Iraqi Journal of Science, 2022, Vol. 63, No. 8, pp: 3359-3365
DOI: 10.24996/ijs.2022.63.8.11

ISSN: 0067-2904

Estimation of Uranium Concentration in Urine Samples of Three Age Groups of Healthy Individuals in Najaf Governorate Using CR-39 and LR-115 Solid State Detectors

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Received: 27/5/2021 Accepted: 10/10/2021 Published: 30/8/2022

Abstract

Uranium concentration was estimated in urine samples of three age groups, G1≤ 30 years, n=28, G2 age range of 31-40 years, n=28, and G3 of age > 40 years, n=32, using two types of detectors CR-39 and LR-115 solid-state nuclear track detector (SSNTD) for results comparison.

Results showed that uranium mean level values for CR-39 were 1.961 ±0.08 µg/L, 1.810 ±0.09 µg/L and 1.814 ±0.076 µg/L for G_1, G_2 and G_3 respectively, while the mean values of uranium concentration using LR-115 were 0.972 ±0.07 µg/L, 0.922 ±0.07 µg/L and 1.018 ±0.08 µg/L in G_1, G_2 and G_3 respectively, with significant statistical difference between the results of CR-39 and LR-115 for each age group.

Mean level values for females was 2.023± 0.09 µg/L and 1.813± 0.05 µg/L for males using CR-39 and it was 1.105± 0.09 µg/L for females and 0.933± 0.04 µg/L for males using LR-115, with significant statistical difference between results for each gender.

It was concluded that $G_1 \leq 30$ years have the highest uranium pollution, noting that females were more polluted with uranium than males.

Keywords: uranium concentration, urine, CR-39, LR-115 and Najaf governorate

تقدير تركيز اليورانيوم في عينات الإدرار لثلاث فئات عمرية أفراد أصحاء في محافظة النجف باستخدام كاشفات الحالة الصلبة CR-39 و LR-115

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الخلاصه

تم تقدير تركيز اليورانيوم في عينات إدرار من ثلاث فئات عمرية ، المجموعة الأولى (G_1) ≥ 30 عامًا ، العدد = 28 ، مجموعة الثانية (G_2) من 31 إلى 40 عامًا ، العدد = 28 ، والمجموعة الثالثة (G_3) > 40

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عامًا ، العدد = 32 ، باستخدام نوعين من أجهزة الكشف CR- 39 و LR-115 ككاشف للمسار النووي للحالة الصلبة (SSNTD) لمقارنة النتائج.

أظهرت النتائج أن قيم متوسط مستوى اليورانيوم لـ CR-39 كانت 1.961 ± 0.08 ميكروغرام / لتر ، 1.810 ± 0.09 ميكروغرام / لتر و 1.814 ± 0.076 ميكروغرام / لتر لـ G_1 و G_2 و G_3 على التوالي ، بينما متوسط قيم تركيز اليورانيوم باستخدام LR- 115 كانت 0.972 ± 0.07 ميكروغرام / لتر ، 0.922 ± 0.07 ميكروغرام / لتر و 1.018 ± 0.08 ميكروغرام / لتر في G_1 و G_2 و G_3 على التوالي ، مع وجود فرق إحصائي معنوي بين نتائج CR-39 و LR-115 لكل فئة عمرية.

كان متوسط قيم المستوى للإناث 2.023 ± 0.09 ميكروغرام / لتر و 1.813 ± 0.05 ميكروغرام / لتر للذكور باستخدام CR-39 وكان 1.105 ± 0.09 ميكروغرام / لتر للإناث و 0.933 ± 0.04 ميكروغرام / لتر للذكور باستخدام LR-115 ، مع وجود فروق ذات دلالة إحصائية بين النتائج لكل جنس.

نستنتج إن من بين الفئات العمرية $G_1 \leq 30$ سنة لديها أعلى تلوث باليورانيوم ، فيما يتعلق بالجنس كانت الإناث أكثر تلوثًا باليورانيوم من الذكور.

Introduction

The presence of radioactive elements in the environment is natural because of the presence of widely distributed natural uranium in the earth crust with a concentration of about 3mg/kg soil. Uranium isotopes are three: U^{234}, U^{235},U^{238}, all decay by α and γ emissions [1]. The last two are widely used in nuclear industries. Human activities, like uranium ores mining, milling and processing, cause the release and redistribution of uranium in the environment. Occupational exposure results from inhalation, while the general population is exposed to uranium primarily due to dietary intake [2].

During the Kuwait-Iraq conflict in 1991, 330 tons of Depleted Uranium (DU) were used, resulting in a significant increase in DU concentration in soils of the conflict areas, also increase in number of DU exposures [2].

