Scientific Paper

Effect of gender and occupations on uranium concentration in human blood and soil samples collected from Babylon, Iraq

Ansam F. SHOWARD\textsuperscript{a}, Murtadha Sh. ASWOOD\textsuperscript{b}
\textsuperscript{a}Department of Physics, College of Education, University of Al-\textsuperscript{\textdegree}Qadisiyah, Al-Diwaniyah, Iraq
\textsuperscript{b}E-mail address: murtadhababylon@gmail.com

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Abstract

Uranium concentrations of human blood and soil samples have been studied at different ages and occupations in Babylon, Iraq. The technique of nuclear track detectors CR-39 with fission track analysis has been used to determine the uranium concentrations in this study. Results have shown that the concentrations of uranium ranged from 0.56 ± 0.06 to 1.24 ± 0.29 ppb with an average of 0.83 ± 0.18 ppb in blood samples. On the other hand, the concentrations of uranium in soil samples ranged from 0.93 ± 0.20 to 2.59 ± 0.15 ppm with an average of 1.72 ± 0.19 ppm. Moreover, the highest averages of concentration have been found in the city center of Babylon, reaching 1.09 ± 0.22 ppb and 2.10 ± 0.23 ppm in blood and soil samples, respectively. The results have further proved that gender and occupations have an effect in increasing the concentrations of uranium. In addition, the concentrations in blood samples are generally lower than the concentration in soil samples.

Key words: uranium; occupations; gender; human blood; soil; CR-39.

Introduction

Uranium is one of the natural radioactive hazardous elements; it has high radioactivity and high toxicity. The natural sources are found in the terrestrial and cosmogenic. While, the artificial sources include nuclear test plants, nuclear power, and others. Naturally, there are four main isotopes for uranium, as $^{235}$U, $^{233}$U, $^{234}$U, in addition to $^{238}$U. Radioisotopes decay primarily to daughters radionuclides and accompany this process alpha (α) and some beta (β) and gamma (γ) emissions. The uranium is considered to be the most important dangerous isotopes, which threatens the security of human safety and the environment. Naturally, there are four main isotopes for uranium, as $^{238}$U, $^{235}$U, $^{233}$U, in addition to $^{234}$U. Radioisotopes decay primarily to daughters radionuclides and accompany this process alpha (α) and some beta (β) and gamma (γ) emissions. The uranium is considered to be the most important dangerous isotopes, which threatens the security of human safety and the environment. Radionuclides enters into the body through mainly three pathways; inhalation, ingestion, and dermal contact, or they may enter through open wounds, to be later transmitted to the human blood and deposited in the bone marrow causing many health problems such as cancer, kidney failure, leukemia, congenital abnormalities, skin diseases and also infertility in women and other diseases. Soil is considered an important major resource for life and food production. It is also considered one way of transmitting radiation to the body, either directly or indirectly. The transfer of radiation is from the soil to the air, plant or animal to finally access the human body. Therefore, it is important and necessary to study them and identify their radioactive elements. The safety of radiological and the monitoring of alpha particles concentration emitted from uranium in blood and soil samples is becoming the main worldwide concern, particularly in the studied area (Babylon city). This is because of the increasing rate of death caused by cancer after 1991 and 2003. Many studies have been published to determine uranium concentrations in the soil of different countries. Recent epidemiological investments have provided direct evidence to the effect of the occupational exposure to external radiation on the health. The present study aims to find the effect of gender and occupation on uranium concentrations in human blood and soil samples collected from Babylon, Iraq using the technique of CR-39 detectors.

Materials and Methods

CR-39 NTDs

CR-39 is a plastic polymer used to measure the uranium concentrations in human blood and soil samples. It has been widely used to measure the radioactivity in many scientific and technology studies. This is because of its high sensitivity and its resistance to various environmental factors. In this study, track detectors with 500 μm thickness produced by the Pershore Moulding LTD Company in the UK have been used to measure the concentration of uranium in human blood and soil samples collected from Babylon, Iraq.
Etching Solution (NaOH)

A sodium hydroxide aqueous solution (NaOH) with 6.25 mol per liter was used as an etching solution to clear the latent tracks on CR-39 resulted from the fission process at 70°C for 6 h. This process was performed by water bath, which consists of a glass beaker with a tight lid in order to keep on the concentrations of the etching solution from vaporization. The etching process is applied after the irradiation of samples.

