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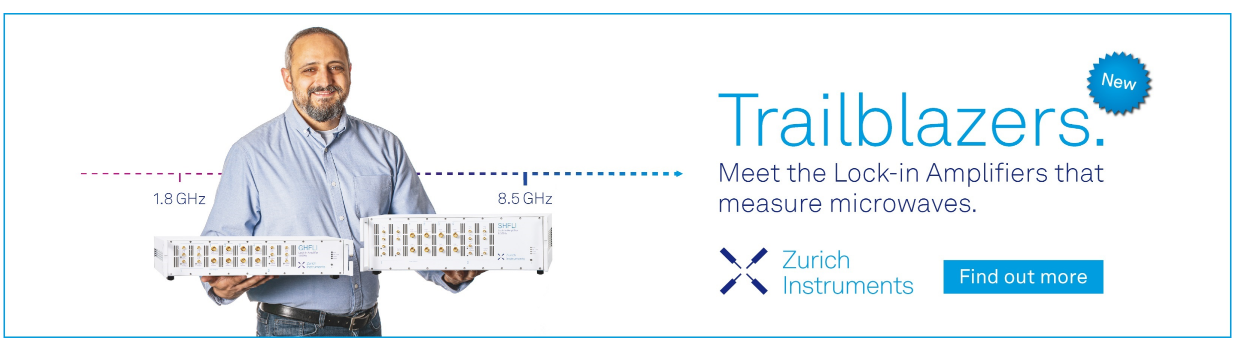

Measurement of Uranium Concentration and Radon Exhalation Rate using Can Technique Method in Some Soils Samples from Rammadi City, Iraq

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Abstract. Uranium, radium, and radon are radioactive effective nuclei that are present in the soil at various levels and to avoid the health hazard they must not exceed the permissible limit.. In present work the interesting with sixteen different soil samples collected from over various regions in Ramadi city, Iraq tested for uranium concentration using locked container technique which includes CR-39 passive detectors as nuclear solid-state track detector (SSNTD). It was found the content of uranium in soil samples have been found (0.71 ppm) to (5.73ppm). The Measurment included radon concentrations were varied from 1.34 $Bqkg^{-1}$ to 24.1 $Bqkg^{-1}$ with an average value of 12.6 $Bqkg^{-1}$, while radon exhalation rate also varied from (10.7x $10^{-3}Bqkg^{-1}$ h^{-1}) to (86.4x 10-3 $Bqkg^{-1}$ h^{-1}). The results were compared with national and worldwide results.

Keyworld: Uranium concentration, Radium content, Radon exhalation, CR-39.

INTRODUCTTION

Natural radiation represented by uranium and radon consider as a big contributor to radiation dose in the world. the exposure to that radiation at a specific location for a long period of time lead radiation hazard to the human. The human cannot avoid the different radiation in our biotic community. The uranium isotopes are one of the 1.1 to 10 ppm uranium that occurs on the earth crust [1] while the radioactive radon ^{222}Rn is correlated with abundance of uranium in the ground. These radioactive elements have difference in each soil and geological material.

The radon case an inert gaseous element can ran away easily from its source dependent on different factors. Hazard indices were widely studied [2],[3],[4] and for contributor to indoor our environmental was done by [5].The knowledge of the results of study uranium in soils useful in view front of health physics. Radon is a naturally radioactive element that occurs from the decay of radium (^{226}Ra), that product of decomposition of ^{235}U, ^{238}U and^{232}Th [6], which has a half-life of 1600 years that as long enough time to spread widely. Concentrations of uranium and thorium give the amount of radon in the soil [7]. Leakage of ^{222}Rn from soil rises as mechanisms that have an effect on internal radon levels. Transporting of^{222}Rn in soil to the surface is related to the size of soil area and is composition. Because of the depending of radon concentrations on soil pores, the radium content a depth and the emitting energy from radium content are very important beside the moisture of soil.

The technique of solid-state nuclear track detection (SSNTD) is very useful method that used widely to determine uranium contents. CR-39 is one of SSNTD has become the important tool for scientific works in, especially for radon gas measurement. Some worked placed samples in contact with the detector to make neutron irradiating detector possible and measuring track from induced fission.[8],[9],[10].

