Experimental investigation of uranium content in urine samples of cancer patients in Al-Diwaniyah Governorate, Iraq

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Abstract. In the current study, the neutron activation technique of the nuclear track detectors (CR-39) has been applied to determine the content of uranium in human urine samples. This study involved two groups of male and female subjects, the first group is cancer patients and the second group is healthy subjects. The urine samples of cancer patients and healthy subjects have been collected from Al-Diwaniyah governorate, southern Iraq. The maximum concentration of uranium for cancer patients was 5.52 μg/l to male, 35 years old, from Al-Hamzah, infected with leukemia, and the minimum concentration was 2.34 μg/l to male, 56 years old, from Al-Sudair, infected with the stomach cancer. In the healthy subjects, the maximum uranium content was 4.63 μg/l to male, 35 years, from Shamiya, and the lower uranium content was 1.02 μg/l to female, 43 years, from Sumer. Uranium content has been found to be significantly higher in cancer patients than those of the healthy subjects. The influence between the concentration of uranium and gender, smoking habit was studied.

1. Introduction

Uranium is primal radioactive element ubiquitously current in the earth, is accessible in the crust of earth near a depth of 2900 km at an average concentration of 0.76 pg per gram of soil [1, 2]. The uranium isotopes that are normally measurable in nature are $^{234}\text{U}$, $^{235}\text{U}$, and $^{238}\text{U}$ with abundances (%) of 0.0055, 0.72, and 99.27 respectively, used for the nuclear applications [3]. The uranium is an element widely distributed in the environment. It takes at many forms of gas, liquid or solid compound [4, 5]. Exposure for uranium occurs through mining, milling, and chemical processing. Uranium can entrance to the human body by inhalation, digestion food or drinking water. The uranium absorbed by human body system (like skeleton, kidney, and liver) and after that excreted, in part, during urine [6, 7], it is weakly absorbed in the gastrointestinal tract, and the urine eliminates most from that which is absorbed [8]. Many reports studied the uranium concentration in the urine due to its importance of the subject on health and the environment. Uranium has great ability to causes contamination of the environment and leading to big problems especially in areas that exposed to uranium weapons, which occurred especially after Gulf Wars during (1991-2003) in southern Iraq region [9, 10]. Several reports detected a relationship between uranium present and cancer patients [9 – 11]. The solubility of uranium varies depending on certain compounds, this solubility determines how quickly and efficiency of the body absorbing them through the lung and intestines respectively. Uranium deposited inside the bones and different organs is in the end returned again into the blood flow, which reasons many healthiness issues, starting from most cancers for kidney failure, skin diseases, respiratory disorders, and other nameless diseases [10]. In the present study, the urine samples were collected from different
subjects in hospitals of Al-Diwaniyah governorate with various ages for both male and female. The study aims to investigation the content of uranium in human urine of the cancer patients and healthy subjects by using the fission track analysis technique of solid state alpha track detector.

2. Material and method

2.1 samples collection
In the current investigation, sixty urine samples are taken from two groups, the first group consist from (30) samples from the cancer patients, were collected from the hospitals in Al-Diwaniyah governorate southern Iraq, this city was one of the sites of military activities during the Gulf wars. The second group included (30) samples from the healthy group that collected from several regions of the governorate as shown in Fig.1. The volunteers from these groups had no previous history of occupational exposure to uranium. The basic questionnaire of the volunteers such as age, gender, and smoking habit is shown in table 1.

![Figure 1. Map showing the study location of Al-Diwaniyah governorate](image)