Collection and Preparation of Samples

Thirty human blood samples from males and females were collected from Morgan, AL-Hashmiah, and AL-Kifl Hospitals as shown in Table 1. After taking about 4 ml from blood, it was placed in EDTA tube in order to prevent the clotting. Later, it was put in plastic Petri dishes with labeled. The blood samples were heated at 37°C for 24 hours using an electric heating incubator to dry, and were then pulverized several times using a hand mill to produce dry powder and homogeneous. An amount of 0.5 gm from this powder was mixed with 0.1 g of starch (C₆H₁₀O₅) as a binder, after that pressed into a pellet of (1 cm and 1.5 mm) diameter and thickness, respectively. The soil samples were collected from the same area where the thirty human blood samples. Then, 100 g from each sample was taken, cleaned from impurities, and kept in polyethylene bags with a special code. Each soil sample was dried in an oven at 110°C for about 24 h to remove moisture. Then, was crushed and sieved using a 2 mm nylon mesh to obtain homogenization. After that, 0.5 g was taken from the soil powder and also mixed with 0.1 g of starch, then pressed into a pellet of (1 cm and 1.5 mm) diameter and thickness, respectively. Blood and soil samples were wrapped with two pieces of CR-39 detector (on both sides for sample), then they were taken for irradiation in the college of Ibn Al-Haytham Education, Department of Physics, at the University of Baghdad, for 7 days. This pellet was placed at a distance of 5 cm from the neutron source of (Am-Be), with a thermal flounce of $(3.024 \times 10^{15} \text{n cm}^{-2})$ on a dish made of paraffin wax as a calming for the neutron emitted from this source. After the irradiation, the CR-39 detectors were etched by NaOH solution and the tracks density was recorded using the Olympus Optical Microscope with a magnification of 400X.

Table 1. Information on human blood and soil samples in this study

| No | Location       | Code of blood sample / gender/ age(year) | Occupation | Code of soil sample |
|----|----------------|------------------------------------------|------------|---------------------|
| 1  | Centre City    | B1/F/25                                  | Housewife  | S1                  |
| 2  |                | B2/M/43                                  | Radiologist| S2                  |
| 3  |                | B3/F/20                                  | Nurse      | S3                  |
| 4  |                | B4/M/41                                  | Teacher    | S4                  |
| 5  |                | B5/F/27                                  | Nurse      | S5                  |
| 6  |                | B6/M/34                                  | Policeman  | S6                  |
| 7  | Al-Mudhatia    | B7/M/43                                  | Driver     | S7                  |
| 8  |                | B8/F/16                                  | Student    | S8                  |
| 9  |                | B9/M/56                                  | Chemical   | S9                  |
| 10 |                | B10/F/45                                 | Teacher    | S10                 |
| 11 | Al-Kifl        | B11/F/27                                 | Teacher    | S11                 |
| 12 |                | B12/F/39                                 | Teacher    | S12                 |
| 13 |                | B13/F/50                                 | Housewife  | S13                 |
| 14 |                | B14/F/62                                 | Teacher    | S14                 |
| 15 |                | B15/M/22                                 | Worker     | S15                 |
| 16 |                | B16/F/29                                 | Nurse      | S16                 |
| 17 | Al-Qasim       | B17/F/39                                 | Housewife  | S17                 |
| 18 |                | B18/F/30                                 | Teacher    | S18                 |
| 19 |                | B19/M/46                                 | Policeman  | S19                 |
| 20 | Al-Shomali     | B20/M/30                                 | Worker     | S20                 |
| 21 | Al-Musayib     | B21/M/55                                 | Teacher    | S21                 |
| 22 | Al-Mhawyl      | B22/F/37                                 | Teacher    | S22                 |
| 23 |                | B23/F/54                                 | Teacher    | S23                 |
| 24 |                | B24/F/49                                 | Housewife  | S24                 |
| 25 |                | B25/F/35                                 | Teacher    | S25                 |
| 26 |                | B26/F/49                                 | Nurse      | S26                 |
| 27 | Al-Iskandaria  | B27/F/25                                 | Housewife  | S27                 |
| 28 | Abo-Griq       | B28/M/37                                 | Nurse      | S28                 |
| 29 |                | B29/F/49                                 | Housewife  | S29                 |
| 30 | Al-Hashimiyah  | B30/F/61                                 | Nurse      | S30                 |
Calculations

Densities of fission tracks for CR-39 detectors have shown a uniform distribution of uranium on the surfaces of the samples. After that, the densities of the induced fission tracks were recorded using an optical microscope. Track densities ($\rho$) were calculated using the following form:

$$\rho = \frac{\text{average number of total tracks}}{\text{area of field view}}$$  \hspace{1cm} \text{Eq. 1}

The concentrations of uranium in human blood and soil samples were measured by comparing the densities of track recorded on CR-39 detectors of the unknown and the standard samples. According to the following relation:

$$U_x = U_s \frac{\rho_x}{\rho_s}$$  \hspace{1cm} \text{Eq. 2}

Where $U_x$ the uranium concentration for blood (ppb) or soil (ppm) in an unknown sample, $U_s$; the uranium concentration for blood (ppb) or soil (ppm) in the standard sample and $\rho_s$; track density (tracks/cm$^2$) of the unknown sample and standard samples.

