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Determination of Uranium Concentration in Human Urine at Al-Tuwaitha Region

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Abstract

In this study, 60 urine samples were collected from healthy volunteer individuals (both males and females) residing in the Tuwaitha region (aged 20-60 years) and compared with 30 urine samples from individuals living in another area of Baghdad, far from AL-Tuwaitha nuclear site (aged 20-60 years). The uranium concentration of these samples was measured using a solid-state nuclear track detector CR-39. The results indicated that the average uranium concentration for the Tuwaitha group was 0.507±0.032μg/L, which is higher than the permissible limits set by the World Health Organization, which is 0.3μg/L. While the uranium concentration for the control group was 0.267±0.045μg/L. The study also explored the relationship between uranium concentrations and gender, age, and smoking habits.

Key words: AL-Tuwaitha region, uranium, CR-39 and urine

تحديد تركيز اليورانيوم في الادرار البشري لمنطقة التويثة

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الخلاصة

في هذه الدراسة تم جمع 60 عينة ادرار من متطوعين أصحاء (ذكور وإناث) من منطقة التويثة (تتراوح أعمارهم بين 60–20 سنة) ومقارنتها مع 30 عينة بول من أفراد يعيشون في منطقة أخرى من بغداد بعيدة عن موقع التويثة النووي (تتراوح أعمارهم بين 60 –20 سنة) باستخدام كاشف الاثر النووي للحالة الصلبة CR–39. أشارت النتائج إلى أن متوسط تركيز اليورانيوم لمجموعة التويثة كان 0.507±0.032 ميكروغرام/لتر وهو أعلى من الحد المسموح به من قبل منظمة الصحة العالمية 0.3 ميكروغرام/لتر، بينما كان تركيز اليورانيوم للمجموعة الضابطة ± 0.267 0.045 ميكروغرام/لتر. كما بينت الدراسة العلاقة بين تركيزات اليورانيوم والجنس والعمر وعادات التدخين.

1.Introduction

Uranium is the heaviest radioactive element found in nature, and it decays emitting alpha particles. It poses a threat to human health and environmental balance due to its radioactive activity; its compounds are highly toxic [1]. Uranium exists in various chemical forms in soil, water, and air; it easily combines with other elements to form uranium oxides, silicates, and carbonates [2]. It has three main isotopes ^{234}U,^{235}U and ^{238}U. Uranium enrichment can be achieved

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through complex processes, increasing the proportion of ^{235}U used as fuel in nuclear reactors or in the production of nuclear weapons [3]. Depleted uranium is formed as a result of this enrichment process, which is used in manufacturing armor and armor-piercing shells [4,5]. The easy solubility of depleted uranium dust content makes it transferable through surface water and groundwater. Consequently, contamination with depleted uranium becomes comprehensive, affecting air, water, and soil. This type of pollution persists in the soil, rendering it permanently contaminated. Removing this dust is difficult or practically impossible, thus leaving the soil polluted indefinitely. There are two effects from exposure to uranium: acute direct effects result from exposure to high doses over a short period, causing symptoms ranging from nausea, vomiting, hair loss, and changes in genetic structure to rapid death. Slow effects occur from exposure to low doses of uranium over long periods, potentially resulting in cancer in spesific organs of the body [6].

In 2003, the storage areas in Al Tuwaitha were subjected to looting, resulting in the leaking of approximately 200 barrels of depleted uranium compounds near the village of Ishtar. These barrels were subsequently transported to nearby areas and used for domestic storage [7,8].

The aim of the current study is to determine the level of uranium radiation contamination by measuring the uranium concentrations in urine samples taken from healthy individuals living in the areas adjacent to the Atomic Energy Organization in Tuwaitha, using a solid-state nuclear track, CR-39.

2. Materials and Methods

2.1. Collection of the Samples

Urine samples were collected from healthy donors (males and females) aged between 20 and 60 years. The first group, the Al-Tuwaitha group, comprised 60 urine samples from residents of the Al-Tuwaitha region, located near the Atomic Energy Organization, covering neighborhoods such as Ishtar, Jeser Diyala, Al-Wardiya, and Al-Tameem. The second group is the control group, consisting of 30 urine samples from individuals residing far from Al-Tuwaitha. Urine samples were collected from November 2022 to January 2023; age, gender, health status, and other relevant data were gathered about the urine donors. Table 1 illustrates the characteristics of the study population based on gender, age, and smoking habits.

