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RADON AND THORON CONCENTRATIONS MESUREMENTS IN LOCAL PRODUCED AND IMPORTED DRY LEGUMES IN IRAQI MARKETS USING SSNTDs TECHNIQUE

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ABSTRACT

In the present study an attempt has been made to develop and to determine radon and thoron concentration in the some dry legumes produced in Iraq and imported dry Legumes, which are available in markets of Basrah Governorate of Iraq. The passive radon method employed has been achieved by means of cylindrical time integrated technique of Solid State Nuclear Track Detectors (SSNTDs). In the dry legumes produced in Iraq the obtained radon concentrations ranged from (379.01Bq/m^3) to (831.58Bq/m^3) while the average value is (421.01Bq/m^3). The thoron concentrations from (120.48Bq/m^3) to (362.62Bq/m^3) while the average value is (270.15Bq/m^3). For imported dry legumes ranged from (69.06Bq/m^3) to (945.19Bq/m^3) while the average is (512.20Bq/m^3) for radon, and (51.86Bq/m^3) to (865.06Bq/m^3) while the average is (279.66Bq/m^3) for thoron. From the measurements all of the dry legumes measured were within permissible level recommended by ICRP (2011) for foods. This study gives us data base about the concentration of radon in dry Legumes found in Basra markets, and compares this data with radon data in vegetable and fish of Basra markets (Iraq).

KEYWORDS: Cylindrical Technique, Dry Legumes, Radon, SSNTDs, Thoron Concentration

INTRODUCTION

Radon 222 is a radioactive decay product of uranium 238 which is present in the earth's crust in varying concentrations. Because radon is a gas, it is capable of movement from the soil to indoors. This movement is dependent on the type of building and/or location. Radon 220 is a radioactive decay product of thorium 232 also present in the earth's crust. Both radon 222 and 220 may also come from some building materials. The concentration of radon in a building may vary from several orders of magnitude. (UNSCEAR, 2009). Because radon is inert, nearly all of the gas inhaled is subsequently exhaled. However, when inhaled, the short-lived radon progeny can deposit within the respiratory tract. Depending on the diffusion properties of the particles (size distribution of the aerosols), the decay products present in the air deposit in the nasal cavities, on the walls of the bronchial tubes and in the deep lung. Two of these short- lived progeny, polonium-218 and polonium-214, emit alpha particles and the energy deposited by these alpha particles may lead to health effects, principally lung cancer (ICRP, 2011). There have been many studies concerning Naturally Occurring Radioactive Materials in soil, water and air which provide information on the nature and levels of background radiation and to observe the change in radioactivity levels in that particular area. Most of these studies show that most soils contain ^{40}K and nuclides of the uranium and thorium series, with a range of their concentrations which varies broadly. For example, the investigation of the concentration and distribution of radioactive nuclides in river sediments and coastal soils in Chittagong, Bangladesh was taken by Chowdhurry et al.(1999), The results of the activity concentration of ^{238}U, ^{232}Th and ^{40}K are higher than average world values which are 35, 30, 400 Bq.kg^{-1} (UNSCEAR, 2000). respectively. In 2004, Matiullah et al. (2004) reported the mean activity of ^{226}Ra, ^{232}Th, ^{40}K and ^{137}Cs in soil samples of Bahawalpur, Pakistan being 32.9, 53.6, 647.4 and 1.5 Bq.kg^{-1}In the same year, the activity concentration levels arising from radionuclides ^{238}U, ^{232}Th and ^{40}K in surface soils in Cyprus were carried out by Tzortzis et al (2004), ranging between $0.01 \leftrightarrow 39.8$ and $0.04 \leftrightarrow 565.8$ Bq.kg$^{-1,}$ respectively. Soil and sediments were used for measuring the natural radioactivity levels of Firtina Valley in Turkey by the team of Karadeniz Technical University of Rize, and Cekmece Nuclear Research and Training. The average concentration of ^{238}U, ^{232}Th, ^{40}K and ^{137}Cs in the area surveyed in that study were found to be 50, 42, 643 and 85 Bq.kg^{-1} in soil samples and 39, 38, 573 and 6 Bq.kg^{-1} in sediment samples by Kuranz et al (2007). Activity concentrations were measured from sediment samples collected along the Upper Egypt Nile River region in 2007 by El-Gamal Nasr and El-Taher (2007). The measurements showed ranges of ^{238}U, ^{232}Th, ^{40}K concentration of $3.83 \leftrightarrow 34.94$, $2.88 \leftrightarrow 30.10$ and $112.31 \leftrightarrow 312.98$ Bq.kg^{-1} respectively Al-Hamrnch and Awadallah (2009) determined the radioactivity levels in various geological formations of soils in the northern Highlands of Jordan ^{222}Rn and ^{220}Rn activities per unit volume were measured in various natural honey samples collected from different regions in Morocco using CR-39 and LR-115 type II solid state nuclear track detectors (SSNTDs). These radionuclides were also measured in soils, plant flowers and nectar solutions corresponding to the honey samples studied (misdaq and Mortassim 2009).