Results and Discussion

Uranium concentrations in human blood samples for healthy people and soil samples are summarized in Tables 2 and 3. Table 2 represents the values of uranium concentrations for the samples. The highest concentration of uranium (ppb) in blood samples was 1.24 ± 0.29 in B19/M/46 blood sample, and the lowest concentration was 0.56 ± 0.06 in B13/F/50 blood sample, which were collected from Al-Qasim and Al-Kif, respectively. On the other hand, the concentrations of uranium (ppm) in soil samples varied from 0.93 ± 0.20 in S30 soil sample to 2.59 ± 0.15 in S25 soil sample, collected from Al-Hashimiyah and Al-Mhawyl, respectively. Table 3 represents the averages of uranium concentrations, the highest average of uranium concentration (ppb) in blood samples was 1.09 ± 0.22, and the lowest concentration was 0.64 ± 0.24 in the city center and Al-Shomali, respectively with a total average to be 0.83 ± 0.18. It was also shown that the highest average of uranium concentrations (ppm) in soil samples was 2.10 ± 0.23, and the lowest average was 0.93 ± 0.20, in the city center and Al-Hashimiyah, respectively with a total average to be 1.72 ± 0.19.

Table 2. Uranium concentrations in human blood and soil samples collected from Babylon, Iraq

| Location   | Code. of blood Sample | Occupation | Uranium concentration in blood (ppb) | Code. of soil sample | Uranium concentration in soil (ppm) |
|------------|-----------------------|------------|--------------------------------------|----------------------|-------------------------------------|
| Centre City | B1                    | Housewife  | 0.88±0.17                            | S1                   | 2.45±0.29                           |
|            | B2                    | Radiologist| 1.16±0.15                            | S2                   | 2.28±0.24                           |
|            | B3                    | Nurse      | 1.13±0.31                            | S3                   | 2.25±0.19                           |
|            | B4                    | Teacher    | 1.04±0.22                            | S4                   | 2.00±0.22                           |
|            | B5                    | Nurse      | 1.10±0.31                            | S5                   | 1.60±0.24                           |
|            | B6                    | Policeman  | 1.23±0.16                            | S6                   | 2.05±0.18                           |
| Al-Mudhatia| B7                    | Driver     | 0.86±0.10                            | S7                   | 2.14±0.15                           |
|            | B8                    | Student    | 0.71±0.13                            | S8                   | 1.70±0.23                           |
|            | B9                    | Chemical   | 0.94±0.22                            | S9                   | 1.55±0.29                           |
|            | B10                   | Teacher    | 0.81±0.14                            | S10                  | 1.09±0.16                           |
| Al-Kif     | B11                   | Teacher    | 0.82±0.13                            | S11                  | 1.88±0.27                           |
|            | B12                   | Teacher    | 0.89±0.10                            | S12                  | 1.71±0.10                           |
|            | B13                   | Housewife  | 0.56±0.06                            | S13                  | 2.13±0.33                           |
|            | B14                   | Teacher    | 0.84±0.18                            | S14                  | 1.85±0.25                           |
|            | B15                   | Worker     | 0.73±0.18                            | S15                  | 1.73±0.19                           |
|            | B16                   | Nurse      | 0.78±0.19                            | S16                  | 2.34±0.17                           |
| Al-Qasim   | B17                   | Housewife  | 0.76±0.18                            | S17                  | 1.57±0.18                           |
|            | B18                   | Teacher    | 1.02±0.17                            | S18                  | 1.82±0.29                           |
|            | B19                   | Policeman  | 1.24±0.26                            | S19                  | 1.77±0.27                           |
| Al-Shomali | B20                   | Worker     | 0.64±0.24                            | S20                  | 1.54±0.20                           |
| Al-Musayib | B21                   | Teacher    | 0.80±0.13                            | S21                  | 1.65±0.29                           |
| Al-Mhawyl  | B22                   | Teacher    | 0.65±0.14                            | S22                  | 2.13±0.15                           |
|            | B23                   | Teacher    | 0.57±0.19                            | S23                  | 1.37±0.13                           |
|            | B24                   | Housewife  | 0.68±0.15                            | S24                  | 2.09±0.12                           |
|            | B25                   | Teacher    | 0.62±0.16                            | S25                  | 2.59±0.15                           |
|            | B26                   | Nurse      | 0.85±0.22                            | S26                  | 1.82±0.14                           |
| Al-Iskandaria | B27               | Housewife  | 0.69±0.14                            | S27                  | 1.88±0.21                           |
| Abu-Griq   | B28                   | Nurse      | 0.90±0.20                            | S28                  | 1.86±0.08                           |
|            | B29                   | Housewife  | 0.83±0.17                            | S29                  | 1.81±0.03                           |
| Al-Hashimiyah | B30              | Nurse      | 0.95±0.19                            | S30                  | 0.93±0.20                           |
| Total mean |                        |            | 0.83±0.18                            |                      | 1.72±0.19                           |
Table 3. Mean uranium concentrations in human blood and soil samples collected from Babylon, Iraq