Three hundred fifteen polluted sites were recorded in Iraq according to the Iraqi ministry of environment /the center of radiation protection / 2005, while United Nations Environment Programme (UNEP)/2005 recorded thousands of such sites[3]. Many studies reported the presence of ionizing radiation pollution in the middle and south governorates of Iraq [13]. Environmental radionuclides, either natural or man-made, and their possible retention in the human body needs careful monitoring for their toxic particles [14]. Biological monitoring is necessary to estimate the potential adverse health effects of radionuclides absorption [4]. Kidney, liver, bone and soft tissues are the vital target organs for the deposition of uranium [5]. Uranium excretion in urine is proportional to uranium level in the body [6]. Urinalysis is used routinely for monitoring accidentally and occupationally exposed individuals [7,8].

Solid state nuclear track detectors (SSNTD), including the LR-115 and the CR-39, are usually used to detect α-particles emitted from uranium [9]. The tracks in SSNTDS are studied with an optical microscope, but for better results, the atomic force microscope has been used to study the tracks for CR-39 and LR-115 detectors [10].

A Japanese study used both CR-39 and LR-115 detectors, for comparison purposes, to measure radon radiation. It was found that LR-115 detector was more sensitive and efficient for the detection of radon radiation than CR-39 detector [11]. In another study, CR-39 and LR- 115 detectors were used in CR-LR technique for the determination of implanted Po^{210} in glass. It was found that the sensitivity of LR-115 depended significantly on the removed layer. The sensitivity increased by a factor of two if the etched layer increased from 5 µm to 6 µm [12].

The aim of the present study is to evaluate uranium concentration in urine samples of three age groups of healthy individuals residing in different regions of Najaf governorate, using two types of solid state nuclear track detectors, CR-39 and LR-115, for comparison purposes.

Experimental method

Sample Collection and arrangement

For uranium concentration measurements, a total of 88 urine samples (males and females) were collected, using 60 ml urine cups, from three different age groups of healthy individuals (G_1: ≤ 30 years, G_2: 31-40 years, and G_3: > 40 years) of Najaf governorate. Urine samples were immediately acidified by adding 1 ml of concentrated HCl to prevent urine polymerization and were placed in a cool box until reaching the bio-laboratory [15].

Solid State Nuclear Track Detector (SSNTD) films: CR-39 detector (made by Pershore Moulding LTD Company, UK) (500µm) and LR-115 detector (Kodak type II (12 µm cellulose nitrate on a 100 µm polyester base) were used in this work. Each was cut into many small pieces of 1cm diameter.

Each urine sample was divided into two parts and put in hermetically sealed cylindrical plastic containers with a diameter of 1cm and 12 cm in length [16]. CR-39 detector was placed in the urine sample in one of the plastic containers, and LR-115 detector in the second container, as shown in Figure 1, and stored in a deep freezer at -80˚C for 90 days [17].

Measurement of uranium concentration

At the end of the 90 days storage period, the exposed detectors were etched using sodium hydroxide solution (NaOH) (2.5 N) at 60˚C for 120 min for the LR-115 detector and 6.25 N NaOH at 70˚C for 7hr for the CR- 39 detector. All the pieces were immersed in the etching solution inside a plain tube size (5ml) until etching time ended.

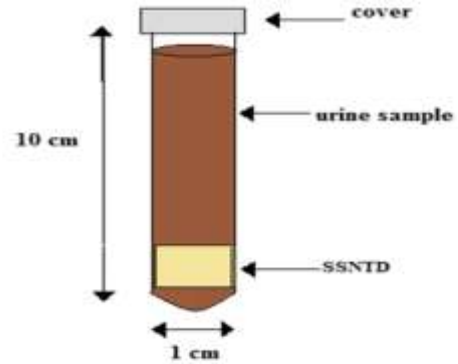

Figure 1-Position of the solid state nuclear track detector (SSNTD) in a well-closed plastic container with the urine sample.

The track density (track/cm^2) of the CR-39 and the LR-115 detectors was calculated using an optical microscope (NOVEL, China) with a magnification power of 10×40. The track density of each detector was corrected for the background radiation. The tracks are shown in Figure 2 for the CR-39 detector and Figure 3 for the LR-115 detector.

Figure 2- α-particles tracks of the CR-39 detector.

Figure 3- α-particles tracks of the LR-115 detector.

The tracks density of uranium from a standard solution is calculated according to the following relation [18]:

$$(\rho) = N / (A \times t) \qquad \text{.......... (1)}$$

Where; ρ = track density (no. /cm^2.h), N = average number of tracks, A = area of field of view (cm^2), t = time of exposure (h).

