Measurement of Uranium Concentration in Some Soil Samples in Jalawla'a City Using CR-39 Detector

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Abstract

In this study, the fission track registration technique with the *CR*-39 detector are using to determination the uranium concentrations for twenty-eight samples of soil distributed in seven districts in Jalawla'a City in Iraq by depth in 5cm.

The uranium concentrations in soil samples measured by using fission tracks registration in (*CR*-39) track detector that caused by the bombardment of (*U*) with thermal neutrons from (^{241} *Am-Be*) neutron source that has flux of (5×10^3 *n* cm^{-2} s^{-1}).

The concentrations values were calculated by a comparison with standard samples. The results showed that the maximum value of uranium is (1.280 *ppm*) in Al-Talea district and the minimum is (0.719 *ppm*) in Al-Uruba district

Keywords: Uranium concentration, soil, nuclear track detector, CR-39.

Introduction

Uranium is a radioactive and chemical element, represents by (U) symbol, and it is a heavy metal with a very high density (18.95 *g* /cm^3, 1.7 times higher than lead's density of 11.35 *g* /cm^3). Metallic uranium has a high melting point (1132 ^oC) and boiling point (4131 ^oC), has a tensile strength similar to most steels and it is chemically very reactive [3]. Natural uranium consists of three isotopes. Their concentrations by mass are U238 99.276%, U235 0.718% and U234 0.0056% [2].[4].

Recently many attempts have been made to develop the alpha sensitive plastic film (ASPF) family of the solid state nuclear detector (*SSNTDs*) for this purpose [5]. *CR*-39 is one of the solid state nuclear detectors which can response to alpha particle with high efficiency [6]. The authors have successfully applied this method for purpose of uranium exploration.

Nuclear track detector is one of the most popular detectors used to study the nature of damage product by heavily ionization radiation such as alpha particle or fission fragment, the technique of measuring the number of particle by observing their track in certain organic or inorganic materials has been used for the study of phenomena in such diverse fields as geology, astrophysics, and nuclear physics. The technique based on the damage created in a solid along the path of heavily ionizing particle [7] as it is a very simple technique, it can be implemented easily in field of studies, since it does not require electronic system [8].

Material and Methods

1- Collection of soil samples

Twenty-eight samples of soil distributed in seven districts in Jalawla'a City in Diyala Governorate were taken from location of study, from depth (5 cm). Then the samples were cleaned, dried in an oven at 70 ^oC for few hours finally they were powdered and sifted by using special sieve (250 μm in diameter) [9].

2- Irradiation of the detectors

Each sample was taken with the weight 0.5 *gm* of soil samples powder was mixed with 0.1*gm* of methy cellulose powder used as a binding material. The mixture was pressed into a pellet of 12 *mm* diameter and 1.5 *mm* thickness using a hydraulic machine.

The pellets were covered with *CR*-39 detector and put in a plate of paraffin wax at a distance of (5*cm*) from the neutron source *Am-Be*, with flux of thermal neutron (5×10^3 *n* cm^{-2} s^{-1}),as shown in Fig. (1)[10].

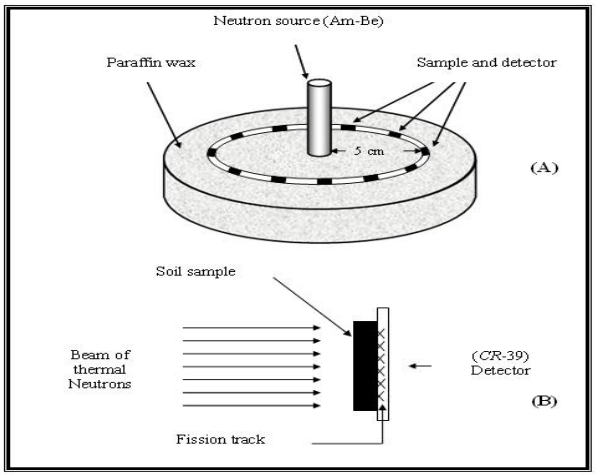

Fig.(1) Uranium concentration estimation by using (CR-39) detector for soil sample [9].

