Study of background radiation in soil and water samples from many regions from Al-Fallujah city

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Abstract: The study of the radiological background calculation, by characterizing the radio nuclides and calculating their specific efficacy in the environment of the city of Fallujah (water and surface soil), using the nuclear impact detector technique in the case. Seven samples of water were collected using the system (GBS ). Determine the concentration of uranium accounts based on comparison with standard models were used detector nuclear impact (CR-39) as a method for the detection of uranium in soil samples for study. The specific efficacy rate of the radon-222 antibody was very close to that of other studies. Knowing the level of natural and industrial radioactivity in the environment of the city of Fallujah using appropriate and different nuclear analysis methods and comparing the results of the measurements with the radiation ackground, which was previously studied and proved to be a radiation background. The results of radioactive material from the soil and water samples record the highest rate of uranium concentration in comparison with the standards reference of (ICRP) (International Commission Radiation Protection). The highest of background radiations of those regions were suffering of military operations. The total mean dose rate of the surveyed areas is found to be roughly thrice that of the world average, and found to be higher than that of other places compared with except. The Results of Solid State Nuclear Track Detector (SSNTD) measurements of natural radioactivity using contact autoradiography for the determination of uranium and non-contact autoradiography for radon emanation are presented.

Keywords: Uranium Concentration, Contamination, Soil, water, CR-39 Detector.

1. Introduction

Uranium has been part of our planet’s crust since it was formed and is present in variable amounts in its rock, soil, air and water. Uranium enters our bodies via the air we breathe, the food we eat and the water we drink [1]. Uranium is a chemical element with the proton number 92 and a molar mass of 238.03 g/mol. It is an alpha-emitting, radioactive and silvery-white heavy metal.
Natural uranium consists of three different isotopes (99.284% U-238, 0.711% U-235 and 0.005% U-234) with a specific activity of 0.68 μCi/g [2]. All of the uranium isotopes are radioactive. Uranium also possesses a number of special characteristics. It has a high density (19.07 g/cm³), only moderately lower compared to tungsten (19.30 g/cm³) and higher compared to lead (11.35 g/cm³). Metallic uranium is chemically considerably reactive; in powder form, it can be spontaneously ignited [3]. It is of importance to mention that in the human body, there is about 0.1 mg of natural uranium [4], which is a natural component from exposure to uranium found in food, water and air. Moderately radioactive dust components settle to the ground surface after the explosion, and by the action of rain and wind, they contaminate the soil and can enter underground water [5]. The DU can thus enter the human organism through the food chain. Children are particularly vulnerable to uranium exposure; contact with DU in war zones or groundwater contamination are the most likely exposure scenarios [6]. Epidemiologic studies are essential for assessing the relationship between exposure to DU and health outcomes and should be focused on the health impacts for those in the civilian population and military veterans. After the various military conflicts in which DU was used, studies were conducted to evaluate whether there were/are grounds for concern about the health hazards of DU for military members and civilians. These epidemiological studies that have examined the levels of uranium in the urine of these groups have come to the conclusion that there were no significant exposure amounts of DU. Studies were not limited to only military field DU ingestion, but also examined civilian life, as in the case of the release of DU in fire. Many of the world's armies possess or are thought to possess DU weapons (Harley et al., 1999). Depleted uranium weapons are regarded as conventional weapons. Ammunition containing DU was used in three recent conflicts:
1. 1991, Iraq and Kuwait (Gulf War);
2. 1995, Bosnia–Herzegovina; and
3. 1999, Kosovo.

2. Materials and Methods

A. Water Bath:
The Memmert water bath, Germany) was used in the present work. It included a thermostat, which could be operated over a range of 20 °C to 110 °C. The chemical etching was carried out at 70 °C, and distilled water was used as the bath liquid. The accuracy of regulation of temperature for the bath used was better than ± 0.1 °C[7].

B. Optical Microscope:
The optical microscope is of the type (NOVEL, CHINA). It is capable of different magnifications of (10x, 40x, and 100x) and eye piece 10x to measure number of tracks and calculating the track density from the following equation:

\[
\text{Track density (ρ)} = \frac{\text{average of total track}}{\text{area of field view}} \quad \text{....(1)}
\]

C. CCD camera: A CCD camera forms light sensitive elements called pixels which sit next to each other and form a particular image of tracks. 9

D. Sensitive balance: The sensitive balance is of type (Satorius, Germany) with accuracy (±0.01 g).
3. Track Detectors:
The detector with thickness (230 μm) were cut into small pieces. The present sheets of (1x1) cm².

