (ELCR) per million persons due to radon ingestion was calculated by the following equation [4]:

$$ELCR = AED_{ig} \times DL \times RF \quad \textbf{(6)}$$

Where DL is the average duration of life (70 years) and RF is risk factor (0.055 sv^{-1}) recommended by the ICRP.

3. RESULTS AND DISCUSSION

4.1 Radiological analysis

Table (2) displays the obtained results of radon, radium and uranium concentrations in vegetable oil samples collected from different markets in Saudi Arabia. The highest concentration of these radionuclides were found 176.227±9.377 Bq/m^3, 0.330±0.018 Bq/L and 0.263±0.014 ppm respectively, in sample SN (Noor derived from Sunflower) and the lowest for these radionuclides were found to be 16.86±0.581 Bq/m^3, 0.032±0.001 Bq/L, 0.025±0.001 ppm respectively in sample OA (Almarai derived from Olive). It found that the highest value of ^{222}Rn, ^{226}Ra and ^{238}U concentrations were lower than the WHO guideline limit of 100-300 Bq/m^3, 10 Bq/L. 11.7 ppm for ^{222}Rn, ^{226}Ra and ^{238}U respectively [9].

Figs (2,3 and 4) illustrate the distribution of radon, radium content and uranium concentration in the oil samples under study. The variation in these radionuclides' concentration may be due to the different sources for oil samples because they were of different plant origin. The plant absorption of radionuclides varies depending on the geological formation of soil crust, the plant itself, and the fertilizer [12]. The pollution by radionuclides may be also directly caused by the absorption of radionuclide from the atmosphere. Consequently, the plant pollution with radionuclides is expected. As seen from Table (2), alpha activities, due to radium and uranium in the cooking oil samples, are lower than those due to radon. This is because radon has less half- life (3.82 d) than radium (1600 y) and uranium ($4.47x10^9$ y) [13]. Figs. (5 and 6) show the relation between radon with radium and uranium with radium, respectively. The results showed that there is a positive correlation between radon and radium, as well as a positive relation between uranium and radium with a good linear correlation coefficient of 0.999 for both in this study. These results provide an indication for the fact that uranium is a good source of radium, and a radium is a good source of radon in all samples.

Table (2): Concentration of Rn-222, Ra-226, and U-238 in cooking oil samples

Sample No.	Sample Code	C_{Rn} (Bq/m^3)	C_{Ra} (Bq/L)	C_U (ppm)
1	**CH1**	**70.023**	**0.131**	**0.104**
	CH2	**69.767**	**0.131**	**0.104**
	CH3	**72.093**	**0.135**	**0.108**
	Mean	70.628±1.275	0.132±0.002	0.105±0.002
2	**CA1**	**109.302**	**0.205**	**0.163**
	CA2	**106.202**	**0.199**	**0.158**
	CA3	**106.783**	**0.200**	**0.159**
	Mean	107.429±1.648	0.201±0.003	0.160±0.002
3	**CP1**	**75.581**	**0.141**	**0.113**
	CP2	**78.450**	**0.147**	**0.117**
	CP3	**74.419**	**0.139**	**0.111**
	Mean	76.150±2.075	0.142±0.004	0.114±0.003
4	**SN1**	**168.992**	**0.316**	**0.252**
	SN2	**186.822**	**0.350**	**0.279**
	SN3	**172.868**	**0.323**	**0.258**
	Mean	176.227±9.377	0.330±0.018	0.263±0.014
5	**SS1**	**113.953**	**0.213**	**0.170**
	SS2	**132.558**	**0.248**	**0.198**
	SS3	**128.682**	**0.241**	**0.192**
	Mean	125.065±9.816	0.234±0.018	0.187±0.015
6	**SL1**	**29.567**	**0.055**	**0.044**
	SL2	**30.491**	**0.057**	**0.045**
	SL3	**28.876**	**0.054**	**0.043**
	Mean	29.645±0.810	0.055±0.002	0.044±0.001
7	**SA1**	**157.364**	**0.294**	**0.235**
	SA2	**153.488**	**0.287**	**0.229**
	SA3	**157.106**	**0.294**	**0.234**
	Mean	155.986±2.167	0.292±0.004	0.233±0.003
8	**ON1**	**29.264**	**0.055**	**0.044**
	ON2	**30.233**	**0.057**	**0.045**
	ON3	**28.165**	**0.053**	**0.042**
	Mean	29.220±1.034	0.055±0.002	0.044±0.002
9	**OP1**	**58.140**	**0.109**	**0.087**
	OP2	**53.488**	**0.100**	**0.080**
	OP3	**62.791**	**0.117**	**0.094**
	Mean	58.140±4.651	0.109±0.009	0.087±0.007
10	**OA1**	**16.860**	**0.032**	**0.025**
	OA2	**17.442**	**0.033**	**0.026**
	OA3	**16.279**	**0.030**	**0.024**
	Mean	16.860±0.581	0.032±0.001	0.025±0.001
11	**OW1**	**69.767**	**0.131**	**0.104**
	OW2	**72.351**	**0.135**	**0.108**
	OW3	**68.798**	**0.129**	**0.103**
	Mean	70.306±1.836	0.132±0.003	0.105±0.003

