Determination of the Concentration of Uranium in Yemeni Surface Soil Samples of Some Hadhramout's Valleys Using Nuclear Track Detector (CR-39) 
(Research Note)

Abdulazize O. Bazohair, Awad A. Bin-Jaza and Abdullah A. Al-Shamy*

ABSTRACT
In this research, a study was conducted to investigate the concentration of uranium in surface soil samples of some Hadhramout’s valleys in Yemen using nuclear track detector (CR-39). The detector foils with the pellets of studied and standard samples were irradiated by thermal neutrons of isotopic neutron source ($^{241}$Am-Be) with neutron flux of ($4.62 \times 10^4$ n/cm$^2$.sec) for ten days. (CR-39) plates were chemically etched in (6.25N) NaOH solution at (60˚C) for four hours. The track of nuclear fission fragments in (CR-39) detector foils which are produced from the nuclear reaction $^{235}$U(n,f) were recorded using an optical microscope (Olympus-Japanese) with 100x magnification. The results of measurement indicate that uranium concentrations in samples ranged from (0.995±0.19) ppm to (4.04±0.54) ppm.

KEYWORDS: Surface soil sample, Uranium, Nuclear track detector (CR-39).

1. INTRODUCTION

The principle of detection by SSNTD’s(*) is based on the fact that heavy charged particles produce material damage along their path due to the excitation and ionization of atoms with which they interact.

Historically, the first nuclear tracks in an insulating solid was reported to have been observed by Young (1958) who bombarded Lithium Fluoride (LiF) with fission fragment, revealed their shallow pits by etching in glacial acetic acid and observed them by optical microscope.

A systematic study of nuclear tracks in solids, however, started only in the early nineteen sixties when Fleischer et al. (1965) noticed the ionized heavy charged particles tracks in plastic detectors for determining the contents in the samples. This technique was applied by Danis and Voljin (1979); Gamboa et al. (1984); Iyer and Chaudhuri (1997); Jones (1991); Singh et al. (1986); Tawfiq (1996); Velickovic et al. (1990); Yegingil and Goksu (1982) to determine uranium concentration in soil samples.

(CR-39) nuclear track detectors were used because of their high sensitivity in recording nuclear fission fragments by the reaction $^{235}$U(n,f) in determining uranium in Yemeni soil samples.

2. EXPERIMENTAL PROCEDURES

Five Yemeni soil samples were collected from some Hadhramouts’ valleys (Khrid, Arf, Huwayrah, Buwaish, Khirbah) as shown in Fig. (1). The soil surface samples are brought to laboratory and cleaned from stones and any other impurities and dried at room temperature, then they were powdered into a fine homogeneous powder using an electric agate mortar. We took (1gm) of studied and standard (from IAEA) samples and mixed every sample with a small quantity of starch ($C_{6}H_{10}O_{5}$) and pulled in the form of pellets with (2cm) diameter and (2 mm) thickness. The detector foils of (1×1cm$^2$) area of (CR-39) which contacted with the pellets of the standard and studied samples were irradiated by thermal neutrons of an isotopic neutron source ($^{241}$Am-Be) with thermal neutron flux of ($4.62 \times 10^4$ n/cm$^2$.sec) for ten days for five times as shown in Fig. (2-a) and (2-b).
Also, (CR-39) plates were irradiated by the previous neutron source without contact with the five standard samples under the same conditions and in different locations of the bulk of paraffin wax.

(CR-39) detector with (250µm) thickness of Hydrocarboneic structure (C12H18O7) was used and has the following characteristics (Cassou and Benton, 1978):
1. It has a highly optical transparent.
2. Very high sensitivity for radiation.
3. It is isotropic and homogeneous.
4. It opposes humidity and temperature except at high temperature.

The (NaOH) solution of (6.25 N) normality was prepared by dissolving (250mg) of granular sodium hydroxide in one liter of distilled water.

(CR-39) plates were chemically etched by suspending in a conical flask filled with (NaOH) solution as shown in Fig. (3), with different concentrations (5,6,7,8 N), putting in water bath and heating at different temperatures (50,60,65,70,80°C) at different times of etchment. It was found that the best normality for (NaOH) solution is (6.25 N) and its temperature (60°C) for four hours etchment the (CR-39) plates. After that they were rinsed in distilled water and dried. The density of fission fragment tracks (number of pits per unit area) was measured by using an optical microscope (Olympus-Japanese) with 100 x magnification.

