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Determination of uranium concentration levels in human hair and nails

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Abstract

The study aims to evaluate the efficiency of the nuclear trace detector technology in determining and comparing the levels of uranium concentration in human hair and nail samples. 45 samples of hair and nail samples are collected from people of both sexes living in three areas close to the Iraqi Atomic Energy Organization. The uranium concentrations are determined by calculations based on a comparison with the standard samples. Uranium concentration levels in hair and nails varied from 20 to 680 ng/g and from 1 to 55 ng/g, respectively. It was found that the concentrations of uranium in hair are higher than the concentrations of uranium in the nails. The study shows the highest concentration of uranium in the hair and nail samples of the residents of the Al Tuwaitha area. Additionally, there is a significant disparity between the levels of uranium concentrations in the hair and nails between men and women, and between the population of the same region.

Introduction

Biomaterials like hair and nails are essentially made of fibrous protein structures, particularly keratin. They are somewhat a representation of physiological processes taking place in the body and are regulated by blood, sweat, hormones, and enzymes, in addition to hereditary factors [1]. A shortfall or the existence of stored substances in the body is evident by changes in their composition and appearance. Therefore, them is an important tissue for monitoring human environmental exposure. Human hair and nails can also be considered a useful proxy indicator of long-term, months to years-long exposure to natural radionuclides and other hazardous metals in the workplace and in the general population [2].

In comparison to physiological fluids like blood, perspiration, or other attainable tissues, nails, and hair have diverse uses and advantages. Hair and nails have many qualities that make them suitable tissues for lab experiments, including removal painlessly, sample collection and transportation, and good stability for temperature. The presence of external pollutants, such as pharmaceuticals or cosmetics, causes an increase in the concentrations of various elements which put some limitations on the analysis of hair and nails [2,3].

Uranium levels in hair are typically eight times greater than those in urine. In order to determine the exposure, uranium content in hair analysis may be used instead of testing numerous urine samples over an extended period of time [4].

The aim of this study is to determine the concentrations of uranium in the hair and nails of people living in the areas of (Al-Twaitha, Al-Wardiya, and Salman Pak) southeast of Baghdad-Iraq, located near the Atomic Energy Organization, to see if the local high radiation background is reflected on the human tissues. The concentrations of radioactive elements were determined using the technique (Solid State Nuclear Track Detectors). The concentration of uranium in various samples, including soil, water, tissues, and biological components, is easily determined using these detectors. The technique (SSNTD) is well known for having advantages over other detectors due to their long-term trace retention, ease of use, and capacity to calculate the alpha track without the need for specialized electronics. They are unaffected by many environmental conditions like heat, humidity, or light. It also possesses high sensitivity to heavy charged particles by collecting traces for a long time [5].

Study area

The site of the Iraqi Atomic Energy Organization is located on an area of 1.3 square kilometres, 18 kilometres southeast of Baghdad, and one kilometre from the Tigris River. The organization was created in 1967 and used in legitimate nuclear operations until then it was finally closed in 2003. During the 1990 Gulf War in Iraq, most of these were heavily bombed. It was also subjected to tampering after the events of the war on Iraq in (2003), and about (80) containers containing uranium oxides were leaked from it, as well as (10-15) radioactive sources from the Energy Organization to its neighboring areas [6,7].

Numerous studies [6-10] have demonstrated that the soil and water of the areas close to the Atomic Energy Organization have high concentrations of uranium. As a result, the study's objective was to examine the levels of uranium in samples of neighbouring residents' hair and nails in order to determine the extent to which this environment's contamination affected human tissues.

The study included three regions:

Al-Tuwaitha is an agricultural area that includes the site of the Atomic Energy Organization, and its population is estimated at about three thousand people.

Al-Wardiya is an agricultural and residential area, and it also contains water bodies. It is about 12 kilometers south of the Atomic Energy Organization, and its population is estimated at about seven thousand people.

Salman Pak is a residential area about 20 km east of the Atomic Energy Organization, and its population is estimated at about seventy-six thousand people.