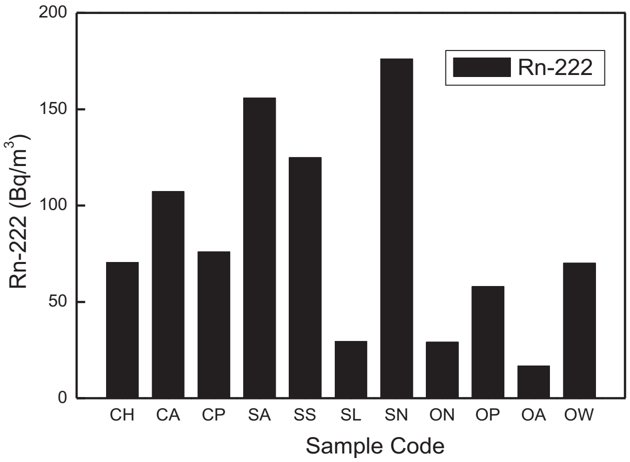

Fig. (2): Distribution of Rn-222(Bq/m^{٣}), for different samples of oils

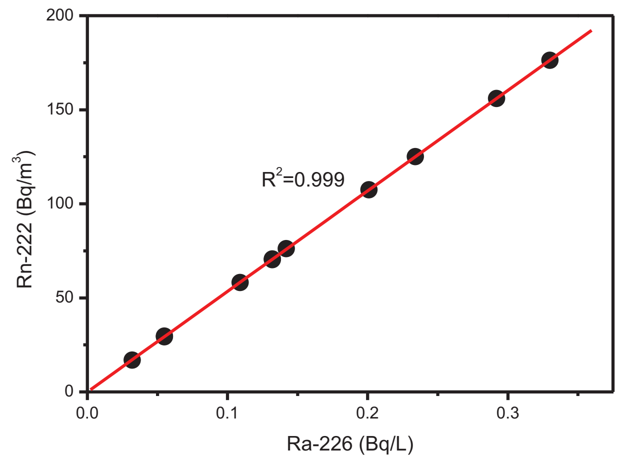

Fig. (5): Correlation between Rn-222 and Ra-226 for different samples of oils

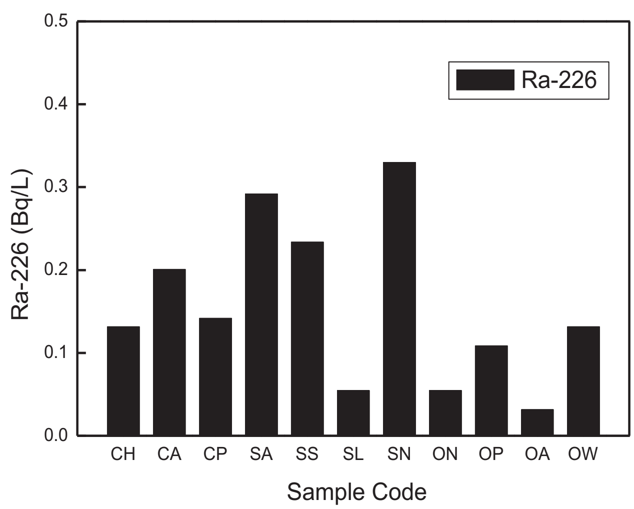

Fig. (3): Distribution of Ra-226 (Bq/L), for different samples of oils

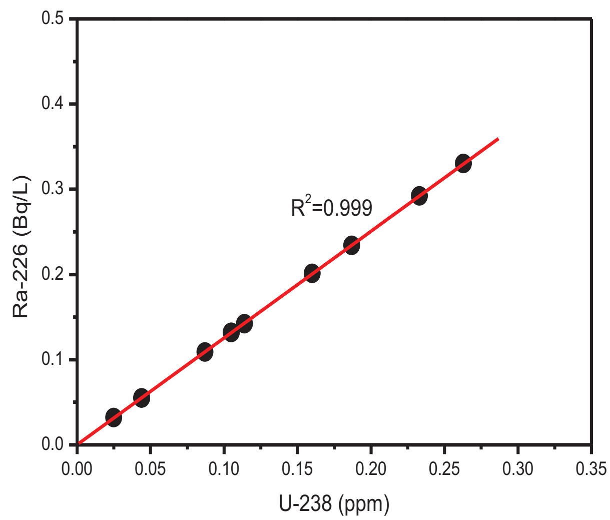

Fig. (6): Correlation between U-238 and Ra-226 for different samples of oils

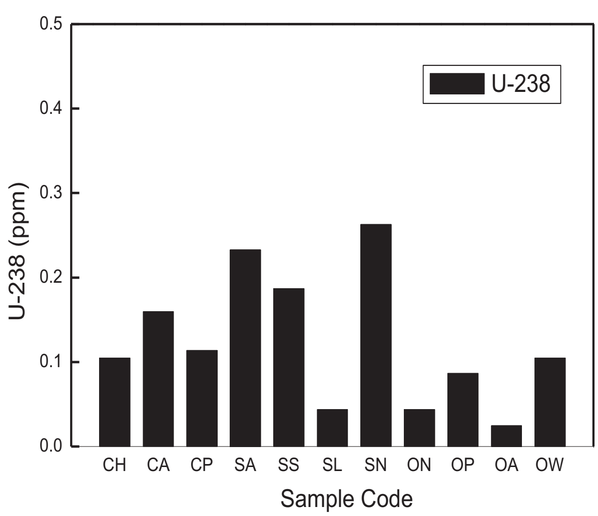

Fig. (4): Distribution of U-238 (ppm), for different samples of oils

4.2 Radiation hazard indices

Table 3 shows the annual ingestion dose and ELCR per million persons due to radon ingestion in the cooking oil samples under study. It is observed that the average of the annual ingestion dose in oil samples varies from 12.657±0.436 in sample OA (Almarai derived from Olive) to 131.417±6.933 nSv/y in sample SN (Noor derived from Sunflower). The maximum value of annual ingestion dose is less than the limit of the recommended range (3-10 mSv/y) recommended by International Commission on Radiological Protection and the action level of 0.29 mSv/y recommended by UNSCEAR for the ingestion exposure caused by natural sources [9]. Additionally, the ELCR per million persons in all oil samples was found to range from 0.049±0.002 to 0.506±0.027. The maximum value was 0.506 per million persons in sample SN (Noor derived from Sunflower).

This value was less than the lower limit of the range (170-230) per million person recommended by International Commission on Radiological Protection [14]. Therefore, the values of ELCR are very low, so, the risk of cancer is negligible. This low value is related to low value of radon concentrations. In