CR-39 Detection Principle

To measure radon cumulative concentration, time-integrated passive radon dosimeters containing CR-39 solid-state nuclear track detectors were used in this study. The selected CR-39 detector is made of polyallyl diglycol carbonate with a thickness of 230 μm. Its effective area is 1 cm² and fixed to the inner side of the container lid to expose them to the radon in the air inside the container [11]. The alpha particles generated from the decay of radon and its daughters in the air volume of the chamber can interact with the CR-39 film, causing a damage to the molecular bonds of the polymer. The damage manifests itself as sub-microscopic damage tracks on the surface of the film. Under certain chemical or electrochemical etching conditions, these latent tracks can be enlarged to observable permanent tracks. By using an optical amplification readout device, the number of these tracks can be calculated and the equilibrium concentration can be given. Poly allyl diglycol carbonate -PADC which is generally referred as CR-39 is the most sensitive of the nuclear track recording plastics[12]. The chemical form of CR-39 is C₁₂ H₁₈ O₇ as shown in figure (1). This plastic detector is made by polymerization of the oxydi-2,1-ethanediyl, di-2-propenyl ester of carbonic acid. It contains two of monomer ally functional groups [CH₂ = CH – CH₂ –] and has the following structure:

\[
\text{Figure 1. Chemical structure of CR-39 C}_{12}\text{ H}_{18}\text{ O}_{7} [13].
\]

4. Etching Conditions Optimization

Before the chemical etching of irradiated detectors, three parameters need to be determined, including the etching solution concentration, the etching temperature and the duration of the etching. Due to the inherent characteristics of the CR-39 detector, there is no general set of etching conditions for all films. There are differences in detectors produced by different manufactures, even different batches from the same manufacturer[14]. To obtain the optimal etching conditions for the detectors used in this study, a series of experiments...
were conducted. The etching solution was fixed in a 6.25 mol/L sodium hydroxide (NaOH) aqueous solution with 250 cm$^3$ and 7 cm high. Additional SSNTDs were fixed to the inner side of the container lid to expose them to the radon inside the container). The CR-39 detectors were visualized in a solution of 6.25 N NaOH for 7 h to get the better conditions for this type of detectors at 70 °C as shown in figure(2).

![Figure (2). Schematic Diagram of Long-Tube for SSNTD Technique.](image)

5. The Etching Solution and macroscopic studies
Sodium hydroxide solution with 6.25 N normality has been used for the etching process, prepared as:

\[ W = \text{Weq} \times N \times V \]  

where:
W = the weight of NaOH needed to prepare the given normality.
Weq = equivalent weight of NaOH = 40.
N = normality = 6.25.
V = volume of distilled water = 250 ml.

![Figure (3). Chemical Etching process for CR-39 detector.](image)
The etchant compartment has a volume of about 250 ml. This apparatus is a closed assembly, except for small 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 70 °C while the etching time was 7 hours.

The macroscopic studies at this step by using suitable zoom in and computes number of tracks with unit area by special lens which divided by series squares. by taking ten reads for every sample and find the average of these tries.

The track density $\rho_x$ can computes by using eq.3.

Density= (tracks/Area*h)..........(3)

Where $h$ (477h.) is the time exposure and the area is 0.0025 cm$^2$.

The determination of uranium concentration computes by the following mathematical relation:

$$C(U) = \frac{(\rho_x + 0.006)}{15.11} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (4)$$

where $C(U)$ is the uranium concentration ppb

where $\rho_x$ (tracks/cm$^2$*h)

The result of equation(4) obtained by using fig. (4) Shows of the relation between uranium concentration and track density in standard sample of the soil.

When the slope value approach to unity, it means that the result of the equation (4) which conclusion true and accuracy as shown from the graph. From graph ($R^2$) is the concentration, the y represent the slope and density is $\rho_x$.

![Fig.(4) The relation between track density and uranium concentration (ppm) for standard soil samples.](image)

**6. Samples preparation**

The Seven geological soils samples were collected from different sites of the city of Fallujah by means of an iron tube with a diameter of 3/4 inch and a length of (50) cm. Depth 30 cm in different places from the areas that were bombed in the city of...
Fallujah, and then put the soil samples for each area in a tightly closed bag. Table (1) shows the names of regions and symbols for each region. The Seven of water samples were collected from standing water from the areas chosen from the same regions, by placing the quantity of water in plastic bottles with a capacity of 1/4 liter. Table (2) shows the names and symbols of the areas from which the samples were taken:

**Table 1** shows the names of regions and symbols for each region concentration in the soil samples.

| Region Symbol | Area                      |
|---------------|---------------------------|
| S 10          | District of officers      |
| S 20          | Byblos neighborhood       |
| S 30          | Military district         |
| S 40          | The industrial district   |
| S 50          | The Golan neighborhood    |
| S 60          | Al-Nazzal neighborhood    |
| S 70          | Teacher neighborhood      |

