In vitro detection of urinary uranium of healthy subjects in Babylon governorate, Iraq

Anees A. Al-Hamzawi1*, Murtadha Sh. Aswood1, Najeba F. Saleh2
1Department of Physics, College of Education, University of Al-Qadisiyah, Al-Diwaniyah, Iraq
2Department of Physics, Faculty of Science and Health, Koya University, Koya, Kurdistan Region, Iraq

*E-mail: anees.hassan@qu.edu.iq; aneesphys@gmail.com

Abstract. The assay of urine samples is the effective method for monitoring the internal exposure of radiological pollutions in healthy human body. This in vitro study was aimed to detection the urinary uranium of healthy people in Babylon governorate, central of Iraq. The effective technique of fission track with alpha detector CR-39 was applied to determine the urinary uranium. The results showed that the urinary uranium ranged between 0.48 ± 0.13 μg/l to 2.15 ± 0.22 μg/l, with the mean value of uranium levels is 1.25 ± 0.09 μg/l. The average value of urinary uranium is higher than ICRP reference mean value of 0.5 μg/l. The levels of urinary uranium varied based on the gender and smoking habit.

1. Introduction
Uranium is a naturally occurring radionuclide found virtually everywhere in the environment. It is found in all sources of water groundwater, surface and drinking water and earth’s crust also in food of animal and vegetal origin [1, 2]. Uranium and its isotopes are considered most serious pollution due to its radiological and toxicological activity which is a threat to the human and the environment [3, 4]. The presence of uranium and its isotopes in the environment can be attributed to the human activities and using of uranium in a wide range of applications such as industrial agricultural and nuclear weapons [5, 6]. The ingestion of food and drinking water or inhalations of airborne particles are considered the main pathways of uranium entrance into the human body [7]. The tolerable daily intake of uranium for humans is 0.6 g/kg of body weight per day as mentioned by World Health Organization [8]. The healthy people may excrete between 0.01 g to 0.4 g of uranium in urine each day depending on the dietary intake [9]. Epidemiological studies have confirmed an association between uranium levels in drinking water and renal excretion of uranium; urinalysis indicates that higher contents of uranium in drinking water result in increased indicators for many healthy problems such as kidney, bladder damage and carcinogenic possibility [10 – 12]. As a result of the human activities and military events during the Gulf wars in 1991, 2003 and followed, the environment in Iraq has been badly affected [4, 13]. The urinary uranium and its influence of gender, healthy status and smoking habit are not well known and not studied in most cities. For this reason, this investigation was aimed to determine the urinary uranium and dependence of uranium on gender and smoking habit of healthy subjects from Babylon governorate central of Iraq. Alpha track detectors CR-39 with fission track analysis technique were applied to determine the trace levels of urinary uranium. The results of this study will enrich current findings on determine the contents of urinary uranium of healthy individuals.
2. Material and method

2.1 Samples collection

This study was based on thirty samples of urine were taken from male and female volunteers, collected from Babylon governorate central of Iraq as shown in Fig.1. The population in Babylon governorate was estimated to be 2, 065,042 people and the total area is 5,119 km$^2$ [14]. Babylon governorate is one of the Iraqi cities which exposed to military events during the Gulf Wars in 1991 and 2003 as well as increase the human activities that led to increased levels of pollution in the environment. The subjects of this investigation completed a questionnaire about their information like: age, gender, medical history and smoking status as shown in Table 1. The subjects had no previous vocational exposure to uranium and its compounds. Human urine samples were stored in cold boxes with the code of the sample and then kept in the refrigerator until the time of the detection.

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

**Table 1.** Demographic information of the volunteers

| Demographic information | Current volunteers |
|-------------------------|--------------------|
| Number of males         | 15                 |
| Number of females       | 15                 |
| Number of smokers       | 10                 |
| Age range (years)       | 2 – 65             |
| Males average age (years)| 32.60              |
| Females average age (years)| 32.27         |

