Determination of Uranium Concentrations in Some Plants and Soils Samples from Baghdad-Iraq Using CN-85 Track Detector

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Abstract

The aim of this study is to measure the concentrations of uranium in17 samples of plants and soils collected from different areas in Baghdad city. The technique is based on the counting of α–particles by using the CN-85 track detector that is one of solid state nuclear track detectors (SSNTDs) and fission fragment track technique. The nuclear reaction used as source of uranium fission fragment is U-235 (n-f) obtained by the bombardment of U-235 with thermal neutrons emitted from Am-Be neutron source with thermal neutron flux of 5000 n/cm^2.s for seven days. The concentration of uranium was calculated by comparison with the standard samples. The concentrations of uranium in plants sample ranged between 0.8 and 2.37 ppm with average of 1.59 ppm. The concentrations of uranium in soils samples ranged between 3.67 and 3.99 ppm with average of 3.82 ppm.

Keywords: SSNTDs**,** CN-85**,** uranium, Ra-226**,** Rn-222**,** track detector

قياس تراكيز اليورانيوم لنماذج من النباتات والتربة في مدينة بغداد باستعمال كاشف الأثر النووي CN-85

عصام درويش ولطفي صالح وروى عبدالله

خلاصة

قيست تراكيز اليورانيوم لسبعة عشر نموذجا من النباتات والتربة والتي جمعت من مناطق مختلفة في مدينة بغداد. حيث تم حساب تراكيز اليورانيوم من خلال الكشف عن جسيمات ألفا باستخدام تقنية كواشف الأثر النووي في الحالة الصلبة (SSNTDs) نوع CN−85 للكشف عن جسيمات ألفا وشظايا الانشطار. استخدمت تقنية عد أثار شظايا الانشطار النووي والناتج من أنشطار نواة اليورانيوم (U−235) من خلال قصفها بالنيوترونات الحرارية المنبعثة من المصدر النيوتروني (Am–Be) بفيض نيوتروني حراري يبلغ ($5\times10^{3}n.cm^{-2}s^{-1}$) ولمدة سبعة أيام متتالية. تم حساب تراكيز اليورانيوم في العينات بالمقارنة مع تراكيز اليورانيوم في النماذج القياسية. تتراوحت تراكيز اليورانيوم في النباتات بين 0.8 و 2.37 جزء بالمليون وبمتوسط 1.59 جزء بالمليون . أما تراكيز اليورانيوم في التربة فكانت ضمن المدى 3.67 − 3.99 جزء بالمليون وبمتوسط 382 جزء بالمليون.3.67−3.99 ppm. تعد هذه النتائج مقبولة بالمقارنة مع الحدود المسموح بها دوليا (11.7 ppm).

كلمات مفتاحية: SSNTDs، CN-85، uranium، Ra-226، Rn-222، كواشف الأثر النووي.

Introduction

Uranium is an element found in rocks since the earth was formed. Not all soils and plants contain uranium, but there are some places in the world where uranium is in the bedrock. Other related elements that may be found in association with uranium include Ra-226, Ra-228 and radon Rn-222. These isotopes are a part of a sequence formed through a transformation (decay) process that begins with the most prevalent form of “natural” (unprocessed) uranium U-238. Radioactive material is found throughout nature. It is in the soils, water, and vegetation. Low levels of uranium, thorium, and their decay products are found everywhere. Some of these materials are ingested with food and water, while others, such as radon, are inhaled [1].

The dose from terrestrial sources also varies in different parts of the world. Locations with higher concentrations of uranium and thorium in their soil have higher dose levels. The major isotopes of concern for terrestrial radiation are uranium and thorium series and their decay products. Soils are made up of four basic components: minerals, air, water, and organic matter. In most soils, minerals represent around 45% of the total volume, water and air about 25% each, and organic matter from 2% to 5% [2].

