Plant Archives Vol. 19 No. 1, 2019 pp. 407-412 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

URANIUM CONCENTRATION, EFFECTIVE RADIUM CONTENT AND RADON EXHALATION RATE ESTIMATION FOR DIFFERENT TEA BRAND SAMPLES IN IRAQI MARKET

Abdalsattar Kareem Hashim[1,*], Laith Ahmed Najam[2], Nabeel I. Ashour[1] and Elham Jasim Mohammed[1]

[1]Department of Physics, College of Science, University of Kerbala, Karbala, Iraq.
[2]Department of Physics, College of Science, University of Mosul, Mosul, Iraq.

Abstract

In this study, the results of the ^{238}U, ^{226}Ra concentrations and ^{222}Rn exhalation rate in 20 tea samples were described using a plastic nuclear track detector (CR-39). Samples were collected from various local Iraqi markets. The chemical was drilled using NaOH solution at 70°C for 8 hours to detect the underlying trajectories, which were then scanned by optical microscopy using appropriate magnification. The effective radium values were found to change from (0.094 to 0.762) Bq/kg with an average 0.328 Bq/kg. The mass exhalation rates values of radon changed from (0.017 – 0.138) m5Ø5Ü5Ø^Ü/kg .h, with a mean 0.059 mBq/kg.h, while the rates of surface exhalation of radon changed from (0.265 – 2.155) m5Ø5Ü5Ø^Ü /5ØZÜ^2.h, with a mean 0.929 mBq/m^2. h. in all samples the uranium content has been found, it is changed from (0.076 to 0.619) ppm with an average value of 0.267 ppm. positive correlation between mass exhalation average and effective radium content for radon(R^2 = 0.9999), while excellent correlation between effective radium content with surface exhalation average for radon and uranium concentrations (R^2 = 1). The outcomes of the samples have showed that its health hazard effects were not dangerous. The results of this study has been compared with the results of other studies of former researchers included other food items can be called within internationally permissible limits and not a threat to human health and life.

Key words : Uranium, radium, radon exhalation rate, tea, CR-39.

Introduction

Iraqis are one of the most tea-drinking people in the many homes and cafes on the market, public places and tourism. So many researchers in Iraq and the world are interested in studying the radiation activity of tea to see the radiation risks associated with the health and lives of people who are more addicted to tea.

There are many methods and techniques used in literature to measure the concentration and activity of radioisotopes such as uranium in environmental samples. Depending on the type of radiation detected, these methods can be classified into three spectra: gamma, alpha, and beta. The choice of any of these spectrum should be made according to the physical type of the sample, the sample mass, the sample import (if the sample is important, then the non-destructive method can be used). Solid-state pathogens (SSNTDs) method can measure the concentration of any charged particles such as alpha particles, then one can be classified as alpha spectroscopy in the field of radioactive contamination. There are many researchers used it to estimate the concentration of Uranium in the environmental samples (Mittal *et al*., 1998; Iyer and Chaudhuri, 1997).

Tea is an aromatic beverage that is usually prepared by pouring hot or boiling water on the healing leaves of the tea plant, *Camellia sinensis*.

Historically, tea has been confirmed for a set of positive health benefits, the recent human studies mention that green tea may help reduce the risk of cardiovascular disease and certain forms of cancer, promote dental health and oral, lower blood pressure, and help control weight, improve anti-virus and antibacterial, provide protection from solar ultraviolet radiation, increase bone mineral density, anti-fibrotic properties and neuro protective power (Ody, 2000).

***Author for correspondence :** E-mail : abdalsattarkareem@gmail.com

Mostly, tea can be divided into parts founded on how they processed. They found 6 different kinds of tea at least : green, black, white , oolong (or wulong) and yellow. The most common types found in the market are black, white, green and wulong fermented tea. Some types, such as traditional oolong tea and borage tea, post-fermentation tea, green tea, can be used medically (Cabrera *et al*., 2006).