3-Chemical etching and microscopic scanning

After the irradiation time 7days [10], the *CR*-39 detectors were removed and etched in a ٦.٢٥*N* aqueous solution of *NaOH* maintained at 60 ˚*C* for ٦ *hr*, which was the normal employed etching time [10]. The detectors were rinsed with distilled water and dried in air. The tracks recorded in *CR*-39 detectors were counted by using optical microscope at a magnification of 400x. The density of the tracks ρ in the detectors was calculated according to the following relation:

$$(\rho_X) = \frac{N_{ave}}{A}$$

Where

ρ: Track density Track /mm^2.

N: Average of total tracks.

A: Area of field view.

4- Uranium concentration

Fission track technique was used for determination uranium concentration in the soil samples by making a comparison between track densities registered on the detectors of the sample and that of the standard geological sample. The uranium content in the unknown samples was determined by using the formula [11]**;**

$$\frac{C_X}{\rho_X} = \frac{C_S}{\rho_S}$$

Where

C_S, C_X: Uranium concentration (*ppm*) for standard and sample respectively.

***ρ_S, ρ_X: track density (*track/mm*^{2}) for standard and unknown sample respectively.

And $C_X = C_S \frac{\rho_X}{\rho_S}$

Fig. (2) Shows this relation, when ($slope = \rho_S / C_S$)

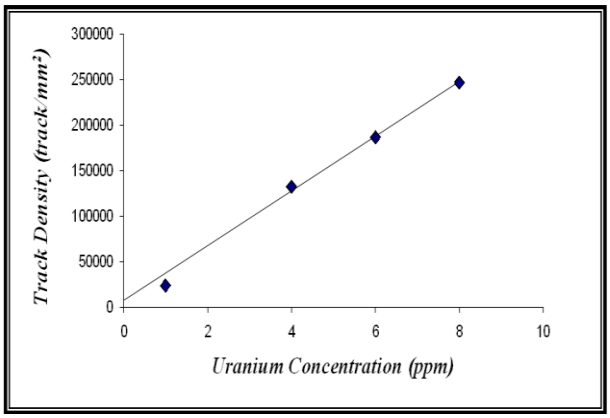

Fig. (2) The relation between track density and uranium concentration for standard geological soil samples [12].

Results and Discussion

Table (1) present the tracks density, uranium concentrations, and the rates for different study areas in irradiated soil samples that measured by *CR*–39 detector. The samples collected from twenty-eight location distributed in seven districts in different sites in Jalawla'a city by (5cm) depth.

Table (1)
Uranium concentration in soil samples.

Study Region	*District*	*Samples*	*Tracks Density (Track/mm2)*	*Uranium Concentrations (ppm)*	*Average Concentration (ppm)*
Diyala Governorate - Jalawla'a City	Al-Talea district	$S1_1$	34741.38±2113.583	1.201	1.280±0.153
		$S2_2$	38017.24±1792.237	1.314	
		$S3_3$	32586.21±1335.511	1.126	
		$S4_4$	42758.62±1531.369	1.478	
	Al-Muaskar district	$S1_5$	31379.31±1163.704	1.084	1.156±0.057
		$S2_6$	33017.24±1468.051	1.141	
		$S3_7$	35344.83±1675.561	1.222	
		$S4_8$	34051.72±1015.958	1.177	
	Al-Tajneed district	$S1_9$	33017.24±1410.682	1.141	0.870±0.194
		$S2_{10}$	25431.03±1363.051	0.879	
		$S3_{11}$	21724.14±792.1867	0.751	
		$S4_{12}$	20517.24±1059.718	0.709	
	Al-Uruba district	$S4_{13}$	21896.55±1163.704	0.757	0.719±0.026
		$S4_{14}$	20344.83±1163.704	0.703	
		$S4_{15}$	20258.62±732.6177	0.700	
		$S4_{16}$	20775.86±857.2663	0.718	
	Al-Shuhada district	$S1_{17}$	19827.59±1573.915	0.685	0.753±0.049
		$S2_{18}$	23103.45±1665.675	0.798	
		$S3_{19}$	22500±1181.311	0.777	
		$S4_{20}$	21724.14±1897.422	0.751	
	Al-Jamaheer district	$S1_{21}$	21982.76±1479.257	0.760	0.780±0.019
		$S2_{22}$	23275.86±1149.425	0.804	
		$S3_{23}$	22758.62±1297.884	0.786	
		$S4_{24}$	22241.38±1714.533	0.769	
	Al-Wihda district	$S1_{25}$	22672.41±1222.531	0.783	0.742±0.046
		$S2_{26}$	19568.97±1350.88	0.676	
		$S3_{27}$	21810.34±1628.071	0.754	
		$S4_{28}$	21896.55±1733.69	0.757	