| Table 1. Statistical description of the two groups involved in the study |
|-------------------------------------------------|
| **Basic information** | **Cancer patients group** | **Healthy group** |
| Number of males | 14 | 14 |
| Number of females | 16 | 16 |
| Age range/years | 19-95 | 19-90 |
| Average age/years (Males) | 57.21 | 55.64 |
| Average age/years (Females) | 43.62 | 42.81 |
| Average age/years (Total) | 49 | 48.8 |
2.2 Experimental method
The experimental technique that was developed to determine the uranium concentration in human urine samples is the same as that published elsewhere [12, 13]. The samples of urine were primarily stored in cold boxes with the code of the sample and then kept in the refrigerator until the time of investigation. Two drops of urine with volume equals to 100 μl were left drying on a square area of CR-39 alpha detector in an environment without dust at room temperature for 24 hours. A non-volatile substance was put on a thin film of the detector and covered by another piece of CR-39 as shown in Fig 2. Samples of urine and detectors were exposure to a beam of thermal neutrons from (Am-Be) neutron source with a total flounce of \( (3.024 \times 10^9) \text{ n cm}^{-2} \) for seven days in order to cause latent damage to the detector due \(^{235}\text{U} (n, f) \) reaction. The irradiation process was carried out in nuclear physics laboratory department of physics college of education Baghdad university. After irradiation process, CR-39 detectors were etched in 6.25 N of sodium hydroxide (NaOH) liquid at 60°C for five hours then rinsed in water [14 – 16]. Densities of the induced fission tracks were recorded by using Olympus optical microscope with magnification of 400×. The concentration of uranium in human urine samples was measured by comparing between the densities of track registered on CR-39 detectors of the unknown samples and that of the standard samples by the following expression [9, 14]:

\[
U_x (\mu g/l) = U_s \rho_x / \rho_s \tag{1}
\]

Where: \( \rho_x \) and \( \rho_s \) are fission tracks densities for the standard samples and unknown samples, respectively. \( U_x \) and \( U_s \) are the uranium concentration for the standard samples and unknown samples, respectively.

![Sample preparation](image)

**Figure 2.** Preparation the droplet of urine samples to determine the uranium content

2.3 Statistical analysis
The results of the present investigation were analyzed by using Statistical Package of the Social Sciences (SPSS) program. Independent sample t Test was used to estimate the significance of the probability level (P) between the studied groups.

3. Result and discussion
Table 2 shows the uranium content in the samples of urine for cancer patients group. The highest value of uranium concentration was 5.52 \( \mu g/l \) for male, 35 years, from Al-Hamzah suffering from leukemia, while the lower was 2.34 \( g/l \) to male, 56 years, from Al-Sudair suffering from stomach cancer. The mean of uranium concentration in urine for this group was 4.017 \( g/l \).
Table 2. Concentration of uranium (g/l) in urine samples of the cancer patients group

| Sample code | Age (Year) | Gender | Cancer Type | Smoking habit | Location    | Uranium content ± Sd. Error |
|-------------|------------|--------|-------------|---------------|-------------|-----------------------------|
| P1          | 35         | M      | Leukemia    | Yes           | AL-Hamzah   | 5.52 ± 0.21                 |
| P2          | 35         | F      | Breast      | No            | Sumer       | 3.81 ± 0.18                 |
| P3          | 63         | M      | Lymphoma    | No            | AL-Badair   | 3.98 ± 0.18                 |
| P4          | 52         | M      | Lymphoma    | No            | Diwaniyah   | 3.62 ± 0.16                 |
| P5          | 50         | F      | Breast      | Yes           | Diwaniyah   | 3.81 ± 0.18                 |
| P6          | 47         | F      | Lung        | Yes           | Sumer       | 0.94 ± 0.18                 |
| P7          | 58         | F      | pancreatic  | No            | Diwaniyah   | 4.31 ± 0.16                 |
| P8          | 55         | F      | Breast      | No            | AL-Hamzah   | 4.66 ± 0.18                 |
| P9          | 48         | F      | Leukemia    | No            | Diwaniyah   | 2.83 ± 0.19                 |
| P10         | 55         | F      | Lymphoma    | No            | AL-Hamzah   | 3.23 ± 0.20                 |
| P11         | 53         | M      | Brain       | Yes           | Shamiyeh    | 4.97 ± 0.20                 |
| P12         | 74         | M      | Leukemia    | Yes           | Sumer       | 3.21 ± 0.17                 |
| P13         | 70         | M      | Bladder     | Yes           | Diwaniyah   | 4.42 ± 0.18                 |
| P14         | 30         | F      | Leukemia    | No            | Sunni       | 4.81 ± 0.20                 |
| P15         | 61         | M      | Spinal      | No            | Diwaniyah   | 3.88 ± 0.14                 |
| P16         | 50         | F      | Cervical    | No            | AL-Hamzah   | 3.20 ± 0.20                 |
| P17         | 56         | M      | Stomach     | No            | Al-Sudair   | 2.34 ± 0.19                 |
| P18         | 40         | F      | Breast      | No            | Diwaniyah   | 3.17 ± 0.14                 |
| P19         | 19         | M      | Leukemia    | No            | Diwaniyah   | 2.85 ± 0.16                 |
| P20         | 33         | F      | Breast      | No            | Shamiyeh    | 3.34 ± 0.12                 |
| P21         | 47         | F      | Breast      | No            | Diwaniyah   | 3.41 ± 0.16                 |
| P22         | 24         | F      | Lymphoma    | No            | Shamiyeh    | 3.87 ± 0.10                 |
| P23         | 73         | M      | Lung        | No            | Diwaniyah   | 3.67 ± 0.17                 |
| P24         | 95         | M      | Prostate    | Yes           | Diwaniyah   | 5.36 ± 0.21                 |
| P25         | 62         | F      | Breast      | No            | Diwaniyah   | 4.11 ± 0.15                 |
| P26         | 34         | F      | Stomach     | No            | Sunni       | 5.06 ± 0.21                 |
| P27         | 30         | F      | Lymphoma    | No            | Sunni       | 4.52 ± 0.11                 |
| P28         | 67         | M      | Liver       | Yes           | Diwaniyah   | 4.01 ± 0.15                 |
| P29         | 42         | M      | Leukemia    | No            | Diwaniyah   | 4.98 ± 0.20                 |
| P30         | 41         | M      | Lung        | No            | Diwaniyah   | 4.49 ± 0.22                 |

