Determination of Outdoor Radon Concentrations at Madenat Al-Elem University College using CR-39 detector

Shaker M.M.Al-Jobori, Khalid H.Mahdi, Wasof O.Hatab, Haziml.Mansour

***Abstract*— In the present work , radon gas concentration ,effectiveradium content and both area (surface) and mass exhalation rates in soil samples collected from different locations in Madenat Al-Elem have been measured using CR-39 track detectors . Values of the average radon gas concentration were found to vary from (25.370 Bq /m3) to (40.580 Bq / m3) . Radium equivalent content values were found to vary from (10.186 Bq / kg) to (16.293 Bq / kg).Area (surface) exhalation rate values were found to vary from (0.439 Bq/ m h) to (0.700 Bq/m h) . Mass exhalation rate values were found to vary from (0.017Bq/ kg h) to (0.027Bq/kg h). All the results obtained in the present work were found to be less than their corresponding world limits .Thus, the present results have revealed that , radon gas concentration , radium equivalent content and both area and mass exhalation rates in the studied area do not pose risk to human health .**

***Index Terms*— Radon gas, soil, CR-39 detector, Area (surface)Exhalation Rate, Mass Exhalation Rate, effective Radium content.**

I. INTRODUCTION

Radon (^{222}Rn) is a radioactive gas with a half- life of about (3.825 day) and decay constant of about (0.1812 day^{-1}) [1]. It is produced by the decay of naturally occurring radionuclide (radium) (^{226}Ra), which is in turn a decay product in the uranium (^{238}U) series [2]. Since radon is a gas, it may escape into the air from the material in which it is formed, and since uranium and radium occur widely in soil, rocks and sand, radon gas is ubiquitous-outdoors as well as indoors, the air that we inhale contains radon. The radon gas has been recognized as a radiation hazard causing excess lung cancer among underground miners [3].

Radon is the largest and most variable contributor of public exposure to radiation. It is estimated that the annual effective dose of radon and its progeny from the inhalation of air is about (55%) of natural public exposure dose rate and prolonged exposure to high levels of radon can cause lung cancer [4]. The proportion of lung cancers attributable to radon is estimated to ranged from about (3%) to (14%).Significant health effects which have been seen in uranium miners who were exposed to high levels of radon. However, studies in Europe,North America and China have confirmed that lower concentrations of radon such as those found in homes also cause health risks and contribute substantially to the occurrence of lung cancers worldwide. The risk of lung cancer increases by about (16%) per (100 Bq/m3) increase in radon concentration, the dose-response relation is linear, i.e. the risk of lung cancer increases with increasing radon exposure [5].

The use of the (CR-39) plastic as a nuclear particle detector has become generalized in the fields of dosimetry, spectroscopy and environmental science due to its high sensitivity. Most of the applications of this detector are proton, alpha and neutron dosimetry and radiography as well as for radon dosimetry and cosmic rays studies [6].

In the present work, radon conccentrations and some other relatedparameterswere determined in Madenat Al-Elem University College using CR-39 detector.

II. EXPERIMENTAL PART

2.1 Calculation of Radon gas concentrations

The alpha particles concentration emitted from Radon gas in soil surface samples were determined by using the nuclear track detector (CR-39) of thickness of about (250 µm) and area of about (1cm×1 cm).

The soil surface samples were collected from different sites in Madenat Al-Elem University Collegeas shown in Figur(1) and Table (1).

The samples were cleaned, and placed in an oven for drying at a temperature of 80°C for 2h until a constant weight was reached.The dried samples were grinded into a fine powder and passed through sieve with size of about 75 µm, and mass of about (10 g).

The Radon gas concentration in soil samples was obtained by using the sealed-cup technique as shown in Figure (1),which were left for about (30 days) to attain seqular equilibrium.

After the exposure time (60 days), the (CR-39) track detectors were etched in (6.25 N) (NaOH) solution at temperature of (60 ^{o}C) for (5 h) [7] and the tracks density were recorded using an optical microscope with magnification of (400X). The density of the tracks (ρ) of the samples were calculated according to the following relation [5].

$$\text{Tracks density } (\rho) = \frac{N_{ave}}{A} \text{ - - - - - - - - - - - - - (1)}$$

Where:

N_{ave} : Average number of total pits(tracks).