Table 1: Characteristics of the study population by gender, age, and smoking habits

Factor		**Group 1 (No=60)**	**Group 2 (No= 30)**
Gender	Male	33 (55.00%)	15 (50.00%)
	Female	27 45.00%))	15 (50.00%)
Age group	20-30	15 (25.00%)	9 (30.00%)
	31-40	17 (28.33%)	7 (23.33%)
	41-50	13 (21.67%)	8 (26.67%)
	51-60	15 (25.00%)	6 20.00%))
Smoking	Yes	33 55.00%))	17 56.67%))
	No	27 45.00%))	13 43.33%))

2.1.1. Measuring the concentration of uranium

For uranium concentration measurements, 10 ml of urine samples were placed in a plastic container with a diameter of 1.5 cm and a length of 10 cm. The samples were immediately acidified by adding 1 ml of strong hydrochloric acid to each urine sample to prevent sample polymerization [9]. The urine samples were left for several hours to ensure secular equilibrium. Subsequently, a detector CR-39 (produced by Pershore Moulding Ltd., UK) (500μm) with an approximate area of 1x1cm^2 was placed in the urine samples and left for 90 days. The process of directly exposing the detector to the urine is known as natural exposure [10]. Figure 1 illustrates a CR-39 detector in a plastic container with a urine sample.

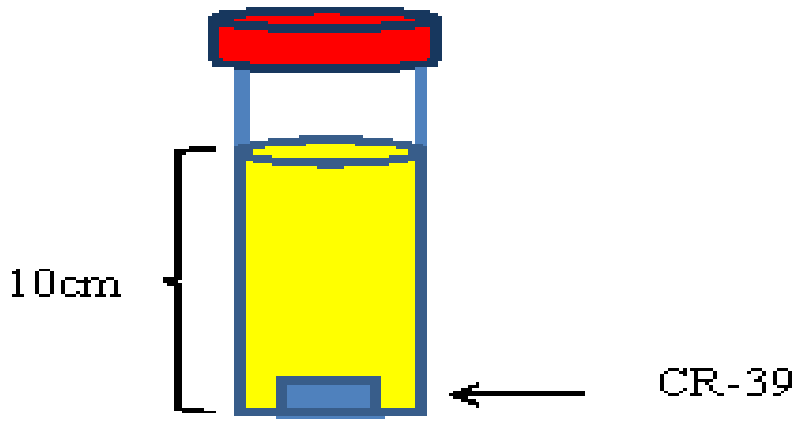

Figure 1: CR-39 detector in urine sample

After the 90-day irradiation period, detectors were removed from the urine samples and washed with distilled water. Subsequently, a chemical etching process was conducted using a solution of sodium hydroxide (NaOH) (6.25 N). All CR-39 detectors were immersed in the etching solution in a 5 ml tube for 5 hours at 60°C. After the completion of the chemical etching process, detectors were removed from the etching solution, washed with distilled water and dried at room temperature for microscopic examination using an optical microscope (NOVEL, China) with a magnification power of 400X to count the resulting tracks determined using Equation 1 [11]:

$$\rho = \frac{N}{A \times T} \quad (1)$$

Where: ρ is the track density in units of tracks /cm^2. h., N is the average number of tracks, A is the area of the field view in units of cm^2, and T is the irradiation time in units of h.

Calibration was performed by comparison with standard samples containing known concentrations of uranium, which are internationally recognized by the International Atomic Energy Agency (IAEA). A calibration curve, which is the linear relationship between uranium concentrations(C_S) and track density(ρ_S) for the standard samples was plotted as shown in Figure 2. The uranium content (U_C) in urine sample can be calculated using the fitting equation, Equation 2, which was obtained from the calibration curve shown in Figure (2).