Study population

Hair and nail samples were collected from three areas adjacent to the Iraqi Atomic Energy Organization, the ages of all contributors ranged from 20 to 65 years. The first area was Al-Tuwaitha. Hair and nail samples were collected from 15 contributors (9 males and 6 females) and the second area was the Al-Wardiya area. Hair and nail samples were collected from 15

contributors. (10 males and 5 females). As for the third area, the Salman Pak area, samples were collected from 15 contributors (8 males and 7 females).

During sampling, contributors were interviewed to obtain some general information about their health, lifestyle, diet, and smoking habits. It was also ensured that all people had been living in the area since their birth. Hair and nail colors were also taken into account.

Sample collection and preparation

For all subjects, scalp hair samples were taken from the same location on the back of the head, less than 1 cm from the scalp, using scissors that had been cleaned in acetone and distilled water. For the nail samples, acetone was used to clean them before a stainless-steel cutting tool was used to make the cuts. This pre-treatment was carried out to stop contamination brought about by the tools used to collect the samples.

After that, the samples were washed with distilled water and exposed to a sunbath for a week to dry them, then burned at high temperatures until they turned into ashes. The ashes were homogenized to obtain a black powder representing the study sample. (0.5g) of powder samples after mixing with certain proportions of starch were pressed into a tablet of thickness (1.5 mm) and diameter (13 mm) using a press with a pressing force of (15 tons).

Foils were prepared from the CR-39 nuclear tracer with a thickness of 175 mm and an area of about 0.5 cm^2, and samples of hair and nails were placed on them in a contiguous manner, 5 cm away from the neutron source (^{241}Am - Be) with a neutron flux ($5x10^3\ n.cm^{-2}.s^{-1}$) for the purpose of obtaining thermal neutrons.

Uranium concentrations were measured in hair and nail samples using the technique of calculating the effects of fission fragments in the detector (CR-39) resulting from the fission of the nucleus of ^{238}U with thermal neutrons from the source of neutrons (^{241}Am-Be) for seven days.

After completing the irradiation, the detectors were etched in NaOH at 70°C for four hours. The detectors were then washed in distilled water. Using an optical microscope (400x), the induced fission track densities were recorded.

Results and Discussion

The concentrations of uranium in hair and nail samples were determined by comparing them to standard samples using the following eq.1 [11]:

$$C^{U}_{Samples} = \frac{C^{U}_{Calibration}\ .\rho_{Sample.\varepsilon}}{\rho_{calibration}\,.\,R_{eff}} \ldots\ldots\ldots\ (1)$$

where, ρ_{Sample} and $\rho_{calibration}$ are the density of tracks in the detector (CR-39) for samples and standards, respectively and calculated by the eq.2 [5].

$$\rho = \frac{The\ avarge\ number\ of\ total\ tracks}{area\ of\ field\ view} \ldots\ldots\ldots\ (2)$$

ε is the etching efficiency: the ratio of the number of tracks etched in the detector to the number of alpha particles that hit it. It is calculated through the eq.3 [11].

$$\varepsilon = 1 - \frac{Bulk\ etch\ rate\ (VB)}{\text{Track etch rate (VT)}} \ldots\ldots\ldots (3)$$

and R_{eff} is the effective range and it is calculated from the eq.4 [11].

$$R_{eff} = V_T t_R + V_B t_R \ \ldots\ldots\ldots (4)$$

Where t_R is the amount of time needed to get to the path's end.

Table 1 shows the levels of uranium concentrations in hair and nail samples among the residents of the Al-Tuwaitha area. It is noted from the table that the highest concentration of uranium in hair samples was (0.86 ppm) for a 41-year-old woman and the lowest centration (0.39 ppm) for a 22-year-old man. The average concentration of uranium in hair samples is 0.631 ppm. As for uranium concentrations in nail samples, the highest concentration was (0.055 ppm) for a 35-year-old woman and the lowest concentration (0.01 ppm) for a 50-year-old woman. The average concentration of uranium in nail samples is 0.0318 ppm.