| Location       | Uranium concentrations in blood sample (ppb) | Uranium concentrations in soil sample (ppm) |
|----------------|---------------------------------------------|--------------------------------------------|
| Centre City    | 1.09±0.22                                   | 2.10±0.23                                  |
| Al-Mudhatia    | 0.83±0.15                                   | 1.62±0.20                                  |
| Al-Kifl        | 0.77±0.14                                   | 1.94±0.21                                  |
| Al-Qasim       | 1.00±0.20                                   | 1.72±0.24                                  |
| Al-Shomali     | 0.64±0.24                                   | 1.54±0.20                                  |
| Al-Musayib     | 0.80±0.13                                   | 1.65±0.29                                  |
| Al-Mhawyl      | 0.67±0.17                                   | 2.00±0.13                                  |
| Al-Ikandaria   | 0.69±0.14                                   | 1.88±0.21                                  |
| Abu-Griq       | 0.87±0.18                                   | 1.84±0.05                                  |
| Al-Hashimiyah  | 0.95±0.19                                   | 0.93±0.20                                  |
| Total mean     | 0.83±0.18                                   | 1.72±0.19                                  |

The high concentration was in B19 blood sample for a Police man living in Al-Qasim, he is working in checkpoint specifically in (X-Ray firing room, were working for 8 hours through one day, approximately) of the city center. And the lowest value was in B13 for a female housewife in Al-Kifl and these results are in agreement with results published by Tawfiq and Al-Jobouri. Furthermore, the high value of the concentration in soil samples was in S25 from Al-Mhawyl, this attributed to the nearness from the military base. The high average of uranium concentration in blood and soil samples in the city center was attributed to the events that happened during the Gulf War 1991 and 2003 on Iraq. In addition to the enormous number of factories and oil pipeline distribution companies and populace density, either the low average of uranium for blood and soil in Al-Shomali and Al-Hashimiyah, respectively attributed to the fact that this region is an agricultural region in addition to nature of the soil. The results showed the average of uranium concentrations of human blood (ppb) in the male was 0.95 ± 0.17, and 0.80 ± 0.17 in female as shown in Figure 1. On the other hand, the results also showed, the uranium concentrations in the blood samples of people working at sites of exposure to radiation, for example (policemen, radiologists, and nurses) were higher than those of non-occupational people or have other free occupational. That means there is a correlation between the uranium concentrations in human blood with the gender and occupations. Moreover, the results also confirmed, the uranium concentrations in human blood samples lower than the concentrations in soil samples as shown in Table 3 and Figure 2. Table 4 shows the comparison between uranium concentrations in blood and soil samples with other studies, the uranium concentration in the present work for the blood samples is higher than concentrations of some selected regions from Iraq and lower than the Southern of Iraq and Karbala. While, the results of the soil samples are higher than USA and Najaf, Iraq, and lower than Iraqi Kurdistan and Malaysia. The uranium concentrations were within the permitted limits that approved by the IAEA and UNSCEAR reported are be 4 ng/L and 2.67 ppm for blood and soil samples, respectively.

Figure 1. The averages of uranium concentrations (ppb) for male and female in human blood samples.

Figure 2. Uranium concentrations averages for human blood and soil samples.

Table 4. The compression of uranium concentrations in human blood and soil samples with other countries

| Country          | Uranium for blood samples in (ppb) | References |
|------------------|------------------------------------|------------|
| Iraq, Southern   | 1.43                               | [2]        |
| Iraq, Karbala    | 75*                                | [23]       |
| Iraq, Selected regions | 0.51                              | [17]       |
| Average World    | 4 ng/L                             | [21]       |
| Iraq, Babylon    | 0.83                               | Present Study |

| Country          | Uranium for soil samples in (ppm) | References |
|------------------|----------------------------------|------------|
| Malaysia         | 12.67*                           | [24]       |
| Najaf city, Iraq | 0.09 - 0.18                      | [25]       |
| Iraqi Kurdistan  | 0.269                            | [26]       |
| Average World    | 2.67*                            | [22]       |
| Iraq, Babylon    | 1.85                             | Present Study |

* Units were converted by the author
Conclusions

The results obtained have shown that the uranium concentrations for human blood and soil samples in the city center were the highest. Further, the uranium concentrations in blood samples for males were higher than the uranium concentrations of females. On the other hand, the concentrations of people working at locations of exposure to radiation, like policemen, radiologist and nurses were higher than the uranium concentrations those of non-occupational people or those have other free occupational.

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