3. RESULTS AND DISCUSSION

After we finished from the chemical etchment of (CR-39) plates, the densities of fission fragment tracks in the solid plates were measured by using an optical microscope with 100x magnification. The track densities on (CR-39) plates without contact with standard samples in the case of irradiation are called total yield background, this value was subtracted from the track densities which were registered on (CR-39) plates by standard samples, the track densities were illustrated in Table (1).

The relation between track density in (CR-39) plates and concentration of uranium in standard samples is shown in Fig. (4).

Uranium concentration of the unknown soil samples were calculated using relation No. (2) as follows:

\[
\frac{C_s(\text{sample})}{C_s(\text{standard})} = \frac{T_s(\text{sample})}{T_s(\text{standard})} \tag{1}
\]

\[
C_s = \frac{T_s}{T_s(\text{standard})} = \frac{T_s}{Slope} \tag{2}
\]

Where:
Cx – The concentration of unknown samples (ppm).

Ts – The track density (No. of tracks / mm²) of unknown samples.

Cs – The concentration of standard samples (ppm).

Ts – The track density (No. of tracks / mm²) of standard samples.

Slope = \( \frac{T_s}{C_s} \) – The slope of the graph as illustrated in Fig. (4).

= 0.3717 x 10² No. of tracks/mm² x ppm

The concentrations of uranium in Yemeni soil samples are illustrated in Table (2).

From Table (2), the minimum value of uranium concentration in studied Yemeni samples is (0.995±0.19)ppm as in sample No.(1) from Khrid’s valley, and the maximum value is (4.04±0.54)ppm in sample No. (5) from Khurbah’s valley, but the average uranium concentration in Yemeni soil samples is (3.19±1.27)ppm. Hence from Table (3) we see that the average uranium concentration in Yemeni studied samples is less than that in some countries of the world.

In all cases, uranium concentration in studied Yemeni soil samples is also less than the average international uranium concentration in soils (>300Bq/kg, >12ppm and [24.3±10.35] ppm in the depths from 30cm to 120cm).
Determination of the Concentration… (Research Note)  Abdulazize O. Bazohair et al.

Table (1): The Track Densities for Standard Samples (with Known Concentration).

<table>
<thead>
<tr>
<th>Standard Samples</th>
<th>Uranium Concentration (ppm)</th>
<th>Track Density No. of Tracks/mm²x10²</th>
</tr>
</thead>
<tbody>
<tr>
<td>JA-2</td>
<td>0.80</td>
<td>0.33±0.02</td>
</tr>
<tr>
<td>JG-1a</td>
<td>1.10</td>
<td>0.40±0.03</td>
</tr>
<tr>
<td>JR-1</td>
<td>3.00</td>
<td>1.10±0.09</td>
</tr>
<tr>
<td>JG-2</td>
<td>4.17</td>
<td>1.59±0.15</td>
</tr>
<tr>
<td>S-14</td>
<td>9.67</td>
<td>3.60±0.21</td>
</tr>
</tbody>
</table>

Fig. (3): The Suspension Method of (CR-39) in the Solution.

Fig. (4): The Relation Between Track Density and Concentration of Uranium in Standard Samples.

Y = 0.0101 + 0.3717 X
Slope = 0.3717x10**2No. of tracks/mm²x2xppm
Table (2): Uranium Concentration in Yemeni Soil Samples.

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Name of Valley</th>
<th>Track Density No. of Tracks/mm²x10⁻²</th>
<th>Uranium Concentration (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-</td>
<td>Khrid</td>
<td>0.37±0.07</td>
<td>0.995±0.19</td>
</tr>
<tr>
<td>2-</td>
<td>Arf</td>
<td>1.18±0.13</td>
<td>3.17±0.35</td>
</tr>
<tr>
<td>3-</td>
<td>Al-Huwayrah</td>
<td>1.42±0.15</td>
<td>3.82±0.40</td>
</tr>
<tr>
<td>4-</td>
<td>Buwaish</td>
<td>1.45±0.17</td>
<td>3.90±0.46</td>
</tr>
<tr>
<td>5-</td>
<td>Khirbah</td>
<td>1.50±0.20</td>
<td>4.04±0.54</td>
</tr>
</tbody>
</table>

Average Concentration: 3.19±1.27

Table (3): Average Uranium Concentration in Some Countries of the World Compared with Yemeni Samples.

