Calculation of Concentrations and Transfer Factors of Uranium from Soil to Plants Using Nuclear Track Detector CR-39

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Abstract: In this study, the concentrations of uranium for four species of plants; Spinacia, Brassica Oleracea, BEASSICA Oleracea Var Capitata and Beta Vulgaris were measured in addition to the measurement of uranium concentrations in the selected soil by calculating the number of significant traces of alpha in CR-39. The 2.455 Bq/kg in Spinacia plant were the highest concentration while the lowest concentration of uranium were 1.91 Bq/kg in BEASSICA Oleracea Var Capitata plant. As for the transfer factor, the highest value 0.416 were found in Spinacia plant and the lowest value 0.323 were found in BEASSICA Oleracea Var Capitata plant. The uranium in the models studied in it did not exceed the international limit, according to the International Atomic Energy Agency.

1. Introduction

Human exposure to radiation permanently from two main sources are natural sources and industrial sources that were made by man for multiple purposes and the exposure of humans to natural resources the basic proportion of exposure such as cosmic rays and radiation from radioactive elements naturally, the materials surrounding us Almost all contain a small percentage of radioactive material [1, 2]. Based on this, the human being is exposed to a low level of radiation background. Radiation has an effect on the environment that may remain for many years to affect the genetic makeup of humans and animals. A genetic defect that appears in later generations. Furthermore, the effect of this pollution reaches water and soil and enters the food chain of both humans and animals [3].

High levels of radiation are produced from radioactive sources and nuclear explosions that cause environmental pollution, which is reflected in humans. The bombing of Hiroshima and Nagasaki in 1945 was the beginning of environmental pollution, followed by underground nuclear explosions during the years 1955-1965 and the nuclear accidents, the most important Chernobyl accident in the former Soviet Union in (1986) a significant impact on the pollution of a large area of the globe in addition to all the processes resulting from the use of radioactive sources in the medical, industrial, agricultural and other applications [4].

Therefore, there was a need to study the effect of radiation and detection and to identify the extent of pollution of the environment and how to treat them. Therefore, several research has been carried out and several techniques have been developed to calculate concentrations of radioactive materials in soil,
water, air, building materials, plants and others. Various techniques have been used to detect radioactive materials, including impact detectors, which are important techniques in determining concentrations of radioactive materials due to their availability, accuracy of results and the absence of complex systems in their measurements. Several studies have been conducted in Iraq and many techniques have been used extensively after the use of depleted uranium in the war on Iraq in 1991 [4].

Most of the countries in the world measure the rate of exposure caused by natural radiation for various purposes, including preventive studies, selection of sites of nuclear installations and preparation of contingency plans [5].

Natural radiation activity results from radioactive elements in the earth's crust as well as from extraneous sources. The natural radiation activity includes three main categories: Ground-based radionuclides (Primordial radionuclides); that have a half-life is so long enough that it has existed since creation and so far, secondary radionuclides derived by means of the radioactive decay of ground-based radionuclides and cosmic rays [6].

The normal radiation activity in most of the Earth regions varies within relatively narrow limits. Iraq is within these areas with an external exposure rate of about 7 ppm of Rontgen / hour, based on the measurements made in 1999 which reinforced the previously published studies for most The provinces of Iraq or the city of Baghdad [7 and 8].

The research aims at finding concentrations of uranium in Beta Vulgaris, Spinacia Oleracea, Brassica Oleracea and Brassica Oleracea Var Capitata plants that cultivated in the Botanical Garden of the College of Science for women since November 2017 to February 2018. The transfer factor of radioactive elements transformed from the soil to cultivated plants through soil and fertilizers and comparison of the transition coefficient between the different types of locally consumed plants using the CR-39 nuclear track detector.

2. Materials and Experimental

Four different types of leafy plants were planted in this study; Beta Vulgaris, Spinacia Oleracea, Brassica Oleracea and Brassica Oleracea Var Capitata plants, where the soil was prepared in the Botanical Garden of the College of Science for Women and the plants planted with the planting of the seeds of these plants in the soil on the distance of 25 cm between one type and another as shown in fig. 1. The plant was obtained after the end of the period devoted to agriculture, which lasted three months from November 2017 to February 2018 and then the plants were taken and dried by exposure to the air, then grinded and sifted so as to get rid of large objects to obtain a homogeneous powder, after that was placed 5 g for each type of plant, 50 g of soil before and after Agriculture (weighed using a sensitive balance), the detector were installed in a glass of plastic, as shown in fig. 2, in effect that the cup for the purpose of detecting radiation in the soil then determined the transfer factor of radioactive material from soil to plant by use nuclear track detector CR-39 thickness 250 μm, the area of $1 \times 1$ cm² and left samples for a month after that was placed detectors in small tubes then performed the scrape for the purpose of showing the effects of alpha, this process was performed using etching solution consisting of sodium hydroxide (NaOH).