2.2 Experimental method

The volume of human urine equals to 100  μl was left on (1 × 1 cm$^2$) area of CR-39 alpha detector to drying for 24 hours in an environment without dust at room temperature. The dried sample of urine was covered by another piece of CR-39 detector. Detectors of CR-39 with urine sample were irradiate to a beam of thermal neutrons from (Am-Be) neutron source for seven days with a total flounce equals to (3.024×10$^{9}$) n cm$^{-2}$ in order to cause latent damage to the detector due $^{235}$U (n, f) reaction. After that, CR-39 alpha detectors were etched in sodium hydroxide (NaOH) liquid under ideal conditions of chemical etching 6.25 normality for five hours at 60 °C then rinsed in water, as reported
elsewhere [1 – 4, 14]. Olympus optical microscope with magnification of 400x was used to record the densities of the induced fission tracks. The concentration of urinary uranium was determined by comparing between the tracks densities registered on CR-39 detectors of the unknown samples and that of the standard samples by the following relation [1, 2]:

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

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

3. Results and discussion

The results of the uranium excretion in urine samples of the healthy volunteers in Babylon governorate are given in Table 2. The maximum value obtained of urinary uranium is 2.15 ± 0.22 \( \mu g/l \) which belongs to a male 51 years old, and the minimum value of urinary uranium is 0.48 ± 0.13 \( \mu g/l \) for a female child 3 years old. The mean value of uranium excretion in urine samples of these participants is 1.25 ± 0.09 \( \mu g/l \).

| Sample code | Gender | Age (years) | Smoking habit | Uranium content |
|-------------|--------|-------------|---------------|-----------------|
| U01         | Male   | 35          | Yes           | 1.77 ± 0.18     |
| U02         | Male   | 15          | No            | 0.96 ± 0.09     |
| U03         | Female | 6           | No            | 0.62 ± 0.17     |
| U04         | Male   | 33          | Yes           | 1.40 ± 0.15     |
| U05         | Male   | 45          | No            | 1.86 ± 0.18     |
| U06         | Female | 58          | Yes           | 1.32 ± 0.19     |
| U07         | Female | 18          | No            | 0.76 ± 0.15     |
| U08         | Female | 21          | No            | 0.93 ± 0.14     |
| U09         | Male   | 22          | No            | 1.16 ± 0.18     |
| U10         | Male   | 61          | Yes           | 2.10 ± 0.19     |
| U11         | Female | 32          | No            | 1.05 ± 0.14     |
| U12         | Female | 3           | No            | 0.48 ± 0.13     |
| U13         | Male   | 37          | Yes           | 1.32 ± 0.15     |
| U14         | Female | 13          | No            | 0.85 ± 0.16     |
| U15         | Male   | 2           | No            | 0.55 ± 0.12     |
| U16         | Female | 30          | No            | 0.98 ± 0.16     |
| U17         | Male   | 51          | Yes           | 2.15 ± 0.22     |
| U18         | Male   | 20          | No            | 1.08 ± 0.20     |
| U19         | Female | 16          | No            | 0.82 ± 0.10     |
| U20         | Male   | 39          | Yes           | 1.45 ± 0.20     |
| U21         | Male   | 10          | No            | 0.75 ± 0.11     |
| U22         | Female | 8           | No            | 0.58 ± 0.09     |
| U23         | Female | 46          | Yes           | 1.51 ± 0.17     |
| U24         | Male   | 24          | No            | 1.37 ± 0.16     |
| U25         | Female | 65          | Yes           | 1.98 ± 0.17     |
| U26         | Male   | 42          | No            | 1.71 ± 0.18     |
| U27         | Female | 48          | No            | 1.19 ± 0.14     |
| U28         | Male   | 53          | No            | 1.95 ± 0.21     |
| U29         | Female | 56          | Yes           | 1.35 ± 0.13     |
| U30         | Female | 64          | No            | 1.62 ± 0.20     |

Mean ± Std. Error: \( 1.25 ± 0.09 \)
Table 3 illustrates the average value of urinary uranium content depending on the gender of volunteers. The mean value of urinary uranium of males and females is $1.44 \pm 0.12 \text{μg/l}$ and $1.07 \pm 0.11 \text{μg/l}$, respectively. From this table the findings reveal that the mean value of uranium excretion in urine samples of male is significantly higher than female. This finding can be attributed that the men ingested more uranium through drinking water or food during long working hours, for this reason the adult male showing a higher urine volume than female [15].