Table 1: The levels of concentrations of uranium in the hair and nails of the population of the Al-Tuwaitha area

No.	Age (year)	Gender	Concentration of uranium in hair (ppm)	Concentration of uranium in nail (ppm)
1	60	Man	0.47	0.054
2	54	Man	0.73	0.031
3	50	Man	0.61	0.035
4	48	Man	0.65	0.017
5	41	Man	0.59	0.031
6	35	Man	0.80	0.02
7	30	Man	0.76	0.0123
8	27	Man	0.53	0.043
9	22	Man	0.39	0.023
10	63	Female	0.45	0.040
11	50	Female	0.67	0.01
12	54	Female	0.72	0.05
13	41	Female	0.86	0.044
14	35	Female	0.59	0.055
15	20	Female	0.65	0.012
	Average		0.631	0.0318

Results of uranium concentrations in hair and nail samples for the residents of The Wardiya region are shown in Table 2, and it is noted from the table that the highest concentration of uranium in the hair samples was (0.45 ppm) for a 59-year-old woman and the lowest concentration (0.30 ppm) for a 23-year-old man. The average concentration of uranium in hair samples is 0.326 ppm. As for uranium concentrations in nail samples, the highest concentration was (0.025 ppm) for a 50-year-old woman and the lowest concentration (0.001 ppm) for a 40-year-old man. The average concentration of uranium in nail samples is 0.01235 ppm.

Table 2: The levels of concentrations of uranium in the hair and nails of the population of the Al-Wardiya area

No.	Age (year)	Gender	Concentration of uranium in hair (ppm)	Concentration of uranium in nail(ppm)
1	65	Man	0.2	0.021
2	50	Man	0.32	0.0096
3	48	Man	0.21	-
4	43	Man	0.41	0.017
5	40	Man	0.29	0.001
6	33	Man	0.43	0.018
7	30	Man	0.23	0.0109
8	27	Man	0.37	0.0098
9	25	Man	0.48	0.009
10	23	Man	0.20	0.019
11	59	Female	0.45	0.014
12	50	Female	0.32	0.025
13	49	Female	0.27	0.012
14	30	Female	0.50	-
15	29	Female	0.21	0.019
Average			0.326	0.01235

* (-) It indicates that the results of uranium concentrations are below the detection limits.

The results of the levels of uranium concentrations in the hair and nail samples of the residents of the Salman Pak region are illustrated in Table 3, and it is noted from the table that the highest concentration of uranium in the hair samples was (0.31 ppm) for a 33-year-old woman and the lowest concentration (0.020 ppm) for a 20-year-old man. The average concentration of uranium in hair samples is 0.071867ppm. As for uranium concentrations in nail samples, the highest concentration was (0.002 ppm) for a 40-year-old woman and the lowest concentration (0.001 ppm) for a 63-year-old man. The average concentration of uranium in nail samples is 0.001007 ppm.

Table 3: The levels of concentrations of uranium in the hair and nails of the population of the Salman Pak area

No.	Age (year)	Gender	Concentration of uranium in hair (ppm)	Concentration of uranium in nail (ppm)
1	63	Man	0.04	0.001
2	58	Man	0.032	-
3	50	Man	0.043	0.0018
4	49	Man	0.021	-
5	40	Man	0.06	0.002
6	34	Man	0.09	
7	30	Man	0.098	-
8	20	Man	0.020	-
9	60	Female	0.071	0.008
10	42	Female	0.1	-
11	37	Female	0.065	-

12	33	Female	0.31	0.0013
13	35	Female	0.09	-
14	27	Female	0.018	-
15	22	Female	0.02	-
	Average		0.071867	0.001007

Fig.1 and Fig. 2 show that people of the Al-Tuwaitha area have higher levels of uranium concentration in their hair and nails than do people of the Al-Wardiya and Salman Pak areas because of the Al-Tuwaitha area's proximity to the Atomic Energy Organization and its uranium pollution.

