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Determination the Concentration (^{238}U) in Human Urine in Ishtar Village in Baghdad, Iraq

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Abstract

In 15 urine samples, the amount of uranium was determined from residents of the village of Ishtar (both males and females) (aged 20-57 years) and compared with 15 urine samples from individuals living in another area of Baghdad, far from Al- Tuwaitha nuclear site (aged 20-60 years). The study was conducted in the months of October and December of 2023 using the CR-39 solid-state nuclear track detector. The results show that the concentrations of uranium in the village of Ishtar ranged from 0.175μg/L to 0.836μg/L with an average of 0.523±0.05μg/L, and from 0.112μg/L to 0.930μg/L with an average of 0.285±0.05μg/L in the control area, with statistically significant differences between the results for both areas. We conclude that the level of uranium concentration in the village of Ishtar is higher than in the control area. Regarding gender, males were found to be more contaminated with uranium than females, and uranium concentrations increased with age.

Introduction:

Since natural uranium is present in the Earth's crust at a concentration of about 3mg/kg soil, the presence of radioactive elements in the environment is natural [1]. There are three primary isotopes of uranium: ^{238}U with a half-life of ($4.5x10^9$ yr) and a relative abundance of about 99.27% of natural uranium, ^{235}U with a half-life of ($7.07x10^8$yr) and a relative abundance of 0.72% of natural uranium, and ^{234}U with a half-life of (245000yr) and a relative abundance of about 0.0055% of natural uranium[2]. Uranium oxides, silicates, carbonates, and hydroxides form when uranium reacts with other elements [3]. Due to the variability of internal uranium toxicity depending on several factors, such as its chemical form, dose rate, and the location of its deposition, it is considered a long-term hazard[4].

The kidneys are the organs most affected by uranium, as it leads to death and damage to kidney cells, impairing their ability to filter and purify the blood depending on the concentration of uranium. Inhaled uranium particles deposit in the upper respiratory tract and most of these particles are either swallowed or expelled through the nose. The particles that are absorbed move to the kidneys and other organs of the body. Insoluble uranium oxides can remain in the lungs for many years and slowly enter the bloodstream if inhaled in large quantities[5]. Through interactions with protein and carbonate, blood transport tissue distribution and uranyl ion excretion are accomplished efficiently in the bloodstream [6]. After uranium enters the bloodstream, it deposits on the surfaces of bones along with calcium and can remain there for many years [7].

Biological monitoring is a crucial tool, as it provides valuable data on environmental exposure and helps determine the impact of environmental pollutants on populations and to what extent. It also aids in assessing health risks because biological monitoring summarizes exposure from various sources and methods, providing information about an individual's total exposure at a given moment [8].

Solid-state nuclear track detectors are characterized by their high sensitivity to radiation and their insolubility in chemical solutions. Due to their properties and advantages, these detectors have been used in various applications, including measuring uranium concentrations in blood, bones, urine, and tissues [9, 10].

The village of Ishtar is located near the Al-Tuwaitha site, previously referred to by the Iraqi Atomic Energy Commission south of Baghdad. In 2003, the Middle East Media Research Institute (MEMRI) reported the presence of tons of radioactive waste stored in barrels alongside uranium and by-products from processing operations. These barrels were used by common people to keep water, which caused radioactive materials to spread and caused additional uranium contamination in the nearby villages [11]. Therefore, the study's objective is to assess the amount of uranium in urine samples collected from the residents of the village of Ishtar to take the necessary preventive measures to maintain a clean, pollution-free environment.

Materials and Methods:

15 random urine samples were collected from donors (aged 20–57) years residing in Ishtar village near AL- Tuwaitha nuclear site, and they were compared with 15 urine samples from individuals living in Baghdad away from AL- Tuwaitha nuclear site, ranging in age (20–60) years. To prevent polymerization of urine, urine samples were immediately acidified by adding 1 ml of concentrated hydrochloric acid (HCl). They were then kept in a refrigerated box until arrival at the bio-laboratory [12]. Urine samples were collected from October to December 2023 after gathering information, including age, gender, health status, and other relevant data. Table (1) illustrates the characteristics of the study population based on gender and age.