The mineral portion consists of three distinct particle sizes classified as sand, silt, and clay. Sand is the largest particle that can be considered soil. Sand is largely the mineral quartz, though other minerals are also present. Quartz contains no plant nutrients, and sand cannot hold nutrients [3].

They are leached out easily with rainfall. Silt particles are much smaller than sand. The smallest of all the soil particles is clay. Clays are quite different from sand or silt, and most types of clay contain appreciable amounts of plant nutrients. Clay has a large surface area resulting from the plate-like shape of the individual particles [4].

Sandy soils are less productive than silts, while soils containing clay are the most productive and use fertilizers most effectively. Soil texture refers to the relative proportions of sand, silt, and clay. Loam soil contains these three types of soil particles in roughly equal proportions. sand, loam is a mixture containing relatively a larger amount of sand and a smaller amount of clay, while a clay loam contains a larger amount of clay and a smaller amount of sand. When cosmic radiation interacts with the gases in the atmosphere, it causes nuclear transformations that release particles such as neutrons and protons. These neutrons and protons interact with other nuclei in the atmosphere, producing radioactive nuclei, such as carbon-14 and tritium (hydrogen-3). Carbon-14 is responsible for less than 1 mrem per year of absorbed radiation in humans, and tritium only about 1 microrem. Long-lived radioisotopes in the earth's crust are also a source of absorbed radiation. One of these that is particularly significant is potassium-40, with a half life of 1.3×10^9 years and making up only 0.019% of all potassium. It is significant because potassium is one of the most abundant elements and because it is an essential component of foods [5].

Experimental details

Seventeen samples of plants (leaf of short trees) and different of soils were collected from many places in Baghdad city as shown in Table 1.

Table 1: Type and location of samples code

Sample code	Type	location
A1	plant	Al-Hurriya square
A2	plant	Baghdad university intersection
A3	plant	Al-Sha'ab main street
A4	plant	Al-Talibiya
A5	plant	Kahramana square
A6	plant	Al-Karrada dakhil
A7	plant	Al-Alawee –al mathaf square
A8	plant	Al-Salhiya
A9	plant	Al-Tahrer square
A10	plant	Bab-al-Muadham
A11	plant	Al- Medan
A12	plant	Street of Dora refinery
A13	soil	Al- Hurriya square
A14	soil	Baghdad university intersection
A15	soil	Kahramana square
A16	soil	Al-Karrada dakhil
A17	soil	Street of Dora refinery

Leaf of trees samples were dried, crushed and sieved through sieve size 212micron, then stored for one month to get a radiological equilibrating. 0.5g was taken from each sample and pressed into a pellet 1cm diameter by using a piston, sheets of 200 µm thickness of CN-85 plastic 1x1cm^2 area were put behind each sample. The samples were irradiated using Am–Be neutron source for seven days with flux of thermal neutrons of 5000n/cm^2.s, which emits fast neutrons in (α,n) reaction, the irradiation time was seven days with influence of thermal neutrons as the following equations [6,7]:

$$^{235}U + {}^{1}_{0}n_{\text{ thermal}} \longrightarrow {}^{236}U \longrightarrow {}^{141}Br + {}^{92}Kr + 3\,{}^{1}_{0}n \quad \ldots\ldots\ldots\ldots\ldots(1)$$

$$^{9}Be + {}^{4}_{2}He \longrightarrow {}^{12}C + {}^{1}_{0}n_{\text{ fast}} + 5.76\text{ MeV} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

The neutron source was surrounded by a paraffin wax which is used for moderating fast neutrons with energy 10^{6} eV to thermal neutrons of energy 0.025eV. (Figure 1).