In this work, we report the results of preliminary test survey carried out using SSNTDs determine radon levels in dry legumes as many as it was possible. We compared the results of radon measurements of the dry legumes with data available in vegetables, fruit and fish.

MATERIALS AND METHODS

Dry legumes samples have been selected from different markets in Basrah Governorate (Iraq). Each type of dry legumes are taken separately and grinding them and sieved. These samples placed in a closed cylindrical plastic container as shown in Figure 1. The closed container containing CR-39 and LR-115 type II (1.5 cm × 1 cm) is left for three months. Within these three months alpha particles emitted from radon, thoron and their corresponding daughter bombard the SSNTDs detectors and registered on the detectors. At the end of exposure time the samples are taken out.

The detectors of CR-39 and LR-115type II etched in NaOH solution 2.5 N at 60˚C for 2 hr for the LR-115 type II detectors and 6.25 N at 70˚C for 7 hr for the CR-39 detectors (Misdaq and Satif, 1996). The registered tracks were counted by optical microscope type ALTAY made in Japan. Where the track density for CR-39 and LR-115 type II were calculated. Using Misdaq and Satif equations (1996), to determinate the ratio of (A_c^{220}/A_c^{222}) and (A_c^{222}) have been determined, where (A_C^{222}) is the activity of radon concentration per unit volume and (A_C^{220}) is the activity of thoron concentration per unit volume of dry legumes samples using the following equations after Misdaq and Satif (1996).

The global density of tracks per unit time (track.cm^{-2}.sec^{-1}) due to the **α**-particles of the radon and thoron groups registered on the LR-115 type II SSNTDs is (ρ_G^{LR}) and for CR-39 is (ρ_G^{CR}) given by:

$$\rho_G^{CR} = A_c^{222} \left[\sum_{i=1}^{3} k_i \, P_i^{CR} \, R_i + \frac{A_c^{220}}{A_c^{222}} \sum_{i=1}^{4} k_i \, P_i^{CR} \, R_i \right] \qquad (1)$$

$$\rho_G^{LR} = A_c^{222} (Bq.cm^{-3}) \left[3 P^{LR} \, \Delta R + 3 P^{LR} \, \Delta R \; \right] \qquad (2)$$

From 1 and 2 We Can Get

$$\frac{\rho_G^{CR}}{\rho_G^{LR}} = \frac{\sum_{i=1}^{3} k_i\, P_i^{CR}\, R_i + \frac{A_c^{220}}{A_c^{222}} \sum_{i=1}^{4} k_i\, P_i^{CR}\, R_i}{3\,P^{LR}\,\Delta R + 3\,P^{LR}\,\frac{A_c^{220}}{A_c^{222}}} \qquad (3)$$

$$\frac{A_c^{220}}{A_c^{222}} = \frac{\sum_{i=1}^{3} k_i\, P_i^{CR}\, R_i - 3P^{LR}\Delta R\,\frac{\rho_G^{CR}}{\rho_G^{LR}}}{3P^{LR}\Delta R\,\frac{\rho_G^{CR}}{\rho_G^{LR}} - \sum_{i=1}^{4} k_i P_i^{CR} R_i} \qquad (4)$$