Therefore, the aimed of present study is to made a measurement the radiation level of radioactive nuclei in some soil samples. It is worth mentioning that these soils samples were collected from different locations in Ramadi city in order to examine the radioactive activity of some radioactive nuclei, which may cause different diseases, especially cancer, as the information data get from the measurement give an capability to used for assess the

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radiological activity of the environment. This research was also targeted toward analyzing uranium concentration and the mass surface exhalation rates of radon, in the samples using the solid state nuclear track detectors (SSNTDs CR-39 and benefited from the seals can technique.

AREA GEOLOGY

Ramadi is an Iraqi city, about 108 km west of Baghdad, which is the center of Anbar Province. This is situated between latitude 33°25' N and longitude 43°18' E. The study area is close to Ramadi city located in the Euphrates Valley, on both sides of Euphrates river course beside Habbanyiah lake (lie 84 km away from capital Baghdad), Fig.1.

The study area is located within the western parts of the sedimentary plain range due to the unstable berth of the Arab plate. In terms of syntax, the region is considered simple, as its sedimentary layers approach the horizontal position and indicators of local faults or spacers or lamellar strings are not present. It is generally graded, and is a term for geo-morphological level. The region is of a terrainic nature separated by a rock wall. One third of this region is a geo-morphological unit with deflection origin.

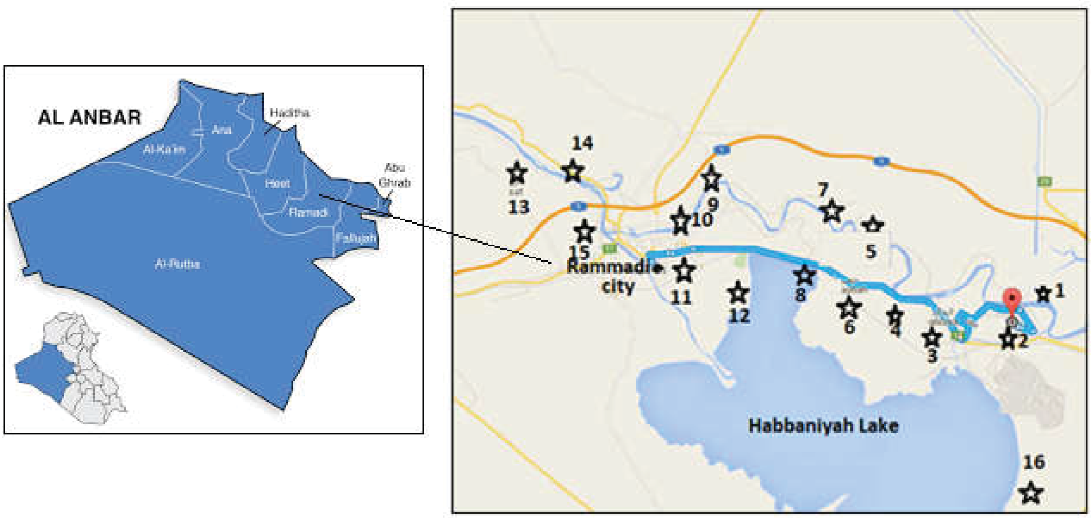


FIGURE 1. Map of study area.

THORETICAL ASPECTS

Using a theoretical model that proposed by Islam et al. [10] one can calculate uranium concentration and deduce the product rate of radon. If we consider an alpha decay chain to transfer from uranium (^{238}U) to ^{206}Pb and ^{235}U to ^{207}Pb, the number of alpha decays will be n=8 and n=7, respectively, so the total number of alphas per unit time will give as $N_\alpha = n\lambda N$ when λN is number of atoms decaying per unit time.