To calculate the uranium concentration (Uc) in the urine sample one could use the following fitting equation [18]:

$$Uc = (\rho + 12.5) / 18.6 \qquad \text{....... (2)}$$

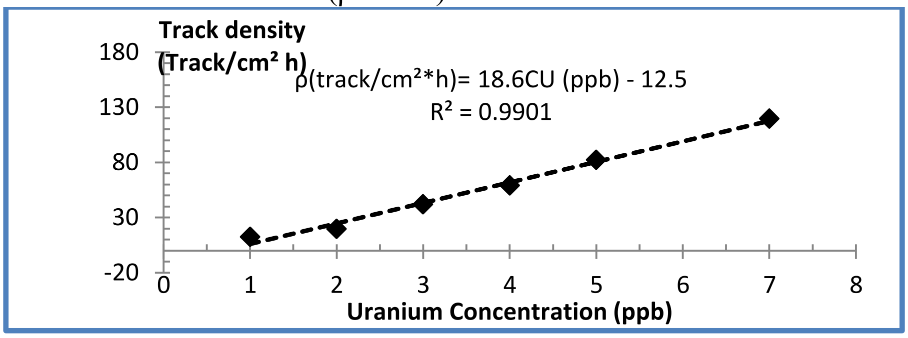

Figure 4- Calibration curve for standard uranium (ppb) [18].

Results and Discussion

The mean level of uranium concentration in urine samples of the three age groups (G_1, G_2, and G_3) was recorded as 1.961 ±0.08 µg/L, 1.810 ±0.09 µg/L and 1.814 ±0.076 µg/L, respectively using the CR-39 detector and it was 0.972 ±0.07 µg/L, 0.922 ±0.07 µg/L and 1.018 ±0.08 µg/L for the same groups using the LR-115 solid state detector. There was significance statistical different between the results of the two detectors for each group (Table 1).

Table 1-Uranium concentration in relation to Age groups

Age groups (years)	Mean ± SE		P-value
	Uc urine-CR39 (µg/L)	Uc urine-LR115 (µg/L)	
G1: Age ≤ 30	1.961 ±0.08	0.972 ±0.07	0.0374 *
G2: Age 31- 40	1.810 ±0.09	0.922 ±0.07	0.0398 *
G3: Age > 40	1.814 ±0.076	1.018 ±0.08	0.0462 *
* (P≤0.05)			

The results of the present study are in agreement with the Japanese study where the efficiency for uranium α-particles in some metals was 16% for LR-115 and 22% for CR-39 solid state detectors [10], while another Japanese study recorded that LR-115 is more sensitive for radiation of radon than CR-39 detector [12].

Local Iraqi studies recorded a 1.03 ±0.020 µg/L mean level value of uranium in urine of healthy women using kinetic phosphorimetry analyzer [19], while it was 0.946 ±0.009 µg/L for healthy individuals using the same technique [20]. The average range of 0.9 µg/L-1.42 µg/L was recorded using fission track technique [1], and it was recorded as 0.91 µg/L-1.82 µg/L in healthy people of Al-Muthana governorate using fission track technique [21].

Table 2 shows the mean level of uranium concentration in relation to gender where it was 1.813± 0.05 µg/L in (67 males) versus 2.023± 0.09 µg/L in (21 females) using CR-39 solid-state detector while it was 0.933± 0.04 µg/L for male versus 1.105± 0.09 µg/L for female using LR-115 detector with significant statistical difference between the results for each gender.

Table 2-Uranium concentration in relation to Gender

Parameters	Mean ± SE	
	Male	Female
Uc urine-CR39	1.813 ±0.05	2.023 ±0.09
Uc urine-LR115	0.933 ±0.04	1.105 ±0.09
P-value	0.0355 *	0.0473 *
* (P≤0.05)		

From there results females recorded the highest mean values when compared with that of males this is in agreements with some local studies [22, 23]. According to World Health Organization (WHO) the reference value is 0.3 µg/L [24]

The concentration of uranium in urine of unexposed individuals is documented for population groups worldwide. The normal levels range from sub ng/L to hundreds ng/L.[2] Uranium in urine has been recorded as (0.9- 6.9) $\times 10^{-3}$ µg/L for smokers and (0.14- 1.0) $\times 10^{-3}$ µg/L for non-smokers Indian people [14].

Another Indian study recorded uranium in urine as 0.0128 µg/L using calcium phosphate neutron activation method [25]. In Kazakhstan, it was recorded as 0.05 µg/L-0.08 µg/L [26].

In United States uranium concentration in urine was detectable in 96.6% healthy people (non-exposures) with average of 0.0345 µg/L [9]. In Japan, it was recorded as 0.0045 µg/L [27]. In Yugoslavia, uranium concentration in urine was recorded as 0.01 µg/L [28]. The geometric mean of uranium concentration in urine of Czech Republic individual was recorded as 0.091 mBq (0.0074 µg/L) [29].

It has been mentioned that different techniques give different results of uranium concentration in biological samples, also daily excretion of urinary uranium in non-exposed people differ according to regional variations [30].

Conclusions

From the results of the present study, the following can be concluded:

1. CR-39 detector is more efficient than LR-115 in detecting uranium in urine samples of healthy individuals.
2. Uranium pollution was noted to be higher in age group ≤ 30 years than in the other age groups as reflected by the highest mean value of uranium concentration in urine samples.
3. Uranium pollution was higher in females than that of males according to the results of the present study.

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