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Country</th>
<th>Average Uranium Concentration (ppm)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-</td>
<td>Romania</td>
<td>4.46±3.24</td>
<td>(Danis and Voljin, 1979)</td>
</tr>
<tr>
<td>2-</td>
<td>Turkey</td>
<td>6.67±2.16</td>
<td>(Yegingil and Goksu, 1990)</td>
</tr>
<tr>
<td>3-</td>
<td>Mexico</td>
<td>5.92±2.56</td>
<td>(Gamboa et al., 1984)</td>
</tr>
<tr>
<td>4-</td>
<td>India</td>
<td>7.41±2.04</td>
<td>(Singh et al., 1986), (Iyer and Chaudhuri, 1997)</td>
</tr>
<tr>
<td>5-</td>
<td>Yugoslavia</td>
<td>4.35±0.21</td>
<td>(Velickovic et al., 1990)</td>
</tr>
<tr>
<td>6-</td>
<td>U.S.A.</td>
<td>4.49±4.59</td>
<td>(Jones, 1991)</td>
</tr>
<tr>
<td>7-</td>
<td>Iraq</td>
<td>5.52±3.46</td>
<td>(Tawfiq, 1996)</td>
</tr>
<tr>
<td>8-</td>
<td>Egypt</td>
<td>(0.41-5.59)</td>
<td>(Hussein and Hussein, 2004)</td>
</tr>
<tr>
<td>9-</td>
<td>Yemen</td>
<td>3.19±1.27</td>
<td>This work</td>
</tr>
</tbody>
</table>

(Saeed, 1986; IAEA, 2005 and Barakat and Hussein, 2004), respectively.

The presence of uranium in Yemeni soil samples resulting from erosion factors in mountain rocks which are surrounding the valleys from which the soil samples were taken. Also, resulting by streams of rains through these valleys which are coming from volcanic mountain series (Al-Khirbash and Al-Anbawi, 1996) around it. Therefore, these uranium concentrations in Yemeni soil samples are within permissible value.

There are many techniques which were used to determine uranium in soils or in rocks, we mention some of these techniques, for example Jamal and Mazen (2004) used alpha spectroscopy technique to determine the concentration of uranium in phosphate wet rocks which is 380 Bq/kg. Wollenberg and Smith (1990) used chemical methods to determine the concentration of uranium in different rock samples of California in U.S. which is about 4.74ppm. From these two studies, it has been noticed that the average concentration of uranium in studied Yemeni soil samples is less than its concentration in the samples of these countries.

4. CONCLUSIONS

From this research we deduce the following:

1- The (CR-39) detector is more sensitive than other plastic detectors like (CN-85, Lexan, Macrofel, LR-115… etc.) for the nuclear ionizing particles.

2- Track densities were registered on the detector by the nuclear reaction ²³⁵U(n,f) which are directly proportional with uranium concentrations in soil samples.

3- The presence of uranium concentrations in soil samples of the valleys of Hadhramout, resulted from erosion factors of the volcanic mountain series surrounding these valleys and transfer it by streams of rains through it.

4- The average uranium concentration in Yemeni soil samples are less than the concentration of uranium in the samples of the other techniques.

5- Uranium concentration in Hadhramout’s valleys are within permissible range, so there is no dangerous level of pollution in soils. Specially most houses in Hadhramout were built from the sands of these valleys, and also these sands are used in agriculture.
REFERENCES

**Title**: Identifying the Nucleolytic Effects of CR-39

**Authors**: Al-Shami Ahmed, Al-Awad Ghaith, Al-Obaid Yasser, and Al-Uzaieb Al-Abd

**Abstract**: The study was conducted to identify the nucleolytic effects of CR-39 in the Yemeni Oases. The research was performed at the Oases in the Yemen. The tested samples were analyzed using CR-39 nuclides and their activities were measured. The results showed that the nucleolytic activity of CR-39 in the Oases' soil samples was significant, with the activity levels ranging from (0.995±0.19) ppm to (4.04±0.54) ppm. The study was submitted on April 17, 2006.