Where k_i is the branching ratio in %, P_i^{CR} represents the probability for an emitted α-particle of energy Eαi to reach and be registered on CR detector, R_i is the range of the α-particle of energy Eαi and index i in the gas volume, P^{LR} represents the probability for an emitted α-particle to reach and be registered on the LR-115 type II and ($\Delta R = R_{max} - R_{min}$) where ($R_{max}$) and ($R_{min}$) are the range of alpha particles in the gas volume which correspond to the lower and upper ends of the energy window which depends on the residual thickness of the LR-115 type II. Knowing ρ_G^{CR} and ρ_G^{LR} from experimental measurements and P_i^{CR}, P^{LR} one can calculate the ratio $\frac{A_c^{220}}{A_c^{222}}$ from the above Equations, then using equations 2, 3,4 one can calculate the activity of radon and thoron. Using the values of alpha-particles transition probability, branching ratio k_i for all the seven alpha particles transition.

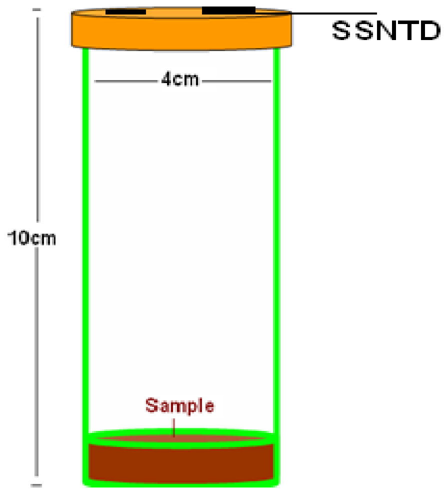


Figure 1: Arrangement of (SSNTDs) Detectors Placed at a Distance of 9 cm above the Dry Legumes Sample in a Cylindrical Plastic Counter

Table 1 shows the data obtained for the probability P_i^{CR} for radon group α-particles and thoron group α-particles to be registered on the CR-39 SSNTDs for the gas volume of the α-particles of energy $E_{\alpha i}$ and index í in the gas volume (Misdaq and satif,1996).

Table 1: Data Obtained for the Probability P_i^{CR} for Radon Group α-Particles and Thoron Group α-Particles to be Registered on the CR-39 SSNTDs for the Gas Volume of the α-Particles of Energy $E_{\alpha i}$ and Index ί in the Gas Volume (Misdaq and Satif 1996)

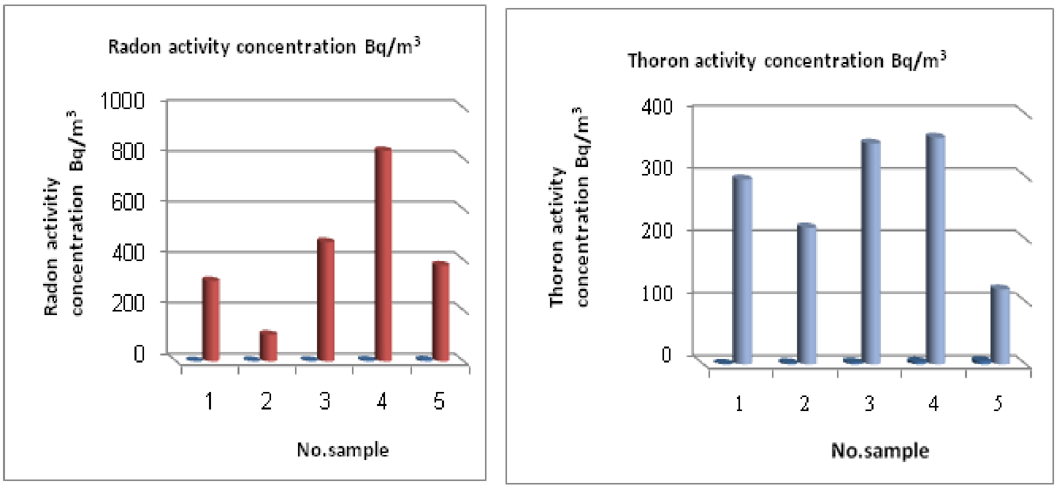
Nuclei		$E_{\alpha i}$ (Mev)	R_i (Cm)	$P_i^{CR}\times10^{-3}$
Radon group α-particles	^{222}Rn	5.49	3.90	2.871
	^{218}Po	6.00	4.65	3.383
	^{214}Po	7.68	6.62	4.44
Thoron group α-particles	^{220}Rn	6.28	4.80	3.391
	^{216}Po	6.78	4.75	3.433
	^{212}Bi	6.08	5.45	3.527
	^{212}Po	8.78	8.36	5.711