Table 1: Distribution of sample study according to gender and age

Factor		**Ishtar village (No=15)**	**Control area (No= 15)**
Gender	Male	8 (53.67%)	8 (53.00%)
	Female	7 (46.66%)	7 (46.66%)

	20-30	4 (26.66%)	4 (26.66%)
Age group	31-40	4 (26.66%)	4 (26.66%)
	41-50	5 (33.33%)	5 (33.33%)
	51-60	2 (13.33%)	2 (13.33%)

Prepared pieces of CR-39 detector with an approximate area of 1×1 cm^2 (thickness 500 micrometers) and placed each piece of CR-39 in a urine sample in a tightly sealed plastic container that is 12 cm long and 1 cm in diameter(Figure 1). After that, the samples were kept for 90 days at -20°C in a freezer.

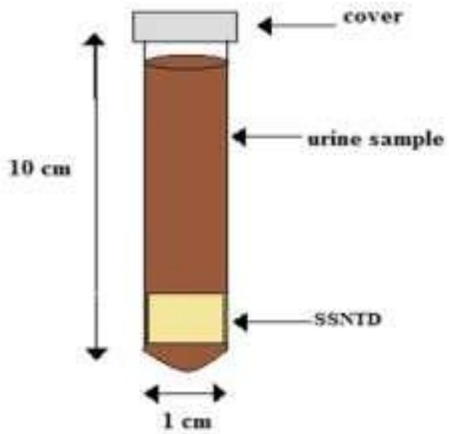

Fig.1 urine sample in a well-sealed plastic container with a CR-39 detector.

After 90 days of radiation exposure, a solution of sodium hydroxide (NaOH)(6.25N) was used to etch the detectors. All detector pieces were placed in a 5 ml tube containing the etching solution and heated using a water bath (LABSCO) - Germany) for 7 hours at 70°C. After the etching period, the detector pieces were removed, washed with distilled water, and dried at room temperature. The track density was determined using an optical microscope (NOVEL, China) with a magnification power of 400X using Eq2[13]:

$$\rho = \frac{N}{(A \times T)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

ρ : track density (tracks /cm^2. h).
N : average number of tracks .
A : area of the field view (cm^2)
T : irradiance Time (h).
The fitting equation that results from the calibration curve depicted in Figure 2 can be used to determine the uranium concentration (Uc) in the urine sample [14]:

$$Uc = (\rho + 12.5) / 18.6 \quad \ldots\ldots\ldots\ldots \quad (3)$$

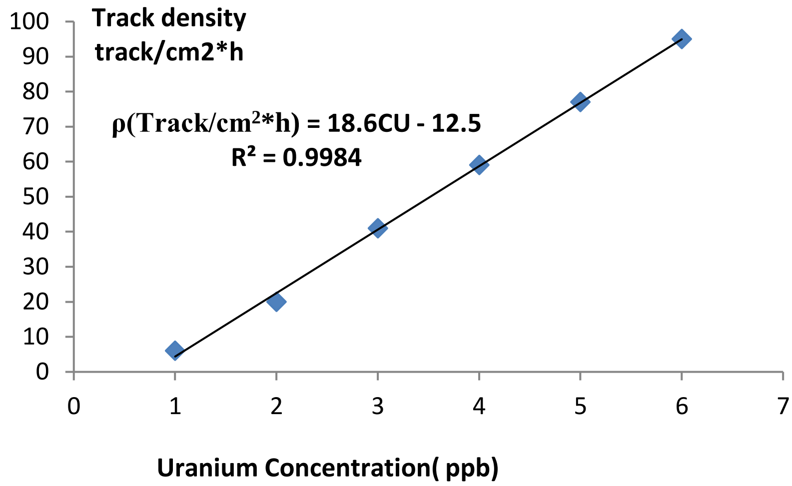

Fig. 2 Curve of calibration for standard uranium (ppb)[14].

Result And Discussion:

Table 2 shows uranium concentrations in urine samples collected from 15 individuals residing in the village of Ishtar. Uranium concentrations in Ishtar ranged from 0.175µg/L(O_3/M/age20) to 0.836µg/L (O_{13}/M/age57), with an average of 0.523 ±0.05µg/L, surpassing the WHO's permissible limit of 0.3µg/L[15].

The elevated uranium concentration in Ishtar is due to its proximity to AL- Tuwaitha nuclear site, 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. And containers of radioactive materials were 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[16].

The scientist Ryan Tully, who specializes in radiation, visited Tuwaitha and its surroundings as part of the Greenpeace team and conducted field radiation measurements. She announced that people in areas close to Tuwaitha receive radiation within 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[16].

Figure 3 shows a positive correlation between uranium concentration values and age groups in Ishtar village, as it increases with age. These results are consistent with another study in the same field, which found that higher uranium concentrations are associated with old age [17].