The soil samples contain C_U (ppm) of uranium with density (ρ) in 1 cm^3 of it contain uranium -238 given as [10]: $\rho\, C_U\, N_A \frac{10^{-6}}{238}$ and for uranium -235 as $\rho\, C_U\, N_A \frac{10^{-6}}{238\times 140}$.

where N_A is Avogadro's number and $\frac{1}{140}$ represent a ratio of the natural abundances of two isotopes ^{238}U and ^{235}U. So, the total numbers of alpha particles produced due to decays is [10]:

$\alpha_{total} = {}^{238}N_\alpha$ from ^{238}U $+ {}^{235}N_\alpha$ from ^{235}U

$$\alpha total = \rho\, CU\, NA \frac{10^{-6}}{238}\left[8\lambda_{238} + \frac{7\lambda_{235}}{140}\right] \quad [cm-3] \tag{1}$$

Number of alpha particles reaching the detector surface can found as a function of mean range (R_α) that is found to be 0.0048 cm from 4-8 Me$^-$V energy [11] that measures ranges of alpha particles emitted by series of random and thoron using TRIM program in the sample.

The trace density (ρ_t) in the plastic detector will found from a layer (dr) as [10]:

$$\rho t = \frac{1}{2}\alpha total \int_0^{R_\alpha}\left(1 - \frac{r}{R_\alpha}\right)dr = \frac{1}{4}\alpha total\, R\alpha \tag{2}$$

Substituting $\alpha_{total} = \frac{4\rho_t}{R_\alpha}$ in eq. (1) the concentration of uranium will be:

$$C_U = \frac{952\,\rho_t}{R_\alpha \rho N_A \left[8\lambda_{238} + \frac{7\lambda_{235}}{140}\right] 10^{-6}} \quad (3)$$

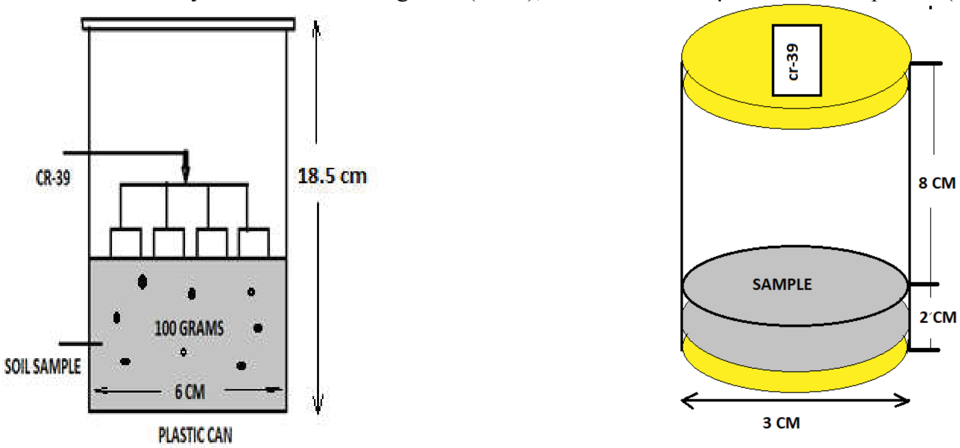
Radon exhalation rate measurement will useful to study health hazards and can calculated in term of mass (E_M) from [12]:

$$E_M(Bq.m^{-2}.h^{-1}) = \frac{C_{Rn} V \lambda}{M\left[T + \tau\left(e^{-\lambda T} - 1\right)\right]} \quad (4)$$

Where C_{Rn} is integrated radon exposure as measured by CR-39 plastic track detector ($Bq.m^{-3}.h$), V is effective volume of the can in (m^3), T is time of exposure of our samples (hr), M mass (kg) of the sample in can, λ is ^{222}Rn decay constant ($7.56x\ 10^{-3}h^{-1}$), τ is the mean life time of radon (5.5 days or 132 h).

MATERIALS AND METHOD

Sixteen different soil samples collected by grab sampling method (each sample collected at specific location at a certain time) from different places over several regions sites. The samples with constant weight (500g) put in plastic package using portable balance from slop of ponds of Habbanyiah lake and Euphrates river at depth about (25cm) from the level of ground with ensure the place have an old age as particular place. The samples dried at 100 ^oC in oven for two hours and cleaned from coarse grains, straw, glass etc. by 250µm sieve to be homogenous fine powder. Experiment performed in summer by a can technique dosimeter, two plastic sealed can has been used with dimensions (18.5 x 6) cm for uranium concentration and (10 x 3) cm for radon gas, will have 100g and 25g of soil sample for uranium and radon, respectively, Fig.2. To achieve results, some preparation was made, cutting the CR-39 sheet, that manufactured by Per shore Molding Ltd. (U.K.), has a thick 500 µm into small pieces (1cm x 1cm).