"After picking, the leaves of Camellia sinensis soon start to oxidize and wilt, unless they are immediately desiccated. The leaves turn gradually darker as their chlorophyll breaks down and tannins are freed. This enzymatic oxidation process, known as leavening in the tea industry, is caused by the plant's intracellular enzymes and due to the tea to darken. In tea transformation, the darkening is stopped at a predetermined step by heating, which disrupt the enzymes responsible. In the production of black tea, the halting of oxidization by heating is carried out simultaneously with drying. Without careful moisture and temperature control during manufacture and packaging, the tea may become ineligible for consuming, due to the growth of undesirable moulds and bacteria. At minimum, it will make the flavour unpleasant". There are three radioactive isotopes of radon element In the natural environment, called: ^{222}Rn (3.82 d), ^{220}Rn (55 s) and ^{219}Rn (~4 s), when studying "radon problem", the ^{220}Rn and ^{219}Rn and their progenies are ignored (Abumurad *et al*., 2007a; Durrani and Ili'c, 1997). The ^{226}Ra is the immediate radon pioneer, a half-life of its 1600 years ,the Radon of mass number 226 spread widely, particularly in the some materials mineral products. The related isotope of ^{226}Ra is ^{238}U; a half-life of its 4.47×10^9 years. It is available in generality of the raw materials from which we operation end products and in all kinds of elements of soil and rocks. Concentrations of Uranium are generally have been showed in parts per million by weight (ppm) or in terms of the "specific activity" expressed in Becquerel per kilogram (Bq/kg). These units are associated by the conversion factor for ^{238}U: 37 Bq/kg =3.0 ppm.'' the amount of the produced Rn atoms depends on the location of the Ra atoms in the grain and on the texture, size and permeability and emanation power of the grains. Also porosity of the material, temperature and pressure play an effective role in the radon emanation into the air". the sources and origin of Rn gas define by these parameters (Nazaroff and Nero, 1988). It is believed that more than fifty percent of the dose equivalent received of radon through inhalation by the population from all sources of radiation naturally occurring and man-made (Von Philipsborn, 2003). It is known that exposure of population to high concentration of radon gas and its progenies for a long period of time, such as in the case in the uranium exploration, can lead to pathological effects like respiratory functional changes and the occurrence of lung cancer (BEIR, 1999). To decrease such risks and knowledge of the exhalation rate from the surface of the construction materials enables one to estimate their contribution to the radon input into the indoor space, therefore must be studies of radon concentration and its effects on human health. Thus, measurements of ^{226}Ra content and Rn concentration and its progenies are necessary for the estimation of health hazard for public. In Iraq, the daily average consumption of tea, spatially black tea is about 0.5 litters while for drinking water is about 2 litters. Therefore, one must be gave attention to the tea. Tea, like any plant, planted in soil which must be contained fertilizers to obtain a good plant and tasty. A fertilizer, in it's made, contains some amount of uranium which can be transfer to the tea plant and accumulated in it. However, in this paper twenty different types of tea, which widely utilized from the public of Iraq, are estimation of ^{238}U, ^{226}Ra concentrations and Rn exhalation average for 20 different tea brand specimens in Iraqi market, using CR-39 as SSNTD technique.

Materials and Methods

20 different tea samples were collected from the Iraqi market where they were investigated. Every 15 grams of tea has been preserved in small cylindrical containers (6.5 cm length and 3.5 cm diameter) marked with appropriate identification number.

The SSNTD commonly known as CR-39 the plastic detector is used for this study. The detectors are small square pieces 1 cm × 1 cm with a thickness of 500 mm (Durrani and Bull, 1987; Gamboa, 1984), they are digging a certain number on the top right corner of the detector to facilitate the process of collection information and distinguish between the detectors for each various samples, and prove this detector in the inner surface of the top of the tube by adhesive two-sided. We used a sensitive balance to measure the weights with a sensitivity (10^{-3}) of the type (VIC-303 US) equipped made by a company (Accul AB Sartorius group). In order to study alpha radioactivity in tea were collected 20 samples of domestic and imported tea from local Iraqi markets. After sampling, the samples were dried and then been grinding samples and screened using a standard sieve to get to the delicate powder samples and placed them in test tubes described as in fig. 1.