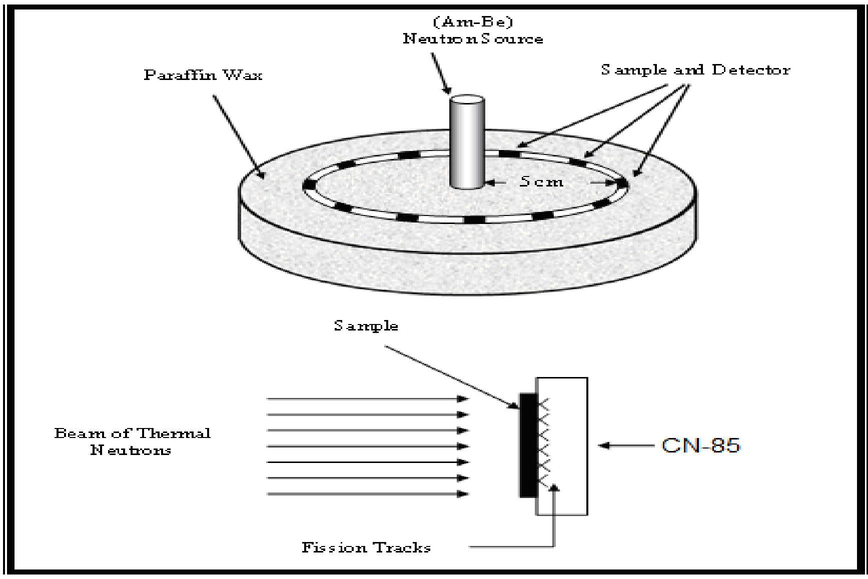

Fig 1: Irradiation of the detectors with samples for neutron source.

After irradiation, we used enchant solution, sodium hydroxide solution (6.25 Normality) for the etching process, which prepared as in the following equation: [8]

$$W = W_{eq} \times N \times V \qquad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where:

W: weight of NaOH that needed to prepare the given normality = 62.5g

W_{eq} : equivalent weight of NaOH = (40g/mole)

V: volume of distilled water = (250 ml).

N: normality = 6.25

The enchant compartment has a volume of 250 mL contains the NaOH solution. This apparatus is closed assembly, except for small vent at the top of the condenser tube, which prevents any change of enchant normality concentration during the experiment due to evaporation. The enchant solution was placed in water bath as type of “Labsco” industrialization in Germany is used in this study. It includes a thermostat, which can be operated over a range of (10–100)^{o}C. However, the water path was maintained at 60^{o}C and the etching time was 2:30 h, then we washed the detectors with distilled water. After that, the optical microscope type Motic industrialization in Malaysia was used for giving magnifications of up to 400X to measure the number of tracks. The tracks that observed in CN-85 track detector after etching is shown in (Figure 2).

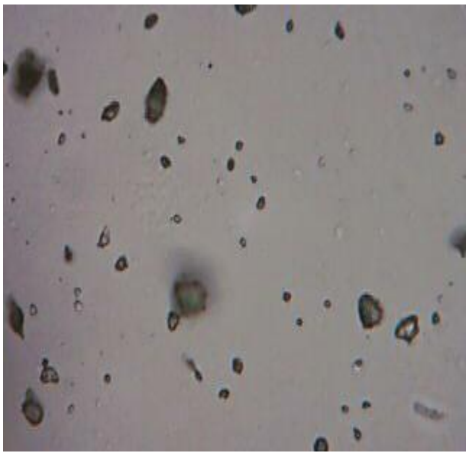

Fig 2: Image of tracks in CN-85 detector after etching

The tracks density is measured using the following equation **[**9**]**:

Tracks density (ρ) = $\frac{\text{Average number of total pits (track)}}{\text{Area of field view}}$ ………............... (4)

Results and Discussion

The uranium concentrations of the samples were measured by comparison between tracks density registered on the detectors of the samples and that of the standard samples by using the following relation: [10]

$$\frac{\rho_x}{\rho_s} = \frac{C_x}{C_s} \qquad \text{……………………(5)}$$

Where:

ρ_X: tracks density in the unknown sample (tracks/mm^2).

ρ_S: tracks density in the standard sample (tracks/mm^2).

C_S : concentration of uranium in the standard sample (ppm).