addition, the lower value of radon in the oil samples may be due to low moisture content that may reduce the radon level in the cooking oil sample [15], [16]. That means that the radon concentration in the cooking oil samples under study does not generate any sort of radiological health risk.

Table (3): Annual ingestion dose (nSv/y), ELCR per million persons due to ingestion of Rn-222 in cooking oil samples

Sample No	Sample Code	Annual ingestion dose (nSv/y)	ELCR per million persons
1	**CH1**	**57.239**	**0.220**
	CH2	**57.030**	**0.220**
	CH3	**58.931**	**0.227**
	mean	57.733±1.042	0.222±0.004
2	**CA1**	**87.455**	**0.337**
	CA2	**84.974**	**0.327**
	CA3	**85.439**	**0.329**
	mean	85.956±1.319	0.331±0.005
3	**CP1**	**58.280**	**0.224**
	CP2	**60.492**	**0.233**
	CP3	**57.383**	**0.221**
	Mean	58.718±1.600	0.226±0.006
4	**SA1**	**116.584**	**0.337**
	SA2	**113.712**	**0.327**
	SA3	**116.392**	**0.329**
	mean	115.563±1.606	0.331±0.005
5	**SS1**	**84.792**	**0.326**
	SS2	**98.636**	**0.380**
	SS3	**95.752**	**0.369**
	mean	93.060±7.304	0.358±0.028
6	**SL1**	**22.001**	**0.085**
	SL2	**22.688**	**0.087**
	SL3	**21.486**	**0.083**
	Mean	22.058±0.603	0.085±0.002
7	**SN1**	**126.022**	**0.485**
	SN2	**139.318**	**0.536**
	SN3	**128.912**	**0.496**
	mean	131.417±6.933	0.506±0.027
8	**ON1**	**21.919**	**0.084**
	ON2	**22.645**	**0.087**
	ON3	**21.096**	**0.081**
	mean	21.886±0.775	0.084±0.003
9	**OP1**	**43.547**	**0.168**
	OP2	**40.063**	**0.154**
	OP3	**47.031**	**0.181**
	mean	43.547±3.484	0.168±0.013
10	**OA1**	**12.657**	**0.049**
	OA2	**13.093**	**0.050**
	OA3	**12.220**	**0.047**
	mean	12.657±0.436	0.049±0.002
11	**OW1**	**52.142**	**0.201**
	OW2	**54.073**	**0.208**
	OW3	**51.418**	**0.198**
	mean	52.544±1.373	0.202±0.005