The tea samples were stored for one month in order to reach the state of radionuclide equilibrium between

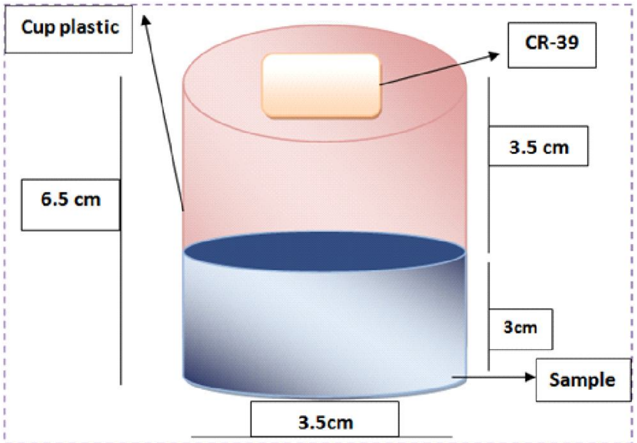

Fig. 1 : Experimental setup for measurements of radium concentration and exhalation radon rates in tea samples.

radium-radon of decay series. A month later, sealed caps were replaced with covers with CR-39 detectors in a double-faced adhesive against samples. Then the CR-39 nuclear track detectors, previously calibrated in the laboratory of the physics department of the Faculty of Science, Karbala University, the nuclear track detectors calibration factor used was 0.223 track.cm^{-2}/Bq.d.m^{-3} (Abdalsattar and Elham Jasim).

After 62 days, the detectors were removed from the cans and chemically drilled to show the nuclear pathways of the alpha particles using a NaOH solution for eight hours and a 6.25 N in a water bath at 70°C. After finishing the chemical scaling process and confirming the nuclear effects, the reagents are washed with distilled water and then dried by air. Microscopic observations are then started to detect the effects of alpha particles on the surface of the reagents manually under a Nikon YS Alphhot Japan optical microscope magnification of (100X). The alpha effects are counted in at least 20 different locations for each detector, Radon decomposition is a purely random statistical phenomenon.

The dissolve radon concentration in tea was calculated using the following equation (Al-Bataina *et al*., 1997; Abdullah and Mohammad Nabil, 2012; Somogi *et al*., 1986):

$$C_s = C_a \frac{\lambda h T}{L} \tag{1}$$

Where, C_a : radon concentration in ambient air (Bq/m^3), which is equal $\left(C_a = \frac{\rho}{KT}\right)$, L : the depth of the sample. h : the distance from the surface of tea sample to the detector, λ : decay constant for radon and T: time of exposing , ρ : track density and K : calibration factor.

Radiation equilibrium was obtained within one month by 98% between radon and radium in the decay series. Once the radiative equilibrium is established, a radon alpha analysis can be used to determine the concentration of stable activity of radium. The concentration of radon activity begins to increase over time, after sealing sealed cans containing tea samples and detectors. Radium concentration of tea samples can be calculated using (Mohamed Abd-Elzaher, 2012; Khan *et al*., 2011a):

$$C_{Ra} = \frac{\rho h A}{K T_e M} \tag{2}$$

Where, T_e is the effective exposure time which is related to the actual exposure time t and decay constant λ for ^{222}Rn with the relation (Shakir *et al*., 2012; Kant *et al*., 2005).

$$T_e = T - \frac{1}{\lambda}\left(1 - e^{-\lambda T}\right) \tag{3}$$

The radon exhalation rate in terms of area is calculated from the next equation (Mohamed Abd-Elzaher, 2012; Abu-Jarad, 1988):

$$E_A = \frac{C V \lambda}{A T_e} \tag{4}$$

Here, E_M is the radon exhalation rate in terms of area (Bq/m^2.d) and A is the area of the tube.