A : Area of field view.

An example of the photograph of observed tracks with the samples is shown in Figure (2).

The Radon gas concentration in the soil samples were obtained by the comparison between track densities registered on the detectors of the samples and that of the standard soil samples which are shown in figure (3), using the relation [7]:

$C_X = C_s(\rho_x / \rho_s)$ ---------- (2)

$Cx = \rho_x$ / slope ---------- (3)

Where:
CX: alpha particles concentration in the unknown sample.
C_S : alpha particles concentration in the standard sample.
P_X: track density of the unknown sample (track/mm2).
P_S: track density of the standard sample (track/mm2).

Figure (1) Map Satellite for Madenat Al-Elem University Collegesite and locations of the Samples.

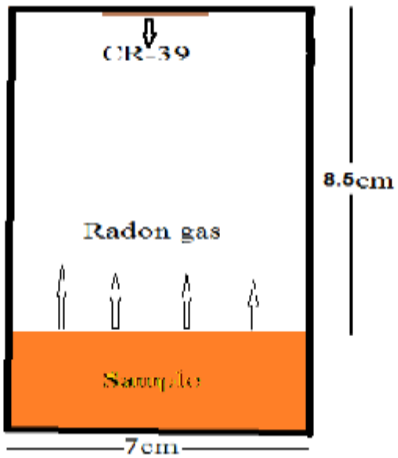

Figure (2)Schematic diagram of the sealed-cup technique.

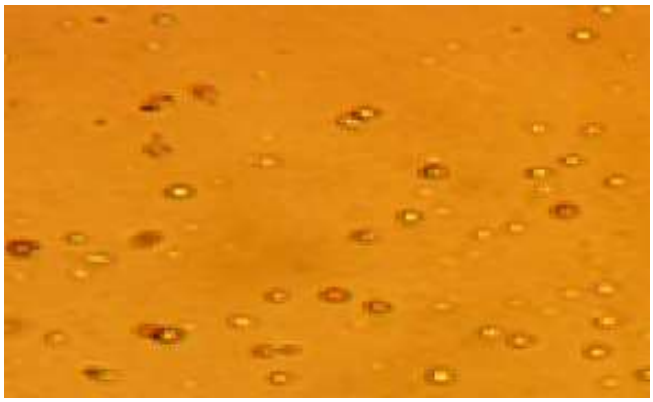

Figure (3)Photograph of tracks in CR-39 detector for a soil sample

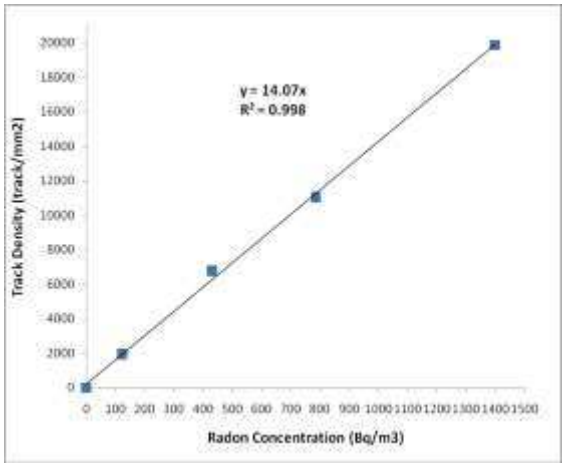

Figure (4)The relation between track density and radon concentration for standard soil samples.

2.2 Effective Radium Content

The effective radium content of the soil surface sample in unit (Bq/kg) can be obtained by using the relation[8]:

$$C_{Ra}\ (Bq.kg^{-1}) = \frac{\rho.h.A}{K\,.\,T_e.M} \text{ ---------- (4)}$$

Where, ρ is track density (track/mm^2),A is the surface area of the sample (0.00385 m^2),K is the calibration factorequal to the slope/ exposure time, h is the distance between the detectors and top of the sample, M is mass of the sample(0.01kg) , $T_e$is the effective exposure time(h) given by the relation[9]:

$$T_e = T - 1/\lambda(1 - e^{-\lambda T}) \text{ ---------- (5)}$$

Where:
λ: The decay constant of radon (0.1814d^{-1}).
T: The time of exposure .