**Table 3.** Average value of uranium content (μg/l) in urine samples as a function of gender

| Gender | No. of subjects | Mean ± Std. Error |
|--------|----------------|------------------|
| Male   | 15             | $1.44 \pm 0.12$  |
| Female | 15             | $1.07 \pm 0.11$  |

To find an age-dependency with uranium content, the results of the present investigation were categorized into seven age groups as shown in Table 4. From this table the average values of the uranium excretion were found to be proportional to the age group. The average value of urinary uranium of the participants in the age more than 60 years is $1.90 \pm 0.14 \text{μg/l}$ and it is about twofold higher than that for the age between 11 – 20 years and about threefold higher than that for the age between 1 – 10 years. This finding indicates a significant of uranium excretion with age because dietary intake during childhood is correlated with age under conditions of continuous level of intake. The increase of uranium content in body with age is also predicted by the ICRP uranium model and other studies [3, 15 – 16].

**Table 4.** Average value of uranium content (μg/l) in urine samples as a function of age group

| Age group (years) | No. of subjects | Mean ± std. Error |
|-------------------|----------------|-------------------|
| 1 – 10            | 5              | $0.60 \pm 0.04$   |
| 11 – 20           | 5              | $0.89 \pm 0.05$   |
| 21 – 30           | 4              | $1.11 \pm 0.01$   |
| 31 – 40           | 5              | $1.40 \pm 0.11$   |
| 41 – 50           | 4              | $1.57 \pm 0.14$   |
| 51 – 60           | 4              | $1.69 \pm 0.21$   |
| Above 60          | 3              | $1.90 \pm 0.14$   |

Figure 2 represents the average of uranium excretion in urine of the participants with smoking status. From this figure the average of uranium levels of smokers and non-smokers is $1.64 \pm 0.11 \text{μg/l}$ and $1.025 \pm 0.14 \text{μg/l}$, respectively. The average value of urinary uranium of smokers is significantly higher than those of non-smokers. This result indicates that the smokers have a high content of urinary uranium than those non-smokers due to uranium in tobacco get in the body by the smoking.

**Figure 2.** Uranium content (μg/l) in urine samples as a function of smoking status
The average value of urinary uranium of the participants is 1.25 μg/l about a factor of 2.5 higher than ICRP reference mean value of 0.5 μg/l [17]; this indicates that the environment in Babylon city has been contaminated as a result of the continuous wars since Gulf war in 1991 up to now as well as the human activities. This explains the increase in cases of cancerous diseases and other health problems in Babil governorate [18]. The levels of urinary uranium excretion in other countries are different and summarized in Table 5. The figures of the present detection are higher than those of individuals from USA, Germany, India, Jordan and lower than those of Finland and Syria.

Table 5. Average value of uranium content (μg/l) in urine samples for different countries

| No | Country     | Uranium content | References |
|----|-------------|-----------------|------------|
| 1  | USA         | 0.035           | [19]       |
| 2  | Germany     | 0.023 ± 0.018   | [20]       |
| 3  | India       | 0.017 ± 0.014   | [21]       |
| 4  | Jordan      | 0.32            | [22]       |
| 5  | Finland     | 2.64            | [23]       |
| 6  | Syria       | 1.41            | [24]       |
| 7  | Iraq – Anbar| 1.31 ± 0.001    | [15]       |
| 8  | Iraq – Babil| 1.25 ± 0.09     | Present work |

Conclusion
The present results exhibited the uranium concentrations in urine samples of the healthy volunteers in Babylon governorate. The obtained value of urinary uranium was found to be higher than the permissible limit recommended by (ICRP). In addition, it reveals that the urinary uranium of male is higher than female. The levels of excretion urinary uranium varied based on the age of the participants.

Acknowledgments
Support from Department of Physics, College of Education, University of Al-Qadisiyah is gratefully acknowledged.

Reference:
[1] Al-Hamzawi A A, Jaafar M S and Tawfiq N F 2015 Concentration of uranium in human cancerous tissues of Southern Iraqi patients using fission track analysis Journal of Radioanalytical and Nuclear Chemistry. 303(3) 1703-1709.
[2] Al-Hamzawi A A, Jaafar M S and Tawfiq N F 2014 Uranium concentration in blood samples of Southern Iraqi leukemia patients using CR-39 track detector Journal of radioanalytical and nuclear chemistry. 299(3) 1267-1272.
[3] Al-Hamzawi A A, Jaafar M S and Tawfiq N F 2014 The measurements of uranium concentration in human blood in selected regions in Iraq Using CR-39 track detector Advanced Materials Research. 925 679-683.
[4] Al-Gharabi M G and Al-Hamzawi A A 2019 Investigation of uranium concentrations in selected soil samples of Al-Diwaniyah governorate, Iraq using CR-39 detector In Journal of Physics: Conference Series. 1234(1) 012061. IOP Publishing.
[5] Al-Hamzawi A A, Jafaar M S and Tawfiq N F 2014 The relationship between uranium contamination and cancerous diseases of Southern Iraqi patients Pensee. 76(3).
[6] Al-Hamzawi A A, Jaafar M S, Tawfiq N F and Salih N F 2013 Uranium concentration in human blood using fission track etch technique Journal of Natural Sciences Research. 13(1) 176-181.
[7] Bersina I G, Brandt R, Vater P, Hinke K and Schütze M 1995 Fission track autoradiography as a means to investigate plants for their contamination with natural and technogenic uranium Radiation Measurements. 24(3) 277-282.
[8] WHO, World Health Organization 1998 Guidelines for Drinking Water Quality 2nd ed, Vol.1, Recommendations Addendum, Geneva.