Table (2) shows the names and symbols of the areas from which the samples were taken:

| Region Symbol | Area                      |
|---------------|---------------------------|
| W 1           | District of officers      |
| W 2           | Byblos neighborhood       |
| W 3           | Military district         |
| W 4           | The industrial district   |
| W 5           | The Golan neighborhood    |
| W 6           | Al-Nazzal neighborhood    |
| W 7           | Teacher neighborhood      |

7. Exposure process

**A- Soil samples:**

Samples from the CR-39 detector were prepared with an area of (1 x 1) cm2 and affixed to the base of a plastic container with a height of 8 cm and a nozzle with a diameter of 7 cm and arranged in such a way that the plastic container was turned.
over the container on the soil as shown in Figure (5) and left for 19 days and twenty-three hours (477 Hours) to ensure that the uranium particles released from uranium are recorded on the detector [16].

**B- Water samples:** Samples from the CR-39 detector were prepared with an area of (1 x 1) cm² and attached to the lid of a plastic container in which the water model was placed in the size of 1/4 liter as in Figure (2) and the container was kept sealed for 19 days twenty-three hours (477 hours) to ensure that the uranium particles released from uranium are recorded on the detector.

![Figure 5. Figure of the plastic container for exposing CR-39 detector to dust models.](image)

8. Results:

The number of effects for each model was calculated and the uranium density was calculated in each sample (soil, water) in each of the mentioned areas using the equation (4) and the uranium concentration was calculated using the previous equation. The following tables show the results obtained [17].

Table (3) shows the total effects, density, and concentration of soil samples.

| Region Symbol | SUM OF TRACKS | density = tracks/cm² * 2 * 10^-6 h | C(U)ppb = (density + 0.006)/15.11 | C(U)mBq/kg = C(U)ppb * 12.4 |
|---------------|--------------|------------------------------------|---------------------------------|-----------------------------|
| 10            | 160          | 13.3                               | 0.88                            | 10.9                        |
| 20            | 290          | 24.16                              | 1.6                             | 19.84                       |
| 30            | 200          | 16.6                               | 1.09                            | 13.51                       |
| 40            | 130          | 10.8                               | 0.72                            | 8.9                         |
Table (4) shows the total effects, density and concentration of water samples.

| Region Symbol | SUM OF TRACKS | density = (tracks/cm^2*10*h) | C(U)ppb = density+0.006)/15.11 | C(U)(mBq/kg) = C(U)ppb*12.4 |
|---------------|---------------|-------------------------------|-------------------------------|-------------------------------|
| s1            | 340           | 28.3                          | 1.87                          | 23.18                         |
| s2            | 80            | 6.66                          | 0.44                          | 5.45                          |
| s3            | 100           | 8.33                          | 0.55                          | 6.82                          |
| s4            | 195           | 16.25                         | 1.07                          | 13.26                         |
| s5            | 300           | 25                            | 1.65                          | 20.46                         |
| s6            | 110           | 9.16                          | 0.6                           | 7.44                          |
| s7            | 226           | 18.33                         | 1.2                           | 14.88                         |

9. Discuss the results:

The results obtained for the uranium concentrations in the soil ranging between (5.24 - 24.8) mBq / Kg and at a rate of (15.28mBq / Kg) the internationally allowed limit for the concentration of uranium in the soil according to the International Health Organization (ICRP) (International Commission Radiation Protection) (0.01488mBq / Kg).

We find that uranium concentrations in all areas of research exceed the internationally permitted limit "and in relatively high proportions" [9,18]. As for the concentration of uranium in the water samples it ranged between (5.45 - 23.18) mBq / Kg at a rate of (13.7mBq / Kg) with an "internationally permissible limit" for the concentration of uranium in water according to the WHO (ICRP), which is (0.496 mBq / Kg), and from this we find that the uranium concentration in all areas of “research has exceeded the internationally permitted limit” [19,20]. Based on the results of the research, it was found that the uranium concentration in all studied areas in the city of Fallujah exceeded the "internationally permitted limit" (0.14632 mBq / Kg). This study shows that the rates of uranium concentration in all areas of research exceeded
the internationally allowed limit, and that the uranium concentration in some regions exceeded the permissible limit significantly.

1. **Conclusion:**
The concentrations of uranium were measured by using a Solid State Nuclear Track Detectors Cr39 for 7 soil samples and 7 water which collected from the regions in Al-Fallujah city. The high concentrations of uranium was in the soil sample. The results showed that the average concentration of uranium in the water samples was higher than the permitted values average. Results of radioactive material from the soil and water samples record the highest rate of uranium concentration in comparison with the standards reference of (ICRP) (International Commission Radiation Protection). The areas of those regions which suffering of military operations showing the higher of background radiations.

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