$$UC = \frac{\rho + 13.7}{18.2} \quad (2)$$

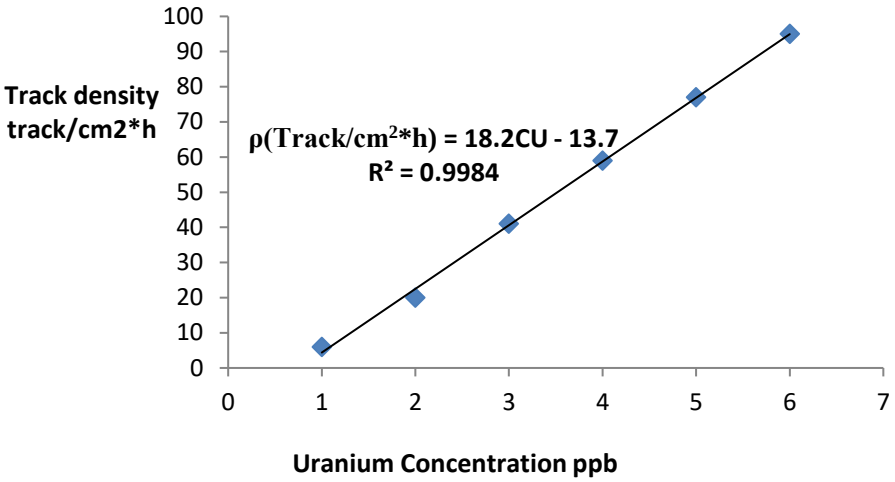

Figure 2: Standard uranium calibration curve (ppb)

Statistical Analysis

The Statistical Analysis System- SAS (2018) program was used of to detect the effect difference groups (patients and control) in study parameters. LSD-Least significant, difference-LSD, and T-test was used to significant compare between means. Chi-square test was used to significant compare between percentage (0.05 and 0.01 probability) in this study.

3. Result and Discussion

Table 2 shows the average concentration of uranium in urine samples for group 1 (G_1) (the Al-Tuwaitha) and group 2 (G_2) (the control group). The average uranium concentration in the Al-Tuwaitha group was 0.507±0.032µg/L, whereas it was 0.267±0.045µg/L for the control group, with a statistically significant($P<0.01$) difference between the two groups. The average uranium concentration for the Al-Tuwaitha group was higher than that of the control group, as depicted in Figure 3. The results indicated contamination of urine samples with uranium in the Al-Tuwaitha group, exceeding the permissible limit set by the World Health Organization(WHO) of 0.3µg/L [12]. The elevated uranium concentration in Al-Tuwaitha region is due to its proximity to the Atomic Energy Organization, which housed numerous laboratories and storage facilities containing a lot of equipment and hundreds of containers of radioactive materials that were looted in April 2003. The containers content of radioactive materials was poured into farms, rivers, and even household drains. Some empty containers were used as water vessels, and the individuals involved were unaware of the consequences of their actions [13].

Scientist Ryan Tully visited Al-Tuwaitha and its surroundings as part of the Greenpeace team, conducted field radiation measurements. He announced that people in areas close to Tuwaitha have received a radiation dose in half an hour, equivalent to the maximum limit a person receives in a year, exposing them to significant risks of cancer and other diseases. Scientist Tully found radioactive contamination in one of the houses there that exceeded the permissible limit by more than 10,000 times [13].

The average uranium content in the Al-Tuwaitha group was 0.520±0.04µg/L in males and 0.491±0.03µg/L in females, as indicated in Table 3. The obtained results indicated that males have higher average values compared to females, which is consistent with some local studies [14]; there was no statistically significant difference between males and females($P>0.01$).

Table 4 shows the average concentrations of uranium in urine samples for the Al-Tuwaitha group according to age, where it was 0.303±0.16 in the age group 20-30 years, 0.459 ±0.04 in the

age group 31-40 years, 0.566±0.07 in the age group 41-50 years, and 0.715±0.06 in the age group 51-60 years. The results show an increase in uranium concentrations with advancing age, there was a statistically highly significant difference between the age groups (P<0.01). Food consumption and advancing age may be the reason behind the accumulation of uranium in the body, which increases with exposure duration. Long-term effects may emerge due to continuous exposure to low levels of uranium over an extended period, including genetic effects and other impacts [15].

Regarding the average concentration of uranium in urine samples for the Al-Tuwaitha group as an indicator of smoking habits is illustrated in Figure 4; the average value for smokers was 0.528±0.04µg/L, whereas it was 0.482±0.04µg/L for non-smokers. It is concluded that the average value of uranium in the urine for smokers is higher than the average value for non-smokers due to the entry of uranium into the body through smoking tobacco [16].

