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Research Article

SIMPLE ANALYSIS OF RADIOACTIVITY, AND ASSESSMENT OF RADIOLOGICAL HAZARDS IN DIFFERENT TYPES OF HOUSEHOLD FOODS

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ABSTRACT

Human are received a different levels of radiation either natural or that man-made. In the present work, radon-222 concentration, and effective radium content were studied for different types of household foods (coffee, powder milk, tea, powder coconut, rice, cornstarch, flour, and sugar) used in Egypt by using CR-39 polymer track detector, it is found a large variations in the values of radon concentrations, and effective radium content for all the samples. Annual effective dose was determined in this study, and its maximum value was 17.70 mSv/y which was found in sugar and the lowest value of its was 4.29 mSv/y which was found in coconut tpowder. Exhalation rate of radon and transfer factor were measured, and also discussed in this study.

INTRODUCTION

From point of view measurements of radon and radium concentrations in foods are main for the health safety. Radium-226 in the environment is broadly spreading, and usually presented in several concentrations in soils, water, foods, sediments and rocks. However, the chemical manner of radium is as like as calcium, therefore radium absorbed to blood from lungs or GI-tract or follows the manner of calcium and is mainly deposited in bone (Abdalsattar *et al*., 2015). Radon-222 is a progeny product of radium-226which is called alpha gas emitter. Its half-life of 3.82 days with alpha energy 5.49Mev. Radon progenies are Po-218 and Po-214 emit alphaparticles. These daughters yields are hard and have a trend to relate themselves to aerosols in around air. When human respire or inhale radon and its progenies along with the normal air, most of the radon is exhaled, its progenies become record to the internal walls and membranes of our respiratory system and continue producing steady damage because of theiralpha activity (Shoeib, and Thabayneh., 2014).

Radiation contamination which are existing in water and soil can be transportedby the food chain to humans and animals (Ammar *et al*., 2016). When the human are eating plants, meat of animals or drinking any fluids (tea, coffee, water, and juice), he can be contaminated with different radioactive isotopes(Ra-226, Rn-222, U-238….etc). Plants contain radioactive isotopesinitiating from the soil, that absorbed it with other natural substances. Also drinking water and fluids can contain low dose. Air which human breath it, is the primary source of radioactive dose that enter the human body, and as well as the main source of radon that found in the earth's atmosphere generated by the automatic decomposition of uranium(IAEA, 1990).The breathing of radon radioactive progenies with ambient air can caused kidney infections, Lung cancer, and skin cancer, it must be know the hazard limits of these radioactive progenies.CR-39 polymer track detector is one of the most common polymer detectors that belong to SSNTDs. CR-39 polymer track detector (Poly-ally diglycol carbonate) is used in a wide range of different scientific and industrial technological applications such as radiological experiments, neutrons spectroscopy and radon dosimetry(Zaki *et al*., 2017). The main purpose of this investigation was to simple analysis for different types of household foods (Coffee, Powder milk, Tea, Powder Coconut, Rice, Cornstarch, Flour, and Sugar)

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used in Egypt by using closed can technique based on solid state nuclear track detector CR-39.

MATERIALS AND METHOD

Through current work, 24 samples from different types of household foods were collected from Egyptian markets which these foods are considered the daily diet of Egypt residents. These household foods are (coffee, tea, powder milk, rice, flour, cornstarch, and powder coconut) were analyzed by closed-can technique (CR-39), 50 gram from each sample was put in plastic can as its natural form without any process, a piece of CR-39 manufactured by TASTRACK Analysis System, Ltd., UK:TASTRACK, which has dimensions (1×1) cm was fixed well in the cover of plastic can in front of the sample, after that CR-39 detector was covered by a piece of sponge to prevent thoron-220 from the arrival to CR-39 detector. Plastic can was closed well by its cover and was left for one month as exposure time, closed can techniques produced in Figure (1). CR-39 polymer detector registers alpha particles which emitted by decay of radium to radon gas as tracks. After the exposure time, CR-39 detectors were assembled from cans and chemically etched in NaOH solution 6.25 M at 70˚C to enlarge and appear the alpha tracks through time equal 8 hour (Hala, and Doaa, 2015; Tayseer and Aymen, 2017). After that, CR-39 detectors were washed by purified water and dried well in air. Numbers of tracks for each detectors were counted by an optical microscope at a magnification of 400×. Background of CR-39 detectors were registered in this study and subtracted from the net tracks for each samples.