2.3 Radon Exhalation Rates

Radon exhalation rates in terms of area and mass were calculated from the following equations[8,9]:

Area Surface Exhalation Rate

$$E_{Area} = \frac{C.V\lambda}{A[T+\lambda^{-1}(e^{-\lambda T}-1)]} \quad (Bq.m^{-2}.\,h^{-1}) \text{ ---------- (6)}$$

Mass Exhalation Rate

$$E_{Mass} = \frac{C.V\lambda}{M[T+\lambda^{-1}(e^{-\lambda T}-1)]} \quad (Bq.kg^{-1}.\,h^{-1}) \text{ ---------- (7)}$$

Where, C is the radon concentration in (Bq / m^3), V is the effective volume of cup (m^3), T is Time of exposure (hour), M is Mass of the sample, λ is the decay constant for radon (h-1).

III. ESULTS AND DISCUSSION

Table (1) present the radon gas concentrations in surface soil samples (obtained by using relation (3)) for the selected regions in Madenat Al-Elem University College studied in the Present work .

From Table (1) it can be noticed that , the highest average radon concentration in surface soil samples was found in indoor gardens location which was equal to (40.580 Bq /m3) , while the lowest average radon concentration was found in College Garage location which was equal to (25.370 Bq /m3) .

A part from indoor garden location , the present results were only slightly higher than (or even consistent when taking in to consideration the combined experimental error) the relatively recent results of Karim [10] , when he studied the average

radon concentrations in surface soil for selected regions in Baghdad Governorate . However , all the present results of the average radon concentrations and for all the studied locations were found to be less than the recommended value of (200 Bq /m3) given by (ICRP , 1993) [11] .

Table (2) presents results for the radium equivalent content (obtained by using equation (4)) , from which it can be noticed that the highest radium equivalent content was found in gardens location which was equal to (10.186 Bq / kg) , while the lowest radium equivalent content was found in college Garage location which was equal to (16.293 Bq / kg) .

For all loactions studied , the present results for effective radium content were found to be less than the permissible value of (370 Bq / kg) as recommended by the Organization for Economic Cooperation and Development [12] .

Also from Table (2) , it can be noticed that the values of the area (surface) and mass exhalation rates were found to be varied from (0.439Bq/ m h) to (0.700Bq /m h) and from (0.017 Bq/ kg h) to (0.027 Bq/ kg h) for area (surface) and mass exhalation rates respectively .It should be mentioned that , the observed values of the radon exhalation rate in the present work were below the world average of (2.5 Bq/ m h) [13] .

IV. Conclusions

Radon gas concentration , effective radium content , area (surface) and mass exhalation rates were obtained for soil samples which were collected from different locations in Madenat Al-Elem University College . The results of the present work were found to be less than their corresponding permissible world values . Thus , the present results revealed that the area is safe as far as the health effect are concerned .

Table (1) Location, Sample number and Radon Concentration for the different locations Studied in Madenat Al-Elem University College.

Location	Sample Number	Track Density (track/mm^2)	Radon Concentration (Bq/kg)
Deanship(A)	A1	2112.304±45.960	30.031
	A2	2407.286±49.064	34.226
	A3	1973.037±44.420	28.052
	A4	1612.008±40.498	22.919
	A5	1817.949±42.637	25.847
	Average	1984.502±44.548	28.215
Indoor gardens (B)	B1	2801.865±52.933	39.836
	B2	2863.268±53.510	40.709
	B3	2989.167±54.673	42.499
	B4	2813.134±53.030	39.982
	B5	2797.434±52.891	39.773
	Average	2854.194±53.425	40.580
College Garage(C)	C1	1949.897±44.158	27.723
	C2	1742.831±41.747	24.779
	C3	1734.533±41.648	24.661
	C4	1861.345±43.143	26.464
	C5	1633.530±40.417	23.225
	Average	1784.399±42.242	25.370
Stadium(D)	D1	1776.521±42.149	25.258
	D2	1990.410±44.614	28.299
	D3	1723.911±41.520	24.510
	D4	1827.963±42.754	25.989
	D5	1833.633±42.821	26.070
	Average	1830.468±42.784	26.025
High pressure lines(E)	E1	1804.866±42.484	25.661
	E2	2240.803±47.337	31.859
	E3	2072.772±45.528	29.470
	E4	2116.099±46.001	30.086
	E5	2360.161±48.581	33.556
	Average	1978.242±44.477	28.126

Table (2) The effective radium content,Area Surface Exhalation Rate And Mass Exhalation Rate.