The radon exhalation rate in terms of mass is calculated by using equation (Mohamed Abd-Elzaher, 2012; Abu-Jarad, 1988):

$$E_M = \frac{C V \lambda}{M T_e} \tag{5}$$

Where, E_M : the radon exhalation rate in terms of mass (Bq/ kg.d), C : the integrated radon exposure with unit (Bq.m^{-3}.h), M : the mass of the tea sample, V : the effective size of the can in (28.848 cm^3), T_e : the exposure time (62 day) and λ : the decay constant for radon.

The uranium concentration C_U of tea samples have been calculated by using the formula (Abbas *et al*., 2013; Rasheed *et al*., 2013):

$$C_U(ppm) = \frac{W_U}{W_S} \tag{6}$$

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

Results and Discussion

In this study, 20 different tea samples were analyzed using closed technique. The values of the effective

Table 1 : Track density, Radon concentration, Radium effective concentration, surface and mass exhalation rates and uranium concentration and for tea samples.

Code	Sample Name	ρ Trak/cm²	C_S Bq/m³	C_{Ra} Bq/Kg	E_MmBq/kg.h	E_AmBq/m².h	C_U ppm
T1	Albulabl tea	3120	225.662	0.556	0.101	1.573	0.452
T2	Alcafe tea	800	57.862	0.143	0.026	0.403	0.116
T3	Tiger tea	940	67.988	0.168	0.030	0.474	0.136
T4	Ceyhan tea	1245	90.048	0.222	0.40	0.628	0.180
T5	Al- waza tea	2100	151.888	0.374	0.068	1.058	0.304
T6	Captain tea	620	44.843	0.110	0.020	0.312	0.090
T7	Alafhdal tea	2250	162.737	0.401	0.073	1.134	0.326
T8	Ahmed tea	545	39.418	0.097	0.018	0.275	0.079
T9	Prairie tea	525	37.972	0.094	0.017	0.265	0.076
T10	Bee tea	1820	131.636	0.324	0.059	0.917	0.264
T11	Black tea Mahmoud	965	69.796	0.172	0.031	0.486	0.140
T12	Perfume tea	4275	309.200	0.762	0.138	2.155	0.619
T13	Cardmom tea	1510	109.215	0.269	0.049	0.761	0.219
T14	Mahmoud green tea	1740	125.850	0.310	0.056	0.877	0.252
T15	Farm tea	1540	111.384	0.274	0.050	0.776	0.223
T16	Alhassan tea	1920	138.869	0.342	0.062	0.968	0.278
T17	Grape tea	1620	117.171	0.289	0.052	0.817	0.235
T18	Royal Tea	4115	297.628	0.733	0.133	2.074	0.596
T19	Zain tea	1630	117.894	0.290	0.053	0.822	0.236
T20	Apple tea	3595	260.017	0.641	0.116	1.812	0.521
Min		525	37.972	0.094	0.017	0.265	0.076
Maximum		4275	309.2	0.762	0.4	2.155	0.619
Mean		1843.75	133.353	0.328	0.077	0.929	0.267

radium content, uranium concentrations, surface exhalation and mass exhalation rates are listed in table 1.

From these data, we noticed that the value of effective radium content in collected samples varies from (0.094 to 0.762 Bq/kg) with a mean value of 0.328 Bq / kg. Also, the mass exhalation average has been varied from (0.017 – 0.138 m*Bq*/kg.h), a mean value of 0.059 mBq/kg.h, the surface exhalation averages found to ranged from (0.265–2.155 mBq/m².h, with a mean value of 0.929 mBq/m².h.