In the table 5, a comparison is made between the results of some international and local studies and our current study regarding uranium concentrations in urine samples using solid-state nuclear track detectors (SSNTDs). The table reveals that the uranium concentrations recorded in our study were lower than some local studies, but on the other hand, they were higher than those found in other countries and exceeded the permissible limit set by the World Health Organization (WHO), which is 0.3µg/L [12]. This is due to the ongoing wars in Iraq since the Gulf War and up to the present time.

Table 2: Comparison between G1 and G2 in uranium concentration in urine

Group	**Mean ± SE**
	Uranium concentration (µg/L)
Group 1	0.507 ±0.032
Group 2/ Control	0.267 ±0.045
T-test	0.110 **
P-value	0.0001
** (P≤0.01).	

Table 3: Relationship between uranium concentration and gender in group1

Parameters	**Mean ± SE**	
	Male	**Female**
Uc (µg/L)	0.520±0.04	0.491 ±0.03
T-test	0.103 NS	
P- value	0.367	
* (P≤0.05), ** (P≤0.01).		

Table 4: Relationship between uranium concentration and age in group1

Age groups (year)	**Mean ±SE**
20-30	0.303±0.16
31-40	0.459 ±0.04
41-50	0.566±0.07
51-60	0.715±0.06
LSD value	0.146^{**}
P – value	0.001
* (P≤0.05), ** (P≤0.01).	

Table 5 : Comparison between uranium concentrations for urine samples of healthy people of the present study with other studies

Location	Uranium concentration (µg/l)	References
Iraq (Baghdad)	0.464-6.121	Fadel [17]
Iraq(Akashat)	1.47	Saleh et al. [18]
Iraq (Baghdad)	0.89308	Qaddoori and Shafik [19]
India	0.0128	Dang et al. [20]
Japan	0.0045	Tolmachev et al. [21]
Al-Tuwaitha region	**0.507±0.032**	**Present study**

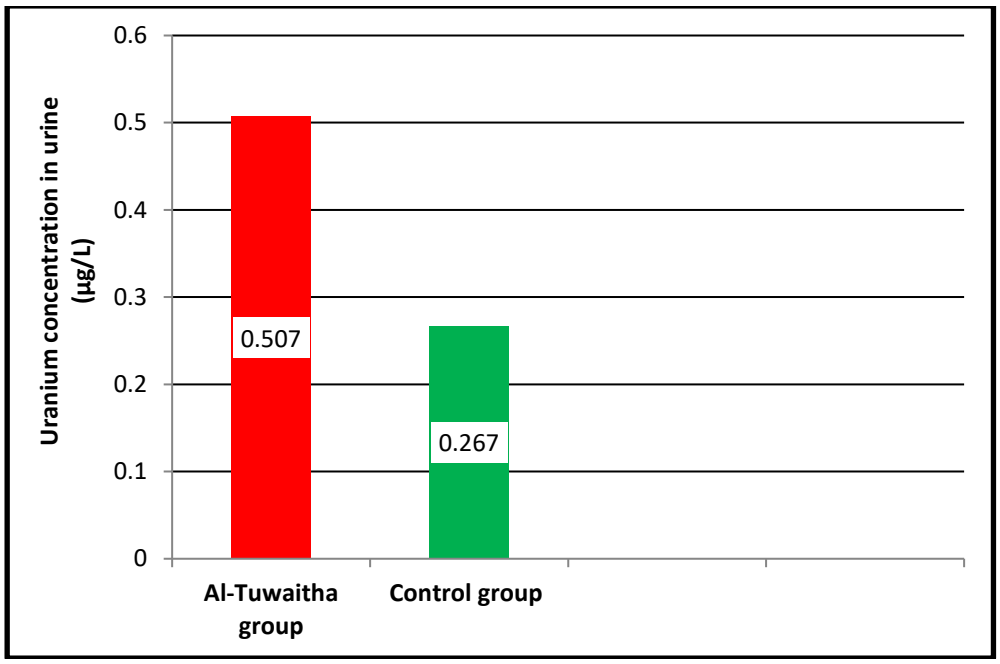

Figure 3: Uranium concentration in the urine samples of the study groups.