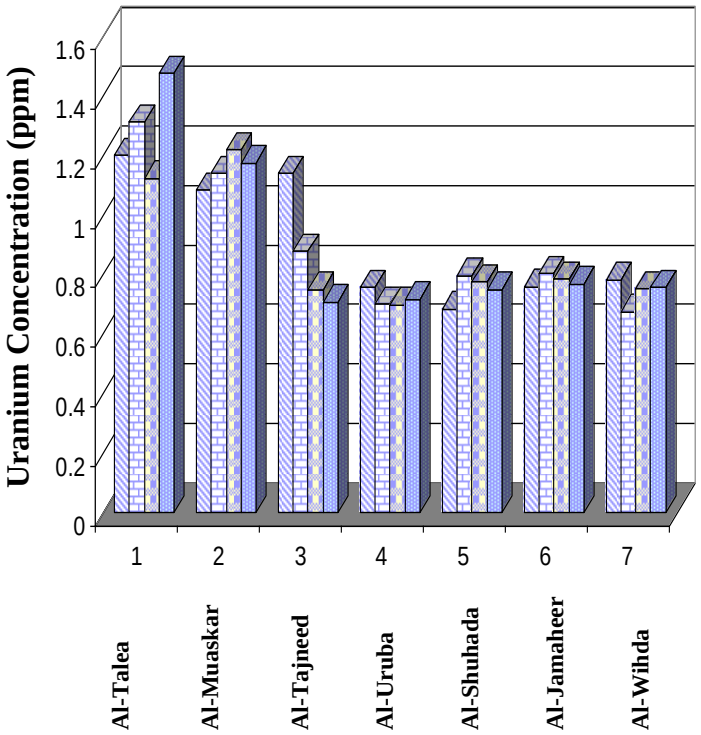

Fig. (3) Average concentration of Uranium in soil samples for study areas.

From these data, we found that the average maximum value of uranium was (1.280 *ppm*) in Al-Talea district and the minimum was (0.719 *ppm*) in Al-Uruba district.

The uranium level in each location was normal and varies from (1.126 to 1.478 ppm) in Al-Talea district, (1.084 to 1.222 *ppm*) in Al-Muaskar district, (0.709 to 1.141 *ppm*) in Al-Tajneed district, (0.700 to 0.757 *ppm*) in Al-Uruba distric , (0.685 to 0.798 *ppm*) in Al-Jamaheer district, (0.760 to 0.804 *ppm*) in Al-Jamaheer district, and (0.676 to 0.783 *ppm*) in Al-Wihda district.

Fig.(3) shows the average uranium concentration in soil samples for seven districts, the uranium concentration in Al-Talea district is relatively higher than the other districts this is due to difference in the composition of the soil in the abundance of minerals and ores. Take into consideration that the samples had been taken from residential areas and the outskirts of the city.

In conclusion, we found that the uranium levels in the soil in this field of study within the acceptable values (11.8 ppm) [13].

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الخلاصة

في هذه الدراسة تم استخدام تقنية تسجيل اثار شظايا الانشطار مع كاشف الاثر النووي *CR*-39 لتحديد تراكيز اليورانيوم في ثمان وعشرون عينة ترابية موزعة في سبعة احياء في مدينة جلولاء في العراق وبعمق تراوح ٥ سم .

تم تحديد تراكيز اليورانيوم في عينات الترب عن طريق تسجيل أثار شظايا الانشطار في كاشف الأثر النووي (*CR*-39) الناتجة من قصف نوى اليورانيوم بالنيوترونات الحرارية من المصدر النيوتروني (^{241}*Am-Be*) بفيض نيوتروني حراري (5×10^3 n cm^{-2} s^{-1}).

تم تحديد التراكيز بالحسابات المعتمدة على المقارنة مع العينات القياسية، ومن خلال النتائج المستحصلة وجد ان اعلى قيمة لليورانيوم هو (1.280 *ppm*) في حي الطليعة وان ادنى قيمة هو (0.719 *ppm*) في حي العروبة.