Measurement of U-238 Concentrations in Soil Samples at Northern Baghdad Location

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Abstract
Studying soil contamination with uranium is necessary to assess environmental and health risks to humans. Uranium concentrations were measured in the soil samples taken from the location of the College of Education, Al-Iraqia University to the north of Baghdad city using the nuclear trace detector CR-39. Uranium concentrations were measured in 10 soil samples from different sites of the location at a depth of 3 cm using the technique of counting the traces of fission fragments resulting from the fission of the uranium nucleus with thermal neutrons. Uranium concentrations were determined by calculations based on comparison with standard samples. The results indicate that the range of uranium concentrations in the soil ranged between 0.730 ppm within the Dean Office garden and the lowest concentration 0.478 ppm within the club garden at a concentration rate of 0.610 ppm. The results obtained are also less than the permissible limit (11 ppm), indicating that the soil is not radioactively contaminated.

Keywords: Uranium-238 concentrations; CR-39 detector; Soil radioactive contamination
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1. Introduction

Uranium is one of the most important radioactive elements in nature. It was discovered by the German chemist Martin Klaproth in 1789. Its name is derived from the planet Uranus. The uranium (U-238) decays by emitting alpha particles and gamma rays, turning into thorium (Th-234) and eventually into the stable element lead [1]. Uranium is found in varying quantities in nature. It is found in the Earth's crust at a concentration of up to 4×10^{-4} % of its weight. It is also found in igneous rocks at a rate of 3 ppm. It is also found in small quantities in the soil sediments between 1.2×10^{-5} and 9.3×10^{-3} % by weight. It is also found in river and sea waters, and its percentage in river waters is usually about $1\text{x}10^{-7}$ %. Uranium is also found in small and varying quantities in plant and animal sediments and the human body. As a general average, the human body contains approximately 90 mg of uranium through the natural intake of water and food, and about 66% is found in the skeleton, 16% in the liver, 8% in the kidneys, and 10% in the rest of the body's tissues [2]. In a report published by the UNCEAR organization in 1988, it was found that the specific radioactivity rate of uranium in the soil is 40 Bq/kg [3], and this was considered the optimal concentration because the difference in the content of radioactivity in the soil is due primarily to the soil type, second, to its composition, and third, to the transport processes occurring in it. So, there was a difference in the concentrations of radionuclides in different parts of the world. [4].

Naturally occurring uranium is ubiquitously present in the environment at a wide range of concentrations. Typical concentrations in different types of environmental media and in biota are given in the following sections. In addition, uranium concentrations in the environment and the bioavailability of uranium have sometimes been altered by human activities (e.g. mining and milling ores containing uranium). Therefore, specific attention is also given to contexts in which uranium concentrations and/or bioavailability have been modified by human activities.

This work aims to measure the levels of uranium concentrations in the soil samples taken from the location of the College of Education, Al-Iraqia University. This institution is located 40 km to the north of Baghdad city.

2. Sample Collection and Preparation

10 soil samples with a depth of 3 cm were collected from different locations of the College of Education, Al-Iraqia University. The samples were dried by exposing them to sunlight for two days, then sieved to get rid of foreign bodies and finely ground until they became a fine powder using a hand mill. 0.5 g of soil was pressed after mixing it with certain proportions of starch into a disc with a thickness of 1.5 mm and a diameter of 13 mm using a press with a pressure force of up to 15 tons. The discs were placed in contact with a CR-39 detector in paraffin wax as a moderator at a distance of 5 cm from the neutron source (241Am-Be) with a neutron flux of $5x10^3$ $n.cm^{-2}.s^{-1}$ for the purpose of obtaining thermal neutrons. Through the nuclear reaction *U*(*n*,*f*), traces of alpha particles were recorded in the detector.