The average concentrations of uranium by gender in the village of Ishtar are shown in Figure 4, where uranium concentrations were higher in males than in females. However, the T-test confirmed that there was no statistically significant difference between males and females (P>0.01).

Table 3 shows uranium concentrations in the urine of 15 individuals residing away from the Tuwaitha nuclear site. The table indicates that uranium concentrations ranged from 0.112μg/L(L_1F/age20) to 0.930μg/L (L_8/F/age60), with an average of 0.285 ±0.05μg/L. It is observed that the levels of uranium detected in these people's urine are more than those documented in the literature [18,19]. The military operations in Iraq, which included the use of ammunition containing depleted uranium, maybe the reason behind this increase in uranium concentration. The health effects resulting from exposure to depleted uranium are similar to those resulting from exposure to natural uranium. This is because the toxicity of natural uranium, which is more radioactive than depleted uranium, is primarily due to chemical toxicity rather than radiation toxicity [20].

Based on the findings shown in Tables 2 and 3, it is clear that uranium concentrations in urine samples from the village of Ishtar are higher than those in the control area, with statistically significant differences between the two areas ($P<0.01$) , as shown in Figure 5. The rise in uranium concentration in Ishtar village has prompted us to speculate that uranium toxicity could be the reason. Most of the time, uranium is found in compounds that can be metabolized by the body to create other compounds. Tetravalent uranium oxidizes to hexavalent uranium in blood and other body fluids, leading to the production of uranyl ions. Mostly, uranium complexes proteins in plasma, bicarbonates, and citrates[21]. Similarly, correlation was found between uranium concentrations and age in the control area (Figure 6).

Local research conducted in Iraq utilizing a kinetic phosphorimetry analyzer discovered that the average uranium level in the urine of healthy females was 1.03 ±0.020 μg/L [22]. For healthy individuals, using the same technique, it was 0.946 ±0.009 μg/L [23]. in Baghdad city as (0.464- 6.212) μg/L [24], 3.212±0.593 μg/L [25] also1.361 μg/L for male and 0.9533 μg/L for female, 3.196 μg/L for radiation field worker [26]. The reported values for healthy persons in Al-Muthana governorate were 0.91 μg/L to 1.82 μg/L. [27]. Urine uranium content in people who have not been exposed is known for many global demographic groupings. Between sub ng/L and hundreds ng/L are the usual ranges[3]. Studies conducted in other countries have shown that the amount of uranium in the urine of Indian smokers ranges between $0.9\times^{-3}10$ and $6.9\times^{-3}10$μg/L, while the urine of non-smokers contains amounts ranging between $0.14\times^{-3}10$ and $1.0\times^{-3}10$[28]. Using the calcium phosphate neutron activation method, another study conducted in India resulted in a uranium content of 0.0128 μg/L in urine [18]. In Kazakhstan, it was observed to be between 0.05 and 0.08 μg/L. [29]. In the United States, 96.6% of healthy individuals (those who had not been exposed) had measurable levels of uranium in their urine, averaging 0.0345 μg/L [30]. It was reported to be 0.0045 μg/L in Japan [31]. Urine samples from Yugoslavia had uranium concentrations of 0.01 μg/L [32]. A person from the Czech Republic had a geometric mean uranium concentration in their urine of 0.091 mBq (0.0074 μg/L) [33]. Regarding the concentration of uranium in biological samples, different techniques lead to different results, and the daily excretion of uranium in urine varies according to regional differences[34].

Table2: Uranium concentration in urine samples in Ishtar village

Symbol	Age (years)	Gender	Uranium concentration in (μg/L)
O_1	34	Male	0.455
O_2	38	Female	0.480
O_3	20	Female	0.175
O_4	47	Male	0.714
O_5	48	Male	0.769
O_6	29	Male	0.295
O_7	35	Female	0.471
O_8	46	Female	0.680
O_9	27	Male	0.283
O_{10}	43	Female	0.537
O_{11}	55	Female	0.819
O_{12}	25	Female	0.214
O_{13}	57	Male	0.836
O_{14}	44	Male	0.634
O_{15}	36	Male	0.476
Min	0.175		
Max	0.836		
Ave	0.523 ±0.05		

Table 3: Uranium concentration in urine samples in control area.