(a) (b)

Figure 2. Experimental setup for the measurement uranium activity and radon exhalation in soil samples.

For uranium, the sample will be attached from the surface with four CR-39 detectors to expose for 24 days to reach ideal state of balance between radium and its daughters from radon isotopes. For radon, nuclear track detectors were installed on the inner surface of each can cap, which replaced with can cover to maintain the state of the radiation balance. After the sample storage period was finished, the detectors were extracted from the cans so that the electrochemical scraping process was performed for all the detectors. The detectors were etched in 6N aqueous NaOH solution using water bath at 65 ^oC as a constant temperature, to shape tracks of the alpha particles that emitting by radon fall on detector, for five hours detectors then washed by running water and distilled water for five minutes for each water.

Alpha particles track ion detectors strips scanned at central region per cm^2 by optical microscopic with magnification of 100X (10X objective and 10X eyepiece). The tracks on the surface of the detectors were counted as track density (ρ_t) ($track/cm^2$) estimated by counted alpha particles by taking the average track density for the four CR-39 in each sample and calculated using the following equation [13]:

$$\rho_t = \sum_i \frac{\rho}{nA} \quad (5)$$

where, A refers to view section area, N_i total number of nuclear pathways and n the number of microscopic observations on the surface of the detector. To have a background radiation of detector, six unexposed CR-39 etched then tested under microscope and all counts of the CR-39 exposed were corrected from this background value.

RESULTS AND DISCUTIONS

The ρ_t for samples will listed in table (1), with corresponding The 18 days of exposure time very useful as long enough to have a large track in detectors and by tracking the mean value of counting one can reduce the error in our statistics.

From Table 1, it should be noted that the values of radon exhalation rates have differences from one location to another, and this may be due to the difference in the nature of the samples, the amount of radium content in them, as it has varying levels all over the world.

The values of radon exhalation rates and radium content are found to be below the world average value of 57.6 $Bq/m^2.h$ (0.016 $Bq/m^2.sec$) and 370 Bq/kg recommended by OECD, 1979 [13], respectively. Hence it can be concluded that the study area is safe from the health hazard of radon and radium point of view. The mean uranium concentration in the soil samples was low and not significant from a health hazard point of view.

TABLE 1. Uranium concentration (ppm) values and radon exhalation rate of sixteen soil samples locations and track density using can technique method.

Sample code	Location Name	ρ_t track/cm^2	Average C_u (ppm)	E_M x 10^{-3} (Bq/hkg)
U1	Mallahma	18.5 ± 0.4	0.71	10.7
U2	Habbaniyah district	36.1 ± 0.48	1.08	16.2
U3	Khaldiya district	36.1 ± 1.03	1.08	16.2
U4	Hallabsa area	38.4 ± 1.18	1.23	18.5
U5	Albu Bali	46.1 ± 1.24	1.38	20.8
U6	Hussabia	49.9 ± 1.30	2.09	31.5
U7	Albu Obaid	51.2 ± 1.37	2.17	32.2
U8	Habbaniyah lake/1	59.7 ± 1.63	2.28	34.3
U9	Tash	66.3 ± 1.72	2.36	37.0
U10	Albu Aitha	72.63 ± 1.79	2.38	42.3
U11	Ramadi city	83.18 ± 1.93	2.81	54.7
U12	Habbaniyah lake/2	128.3 ± 2.18	3.63	65.2
U13	Albu Assaff	147.1 ± 2.41	4.33	72.2
U14	Albu Ali Jassim	152.3 ± 2.63	4.74	78.1
U15	Albu Resha	167.3 ± 2.79	5.18	81.0
Uρ16	Habbaniyah lake/3	178.5 ± 3.01	5.73	86.4

The observed values of uranium and radon exhalation rate of soil samples of different places are shown in Table (1). From the result one can deduced that an increased value of radon exhalation rate of soil samples at most of the places where the uranium concentrations are also found to be relatively large because of it deposit and formation of soil contents. Because of these results, it seems to deduce that radon atoms located in the interstitial space between grains of soil. Radon exhalation rate in soil in terms of mass varies from (10.7) Bq/kg.h to (86.4) Bq/kg.h while uranium concentration, the maximum value has been found in (5.73 ppm)) and minimum one in sample (0.71 ppm).