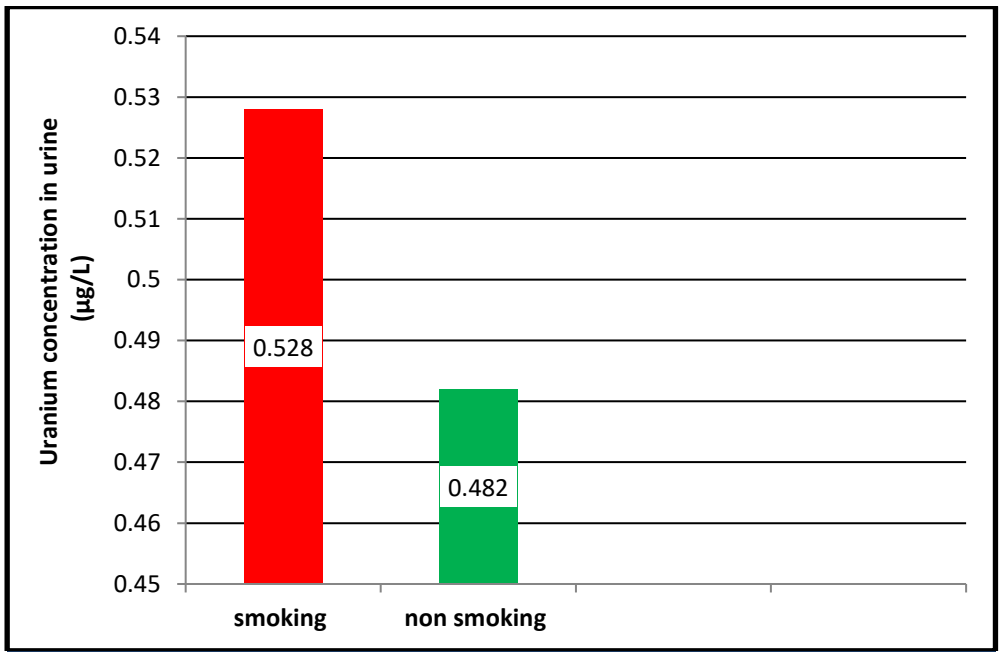

Figure 4: uranium concentration in urine relation to smoking.

4. Conclusions

The following points were concluded from this study:

1. The highest concentrations of uranium were found in the Tuwaitha region, exceeding the permissible limit set by the World Health Organization (WHO), which is 0.3µg/L[13]. The reason for this value is attributed to the bombing and sabotage of the Tuwaitha nuclear site. Containers containing uranium oxides and radioactive sources leaked from the site to its neighboring areas after the events of the war on Iraq in 2003.
2. Uranium concentration in urine was higher in males than in females.
3. The concentration of uranium in urine was found to increase with age.
4. The concentrations of uranium in urine samples of smoker individuals were higher than those of non-smokers due to the entry of uranium into the body through cigarette smoke.

References

[1] S. K. Abbas, D.S.Saleh, H.S. Hussain, "Measurement of uranium concentrations in urine samples of adult healthy groups in Najaf governorate with estimation of urine concentrations of 8-OHdG compound as biomarker for DNA damage," *Journal of Physics: Conference Series*, vol. 1879, no.3, pp. 032097, 2021.

[2] H. A.-U. Mohammed, H. S. Hussain, and A. A. Abojassim, "Radon and radon progeny concentrations detection for human serum samples in Kerbala governorate," in *AIP Conference Proceedings*, AIP Publishing, 2022.

[3] F. P. Carvalho and J. M. Oliveira, "Uranium isotopes in the Balkan's environment and foods following the use of depleted uranium in the war," *Environ. Int.*, vol. 36, no. 4, pp. 352–360, 2010.

[4] L. C. Sujo *et al.*, "Uranium-238 and thorium-232 series concentrations in soil, radon-222 indoor and drinking water concentrations and dose assessment in the city of Aldama, Chihuahua, Mexico," *J. Environ. Radioact.*, vol. 77, no. 2, pp. 205–219, 2004.

[5] D. P. Arfsten, K. R. Still, and G. D. Ritchie, "A review of the effects of uranium and depleted uranium exposure on reproduction and fetal development," *Toxicol. Ind. Health*, vol. 17, no. 5–10, pp. 180–191, 2001.