C_X : concentration of uranium in the unknown sample (ppm).

By plotting the concentrations of uranium with the tracks densities for the standard samples as shown in Figure 3, the slope of the straight line and equal to (ρ_S/ C_S) then Eq. 5 becomes:

$C_X = (\rho_X / \text{slope})$ ……………………….. (6)

Uranium concentrations in plants and soils are shown in Tables 2 and 3.

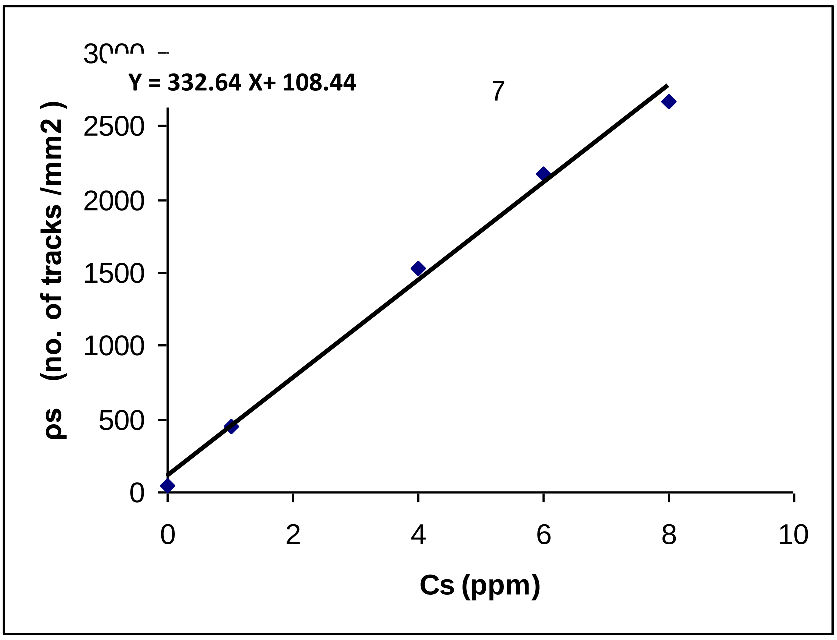

Fig 3: The relationship between the uranium concentrations and tracks densities in the standard samples .

Table 2. Uranium concentration in plants samples.

sample code	tracks density ρ tracks/mm^2)(	uranium concentration (ppm)
A1	616.29 ± 24.82	1.85 ± 1.33
A2	282.96 ± 16.82	0.86 ± 0.09
A3	460.74 ± 21.46	1.38 ± 0.17
A4	266.66 ± 16.32	0.80 ± 0.07
A5	334.81 ± 18.29	1.00 ± 0.10
A6	278.51 ± 16.68	0.83 ± 0.08
A7	791.11 ± 26.81	2.37 ± 1.53
A8	642.96 ± 25.35	1.93 ± 1.38
A9	589.62 ± 24.28	1.77 ± 1.23
A10	594.07 ± 24.37	1.78 ± 1.36
A11	762.96 ± 27.62	2.29 ± 1.51
A12	761.48 ± 27.59	2.29 ± 1.51
average	**529.09 ± 22.53**	**1.59 ± 1.25**

Table 3. Uranium concentration in soils samples.

sample code	tracks density ρ tracks/mm^2)(	uranium concentration (ppm)
A13	1328.88 ± 36.45	3.99 ± 1.99
A14	1220.74 ± 34.93	3.67 ± 1.91
A15	1293.33 ± 35.96	3.88 ± 1.96
A16	1250.37 ± 35.36	3.76 ± 1.93
A17	1274.07 ± 35.69	3.83 ± 1.95
average	**1273.47 ± 35.67**	**3.82 ± 1.94**

The uranium concentration of plants and soils are shown in Figures (4),(5).