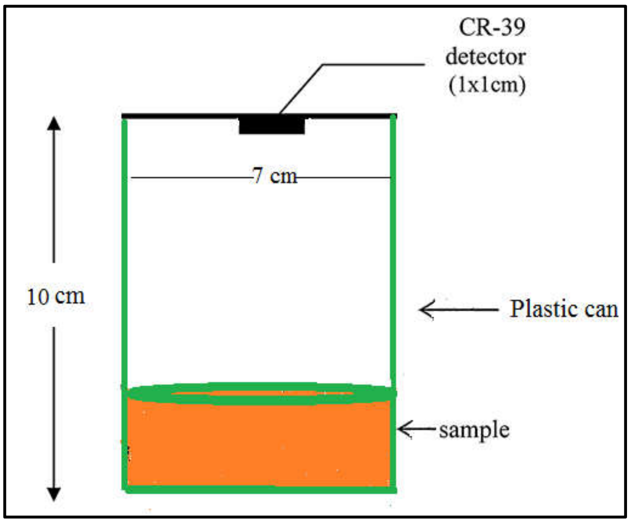

Figure 1 Closed can technique of CR-39 with household foods samples

Theoretical Concepts

The activity concentration of radon (Bq/m^3) can be calculated by using the following equation (Ayman and Ali, 2015; Heiyam *et al.*, 2016; Ridha, and Hasan 2016 Tayseer and Aymen, 2017):

$$C = \frac{\rho}{K.T} \qquad (1)$$

Where K is the calibration factor (Bq /m^3 d) / (track/cm^2), ρ is track density (number of tracks/cm^2) and T is exposure time (in days). The calibration factor value (0.20 ± 0.01) as reported at many studies(Ayman and Ali, 2015; Heiyam *et al.*, 2016 ; Ridha, and Hasan 2016).

The effective radium content C_{Ra} (Bq/kg) can be found from the equation (Khan *et al.*, 2012; Ridha, and Hasan 2016)

$$C_{Ra} = \frac{\rho h A}{k T_e M} \qquad (2)$$

where ρ is the counted track density, h is the distance between the detector and the top of the sample, K is the calibration factor of the CR-39 detector, M is the mass of the sample, and T_e is the effective exposure time which can be determined by the following equation.

$$T_e = T - \frac{(1-e^{-\lambda_{Rn}T})}{\lambda_{Rn}} \qquad (3)$$

Where T is the exposure time, and λ_{Rn} decay constant for radon (h^{-1}).

The radon exhalation rate can be determined from the relation reported by (Khan *et al.*, 2012; Ridha, and Hasan 2016)

$$E = \frac{C_{Rn}\lambda V}{A T_e} \qquad (4)$$

Where, C_{Rn} is radon exposure (Bqm^{-3}h), λ_{Rn} decay constant for radon (h^{-1}), A is surface area of water samples (m^2), V is volume of the can (m^3).

The annual effective dose (E_{eff}) (mSv/y) can be obtained using the equation(Abdalsattar *et al*, 2017)

$$E_{eff} = C \times F \times H \times T \times D \qquad (5)$$

where (H) is the occupancy factor which is equal to (0.8), (T) is the time in hours in a year, (T = 8760 h/y), and (D) is the dose conversion factor which is equal to [9×10^{-6} (m Sv) / (Bq.h.m^{-3})] (UNSCEAR, 2000).