CONCLUSION

The concentration of ^{222}Rn, ^{226}Ra and ^{338}U were below the recommended value. Likewise, the annual dose due to ingestion of radon was lower than the limit range (3-10 mSv/y) recommended by ICRP and UNSCEAR. Consequently, the risk of cancer is negligible. The obtained results reveal that all the cooking oil samples are radiologically safe for consumption. This result serves as a baseline radiological data on cooking oil for future studies.

REFERENCES

[1] N. Dinh Chau *et al.*, “Natural radioactivity in groundwater - a review,” *Isotopes Environ. Health Stud.*, vol. 47, no. 4, pp. 415–437, 2011, doi: 10.1080/10256016.2011.628123.

[2] R. L. Murray, “Understanding radioactive waste,” 1981.

[3] W. H. O. WHO, “Nuclear accidents and radioactive contamination of foods,” no. March, pp. 1–5, 2011.

[4] R. A. Alhiall and A. A. Alsalihi, “Radiation dosimetry of some rice types consumed in Basrah Governorate/Iraq by using thermoluminescence technique and SAM940-2G,” *Int. J. Environ. Sci. Technol.*, vol. 16, no. 11, pp. 6579–6586, 2019, doi: 10.1007/s13762-018-2176-y.

[5] B. A. El-Badry and T. I. Al-Naggar, “Estimation of indoor radon levels using etched track detector,” *J. Radiat. Res. Appl. Sci.*, vol. 11, no. 4, pp. 355–360, 2018, doi: 10.1016/j.jrras.2018.07.002.

[6] A. M. Abdalla and A. Al-Hajry, “Radon irradiation chamber and its applications,” *Nucl. Instruments*

Methods Phys. Res. Sect. A Accel. Spectrometers, Detect. Assoc. Equip., vol. 786, pp. 78–82, 2015, doi: 10.1016/j.nima.2015.03.043.

[7] B. A. El-Badry, T. I. Al-Naggar, and G. A. Khouqeer, “Monitoring the levels of radon and toxic elements pollutants in bottled drinking water,” *Int. J. Radiat. Res.*, vol. 18, no. 3, pp. 427–435, 2020, doi: 10.18869/acadpub.ijrr.18.3.427.

[8] R. M. Yousuf and K. O. Abullah, “Measurement of Uranium and Radon Concentrations in Resources of Water from Sulaimany Governorate -Kurdistan Region-Iraq,” vol. 3, no. 6, pp. 632–638, 2013.

[9] U. Nations, S. Committee, and A. Radiation, *SOURCES AND EFFECTS United Nations Scientific Committee on the Effects of Atomic Radiation*, vol. I. 2000.

[10] K. Ganesan, K. Sukalingam, and B. Xu, “Impact of consumption of repeatedly heated cooking oils on the incidence of various cancers- A critical review,” *Crit. Rev. Food Sci. Nutr.*, vol. 59, no. 3, pp. 488–505, 2019, doi: 10.1080/10408398.2017.1379470.

[11] N. R. Council and others, *Risk assessment of radon in drinking water*. National Academies Press, 1999.

[12] F. Carini, “Radionuclides in plants bearing fruit: An overview,” *J. Environ. Radioact.*, vol. 46, no. 1, pp. 77–97, 1999, doi: 10.1016/S0265-931X(98)001039.

[13] A. A. Abojassim, H. A. A. Mraity, A. A. Husain, and M. Wood, “Estimation of the excess lifetime cancer risk from radon exposure in some buildings of Kufa technical institute, Iraq,” *Nucl. Phys. At. Energy*, vol. 18, no. 3, pp. 276–286, 2017, doi: 10.15407/jnpae2017.03.276.

[14] S. Al-omari, “Radioactivity measurement of 222 Rn , 226 Ra and 238 U in pharmaceuticals and evaluation of cancer risk,” vol. 10, no. 1, pp. 61–73, 2015.

[15] M. Hosoda, M. Shimo, M. Sugino, and M.Fukushi, “Effect of Soil Moisture Content on Radon and Thoron Exhalation,” vol. 3131, 2012.

[16] B. Singh, S. Singh, B. S. Bajwa, J. Singh, and A. Kumar, “Soil gas radon analysis in some areas of Northern Punjab, India,” *Environ. Monit. Assess.*, vol. 174, no. 1–4, pp. 209–217, 2011, doi: 10.1007/s10661-010-1451-2.