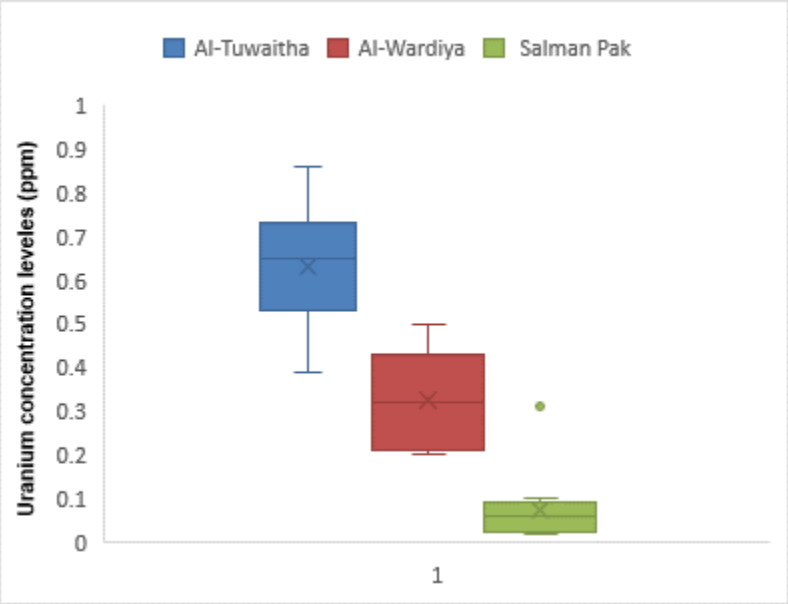

Fig. 1 Uranium concentration levels in hair samples in the study areas.

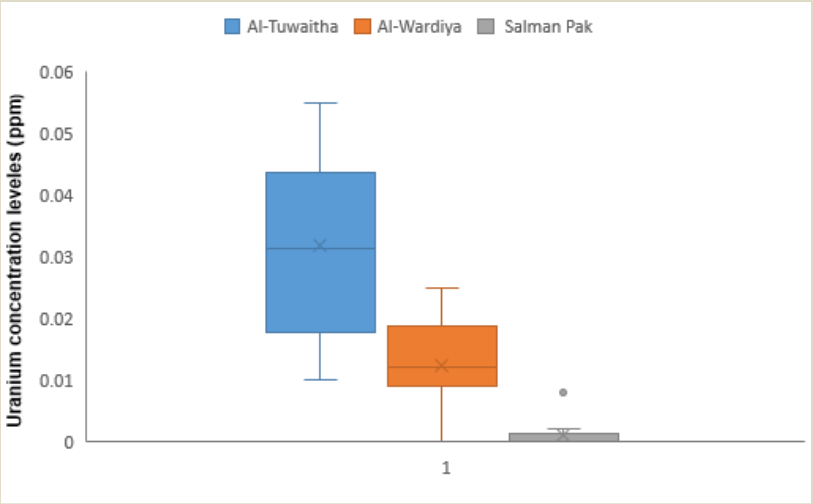

Fig. 2 Uranium concentration levels in nail samples in the study areas

Fig. 3 shows that among people of the Al-Tuwaitha, Al-Wardiya, and Salman Pak areas, the average levels of uranium concentration in hair samples are greater than the average levels in nail samples.