As well as, It has been shown that the highest uranium concentration was 0.619 ppm in (Perfume tea) while the lowest uranium concentration was 0.076 ppm in (Prairie tea) with mean value 0.267 ppm. These results are less than those of Iraqi researchers when they studied radiation activity in foods such as rice and vegetables (Abdalsattar and Laith, 2015). Radium concentrations in this study were higher than the radium concentrations in tea and coffee for other researchers (Al–Goubory, 1999; Yasser *et al.*, 2009). By comparing the results of the study with the permissible limits of the radiation activity of uranium and radium in some foodstuffs globally, it can be said that these results do not constitute a danger to the health of people and can be considered within the limits allowed internationally. The difference and variation in the concentration of tea samples used in the study for uranium and radium and the rate of the emission of radon is due to many reasons. Tea is an agricultural plant grown in different agricultural soils, where the nature of agricultural soil varies from place to place, in addition to the type of chemical fertilizer used in the cultivation of tea and the extent of contain the nuclei radiation, which lead to increased radiation activity in tea and other food that is grown in those soils.

Fig. 2 have shown the distribution of radium content for all different tea samples. Fig. 3 shows the positive correlation between effective radium content and mass exhalation rate for radon ($R^2 = 0.9999$), while figures 4 and 5 show excellent correlation between effective radium content with surface exhalation rate for radon and uranium concentrations (R^2=1), respectively.

A study of uranium concentration, effective radium content and radon exhalation rates from different food

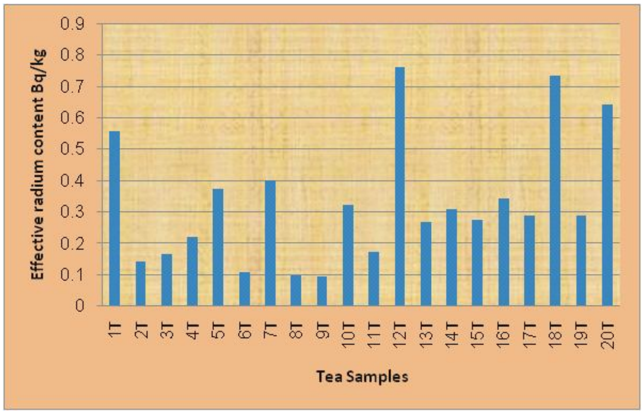

Fig. 2 : Effective radium content for different tea samples.

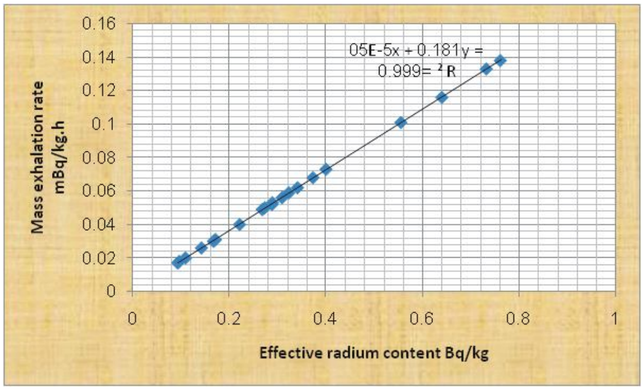

Fig. 3 : Correlation between effective radium content and mass exhalation rates for different tea samples.

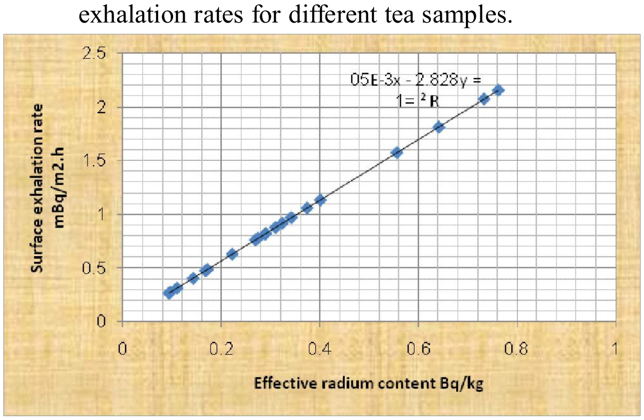

Fig. 4 : Correlation between effective radium content and surface exhalation rates.

samples is important for understanding the relative contributions of individual materials to the total uranium, radium and radon content found inside the body. A relatively high value of radon content in different food samples in due to the naturally occurring of uranium and radium isotopes in soil.

