## Uranium Concentrations Measurement in the Soil of Wasit Governorate

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# قياس تراكيز اليورانيوم في تربة محافظة واسط

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#### الخلاصة

الهدف من هذه الدراسة هو قياس تراكيز اليورانيوم في عينات من التربة جمعت من مناطق واقعة في محافظة واسط على عمق (5-15) سم. محافظة واسط على عمق (5-15) سم. تم قياس تراكيز اليورانيوم في عينات الترب عن طريق تسجيل أثار الانشطار في كاشف الأثر النووي (CR-39) الناتجة من قصف نوى ( $U_{292}^{235}$ ) بالنيوترونات الحرارية من المصدر النيوتروني ( $CR-39^{241}$ ) بغيض نيوتروني بلغ ( $^{1-s} r cm^{-2} s^{-1}$ ). تركيز اليوانيوم  $U_{292}^{235}$  كان مقاسا في جميع مناطق الدراسة وأعلى واوطا تركيز لليورانيوم  $U_{292}^{235}$ كان والمنطقة (I.11 ppm والتي تمثل منطقة زوية الزراع في قضاء العزيزية والمنطقة (K5) والتي تمثل حي الأنوار في مدينة الكوت على التوالي.

#### ABSTRACT

The aim of this study is to measure the uranium concentrations in soil samples taken from regions situated in Wasit governorate at depth(5-15)cm. The determination of uranium concentration in soil CR-39 Track detector. The nuclear reaction used a source of nuclear fission fragments  $^{235}_{92}U$  (n , f) obtained by the bombardment of  $^{235}_{92}U$  with thermal neutrons from (Am-Be) source which has flux of (5 ×10<sup>3</sup> n cm<sup>-2</sup> s<sup>-1</sup>).

Radionuclide( $^{235}_{92}U$ ) was measured to all the zones of the study. The maximum and minimum activity concentration of ( $^{235}_{92}U$ ) were (3.75 ppm) and 1.11 ppm) at the zones(A1)and (K5) respectively.

#### **1-INTRODUCTION**

Natural Uranium contains 99.274% of <sup>238</sup>U,0.720% of <sup>235</sup>U,and 0.0055% of <sup>234</sup>U, which all have 92 protons in the nucleus, but 146,143 and 142 neutrons, respectively. The half-lives of <sup>238</sup>U, <sup>235</sup>U,and<sup>234</sup>U are  $4.49 \times 10^9$ y,  $7.10 \times 10^8$ y, and  $2.48 \times 10^5$ y,respectively. The longer half-life the less radioactive decay products appear in a given time interval and could affect human health[1].

All natural elements with atomic numbers(Z>83)are radioactive. The four distinct natural decay series[2], are represented in Table(1).

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Series	First Isotopes	Half-Life	Last Isotopes
Uranium	<sup>238</sup> U	$4.49 \times 10^{9} y$	<sup>206</sup> Pb
Actinuim	<sup>235</sup> U	7.10×10 <sup>8</sup> y	<sup>207</sup> Pb
Thorium	<sup>232</sup> Th	$1.39 \times 10^{10}$ y	<sup>208</sup> Pb
Neptunium	<sup>237</sup> Np	$2.14 \times 10^{6}$ y	<sup>209</sup> Bi

Table(1):Radioactive decay Series

There are three radioactive series, called uranium, thorium and actinium series. Neptunium series is included in this table too, which does not occur in nature because its half life  $2.1 \times 10^6$ y is much smaller than the age of the universe  $3 \times 10^9$ y.

#### **Artificial Sources**

Over the last few decades man has "artificially" produced several hundred radionuclides, and learned to use the power of the atom for a wide variety of purposes, from medicine to weapon, from the production of energy to the detection of fires, from illuminating watches to prospecting for minerals. All increase the radiation dose both to individual people and to man-kind as a whole.

Individual doses from man-made sources of radiation vary greatly. Most people received relatively small amounts of artificial radiation, but few get many thousand times the amount they receive from natural sources.

The variability is generally greater for man-made sources than for natural ones. Most man-made sources,too,can be controlled more readily than most natural ones, through exposure to external irradiation due to fallout from past nuclear explosion [3,4].

#### Solid State Nuclear Track Detector(SSNTD<sub>S</sub>)

D.S Young was the first to observe track in LiF crystals in 1958.Later,Silk and Barnes made direct observations of heavy charged particles tracks in mica using a transmission electron microscope in 1959. The pioneers in the nuclear track detector field,P.B.Price1962,R.L.Fleischer1963, made extensive developments of the technique, observing nuclear tracks in dielectric solid crystals, plastics and glasses. Because of their properties, like lightweight, large geometrical factor,simplicity,flexibility and the ability to discriminate against lightly ionizing particles, in certain fields of physics, these detectors have potential advantages

over other detectors in  $SSNTD_s$  the path of an individual heavily ionizing charged particle is revealed by a suitable chemical etching of the damaged trail[5].