Transfer factor (TF) for radionuclides (Rn-222, and Ra-226) in household foods

Concentrations of radionuclides in foods which are grown in the soil depend on the concentrations of theses radionuclides in dry soils. Transfer Factor (TF) can be calculated by the following equation (IAEA, 2010;Oufni *et al.*, 2013; Mohammad *et al.*, 2017):

$$TF = \frac{C_{foods}\ (Bqkg^{-1} dry\ wight)}{C_{Soil}\ \ (Bqkg^{-1} dry\ wight)} \qquad (6)$$

whereC_{foods} is the activity concentration of^{226}Ra or^{222}Rn in dry weight of foods samples and C_{Soil} is the average activity concentration of radionuclide (^{226}Ra or^{222}Rn) in dry weight of soil samples.

RESULTS AND DISCURSIONS

The data of track density (track/cm^2), concentration of radon-222 (Bq/m^3), effective radium content (Bq/kg), exhalation rate (mBqm^{-2}h^{-1}), and annual effective dose (mSv/y) for eight types from household foods are presented in table (1). The average activity concentrations of Rn-222 are262.19±18.31, 333.05±8.07, 276.36±15.35, 170.07±37.52, 304.71±11.03, 517.29±34.88, 233.84±24.22, and 701.53±73.30 Bq/m^{3}for coffee, powder milk, tea, powder coconut, rice, cornstarch, flour, and sugar respectively. Its observed from figure(2), there are a large variations in the values of radon concentrations along all the samples, while the maximum values of Rn-222 concentration are observed at sugar, and cornstarchare 701.53±73.30, and 517.29±34.88Bq/m^3 respectively, and the lowest value was observed at Powder coconut is170.07±37.52Bq/m^3. This variation may be due to the differences in the nature of these samples and also its bases content (Abdalsattar *et al*., 2015). The average values of radon concentrations at coffee, powder milk, tea, powder coconut, rice, and flour found to be lower than the recommended value 400Bq/m^3(ICRP, 1987), but its concentrations at cornstarch, and sugar were relatively higher than the recommended value. The high values of radon concentrations in foods are due to the presence of any type of ionizing radiation found in the air, soil or water which are transferred to the food and are grown on it (Maria *et al*., 2016). The source of radon in foods is mainly from the activity concentration of its parent Ra-226, when radionuclide such as radium intake from the soil and irrigation water through the root and as a result of that it is transferred to foods (Nasrin *et al*., 2017). When human are ingested radon daughters undergoes radioactive decay are transported to lung and causes changes to DNA structures. Also, several studies on lung cancer indicate the role of radon and thoron in causing the same (Ramsiya *et al*., 2017).

content for all types of household foods were found to be lower than the permission level of 370Bqkg^{-1}(OECD, 2009).

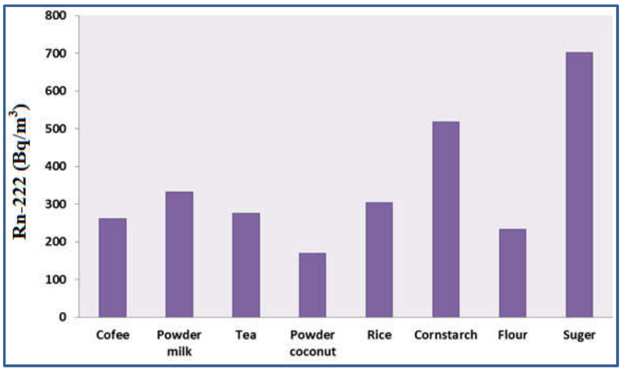

Figure 2 Radon-222 concentrations for different types of for household foods

The average values of exhalation rate of radon are 365.61±25.52, 464.42±11.25, 385.37±21.40, 237.15±52.31, 424.90±15.38, 721.33±48.65, 326.08±33.76, and 978.25±102.22mBqm^{-2}h^{-1}for coffee, powder milk, tea, powder coconut, rice, cornstarch, flour, and sugar respectively as shown at table (1).