The fixing of "radium and uranium" concentrations in tea samples is very important in the study of the natural resources of these isotopes.

We found the uranium content in the tea samples

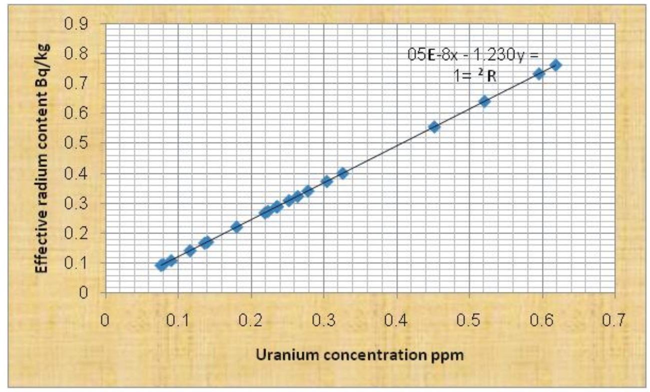

Fig. 5 : Correlation between uranium concentration and effective radium content.

was low and not significant from a health hazard point of view.

Conclusion

The concentrations of Uranium, radium and radon exhalation rate were measured using a closed can technical process.

The results shows that the radium and uranium concentration in tea samples were extended between (0.094 to 0.762 Bq/kg) and (0.076 - 0.619 ppm) respectively. In addition, the highest ratio of concentration was found in Perfume tea (T12), whereas the lower ratio of concentration was found in the Prairie tea (T9). Also shows that, the mean values of radium and uranium concentrations for all tea samples are equal, 0.328 Bq/kg and 0.267 ppm, respectively. positive correlation between effective radium content and mass exhalation rate for radon(R^2=0.9999), while excellent correlation between effective radium content with surface exhalation rate for radon and uranium concentrations (R^2 = 1), respectively. The results have showed that the samples were safe as far the health hazard effects are concerned. Of the results of the study and compared with the results of other studies of former researchers included other food items can be called within internationally permissible limits and not a threat to human health and life.

References

Abbas, J. Al-Saadi, Abdalsattar, K. Hashim, Fadhil and M. Hussein (2013). Measurement Of Radon And Uranium Concentrations In The Dates And Their Seeds Of Different Regions In Karbala Governorate. *Journal of Babylon University/Pure And Applied Sciences*, **21(6)** : 2134-2147.

Abdalsattar, K. Hashim and Laith A. Najam (2015). Alpha Radioactivity in Various Brands of Rice in Iraqi Market. *International Journal of Environmental Monitoring and Protection*, **2(5)**: 70-75.

Abdalsattar Kareem Hashim and Elham Jasim Mohammed (....). Natural Radioactivity Due To Radon In Dwellings Of Karbala City, Iraq. *Int. J. Adv. Res*., **4(8)** : 1164-1171.

Abdalsattar Kareem Hashim and Laith Ahmed Najam (2015). Radium and Uranium Concentrations Measurements in Vegetables Samples of Iraq. *Detection*, **3** : 21-28.

Abdullah, I. and Mohammad Nabil N. Al-Zubaidy (2012). Estimation of natural radioactivity in water and soil in some villages of Irbid city. Applied Physics Research; Published by *Canadian Center of Science and Education*, **4 (3)** : 1916-9647.

Abumurad, K. M., B. Al-Bataina, A. Ismail, M. Kullab and A. Al-Eloosy (1997a). A survey of radon levels in Jordanian dwellings during an autumn season. *Radiat. Prot. Dosim*., **69** : 221–226.

Abu-Jarad, F. (1988). Application of nuclear track detectors for radon related measurements. *Nuclear tracks Radiat. Meas*., **15(1-4)** : 525-534.