RESULTS AND DISCUSSIONS

Table 2 shows the scientific name of the dry legumes with sample No., the track density of L-115 type II (ρ_G^{LR}), track density of CR-39 (ρ_G^{CR}), A_c^{222} radon activity and A_c^{220} thoron activity, for the dry legumes produced in Iraq.

Table 2: Values of Radon and Thoron Concentration in Dry Legumes Produced in Iraq

No. of Samble	The Scientific Name of Legumes Sample	ρ_G^{LR} X 10^{-5} (Tr.Cm $^{-2}$.S^{-1})	ρ_G^{CR} X 10^{-5} (Tr.Cm $^{-2}$.S^{-1})	A_c^{222} Bq/M^3	A_c^{220} Bq/M^3
1	Vigna radiata (L.) wilczek	2.1±0.0177	3.91±0.0233	318.06±8.94	296.01±3.78
2	Vicia faba	1.8±0.0236	3.663±0.034	105.20±10.40	218.75±3.51
3	Cicer	2.8±0.0297	5.183±0.0403	471.23±14.22	353.33±5.56
4	Vigna	3.9±0.0287	7.279±0.0302	831.58±19.47	362.62±11.10
5	Lens exculenta	1.7±0.0153	2.997±0.0193	379.01±8.28	120.48±3.82



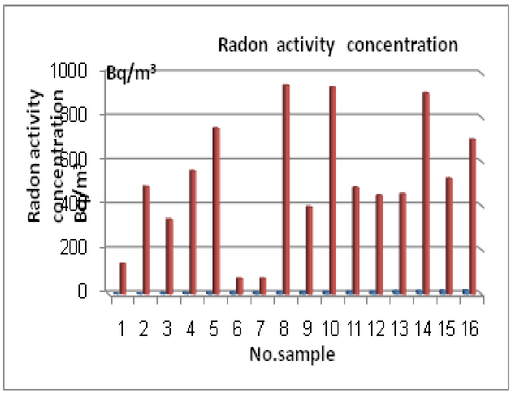
(a) (b)

Figure 2: Activities Concentrations in Dry Legumes Produced in Iraq (A) Radon (B) Thoron

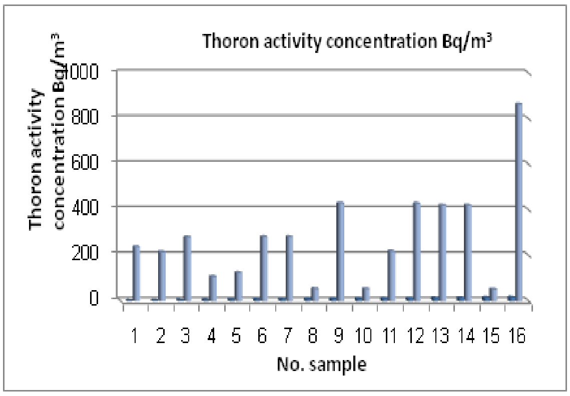
In Table 2 we noted that the (A_c^{222}) is (831.58Bq/m^3) in sample (4) for (Vigna) Which represents maximum value, While the minimum value was (105.20 Bq/m^3) in sample (2) for (Vicia faba) as shown in figure (2-a). While the maximum value for the (A_c^{220}) is (362.62Bq/m^3) in sample (4) for (Vigna), and the minimum value was (120.48Bq/m^3) in sample (5) for (Lens exculenta) as shown in figure (2-b). Table 3 shows the scientific name of the dry legumes with sample No., the track density of L-115 type II (ρ_G^{LR}), track density of CR-39 (ρ_G^{CR}), A_c^{222}radon activity and A_c^{220} thoron activity, for imported dry legumes.

