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Determination of Radon Concentrations in Soil Around Al-Tuwaitha Site Using CR-39 Detector

Abstract: *In this work radon concentration in 37 soil samples collected from 17 regions surround the (Al Tuwaitha) were measured by using solid-state nuclear track detector (SSNTD.s) CR-39 with natural exposure of one month, and by comparison with standard samples. The radon concentration in the soil samples was about (9.583 ± 0.369 – 28.029 ± 0.631) Bq/m^3 in locations one (Rotate Salman) and eight (An area agricultural near high-voltage towers) respectively, with rate of (20.939 ± 0.541) Bq/m^3. The specific activity of radium (Ra) dissolved during generate radon were ranging between (٢.٣٧ – ٩.٨٥٧) Bq.kg^{-1}, with rate of (٧.٣٩٣) Bq.kg^{-1}, surface emission of radon gas rate in the soil was found between (0.١٤٤ – ٠.٤٢٢ Bq/m^2.h) with rate of (٠.٣١٤ Bq/m^2.h) and their mass emission of radon gas rate has the highest value of (0.٠١٦ Bq / kg . h) and lower value (0.0٠٥ Bq / kg . h) with rate of (0.0١٢ Bq / kg . h. These results are within the acceptable limit that recorded by UNECEAR and ICRP.*

Keywords- *Radon gas, soil, CR-39 detector, Area Exhalation Rate, Mass Exhalation Rate, Radium concentration.*

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1. Introduction

Radon is a noble element, which has 86 protons, chemically inert and radioactive by emission α-particle, which has high ability to migrate through material like soil, air, etc. [1]. Radon has three important isotopes. They are: (1) radon (^{222}Rn) which is a produced from ^{238}U series, (2) Theron (^{220}Rn) which is a produced from ^{232}Th series and (3) actinon (^{219}Rn) which is a produced from ^{235}U series. Radon daughters or radon decay products, or radon progeny are ^{218}Po, ^{214}Pb, ^{214}Bi, and ^{214}Po [2]. Two of these, ^{218}Po and ^{214}Po emit alpha particles which are the main source of radiation damage when they decay in the lung [3]. UNSCER has been reported that radon and its progeny contributed about 50% of total effective dose [4]. The aim of present work was the calculation of outdoor radon concentrations around Al-Tuwaitha sites in order to monitor the radiation level in this area and its effects.

2. Experimental-Part

Radon emitted from soil surface samples which determined by using CR-39 track detector of thickness (250μm) with dimensions of (1×1 cm^2). Soil samples were collected from a different area from the Tuwaitha in Baghdad as shown in Table 1 and Figure 1. The samples were dried at 80°C by using the oven for 2 hours, then grind to a fine powder and sieved with 75 μm, and then (10 g) of the sample placed in a cup for the exposure process. The concentration of Radon in soil samples was obtained by using the sealed-cup technique as shown in Figure 2. The exposure time was thirty day, then the detector etched by (6.25 N) with (NaOH) solution at (60 oC) for (5 hours) .The number of tracks was calculated by optical microscope by magnification of (400X). Then the density of tracks was calculated by following relation [5]. The density of track (ρ) was calculated by dividing the number of tracks on the area of view.

Figure 3 shows the photograph of tracks. By comparison with standard soil sample (figure 4), we can determine the concentration of radon in samples using the relation [5]:

$$C_x = C_s (\rho_x / \rho_s) \quad (1)$$

$$C_x = \rho_x / \text{slope} \quad (2)$$

C_x is the concentration in the sample and C_s is the concentration in the standard sample.

ρ_x is the density of tracks in unknown sample with (track/mm^2) and ρs density of tracks in the standard sample with (track/mm^2).

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Figure 1: Map Satellite for AL-Tuwaitha site and locations of the Samples