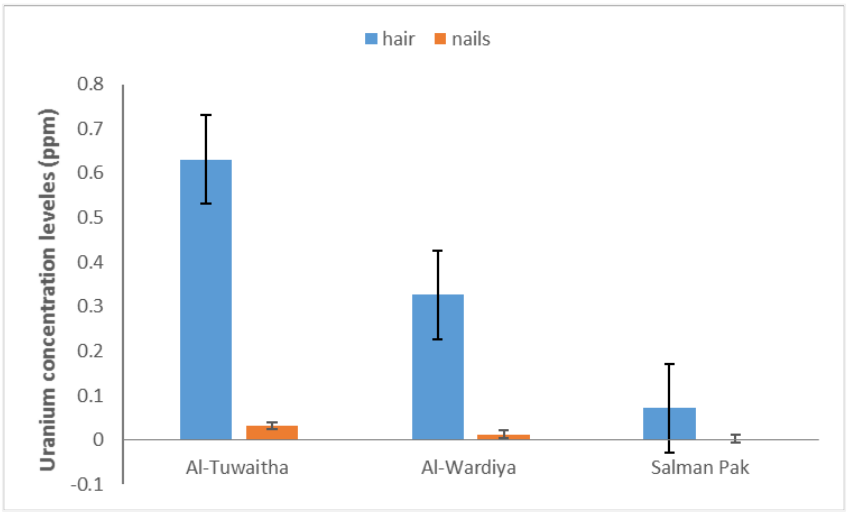

Fig. 3 Average uranium concentration levels in hair and nail samples in the study areas

Fig. 4 and Fig. 5 show that the average concentrations of uranium in hair and nail samples are higher for men than for women among people of the Al-Tuwaitha, Al-Wardiya, and Salman Pak areas.

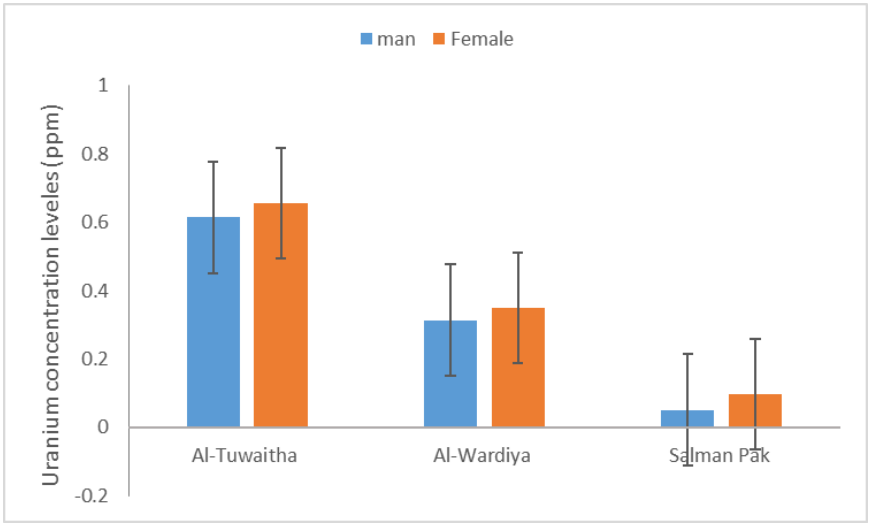

Fig. 4 Average uranium concentration levels in hair samples for men and females in the study areas**.**

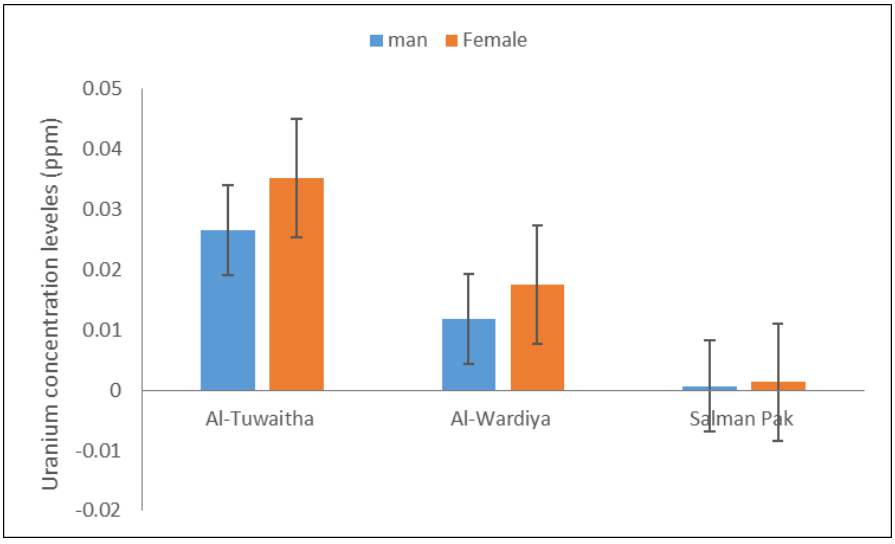

Fig. 5 Average levels of uranium concentration in nail samples for men and females in the study areas.