Symbol	Age (years)	Gender	Uranium concentration in μg/L
L_1	20	Female	0.112
L_2	31	Male	0.196
L_3	41	Male	0.232
L_4	51	Female	0.317
L_5	30	Male	0.190
L_6	43	Male	0.262
L_7	50	Female	0.299
L_8	60	Female	0.568
L_9	25	Male	0.131
L_{10}	32	Female	0.197
L_{11}	44	Male	0.278
L_{12}	52	Female	0.568
L_{13}	27	Female	0.158
L_{14}	34	Male	0.204
L_{15}	40	Male	0.212
Min	0.090		
Max	0.930		
Ave	0.285 ±0.05		

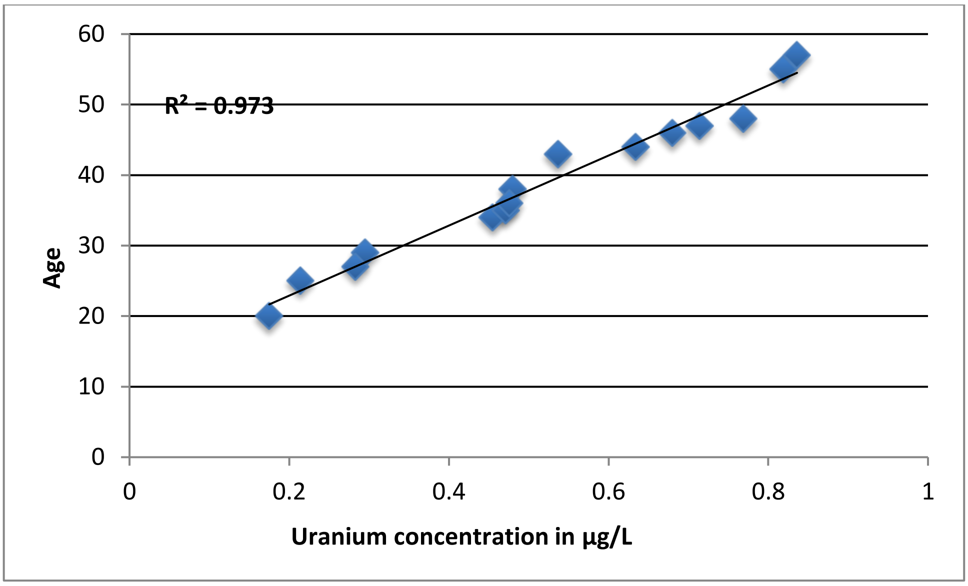

Fig. 3 Relationship between age and uranium content in Ishtar village.

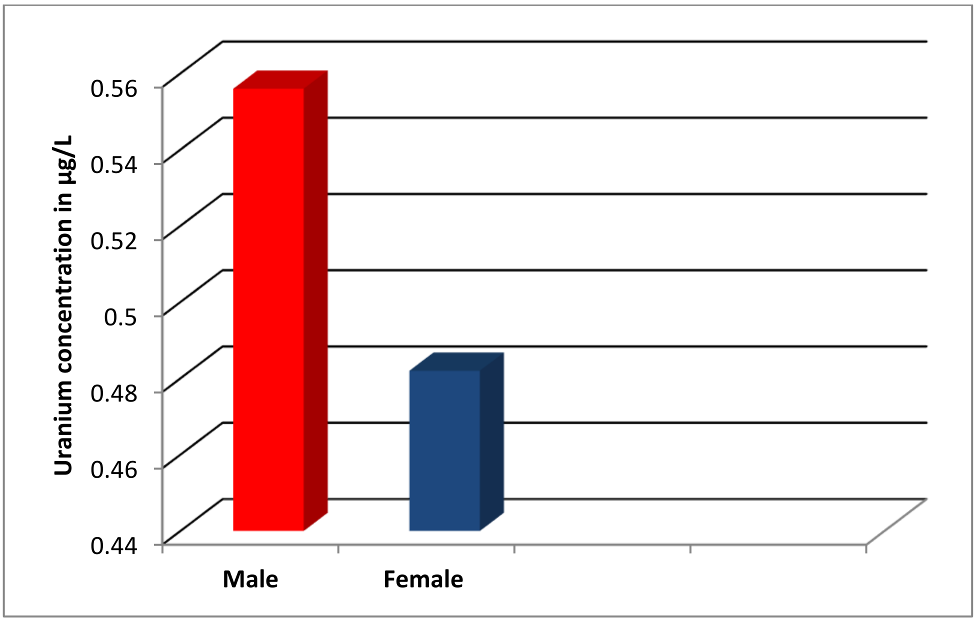

Fig. 4 Uranium concentration in urine relation to gender in Ishtar village.