Table 3: Values of Radon and Thoron Concentration in Imported Dry Legumes

No. of Sample	The Scientific Name of Legumes Sample	ρ_G^{LR} X 10^{-5} (Tr.Cm $^{-2}$.S^{-1})	ρ_G^{CR} X 10^{-5} (Tr.Cm $^{-2}$.S^{-1})	A_c^{222} Bq/M^3	A_C^{220} Bq/M^3
1	Indian vigna radiate (L.)wilczek	1.3±0.01	2.474±0.02	136.46±8.88	238.27±4.06
2	Canadian pisum sativum	2.4±0.01	4.282±0.03	486.16±6.20	215.70±0.66
3	Egyption phaseolus vulgaris	2.1±0.02	3.91±0.024	338.04±10.54	280.28±4.91
4	Crushed cicer candian	2.1±0.03	3.6 1±0.023	558.18±8.94	107.06±3.78
5	U.S. bean	3±0.027	5.114±0.03	749.83±18.79	124.46±10.91
6	Iranian cicer	1.2±0.012	2.406±0.025	69.06± 7.91	281.80±2.69
7	Chinese cicer	1.2±0.0134	2.406±0.019	69.06±5.88	281.80±1.97
8	Madagascar vigna	3.4±0.034	5.709±0.05	945.19±18.85	53.87±2.32
9	Uzbekistan vigna radiate(L.) wilczek	2.8±0.022	5.3±0.03	393.93±10.45	430.51±3.95
10	Soft Australian cicer	3.2±0.024	5.3±0.031	936.11±12.37	53.3±3.46
11	Soft Turkish phaseolus vulgaris	2.4±0.02	4.282±0.03	482.28±7.98	218.75±2.06
12	Canadian lens exculenta	1.8±0.024	3.14±0.05	447.65±5.02	428.99±8.67
13	Rough Turkish phaseolus vulgaris	3±0.025	5.567±0.06	452.85±12.00	421.45±11.57
14	Argentina pisum sativum	2.8±0.03	4.712±0.04	909.93±15.47	421.45±6.81
15	Indian cicer	4.8±0.05	9.135±0.034	522.61±25.16	51.86±2.62
16	Turkish lens exculenta	4.6±0.04	8.469±0.042	698.95±20.81	865.06±1.85



(a)



(b)

Figure 3: Activities Concentrations in Imported Dry Legumes (A) Radon (B) Thoron

We observed in Table 3 the activity of radon(A^{222}) in the imported dry legumes between maximum value (945.19Bq/m^3) for samples (No.8) for (Madagascar vigna) and minimum value (69.06Bq/m^3) for samples (N0.6,7) for (Iranian cicer and Chinese cicer) as shown in figure (3-a).While the result of the activity of thoron (A^{220}) between the maximum value (865.06Bq/m^3) for samples(No.16) for (Turkish lens exculenta) and minimum value (51.86Bq/m^3) for sample(No.15) for (Indian cicer) as shown in figure(3-b).

Al-Khalifa et al,(2010) studied the (Radon concentration in fruits and vegetables) and got the result (177Bq/m^3) as high value in watermelon produced in Iraq and (82 Bq/m^3) as less value while the imported (155Bq/m) in china orange represents high value and (48 Bq/m^3) in Turkish apple as minimum value. Al-Khalifa et al., (2013) studied the radon activity in the local and imported fish of Basra Governorate by using SSNTDs technique. The obtained radon concentration ranged from (309.4 Bq/m^3) to (1600 Bq/m^3) in local fish and from (507.3 Bq/m^3) to (1100 Bq/m^3) in imported fish.

CONCLUSIONS

To conclude, the radon and thoron activity have been measured in most dry legumes which include both dry legumes produced in Iraq and imported. From the measurements all of the dry legumes measured were within permissible level recommended by WHO (2009). It is therefore suggested that extensive study of radon activity in different food which are available throughout the country may be initiated.

Determination of the uranium level is also necessary to be carried out. The study also show the nuclear track technique using CR-39 and LR-115 type II SSNTDs is a good tool to characterize the risk due to the radon and thoron emanation. It has the advantage to simple, inexpensive, sensitive and non-destructive. This study is the first radon and thoron concentration measurements in Iraq for dry legumes produced and imported in Basra Governorate markets of Iraq and gave the data base for researchers in the field of Radon and Thoron radioactivity.

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