These values of radon can be attributed to the affected release radon from soil to the soil porosity, meteorological factors and atmospheric pressure [13].

The annual effective doses (E_{eff}) (mSv.y^{-1}) caused by the exposure to the radon and related with radon concentration as in the expression [14,15]:

$$E_{eff} = C_{Rn} \times \frac{F}{3700} \times \frac{8760}{170} \times F_{DC} \tag{6}$$

Where, 8760 is the number of hours per year as time spent indoors, 170 is the number of hours per working month and 3700 is afactor necessary to express exposure to radon in WLM (working level month is old unit still used), F is the equilibrium factor between radon and its short-lived products that taken in the calculation (0.4) [16]. Radon progeny equilibrium quantity may have value $0 < F < 1$, that mean estimation of effective dose equivalent must made using dose conversion factor (f_{DC}) of 6.3 mSv (WLM)$^{-1}$ [17].

Radon concentrations values in Table (2) were considered as annual averages and used in annual effective doses E_{eff} calculation for each sample included in the survey. The annual effective doses average value ranged from 0.09, 2.55 and 1.44 mSv.y^{-1}, respectively.. The low values of effective dose rate perhaps because of the washing of radioactive minerals that working on effect on the total effective dose rate as sampling sites is near the river and lake. The ICRP suggests an annual effective dose of around 10 mSv from ^{222}Rn as a level at which action would be warranted to reduce exposure [19]. For healthy safety purposes, the results give a derivation that the health risks resulting about radon in the soil samples was very low.

TABLE 2. Radon concentration and effective annual dose of radon in soil samples.

Sample code	Location Name	E_{eff} (mSvy^{-1})			C_{Rn} (Bqm^{-3})		
		Min.	Max.	Ave.	Max.	Min.	Ave.
U-1	Mallahma	0.09	1. 35	0.72	1.34	3.12	2.23
U-2	Habbaniyah district	0.11	0.64	0.375	5.34	7.5	6.42
U-3	Khaldiya district	0.1	0.68	0.39	1.58	5.34	3.42
U-4	Hallabsa area	0.16	0.2	0.18	12.4	14.9	13.65
U-5	Albu Bali	0.18	0.98	0.58	34.9	45.3	40.1
U-6	Hussabia	0.27	0.3	0.285	18.1	24.1	12.6
U-7	Albu Obaid	0..25	2.55	1.4	3.57	8.4	5.98
U-8	Habbaniyah lake/1	0.33	0.64	0.47	6.4	8.63	7.51
U-9	Tash	0.43	0.81	0.62	8.9	15.56	12.23
U-10	Albu Aitha	0.48	0.85	0.665	4.5	7.0	5.75
U-11	Ramadi city	0.54	0.94	0.74	12.54	16.45	14.5
U-12	Habbaniyah lake/2	0.69	1.85	1.225	3..54	18.65	11.1
U-13	Albu Assaff	0.64	2.42	1.53	8.10	10.1	9.1
U-14	Albu Ali Jassim	0.74	1.54	1.14	3.5	21.5	12.5
U-15	Albu Resha	0.88	2.12	1.5	4.56	16.7	10.63
U-16	Habbaniyah lake/3	1.24	3.46	2.35	3.01	5.2	4.1

CONCLUSIONS

The concentration of uranium, radium content and radon mass exhalation rates have been measured successfully using CR-39 plastic track detectors by the sealed can technique. Uranium concentration has high maximum value in Habbiniyah Lake/3 and the other values are in acceptable word limit of (11.7ppm) according to (UNSCEAR 2000) [18]. Radon estimation results of concentration and the resulting doses in all soil samples are very low and below the allowed limit from ICRP [19,20]. Hence it can be concluded that the study area is safe from the health hazard of radon and radium point of view. and agree with most radiological health studies. Measurements can be taken as a baseline database of values of these radionuclides in the soils.

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