Table 1 Track Density (track/cm^2), Radon-222 Concentration (Bq/m^3), Effective Radium Content (Bq/kg), Exhalation rate (mBqm^{-2}h^{-1}), and Annual Effective Dose (mSv/y) for household foods

Foods type	Sample code	Track density (track/cm^2)	Rn-222 (Bq/m^3)	Effective Radium content (Bq/kg)	Exhalation rate (mBqm^{-2}h^{-1})	Effective dose (mSv/y)
	C1	28571.43	297.62±10.92	6.94±0.26	415.01±15.22	7.51±0.28
Coffee	C2	24489.80	255.10±19.79	5.95±0.47	355.73±27.58	6.44±0.50
	C3	22448.98	233.84±24.22	5.46±0.57	326.08±33.76	5.90±0.61
Average	Av	25170.07	262.19±18.31	6.12±0.43	365.61±25.52	6.61±0.46
	P1	36734.69	382.65±6.81	8.93±0.15	533.59±9.51	9.65±0.17
powder milk	P2	30612.24	318.88±6.49	7.44±0.16	444.66±9.04	8.04±0.16
	P3	28571.43	297.62±10.92	6.94±0.26	415.01±15.22	7.51±0.28
Average	Av	31972.79	333.05±8.07	7.77±0.19	464.42±11.25	8.40±0.20
	T1	28571.43	297.62±10.92	6.94±0.26	415.01±15.22	7.51±0.28
Tea	T2	30612.24	318.88±6.49	7.44±0.16	444.66±9.04	8.04±0.16
	T3	20408.16	212.59±28.65	4.96±0.68	296.44±39.94	5.36±0.72
Average	Av	26530.61	276.36±15.35	6.45±0.37	385.37±21.40	6.97±0.39
	O1	16326.53	170.07±37.52	3.97±0.88	237.15±52.31	4.29±0.95
Powder Coconut	O2	18367.35	191.33±33.08	4.46±0.78	266.79±46.13	4.83±0.83
	O3	14285.71	148.81±41.95	3.47±0.99	207.51±58.49	3.75±1.06
Average	Av	16326.53	170.07±37.52	3.97±0.88	237.15±52.31	4.29±0.95
	R1	20408.16	212.59±28.65	4.96±0.68	296.44±39.94	5.36±0.72
Rice	R2	34693.88	361.39±2.37	8.43±0.05	503.95±3.33	9.12±0.06
	R3	32653.06	340.14±2.06	7.94±0.05	474.30±2.86	8.58±0.05
Average	Av	29251.70	304.71±11.03	7.11±0.26	424.90±15.38	7.69±0.28
	S1	55102.04	573.98±46.70	13.39±1.08	800.38±65.14	14.48±1.18
Cornstarch	S2	44897.96	467.69±24.54	10.91±0.57	652.17±34.23	11.80±0.62
	S3	48979.59	510.20±33.40	11.90±0.77	711.45±46.59	12.87±0.84
Average	Av	49659.86	517.29±34.88	12.07±0.81	721.33±48.65	13.05±0.88
	F1	26530.61	276.36±15.36	6.45±0.36	385.37±21.40	6.97±0.39
Flour	F2	18367.35	191.33±33.08	4.46±0.78	266.79±46.13	4.83±0.83
	F3	22448.98	233.84±24.22	5.46±0.57	326.08±33.76	5.90±0.61
Average	Av	22448.98	233.84±24.22	5.46±0.57	326.08±33.76	5.90±0.61
	U1	61224.49	637.76±60.00	14.88±1.39	889.32±83.68	16.09±1.51
Sugar	U2	73469.39	765.31±86.60	17.86±2.01	1067.18±120.77	19.31±2.19
	U3	67346.94	701.53±73.30	16.37±1.70	978.25±102.22	17.70±1.85
Average	Av	67346.94	701.53±73.30	16.37±1.70	978.25±102.22	17.70±1.85

Table (1) displays the average values of effective radium content are 6.12±0.43, 7.77±0.19, 6.45±0.37, 3.97±0.88, 7.11±0.26, 12.07±0.81, 5.46±0.57, and 16.37±1.70 Bqkg^{-1} for coffee, powder milk, tea, powder coconut, rice, cornstarch, flour, and sugar respectively. All values of effective radium

A positive strong correlations were observed between effective radium content with both radon concentration, and exaltation rate with linear coefficients (R^2 = 1) as revealed at figure (3a& b). The correlations coefficients are positively linear, these may be due to the values of radon concentrations and exhalation rate are mainly dependent on the values of effective radium, and the radon exhalation analysis is significant for knowing the relative impact of the material to the total radon concentration found in food samples and useful to study radon health hazard (Hesham *et al*., 2016; Kazuki *et al*., 2017).