## **Types of Solid State Nuclear Track Detectors**

There are two types of SSNTD<sub>s</sub>:

## **1-Inorganic Detectors**

Inorganic detectors are compounds where Carbon and Hydrogen do not enter in its structure, and created a (Ionic Bond) between its atoms[6].

## **2- Organic Detectors**

Organic detectors are compounds where Carbon and Hydrogen enter in its structure, and create a (Covalent Bond) between its atoms, this type of SSNTDs have a sensitivity larger than inorganic detectors because the bonds of C-C, C-H which are easy broken after exposing to the radiation, also the organic detectors have a high analytic power larger than inorganic detectors. While the threshold energy for organic detectors is less than inorganic detectors [7].

## **Tracks Formation in Organic Materials**

In case of organic polymers the favorable theory for track formation is that based on the radio chemical damage mechanism.

The etched tracks are formed by the breaking of the long polymer chains to short chains when irradiated [8]. The result is new chain ends, i.e, chemically reactive sites are formed [9]. As it is known, the polymer is a chemical compound of large molecules which consist of a small repeated units called monomers. The monomer is a collection of atoms connected by covalent bonds. The passage of ionizing particles ( e.g proton, deuteron, alpha- particle, etc.) through the polymer will excite and ionize the polymer molecules. Some excited molecules may in their turn, de excite through the emission of radiation or through non radioactive transitions. Excitation energy can also be transferred from one molecule to another figure (2).

Both ions and excited molecular chains along its path so as to form a complex array of stable molecules, free radicals, ionized molecules and radical ions. Further reactions among these ions, free radicals and molecules will take place. However, because life time of these free ions is relatively small, only free radicals react among them or with other molecules [10,11]. Finally, the net effect on the plastic will be the production of many broken

molecular chains, leading to reduction in the average molecular weight of the substance. Therefore, the rate of chemical etchant attack on plastic increases as the molecular weight decreases. It is likely that the damage region is more etchable than the bulk material which leads to the etching along the track and is greater in rate than that of the bulk material[9].

### **CR-39** Track Detector

Taking into account sensitivity, resolution, and variability of their response, the best SSNTD materials appeared to be optically clear amorphous, thermoset plastics (polymers), which have high homogeneity and isotropy, high optical transparency and uniformity.



Fig.(2) A laten track is formed the breakage of polymeric chain by the passage of charged particle[12].

A plastic material fulfilling those requirements was synthesized in 1978 by Cartwright et al.(Price and Cartwright), and it was called CR-39 (Columbia Resin). Others, more sensitive SSNTDs[13] used for recording fission fragment tracks[14] (improved versions of CR-39) were manufactured in the eighties and they are commercially available as PM-355, PM-500, PM-600 plastics.

It should, however, be noted that a thermoset material (such as CR-39) is usually made within the extrusion and quenching process. Therefore, its quality and especially its particle detection characteristics depend strongly on the applied technological procedures. Hence, every newly acquired batch of SSNTD sheets should be carefully calibrated before using for quantitative measurements of ions[15].

#### The Chemical Form of CR-39

A polyaillyl diglycol carbonate detector, is known commercially (CR-39) and is made by the polymerization of the oxydi-2, 1-ethanediyl di-2-propenyl ester of carbonic acid. The monomer is an ally resin, which means that it contains the following functional group [16]:

## $[C H_2 = C H = C H_2]$

The monomer itself contains two of these functional groups and has the following structure in Fig.(3).

$$O \\ || \\ CH_2 - CH_2 - O - C - O - CH_2 - CH_2 = CH_2 \\ O \\ CH_2 - CH_2 - O - C - O - CH_2 - CH_2 = CH_2 \\ || \\ O$$

Fig. (3) The chemical form of CR-39 plastic[17].

In general the chemical formula for CR-39 may be written as  $(C_{12}H_{18}O_7)n$ , where H content is 6.6 % wt, C content is 52.6 % wt and O content is 40.8 % wt[16].

The detector (CR-39) has a high efficiency to record the tracks in comparison with other detectors and it has some specifications as[4]:

1- Optically transparent.

2- Very sensitive to radiation where  $\beta$  is the ratio of particle velocity to the velocity of light and uniformity.

3- Highly isotropic and homogeneous.

4-Not cross-linking after radiation damage has broken the chemical bonds.

5- Having a non-solvent chemical etchant.

6- This polymer is resistant almost to all solvents, and the heating.

Ionizing particles passing through polymeric track detectors produce latent track, which are trails of radiation damage [18]. The best means of observing the tracks is by etching the SSNTDs material with a chemical solution, which preferentially attacks the damaged material and enlarges the original track to a size, which is visible in the optical microscope[19].