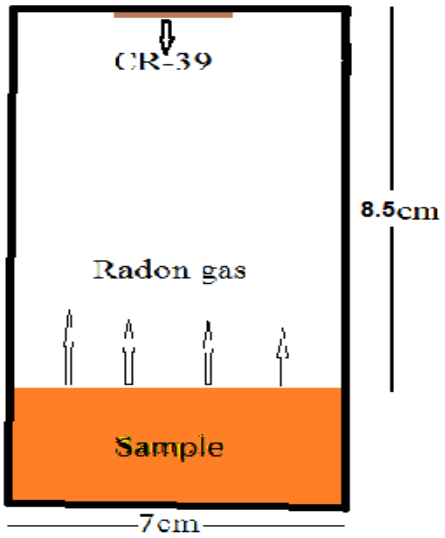

Figure 2: The sealed cup technique

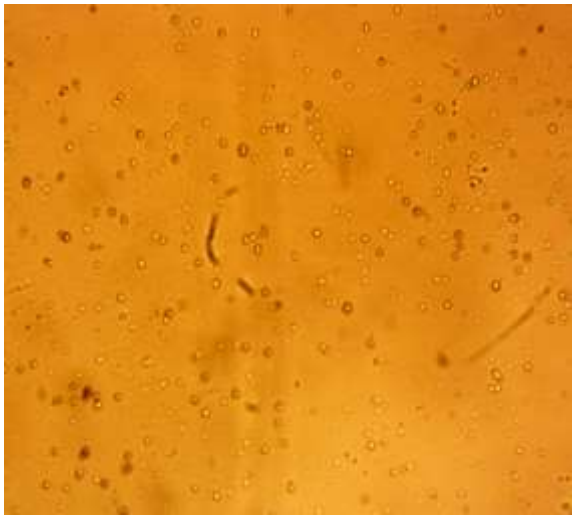

Figure 3: The photograph of tracks for one of the samples

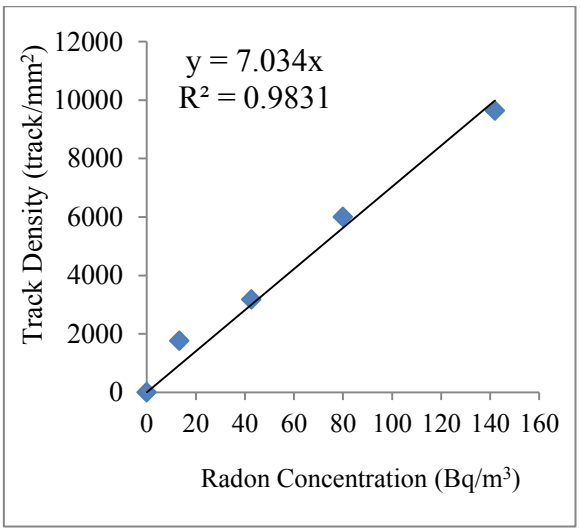

Figure 4: Track density vs. radon concentration for standard soil samples

Effective radium content can be calculated by using the following relation [6].

$$C_{Ra}\left(\frac{Bq}{kg}\right) = \frac{\rho.d.A}{K.T_e.M} \quad (3)$$

Where:

ρ is track density (track/mm^2), A is surface area of the sample in (0.00385 m^2), K is the calibration factor equal to the slope / exposure time, d is distance between the detectors and top of the sample in (0.102 m), M is Mass (0.01kg) of the sample , T_e is the effective time for exposure and given by the relation [7].

$$T_e = T\text{-}1 / \lambda (1- e^{-\lambda T}) \quad (4)$$

Where:

λ: Constant of radon decay (0.1814d^{-1}).

T: Exposure time (in this study was 30 day).

The area and mass exhalation rate for radon were calculated by following equations:

Area Exhalation Rate

$$E_{Area} = \frac{C.V.\lambda}{A[T+\lambda^{-1}(e^{-\lambda T}-1)]} \quad (Bq\ .\ m^{-2}.\ h^{-1}) \quad (5)$$

Mass Exhalation Rate

$$E_{Mass} = \frac{C.V.\lambda}{M[T+\lambda^{-1}(e^{-\lambda T}-1)]} \quad (Bq\ .\ kg^{-1}.\ h^{-1}) \quad (6)$$

Where, C is a concentration of radon in (Bq/m^3), V is the effective volume of a cylinder (m^3), T is exposure time in (hours), M is the sample mass (kg) [6,7].

Table 1: The symbol, locations and the (GPS) of samples.

No.	symbol	Locations	GPS
1	S.1	Rotate Salman near (Taha mosque)	33°12'59.0"N, 44°32'59.3"E
	S.2		
2	S.3	Stores of the tuwaitha site	33°13'15.9"N, 44°32'22.7"E
	S.4		
3	S.5	Municipal council	33°13'12.3"N, 44°31'31.3"E
	S.6		
4	S.7	The hospital (Ibn Zahr)	33°13'25.4"N, 44°30'39.4"E
	S.8		
5	S.9	Beginning of tuwaitha site	33°13'19.6"N, 44°30'40.7"E
	S.10		
6	S.11	End of tuwaitha site	33°12'14.3"N, 44°29'42.3"E
	S.12		
7	S.13	High-voltage towers	33°10'55.7"N, 44°30'01.5"E
	S.14		
	S.15		
8	S.16	An area agricultural near high-voltage towers	33°10'40.6"N, 44°29'49.8"E
	S.17		
9	S.18	Orchard near the end of the tuwaitha site	33°12'05.3"N, 44°29'39.4"E
	S.19		
	S.20		
10	S.21	Department liquefaction water	33°12'54.5"N, 44°30'17.5"E
	S.22		
11	S.23	Near a large mound of dirt	33°12'37.0"N, 44°30'36.2"E
	S.24		
	S.25		
	S.26		
12	S.27	Farm(1) in Jabir Al-Ansari neighborhood	33°11'46.8"N, 44°32'45.5"E
	S.28		
13	S.29	Farm(2) in Jabir Al-Ansari neighbourhood	33°11'50.5"N, 44°32'39.0"E
	S.30		
14	S.31	Farm(3) in Jabir Al-Ansari neighborhood	33°11'43.8"N, 44°32'41.7"E
	S.32		
15	S.33	Farm(4) in Jabir Al-Ansari neighborhood	33°11'39.9"N, 44°32'34.1"E
	S.34		
16	S.35	Ishtar region	33°11'32.9"N, 44°31'49.3"E
	S.36		
17	S.37	Al -Waredya region	33°11'16.3"N, 44°32'22.5"E