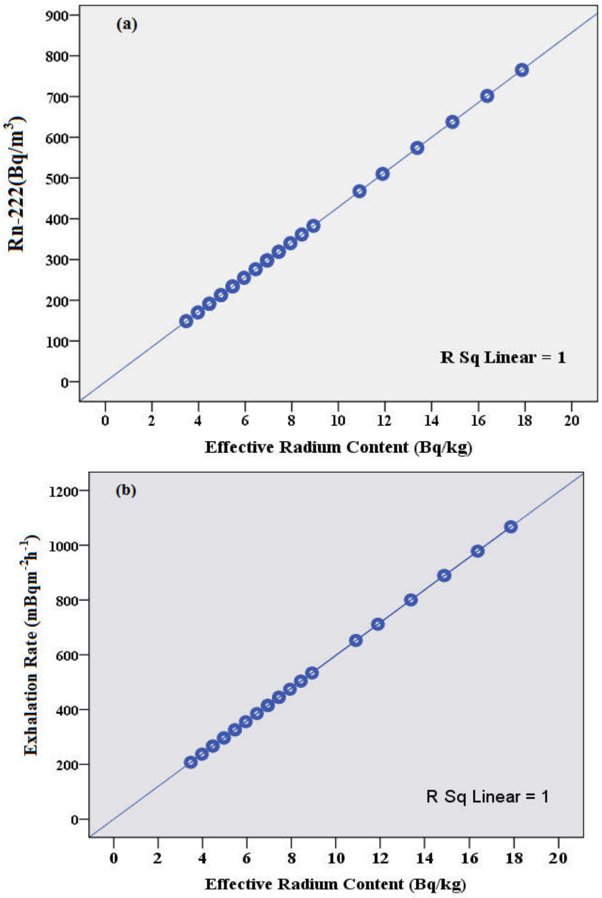

Figure 3 Relations between effective radium content with (a) Rn-222 (Bq/m^3), (b) Exhalation rate (mBqm^{-2}h^{-1}).

We can see from figure (4) the high value of effective dose was observed in sugar, and the lower value of effective dose was observed at powder coconut, and there are a large variations in the values of effective dose for all the types of samples as 6.61±0.46, 8.40±0.20, 6.97±0.39, 4.29±0.95, 7.69±0.28, 13.05±0.88, 5.90±0.61, 17.70±1.85mSv/y for coffee, powder milk, tea, powder coconut, rice, cornstarch, flour, and sugar respectively. All values of effective dose within the recommended limit (3-10 mSv/y) (ICRP, 1993), except its values for cornstarch and sugar are relatively high.

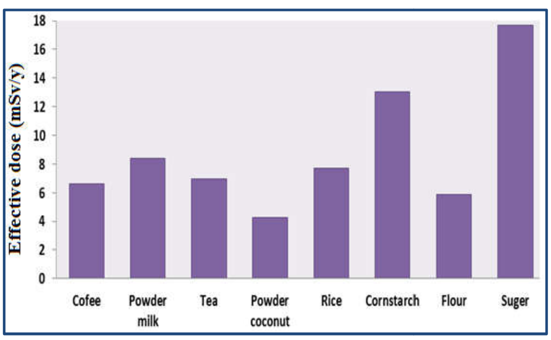

Figure 4 Average values of annual effective dose for different types of household foods

The values of transfer factor (TF) for radionuclides Rn-222, and Ra-226 in different types of household foods were presented at table (2). The values of TF of Rn-222 varied from 0.60±0.17 to3.06±0.35with an average of 1.40±0.11, while the values of TF of Ra-226 varied from 0.11±0.029 to 0.54±0.060with an average of 0.25±0.02.All values of TF for both radionuclides Rn-222, and Ra-226 are high, this may be due to organic substance content or small pH number of soil, so the radionuclides are absorbed at high levels through plants or seeds due to increase in the value of organic matter in the soil.