#### **2-Experimental Part**

The materials and apparatus which are used in these technique are:

1- The Track Detectors: CR-39 nuclear track detector in thickness (250  $\mu$ m) and area approximate to (1 cm<sup>2</sup>) were used.

2- Sensitive Balance: Balance of type (Sartorius ISO 9001) Industrialization in Germany was used.

3-Piston:Using piston from type(PERKIN-ELMER )which the strength of piston approach to(10 tons )industrialization in Germany.

4-KBr: Potassium bromide is used as binding material.

5-Water path: Water bath of the type "Labsco" (Germany) was used in the present work. It includes a thermostat, which can be operated over a range of 20 °C

to 110 °C. However, in this study the chemical etching was carried out at 60 °C, and distilled water was used as the bath liquid. The accuracy of regulation of temperature is better than  $\pm 0.1$  °C.

6-Optical microscope: The optical microscope is type of (Olympus) industrialization in Japan. It is capable of giving magnifications of up to (400x) and eye piece (10x) to measura number of track density, the calculation track density from equation:

Track density  $(\rho)$  = average of total pits / area of field view

7-Neutron source(Am-Be): An (Am–Be) source with flux  $(5 \times 10^3 \text{ n/cm}^2 \text{.s})$  was used.

This source consists of a rod of (Am-Be) surrounded by a paraffin wax. The paraffin wax is usually used for moderating the fast neutrons to thermal neutrons energies.

## **Preparing of the Samples:**

Soil samples were taken from different locations in Wassit governorate in Iraq ,as shown in Table(2).Soil samples were dried and cleaned from the doping grind using special sieve.

0.5gm of soil samples were mixed 0.1g of KBr used as a binding material. The mixture was pressed into a pellet of 1cm diameter and 1.5mm thickness.

The pellets were covered with(CR-39)detector and put in a plate of paraffin wax at a distance of(5cm)from the neutron source(Am-Be)as shown Fig.(3),with flounce of thermal neutron( $3.024 \times 10^{9}$  n.cm<sup>-2</sup>) and flux( $5 \times 10^{3}$  n cm<sup>-2</sup>s<sup>-1</sup>), to obtain induced fission fragments from the equation (1):

 $^{235}U + ^{1}_{0}n$  thermal  $\rightarrow (^{236}U)^{*} \rightarrow \text{fission fragments} + (2-3)^{1}_{0}n + Q$  .....(1)

After the irradiation time is (7 days),(CR-39)detectors were etched in(6.25N) NaOH solution , which is prepared as:

Where

 $W_{eq}$ =The equivalent weight of NaOH=addition of the atomic weight of Na,O and H=40

N=The normality

V= The volume of distilled water=250 ml.

WeqNaOH=23+16+1=40

Number of samples	Location	Symbols
1	Al-damok	K1
2	Door Al-zobat	K2
3	Al-Hawraa	K3
4	Sheek Saad	K4
5	Al-anwar	K5
6	Digili region/29	K6
7	Digili region/36	K7
8	Niwab Al-Zobat	K8
9	Al-Chamaheer	K9
10	Al-Kagiya	K10
11	Al-Akar	H1
12	Al-Asree	H2
13	Al-Bashaer	H3
14	Hai Saheed	H4
15	Al-Mofakiya	H5
16	Al-Wahda	H6
17	Al-shohdaa	H7
18	Al-Motanabi	N1
19	Hai Al-Baladya	N2
20	Hai Al-Shorta	N3
21	Mothalath Al-Kilabeen	N4
22	Al-Hai Al-Tichari	N5
23	Al-Ahrar	N6
24	Al-Kotaa	N7
25	Zorbatya	B1
26	Al-Kalaa	B2
27	Al-Kalal river	B3
28	Jasan	B4
29	Farris karya	B5
30	Zawayat Al-Zera'a	A1
31	Al-Hafriya	A2
32	Zobaee Karya	A3
33	Al-Soos factory	A4
34	Al-Doboni	A5
35	Abd Al-Wahid	A6
36	Al-Tanmya	S1
37	Al-ASraa	S2
38	Jwimisa Al-Karbiya	S3
39	Hai Dijla	S4
40	Al-Zobidiya	<b>S5</b>

Table(2)Number,Location and sympol of samples in Wassit governorate.

From eq.(2)

W= $40 \times 6.25 \times 1/4$  liter= $250 \times 1/4$ =62.5 gm NaOH in 250 ml water.

The etchant compartment has a volume of about 250 ml contains the NaOH solution 6.25 N.This apparatus is closed assembly, except for small



Fig.(3) The irradiation of the detectors and samples by the neutron source.

vent at the top of the condenser tube, which prevents any change of etchant normality (concentration)during the experiment due to evaporation .