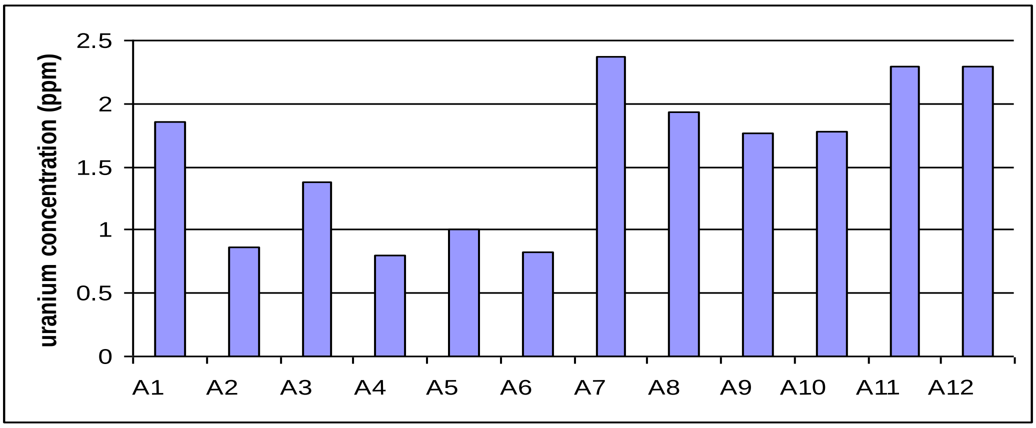

Fig 4: Uranium concentrations in plants samples

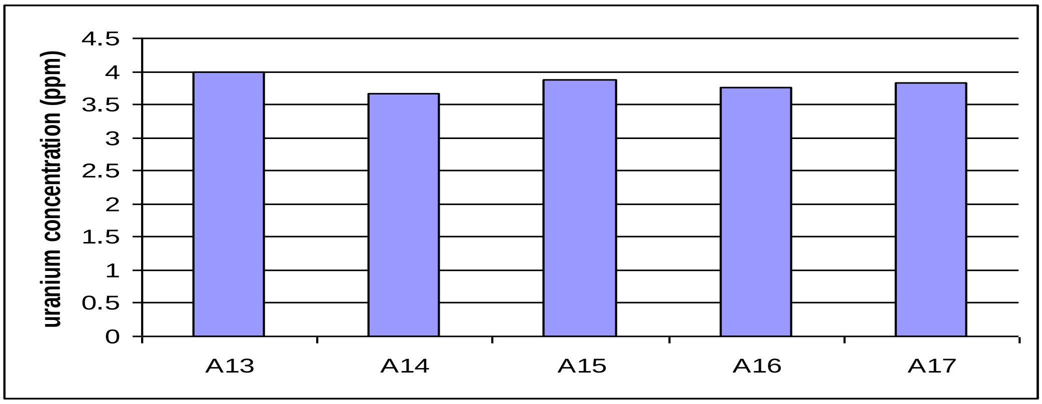

Fig 5: Uranium concentrations in soils samples

Table 2 shows the uranium concentrations of plants samples that vary from (0.8 ppm) to (2.37ppm), the minimum of uranium concentration was (0.8 ppm) in Al-Talibiya sample, and the maximum of uranium concentration was (2.37ppm) in Al-Alawee-almathaf -square sample. The average of the uranium concentrations of plants samples was (1.59ppm). Table (3) shows the uranium concentration of soils samples that vary from (3.67ppm) to (3.99ppm), the minimum of uranium concentration was (3.67ppm) in Baghdad university intersection sample, and the maximum of uranium concentration was (3.99ppm) in Al-Hurriya- square sample. The average of the uranium concentrations of soils samples was (3.82ppm). The average of the uranium concentration of soils was more than the average of the uranium concentration of plants because the soils are contained sands, slit and clay that comes from nature and air pollution such as smoke of cars, generators and factories. The results of the uranium concentration of plants and soils are quite low compared with the allowed limit (11.7 ppm) [11].

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