No.	Radon Concentration (Bq/kg)	Radium Equivalent (Bq/kg)	Surface emission rate (Bq/ m h)	mass emission rate (Bq/kg h)
A	28.215	11.329	0.487	0.019
B	40.580	16.293	0.700	0.027
C	25.370	10.186	0.438	0.017
D	26.025	10.449	0.449	0.017
E	28.126	11.293	0.485	0.019

References

[1] Deka P.C., Subir S., Bhattacharjee B., Goswami T.D., Sarma, B.K. and Ramachandran, T.V., "Measurement of radon and thoron concentration by using LR-115 type-II plastic track detectors in the environ of Brahamaputra Valley, Assam, India", Radiation Measurements, 36, pp.431-434, (2003).

[2] 2-Lubin J.H., Wang Z.Y., Wang L.D., Boice J.D., Cui H.X., Zhang S.R., Conrath S., Xia Y., Shang B., Cao J.S., and Kleinerman, R.A., "Adjusting lung cancer risks for temporal and spatial variations in radon concentration in dwellings in Gansu province" Radiat. Res. , 163, pp.571-579, (2005).

[3] 3-Shashikumar.T.S, Chandrashekara.M.S, Paramesh.L " Studies on Radon in soil gas and Natural radionuclides in soil, rock and ground water samples around Mysore city" International Journal of Environmental Sciences, 1,No.5, pp.787-797, (2011).

[4] 4-Dey G. K. and Das P. K. "Estimation of radon concentration in dwellings in and around Guwahati" Indian Academy of Sciences, 121, No.1, pp.237-240, (2012).

[5] 5-Chauhan R.P., Nain M., and Kant K., " Radon diffusion studies through some building materials: Effect of grain size", Radiation Measurements, 43, pp.445-448, (2008).

[6] 6-Al-Fifim Z., El-Araby E.H. and ElhaesH.,"Monitoring of Radon Concentrations in Jazan Beach Soil " Journal of Applied Science, 8, No.2, pp.823-827, (2012).

[7] 7- Khalid H. Mahdi, Hadeel G. Ishnayyin. and Lina M. Haider, "Radon Concentration and its Doses in Dwellings of Baghdad City and In Dora Refinery Using Nuclear Track Detector (CR-39)", J. Chem. Bio. Phy. Sci. Sec. C, Vol.5(3), p(3336-3350), May 2015 – July 2015.

[8] 8-Zubair M, Shakir Khan M. and Verma D, "Measurement of radium concentration and radon exhalation rates of soil samples collected from some areas of Bulandshahr", Iran.j. Radia. Res., 10(2): 83-87, (2012).

[9] 9-Abd-Elzaher M, An over view on studying 222Rn exhalation rate using passive technique solid- state nuclear track detector, American Journal of Applied Science, 9(10), 1653-1659,(2012).

[10] 10- Karim M . S . , " Study of Radio activity and Radon gas Emanation in some Iraqi Governorates " , Ph . D . Thesis , college of Education , Al-Mustansiriyah University , (2015) .

[11] 11- ICRP " International Commission on Radiological Protection Against Radon-222 at Home and work " Publication 65 , Pergamon Elsevier , 35, P .242 , (1993) .

[12] 12- Organization for Economic Cooperation and Development (OECD) , Nuclear Energy Agency , Paris , France , (1979) .

[13] 13- UNSCEAR . Report of the United Nations Scientific Committee on the Effect of Atomic Radiation to the General Assembly . ANNEX B Exposures from natural radiation sources , (2000)