The etching process is performed for 4 hours at 70 °C. After the etching process, the detectors are removed from the solution by forceps and washed with distilled water to remove the base solution and then dried after microscopic imaging as shown in fig 2.

The intensity of the tracks $\rho$ in track / mm² were calculated using the following equation:

$$\rho = \frac{N_{av}}{A}$$  \hspace{1cm} (1)

$N_{av}$: Average number of tracks in the detector.
A: The area of detector in mm².

Uranium concentrations of the samples were calculated using the relationship [9]:

$$\frac{C_x}{C_s} = \frac{\rho_x}{\rho_s}$$  \hspace{1cm} (2)

As follows:
$C_x$: Concentration of uranium in the unknown sample (ppm or ppb).
$C_s$: Concentration of uranium in standard sample (ppb or ppm).
$\rho_x$: Tracks intensity in the unknown sample (Tracks / cm$^2$).
$\rho_s$: Tracks intensity in standard sample (Tracks / cm$^2$).

\[
\frac{C_s}{\rho_s} = 67.424
\]

The curve of standard concentrations of uranium in soil and plants were shown in fig. 4 [10].

The transfer factor $T.F$ for uranium from soil to cultivated plants was calculated from the following relationship:

\[
T.F = \frac{\text{Uranium concentration in fresh plant}}{\text{Uranium concentration in dry soil}}
\]  

3. Results and Discussion

The uranium concentrations in soil, cultivated plants and transfer factor were listed in table 1.

From table 1 one can note that the highest concentration of uranium was 2.455 Bq/kg in the Spinacia plant and the lowest concentration was 1.91 Bq/kg in the BEASSICA Oleracea Var Capitata plant as in Fig 5.

As for the transfer factor was the highest value 0.416 in the plant Spinacia and the lowest value 0.323 in BEASSICA Oleracea Var Capitata as shown in fig 6.

4. Conclusions

We can conclude from this study that the Spinacia plant has the highest absorption value of uranium from the soil so it is recommended for use in the treatment of radioactive waste and is not recommended for use for nutrition, and found that the plant less valuable in the absorption of uranium from the soil is the BEASSICA Oleracea Var Capitata plant is recommended for use for the purpose of nutrition is not recommended in the field treatment of radioactive waste.

The transfer factor of uranium from soil to plant is closely related to uranium concentrations in soil and cultivated plants. The difference in transition coefficient may be due to the nature of the models used for the soil, plant and amount of uranium absorbed by the plant.

The uranium concentrations in the studied plants are within the range allowed globally [11].

To increase the environmental awareness of the citizens and to enable them to live in peace, we suggest conducting similar studies for this study in all regions of Iraq.

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Table 1. Uranium concentrations in soil, cultivated plants and transfer factor.

| Samples                        | Track density | U (ppm) | U (Bq/kg) | T.F |
|-------------------------------|---------------|---------|-----------|-----|
| Soil                          | 32.12         | 0.476   | 5.9       |     |
| BEASSICA Oleracea Var Capitata| 10.416        | 0.154   | 1.91      | 0.323|
| Brassica Oleracea             | 11.901        | 0.176   | 2.182     | 0.369|
| Beta Vulgaris                 | 12.946        | 0.192   | 2.38      | 0.4 |
| Spinacia                      | 13.392        | 0.198   | 2.455     | 0.416|

Fig. 1: Plants studied; Beta Vulgaris, Spinacia Oleracea, Brassica Oleracea and Brassica Oleracea Var Capitata.
Fig. 2: Schematic diagram showing the geometry of uranium dosimeter used in the study.

Fig. 3: View the track counting.

Fig. 4: The relation between track density and uranium concentration (ppm) for standard geological soil samples [10].
Fig. 5: Uranium concentration in all types of plant.

Fig. 6: Transfer factor in all types of plant.