[9] Zarkadas C, Karydas A G and Paradellis T 2001 Determination of uranium in human urine by total reflection X-ray fluorescence Spectrochimica Acta Part B: Atomic Spectroscopy. 56(12) 2505-2511.

[10] Zamora M L, Tracy B L, Zielinski J M, Meyerhof D P and Moss M A 1998 Chronic ingestion of uranium in drinking water: a study of kidney bioeffects in humans Toxicological Sciences. 43(1) 68-77.

[11] Kurttio P, Auvinen A, Salonen L, Saha H, Pekkanen J, Mäkeläinen I, Väisänen S B, Penttilä I M and Komulainen H 2002 Renal effects of uranium in drinking water Environmental Health Perspectives. 110(4) 337-342.

[12] Tirmarche M, Harrison J D, Laurier D, Paquet F, Blanchardon E, and Marsh J W 2010 Lung cancer risk from radon and progeny and statement on radon Annals of the ICRP. 40(1) 1-64.

[13] Al-Hamzawi A A and Al-Gharabi M G 2019 Heavy metals concentrations in selected soil samples of Al-Diwaniyah governorate, Southern Iraq SN Applied Sciences. 1(8) 854.

[14] Al-Hamzawi A A, Tawfiq N F, Aswood M S and Najim F A 2019 Determination of radon concentrations near mobile towers in selected cities of Babylon governorate, Iraq In Journal of Physics: Conference Series. 1234(1) 012026. IOP Publishing.

[15] Saleh A F, Elias M M and Tawfiq N F 2013 Determination of uranium concentration in urine of workers in an Iraqi phosphate mine and fertilizer plants Journal of radioanalytical and nuclear chemistry. 298(1) 187-193.

[16] ICRP, International Commission on Radiological Protection 1995 Age dependent dose to members of the public from intake of radionuclides: Part 3 Ingestion dose coefficients, ICRP publication 69 Pergamon Press, Oxford, UK.

[17] ICRP, International Commission on Radiological Protection 1975 Report of the Task Group on Reference Man ICRP Publication 23 Pergamon Press, Oxford, UK.

[18] Showard A F and Aswood M S 2019 Measuring of Alpha particles in Blood samples of Leukemia patients in Babylon governorate, Iraq In Journal of Physics: Conference Series. 1234(1) 012062. IOP Publishing.

[19] Ting B G, Paschal D C, Jarrett J M, Pirkle J L, Jackson R J, Sampson E J and Caudill S P 1999 Uranium and thorium in urine of United States residents: reference range concentrations Environmental research. 81(1) 45-51.

[20] Schramel P, Wendler I, Roth P and Werner E 1997 Method for the determination of thorium and uranium in urine by ICP-MS Microchimica Acta. 126(3-4) 263-266.

[21] Dang H S, Pullat V R and Pillai K C 1992 Determining the normal concentration of uranium in urine and application of the data to its biokinetics Health physics. 62(6) 562-566.

[22] Al-Jundi J, Werner E, Roth P, Hörlriegl V, Wendler I and Schramel P 2004 Thorium and uranium contents in human urine: influence of age and residential area Journal of environmental radioactivity. 71(1) 61-70.

[23] Karpas Z, Paz-Tal O, Lorber A, Salonen L, Komulainen H, Auvinen A and Kurttio P 2005 Urine, hair, and nails as indicators for ingestion of uranium in drinking water Health physics. 88(3) 229-242.

[24] Othman I 1993 The relationship between uranium in blood and the number of working years in the Syrian phosphate mines Journal of environmental radioactivity. 18(2) 151-161.