Tables 4 and 5 show the levels of uranium concentrations in hair and nail samples in a number of countries, which were measured by different techniques. It is noted through tables (4 and 5) the different levels of uranium concentrations. In general, these differences can be attributed to the use of various analytical methods in measuring the levels of uranium concentrations, or in the method of collecting and preparing samples, or regional differences, or basic demographic differences that are affected by nutrition, the environment, and the use of cosmetics and pharmaceuticals.

Table 4: A comparison of the techniques used to quantify the levels of uranium in hair in various nations throughout the world.

Country	Concentration ofuranium (ng/g)	Technology	Reference
Blakan	0.9-449	ICPMS	[12]
Brazial	150	ICPMS	[13]
Finland	6.5-250000	ICPMS	[14]
France	2-30	ICPMS	[15]
Greece	12-170	Alpha Spectrometry. (PLPS) Detector	[16]
Israel	10-180	FLAS-ICPMS	[17]
Serbia	0.25-77.1	ICPMS	[2]
Sweden	6-436	ICPMS	[18]
Chain	22.2-634.5	ICPMS	[19]
Slovenia	2.7-330	radiochemical neutron-activation analysis	[20]
Korea	1-39	nuclear track detection technique	[21]
Iraq /Fallujah	20-400	ICPMS	[22]
*Iraq / Baghdad	20-680	nuclear track detection technique	Percent work

* 1 ppm = 1000 nanogram/gram

Table 5: A comparison of the techniques used to quantify the levels of uranium in nail in various nations throughout the world

Country	Concentration of uranium (ng/g)	Technology	Reference
Finland	1-43.200	ICPMS	[14]
Sweden	2-47	ICPMS	[18]
Serbia	2.6-44.7	ICPMS	[2]
Iraq / Baghdad	1-55	nuclear track detection technique	Percent work

* 1 ppm = 1000 nanogram/gram

Conclusion

This study shows the importance of nuclear trace detector technology in determining the lowest levels of uranium concentrations. It is also an effective method of environmental monitoring.

When comparing areas with high levels of uranium concentrations (Al-Tuwaitha and Al-Wardiyeh areas) and areas with low levels of uranium concentration (Salman Pak), hair and nail samples appear to be valuable tissues for measuring human environmental exposure. The levels of uranium concentrations in the hair samples are higher than in the nails.

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تحديد مستويات تركيز اليورانيوم في شعر وأظافر الإنسان

زينة جميل رحيم
قسم الفيزياء، كلية التربية، الجامعة العراقية، العراق.

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اليورانيوم، الاظافر، الشعر، كاشف الاثر.

معلومات المؤلف
الايميل: zeanenaya@gmail.com
الموبايل:

الخلاصة:
تهدف الدراسة إلى تقييم كفاءة تقنية كاشف الاثر النووي في تحديد ومقارنة مستويات تراكيز اليورانيوم في عينات شعر واظافر الانسان. تم جمع 45 عينة من الشعر والأظافر لأشخاص من كلا الجنسين يعيشون في ثلاث مناطق قريبة من هيئة الطاقة الذرية العراقية. تم تحديد تراكيز اليورانيوم من خلال المقارنة مع العينات القياسية. تراوحت مستويات تراكيز اليورانيوم في الشعر والأظافر (من 18 إلى 350) نانوغرام / غرام و (من 1 إلى 55) نانوغرام / غرام على التوالي. وجد أن تراكيز اليورانيوم في الشعر أعلى من تراكيز اليورانيوم في الأظافر. أظهرت الدراسة أعلى تركيز لليورانيوم في عينات الشعر والأظافر لدى سكان منطقة التويثة. بالإضافة إلى ذلك، هناك تفاوت كبير بين مستويات تراكيز اليورانيوم في الشعر والأظافر بين الرجال والنساء، وبين سكان المنطقة الواحدة.