[6] P. Roth, V. Höllriegl, E. Werner, and P. Schramel, "Assessment of exposure to depleted uranium," *Radiat. Prot. Dosimetry*, vol. 105, no. 1–4, pp. 157–161, 2003.

[7] F. A. Al-Musawi, R. M. Idan, and A. L. M. Salih, "Reservoir characterization, Facies distribution, and sequence stratigraphy of Mishrif Formation in a selected oilfield, South of Iraq," in *Journal of Physics: Conference Series*, IOP Publishing, vol. 1660, p. 12073, 2020.

[8] A. T. Zaboon, A. Al Obaidy, and H. M. J. Al Sharaa, "Cobalt-60 and cesium-137 soil contamination in Al Tuwaitha nuclear site, using GIS technique," *Eng. &Tech. J.*, vol. 32, part(A), no. 13, p. 3209, 2014.

[9] D. F. Razzaq, D. S. Saleh, Asia H. Al-Mashhadani, "Studying the uranium pollution in reduction the levels of the C-Peptide and Vitamin D for healthy and diabetic patients in Najaf City Iraq," *AIP Conference Proceedings*, vol. 2290, pp. 0027502, 2020.

[10] Y. Matsumoto, Y. Ogawa, R. Yoshida, A. Shimamori, H. Kasai, and H. Ohta, "The stability of the oxidative stress marker, urinary 8-hydroxy-2'-deoxyguanosine (8-OHdG), when stored at room temperature," *J. Occup. Health*, vol. 50, no. 4, pp. 366–372, 2008.

[11] S. K. Abbas, H. S. Hussain, and D. S. Saleh, "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," *Iraqi J. Sci.*, vol. 63, no. 8, pp. 3359–3365, 2022, doi: 10.24996/ijs.2022.63.8.11.

[12] W. H. Organization, *Guidelines for drinking-water quality*, vol. 1. world health organization, 2004.

[13] H. R. Fadhil, S. K. A. L. Nasri, and I. T. Al-Alawy, "Measurement of Radiation Background and Estimation of the Annual Effective Dose for Workers in the Radiochemistry Laboratories at the Al-Tuwaitha Site," *Iraqi J. Sci.*, vol. 63, no. 11, pp. 4749–4760, 2022.

[14] A. R. Zainab, "Determination of uranium and radon concentrations in selected blood samples of Karbala governorate," M.Sc. Thesis, Karbala Univ. Iraq, 2022.

[15] A. S. Mahmood, O.S. Shafeq, and M.S. Shafiq, "Uranium concentration variation dependency on gender correlated with age of bladder cancer patient," *International J. of Research in Pharmaceutical*

Sci., vol. 10, no. 3, pp. 1730-1734, 2019.

[16] A. H. Al-Mashhadani, D. S. Saleh, and D. F. Razzaq, "Measurement the uranium, radon and radium concentrations in urine samples for diabetics in Najaf city," in *IOP Conference Series: Materials Science and Engineering*, IOP Publishing, vol. 928, p. 72108, 2020.

[17] K.H. Fadel, "*Estimation IL-6 level in Patients with Respiratory Diseases That Caused by Bacteria and Other Causative Agents in Some Baghdad Hospital*," M.Sc. Thesis, Baghdad Univ. Iraq, 2014.

[18] A. F. Saleh, M. M. Elias, and N. F. Tawfiq, "Determination of uranium concentration in urine of workers in an Iraqi phosphate mine and fertilizer plants," *J. Radioanal. Nucl. Chem.*, vol. 298, pp. 187–193, 2013.

[19] S. M. Qaddoori and S. S. Shafik, "CR-39 As A Tool For Uranium Concentration Calculation In Bio Assay Sample: Bladder Cancer As Case Study," *Res. J. Pharm. Biol. Chem. Sci.*, vol. 9, no. 6, pp. 228–239, 2018.

[20] H. S. Dang, V. R. Pullat, and K. C. Pillai, "Determining the normal concentration of uranium in urine and application of the data to its biokinetics," *Health Phys.*, vol. 62, no. 6, pp. 562–566, 1992.

[21] S. Tolmachev, J. Kuwabara, and H. Noguchi, "Concentration and daily excretion of uranium in urine of Japanese," *Health Phys.*, vol. 91, no. 2, pp. 144–153, 2006.