3. Results and Discussion

Radon concentrations results in Table 2 shows that the high value was (28.029 ± 0.631) Bq/m^3 in location no.8 (an area agricultural near high-voltage towers) and the low value was (9.583 ± 0.369) Bq/m^3 location no.1 (Rotate Salman near taha mosque), with rate of (20.939 ± 0.541) Bq/m^3 , Radium concentrations shows that the high value was (٩.٨٥٧) Bq/kg in location no.8 and low value was (٣.٣٧) Bq/kg in location no.1, with rate of (٧.٣٩٣) Bq/kg.

The area exhalation rate was (٠.٤٢٢ Bq/m^2.h) in location no.8 and (0.١٤٤ Bq/m^2.h) in location no.1, with rate of (٠.٣١٤ Bq/m^2.h), and the mass exhalation rate was (0.٠١٦ Bq/kg.h) in location no.8 and (0.0٠٥ Bq/kg.h) in location no.1, with rate of (0.0١٢ Bq/kg.h).

All the results were below the acceptable levels as limited by UNSCEAR [4] and ICRP [8].

Table 2: Results of radon concentration, rate of radon exhalation and radium content in soil samples collected from studies area around AL-Tuwaitha site.

Location	Track Density (Track/mm^2)	C_{Rn} Bq/m3	S.A.* (ppm)	C_{Ra} Bq/kg	E_{Area} Bq.m^{-2}.h^{-1}	E_{Mass} Bq.kg^{-1}.h^{-1}
1	674.000 ± 25.962	9.583 ± 0.369	0.776	3.37	٠.١٤٤	٠.٠٠٥
2	873.228 ± 29.550	12.415 ± 0.420	1.005	4.366	٠.١٨٧	٠.٠٠٧
3	1094.285 ± 33.080	15.558 ± 0.470	1.259	5.471	٠.٢٣٤	٠.٠٠٨
4	1435.714 ± 37.891	20.413 ± 0.539	1.652	7.175	٠.٣٠٧	٠.٠١٢
5	1728.570 ± 41.576	24.576 ± 0.591	1.989	8.643	٠.٣٧٠	٠.٠١٤
6	1157.142 ± 34.017	16.452 ± 0.484	1.332	5.786	٠.٢٤٨	٠.٠٠٩
7	1828.570 ± 42.762	25.998 ± 0.608	2.105	9.143	٠.٣٩٢	٠.٠١٥
8	1971.428 ± 44.401	28.029 ± 0.631	2.269	9.857	٠.٤٢٢	٠.٠١٦
9	1700.000 ± 41.231	24.170 ± 0.586	1.957	8.5	٠.٣٦٤	٠.٠١٤
10	1457.142 ± 38.173	20.717 ± 0.543	1.677	7.286	٠.٣١٢	٠.٠١٢
11	1578.570 ± 39.731	22.444 ± 0.565	1.817	7.893	٠.٣٣٨	٠.٠١٣
12	1410.000 ± 37.550	20.047 ± 0.534	1.623	7.05	٠.٣٠٢	٠.٠١٢
13	1964.285 ± 44.320	27.928 ± 0.630	2.261	9.821	٠.٤٢١	٠.٠١٦
14	1657.142 ± 40.708	23.561 ± 0.579	1.907	8.286	٠.٣٥٥	٠.٠١٤
15	1492.857 ± 38.638	21.225 ± 0.549	1.718	7.464	٠.٣٢٠	٠.٠١٢
16	1564.285 ± 39.551	22.240 ± 0.562	1.800	7.821	٠.٣٣٥	٠.٠١٣
17	1450.000 ± 38.079	20.616 ± 0.541	1.669	7.25	٠.٣١١	٠.٠١٢
Average	1472.778 ± 38.072	20.939 ± 0.541	1.695	٧.٣٩٣	٠.٣١٤	٠.٠١٢

* S.A.: Specific activity

Note: The results in Table 2 represent the highest reading of among samples for the study sites.

4. Conclusion

Our conclusions were as follows:

1- Some of the results were close to the high acceptable levels, so it was necessary to study and monitoring this area periodically because it is the main source of nutrition, which there is an active agriculture in it.

2- The high levels of concentrations were in location no.8 near the high-power lines towers, which is was in agreement with Ref[9] about the effect of electromagnetic filed by high-power lines and with Ref[10] about the uranium concentrations in this area.

3- We think that the differences in concentrations of radon were due to many factors like moisture contents in the soil, the direction of the wind, the distance from high-power lines and the type of fertilizers that used in this area.

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Prof. Dr. Khalid H. Mahdi has a Ph.D. degree in nuclear physics from University of Baghdad, Iraq

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