Mean ± Std Error: 4.017 ± 0.17

Urinary uranium of the healthy group is shown in table 3, from this table the results ranged between 4.63 g/l for male, 36 years, from Al-Shamiya and 1.02 g/l for female, 43 years, from Sumer. The mean of uranium level in urine for this group was 2.01 g/l. Tables 2, 3 illustrate the mean value of urinary uranium of the cancer patients group was two times higher than the healthy group. This finding indicates that the cancer patients exposed to high level of uranium by inhalation or ingestion air and food contaminated with uranium due to the military and human activities. Statistically significant difference in urinary uranium levels between healthy subjects and cancer patients group was observed by independent sample test (P < 0.001).
Table 3. Concentration of uranium (μg/l) in urine samples of the healthy subjects

| Sample code | Age (Year) | Gender | Smoking habit | Location     | Uranium content ± Std Error |
|-------------|------------|--------|---------------|--------------|-----------------------------|
| H1          | 36         | M      | Yes           | Shamiyah     | 4.63 ± 0.19                 |
| H2          | 35         | F      | No            | Al-Hamzah    | 1.84 ± 0.10                 |
| H3          | 63         | M      | Yes           | Shamiyah     | 2.02 ± 0.15                 |
| H4          | 53         | M      | Yes           | Sunni        | 2.07 ± 0.12                 |
| H5          | 50         | F      | No            | Diwaniyah    | 2.13 ± 0.13                 |
| H6          | 48         | F      | No            | Diwaniyah    | 2.01 ± 0.16                 |
| H7          | 57         | F      | No            | Diwaniyah    | 1.69 ± 0.15                 |
| H8          | 56         | F      | No            | Diwaniyah    | 1.22 ± 0.15                 |
| H9          | 43         | F      | No            | Shafei       | 1.14 ± 0.18                 |
| H10         | 57         | F      | No            | Shamiyah     | 1.52 ± 0.13                 |
| H11         | 52         | M      | Yes           | Sumer        | 2.95 ± 0.18                 |
| H12         | 75         | M      | Yes           | Afak         | 2.20 ± 0.15                 |
| H13         | 70         | M      | No            | Diwaniyah    | 1.92 ± 0.12                 |
| H14         | 25         | F      | No            | Sunni        | 1.35 ± 0.17                 |
| H15         | 50         | M      | No            | Diwaniyah    | 1.03 ± 0.16                 |
| H16         | 49         | F      | No            | AL-Hamzah    | 1.70 ± 0.17                 |
| H17         | 56         | M      | Yes           | Diwaniyah    | 2.01 ± 0.16                 |
| H18         | 44         | F      | No            | Diwaniyah    | 1.66 ± 0.15                 |
| H19         | 19         | M      | No            | Diwaniyah    | 1.64 ± 0.13                 |
| H20         | 32         | F      | No            | Diwaniyah    | 1.41 ± 0.11                 |
| H21         | 43         | F      | No            | Sumer        | 1.02 ± 0.15                 |
| H22         | 23         | F      | No            | Diwaniyah    | 1.66 ± 0.14                 |
| H23         | 70         | M      | Yes           | Al-Hamzah    | 2.57 ± 0.18                 |
| H24         | 90         | M      | No            | Diwaniyah    | 2.94 ± 0.19                 |
| H25         | 63         | F      | No            | Al-Sudair    | 2.10 ± 0.16                 |
| H26         | 33         | F      | No            | Diwaniyah    | 2.11 ± 0.14                 |
| H27         | 27         | F      | No            | Daghara      | 1.83 ± 0.16                 |
| H28         | 63         | M      | No            | Al-Hamzah    | 2.07 ± 0.15                 |
| H29         | 41         | M      | Yes           | Diwaniyah    | 3.40 ± 0.13                 |
| H30         | 42         | M      | Yes           | Sumer        | 2.63 ± 0.16                 |