The chemical etching process of the CR-39 detector was carried out after the irradiation stage using sodium hydroxide (NaOH) solution. The traces of alpha particles were detected using the appropriate magnification of the optical microscope. Then, the traces were counted per unit area using a special lens divided into several squares to obtain the density of the traces using Eq. (1) [5]:

$$TD = \frac{N_p}{A} \qquad (1)$$

where *TD* is the track density, N_p is the average number of total pits (tracks), and *A* is the area of field view

3. Results and Discussion

The U-238 concentrations were calculated in soil taken from different locations using the technique of counting the traces of alpha particles emitted from the element U-238 using a CR-39 detector. By comparing them with standard samples using the relationship between the density of alpha particles traces with the known concentrations of the element U-238, the relationship was linear as in Fig. (1). From the slope of the graph, the concentrations of U-238 for unknown soil samples were calculated using Eq. (2) [6]:

$$C_x = \frac{C_S}{\rho_S} \times \rho_x = \frac{\rho_x}{Slope} \qquad (2)$$

Where C_x and C_S are the U-238 concentrations in unknown and standard samples, respectively, ρ_S and ρ_x are alpha particles trace densities for standard and unknown samples, respectively

The results of U-238 concentrations in the soil samples are listed in table (1). It is noted from this table and Fig. (2) that the results of uranium concentrations in the soil ranged between 0.478 ppm as a minimum in the club garden site and 0.730 ppm as a maximum in the deanship garden with a concentration rate of 0.610 ppm.

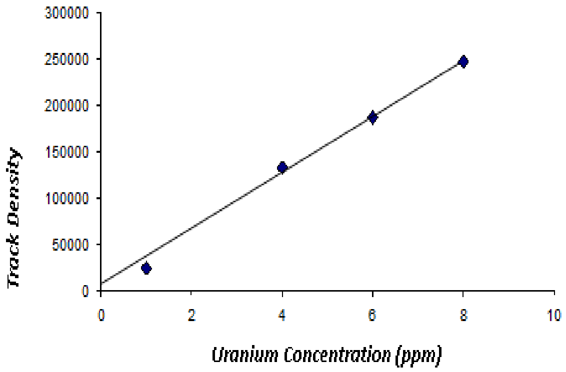

Fig. (1) Relationship between the track density and the uranium concentrations of standard soil samples

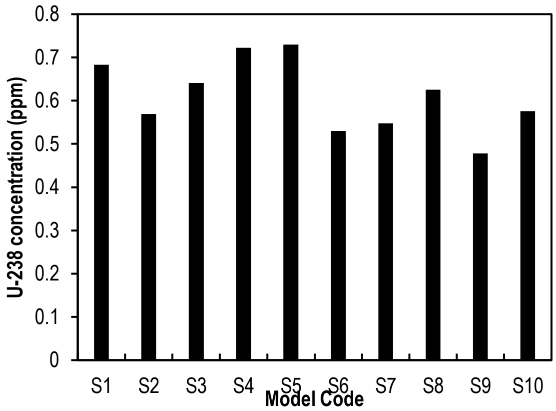

Fig. (2) U-238 levels in soil samples taken from the location of the College of Education, Al-Iraqia University

The reason for this discrepancy in the levels of uranium concentrations in the soils taken from the test location may be due to the type of the used fertilizer. Agricultural fertilizers contain a percentage of white phosphorus, which is closely related to uranium emission [7]. The levels of uranium concentrations fall within the internationally permissible limit of 11 ppm [9]. This indicates that the soil samples taken from the location of the College of Education, Al-Iraqia University is not radioactively contaminated.

Table (1) U-238 concentration levels and alpha particle trace density in soil samples at the location of the College of Education, Al-Iraqia University

Model Name	Model Code	U-238 Concentration (ppm)
Scientific departments garden	S1	0.683
Central library garden	S2	0.569
College entrance garden	S3	0.641
Literary departments garden	S4	0.722
Dean office garden	S5	0.730
Out of college 1	S6	0.530
Out of college 2	S7	0.548
College garage	S8	0.625
College club garden	S9	0.478
Laboratory garden	S10	0.576

4. Conclusions

Measuring uranium concentration levels in soil is an important preventive step to protect human health and the environment and ensure the safety of residential areas. Uranium concentration levels were measured in 10 soil samples taken from different locations inside and outside the College of Education, Al-Iraqia University. The results obtained are less than the permissible limit (11 ppm), indicating that the soil is not radioactively contaminated.

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