The etching was performed at 60°C while the etching time was 5h.

The density of the fission  $tracks(\rho)$ =Average number of total pits(tracks)/Area of field view (3)

The uranium concentrations in the soil samples were measured by comparison between track densities registed on the detectors of the sample pellet and that of the standard geological sample pellets from the relation:

 $C_{\mathbf{X}}(\text{sample}) / \rho_{\mathbf{x}}(\text{sample}) = C_{\mathbf{s}}(\text{standard}) / \rho_{\mathbf{s}}(\text{standard})$ (4)  $C_{\mathbf{X}} = C_{\mathbf{s}}(\rho_{\mathbf{x}} / \rho_{\mathbf{s}}) \dots \dots (3-4)$ Fig.(3-6) shows this relation, when (slope =  $\rho_{\mathbf{s}} / C_{\mathbf{s}}$ ). Where:

C<sub>X</sub>= uranium concentration in unknown sample(ppm).

C<sub>s</sub>=uranium concentration in standard sample(ppm).

 $\rho_x$ =track density of unknown sample(tracks/mm<sup>2</sup>).

 $\rho_s$ =track density of standard sample(tracks/mm<sup>2</sup>).



Fig.(4) The relation between track density and uranium concentration (ppm) for standard geological soil samples.

## **3-Results**

Table(3)Uranium concentration in the soil of Wasit governorate with depth(5-15)cm from the surface of earth in(2009)year that were measured by solid state nuclear track detector(CR-39)technique, the concentrations were in range (1.11–3.75 ppm )and the average(1.94ppm).

No of	Symbol	Density of tracks (No.	Concentration of
Samples	of sample	of tracks/mm <sup>2</sup> )	Uranium C <sub>x</sub> (ppm).
1	K1	5899.9±495.19	1.84
2	K2	5713.02±374.15	1.78
3	К3	4875.74±368.13	1.52
4	K4	4021.203±309.93	1.25
5	K5	3572.49±342.96	1.11
6	K6	4062.13±215.29	1.26
7	K7	3715.48±377.89	1.16
8	K8	5761.83±427.896	1.79
9	К9	4198.72±679.15	1.31
10	K10	4079.88±233.52	1.27
11	H1	4091.72±251.61	1.27
12	H2	5331.36±167.88	1.66
13	НЗ	6284.024±364.67	1.95
14	H4	8185.4±514.97	2.55
15	H5	7961.54±701.17	2.48
16	H6	7928.99±461.55	2.47
17	H7	6766.27±167.23	2.1
18	N1	6863.91±334.23	2.14
19	N2	7559.17±185.06	2.35
20	N3	9203.65±836.47	2.86
21	N4	5814.8±851.85	1.81
22	N5	4526.63±508.07	1.41
23	N6	9938.36±912.29	3.09
24	N7	4861.93±284.49	1.51
25	B1	7363.91±218.77	2.29
26	B2	4992.6±876.027	1.55
27	<b>B3</b>	3698.225±506.775	1.15
28	B4	6112.43±494.11	1.9
29	B5	8173.07±1355.45	2.54
30	A1	12058.68±1468.88	3.75
31	A2	7257.396±415.73	2.26
32	A3	4338.757±135.79	1.35
33	A4	4963.018±199.95	1.54

 Table (3): Uranium Concentrations in Soil Samples of Wasit Governorate

34	A5	4368.836±137.077	1.39
35	A6	4585.799±215.185	1.43
36	S1	7295.365±400.4935	2.27
37	S2	9384.615±165.2572	2.92
38	<b>S</b> 3	6230.277±845.368	1.94
39	<b>S4</b>	8826.43±275.588	2.74
40	<b>S5</b>	8409.76±993.16	2.62

The uranium content in soils samples are less than the allowed limit(11.7 ppm)from UNSCEAR[4].

#### **4-Discussion**

The maximum and minimum activity concentration of  $\binom{235}{92}U$  with depth (5-15) cm were (3.75 ppm and 1.11 ppm) at the zones(A1)and (K5) respectively.

The highest concentration of uranium in the zone A1 (3.75 ppm), because the area had a battalion of tanks and bombed by U.S. forces on 1-4-2003 at the invasion of Iraq, called the (Zawayat Al-Zera'a) near the maize factory, Followed by the region N6(3.09 ppm)), called the (Al-Ahrar, followed by S2(2.92ppm), called the (Al-ASraa) and followed by the N3 (2.86ppm), which called the (Hai Al-Shorta) bombed by U.S.A forces when they entered Iraq in 2003.



Fig.(5)Fission fragment tracks by solid state nuclear track detector(CR-39).



Fig.(6)Concentration of U-235 with location.

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