Mean ± Std Error 2.01 ± 0.15

Table 4 shows the average of uranium content in human urine depending on the gender of volunteers. The mean value of uranium level in urine of males and females cancer patients group is 4.09 ± 0.18 μg/l and 3.94 ± 0.16 μg/l respectively, while the mean value of urinary uranium of males and females healthy subjects is 2.43 ± 0.15 μg/l and 1.64 ± 0.14 μg/l respectively. The results reveal that the uranium levels in urine samples of men cancer patients and healthy subjects are more than women of the study groups. The case behind this result can be attributed that the males ingested more uranium through food and water where they drink water in sufficient amounts during long working hours or maybe the exposure to the uranium from the working place, therefore the adult male showing a higher urinary uranium than female. [12]. The mean value of uranium concentrations in urine samples of the study groups as a function of the smoking habit plotted graphically in Figure 3. As presented in this figure the mean value of uranium concentration of smokers and non-smokers of cancer patients group is 4.60 ± 0.18 μg/l and 3.67 ± 0.17 μg/l respectively, while the mean value of uranium content of smokers and non-smokers of healthy subjects is 2.92 ± 0.15 μg/l and 1.74 ± 0.14 μg/l respectively. The mean values of urinary uranium for smokers of cancer patients and healthy subjects are higher than
those for non-smokers of cancer patients and healthy subjects. This is because people who smoke have a higher dose of uranium in their bodies than non-smokers due to uranium in tobacco get in the body by the smoking. Many studies reported high levels of alpha emitters and uranium in different organs of the human body of smokers such as tooth, blood, hair and soft tissues [9, 17].

**Table 4.** Concentration of uranium (μg/l) in urine samples as a function of gender

| Gender          | No. of subjects | Mean ± Std Error |
|-----------------|-----------------|------------------|
| Cancer patients  |                 |                  |
| Male            | 14              | 4.09 ± 0.18      |
| Female          | 16              | 3.94 ± 0.16      |
| Healthy group   |                 |                  |
| Male            | 14              | 2.43±0.15        |
| Female          | 16              | 1.64±0.14        |

**Figure 3.** Uranium concentrations in urine sample as a function of smoking habit

Table 5 represents the comparison of the present results with the results of other researchers for the different countries. The results of the present investigation show that the urinary uranium concentrations of cancer patients and healthy subjects are 4.017 ± 0.17 μg/l and 2.01±0.15 μg/l, respectively. These values are higher than those that found in other countries. On other hand, the results of the study groups are about a factor of 4 to 8 higher than ICRP references mean value of urinary uranium 0.5 μg/l [18]; this indicates that the Iraqi environment has been badly polluted due to continuous wars since Gulf war up to now.

**Table 5.** Uranium concentration (μg/l) in urine samples for different countries

| country                  | uranium content | References |
|--------------------------|-----------------|------------|
| Jordan                   | 0.32            | [1]        |
| India                    | 0.017 ± 0.014   | [6]        |
| Iraq, Al-Anbar           | 1.31 ± 0.001    | [11]       |
| ICRP                     | 0.5             | [18]       |
| USA                      | 0.035           | [19]       |
| Finland                  | 2.64            | [20]       |
| Iraq, Al-Diwaniyah Cancer patients | 4.01 ± 0.17 | Present work |
| Healthy subjects         | 2.01±0.15       |            |
Conclusion
The present results exhibited that the uranium levels in urine samples of the cancer patients are higher than those of the healthy subjects. In addition, it reveals a direct relation between the uranium exposure and cancerous disease. The results of the present investigation are higher than ICRP references mean value of urinary uranium 0.5 μg/l.

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