Al-Bataina, B., A. Ismail, M. Kullab, K. Abumurad and H. Mustafa (1997). Radon measurements in different types of natural waters in Jordan. *Radiation Measurement*, **28(1)** : 591- 594.

Al–Goubory, M. (1999). Determination of ^{222}Rn in Different Types of Tea. *M.Sc. Thesis*, College of Science, Mosul University.

BEIR (Committee on Biological Effects of Ionizing Radiation) (1999). *Health Effects of Exposure to Radon*. BEIR VI. National Academy Press, Washington, DC.

Mittal, S., S. S. Bhatti, A. S. Jodha, S. Saravanan, D. Gopalani, S. Kumar and P. C. Kalsi (1998). Proc. XI National Symp. "On SSNTDs and applications", ed. Surinder Singh, Amritsar, 307.

Cabrera, C., R. Artacho and R. Giménez (2006). Beneficial effects of green tea – a review. *Journal of the American College of Nutrition*, **25 (2)** : 79–99. PMID 16582024.

Durrani, S. A. and R. K. Bull (1987). Solid State Nuclear Track Detector Principle, Method and Application, International Series in Natural Philosophy. Volume-III.

Durrani, S. A. and R. Ili'c (eds.) (1997). Radon Measurements by Etched TrackDetectors: Application to Radiation Protection, Earth Sciences and the Environment. World Scientific, Singapore.

Gamboa, Estisona, A. Moreno, J. I. Golzari and F. Costillo (1984). *Nuclear Track and Measurement*, **1** : 443-445.

Iyer, R. H. and N. K. Chaudhuri (1997). Development of the Track Registration Technique in Solid State Nuclear Track Detector from Solution Media and Its Application. *J. Rad. Meas*, **27(4)** : 529-.548,.

Kant, K., S. B. Upadhyay and S. K. Chakarvarti (2005). Alpha activity in Indian thermal springs. *Iran. J. Radiat. Res.*, **2 (4)** : 197-204.

Khan, M. S., M. Zubair, D. Verma, A. H. Naqvi, A. Azam and M. K. Bhardwaj (2011a). The study of indoor radon in the urban dwellings using plastic track detectors. *Environ Earth Sci*., **63** : 279–282.

Mohamed Abd-Elzaher (2012). An Overview on Studying 222Rn Exhalation Rates using Passive Technique Solid-State Nuclear Track Detectors. *American Journal of Applied Sciences*, **9 (10)** : 1653-1659.

Nazaroff, W. W. and A. V. Nero Jr (eds.) (1988). Radon and its Decay Products in Indoor Air John-Wiley and Sons.

Ody, P. (2000). *Complete Guide to Medicinal Herbs*. New York, NY: Dorling Kindersley Publishing.48.

Rasheed, M. Yousuf and Kamal O. Abullah (2013). Measurement of Uranium And Radon Concentrations in Resources of Water From Sulaimany Governorate -Kurdistan Region-Iraq. *ARPN Journal of Science And Technology*, **3(6)** : 632-638.

Shakir Khan, M., D. S. Srivastava and Ameer Azam (2012). Study of radium content and radon exhalation rates in soil samples of northern India. *Environmental Earth Sciences*, **67(5)** : 1363-1371.

Somogi, G., A. Hafez, I. Hunyadi and M. Toth - Szilagyi (1986). Measurement of Exhalation And Diffusion Parameters of Radon In Solids By Plastic Track Detectors. *Nucl. Track Radiat. Meas*., **12 (1-6)** : 701-704.

Von Philipsborn, H. (2003). Radioactivitaet und Strahungsmessung. Bayerisches Staatsministerium fuer Umwelt, Gesundheit und Verbrauerschutz, 8(Chapter 2).

Yasser, H. Al-Mashhadani Khalid and A. Jassim Hayfa A. Al–Sawaf (2009). Radon and Radium Determination in Coffee Using CR-39 Nuclear Track Detector. *J. Raf. Sci*., **20(1)** : 105- 108.