Table 2 Transfer factor of Radon-222, and Ra-226 for different types of household foods

Foods type	Sample code	TF for Rn-222	TF For Ra-226
	C1	1.19±0.04	0.21±0.008
Coffee	C2	1.02±0.08	0.18±0.015
	C3	0.94±0.10	0.17±0.017
Average	Av	1.05±0.07	0.19±0.013
	P1	1.53±0.03	0.27±0.004
powder milk	P2	1.28±0.03	0.23±0.004
	P3	1.19±0.04	0.21±0.008
Average	Av	1.33±0.03	0.24±0.006
	T1	1.19±0.04	0.21±0.008
Tea	T2	1.28±0.03	0.23±0.004
	T3	0.85±0.11	0.15±0.021
Average	Av	1.11±0.06	0.20±0.011
	O1	0.68±0.15	0.12±0.027
Powder Coconut	O2	0.77±0.13	0.14±0.023
	O3	0.60±0.17	0.11±0.029
Average	Av	0.68±0.15	0.12±0.026
	R1	0.85±0.11	0.15±0.021
Rice	R2	1.45±0.01	0.26±0.002
	R3	1.36±0.01	0.24±0.002
Average	Av	1.22±0.04	0.22±0.008
	S1	2.30±0.19	0.41±0.033
Cornstarch	S2	1.87±0.10	0.33±0.017
	S3	2.04±0.13	0.36±0.023
Average	Av	2.07±0.14	0.37±0.024
	F1	1.11±0.06	0.20±0.010
Flour	F2	0.77±0.13	0.14±0.023
	F3	0.94±0.10	0.17±0.017
Average	Av	0.94±0.10	0.17±0.017
	U1	2.55±0.24	0.45±0.042
Sugar	U2	3.06±0.35	0.54±0.060
	U3	2.81±0.29	0.50±0.052
Average	Av	2.81±0.29	0.50±0.051

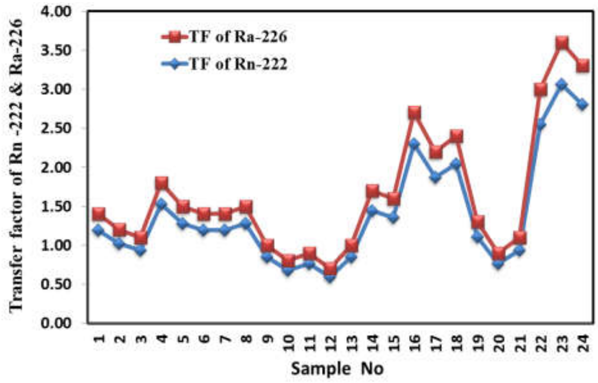

Figure 5 Transfer factor of Ra-222, and Ra-226 for different types of household foods.

Therefore, the uptake of radium in plant increases by increasing the concentration of organic acids and organic acids especially citric acid play an effective role on the uptake of Ra-226 by the plants due to pH reduction and complex formation of organic acids with elements in the soil (Oufni *et al*., 2013; Harb *et al*., 2014; Mohammad *et al*., 2017). Figure (5) shows there are a wide range of variations in the values of transfer factor of Rn-222, and Ra-226 along all the samples.

CONCLUSION

Analysis the concentrations of Radon-222 and Radium-226for different types of household foods samples are very substantial for realizing the comparative contributions of specific substances to the whole radon content set within the human body. From our results, we can found that the range of radon - 222 concentrations at different types of household foods are 170.07 (at Powder Coconut) - 701.53 (at sugar)Bq/m^3, Radon concentrations are varied from one type to another of household foods samples, the values of Radon-222 are higher than the recommend value of ICRP for cornstarch and sugar. All values of effective radium content for all food samples are lower than the recommended value. Exhalation rate of radon is relatively high at all samples .The average values of annual effective dose in mSv/y are within the recommended limit of ICRP values except its values for cornstarch and sugar are relatively high, and there are a wide range of variations in the values of transfer factor for Rn-222, and Ra-226 for all types. Then all types of foods which are analysis in this study are safe for using except the kinds of sugar and cornstarch.

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