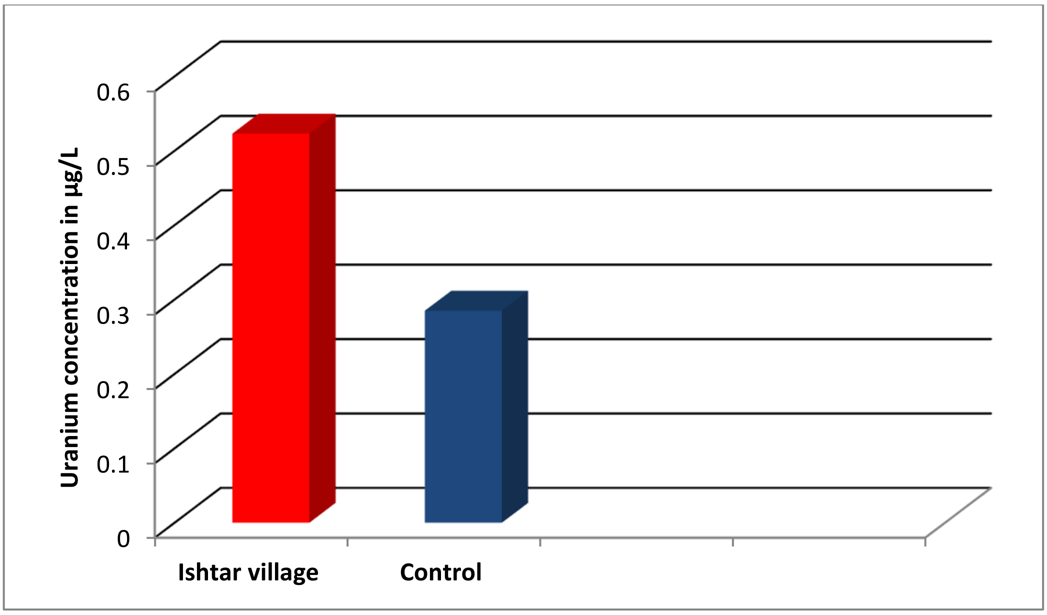

Fig. 5 Comparison between Ishtar village and control in Uranium concentration in urine.

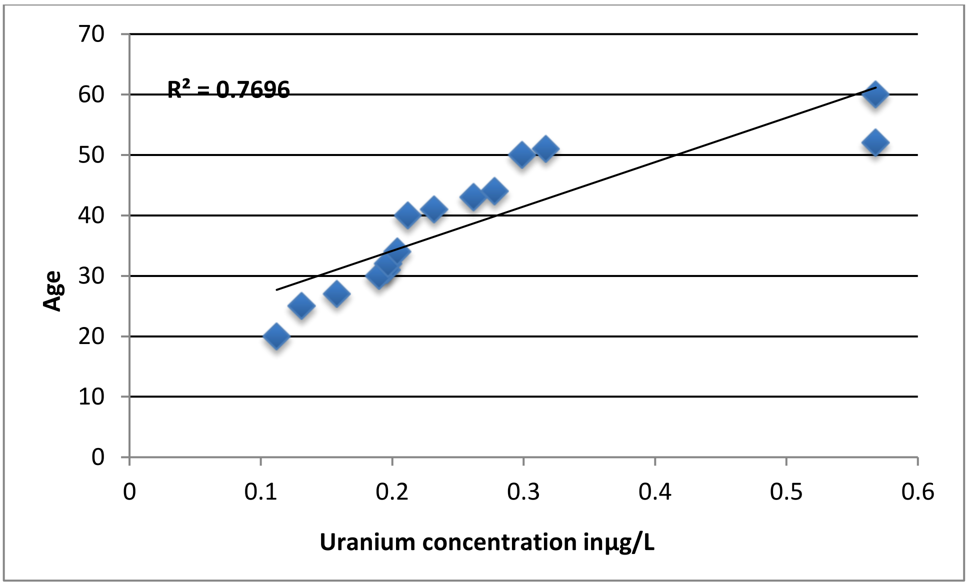

Fig. 6 Relationship between age and uranium content in control area.

Conclusion:

In this study, uranium concentration was measured in urine samples collected from 15 individuals residing in the village of Ishtar near the Tuwaitha nuclear site and compared with 15 individuals residing in another area in Baghdad far from Tuwaitha. The results showed that urine samples from the village of Ishtar contained higher amounts of uranium compared to the control group.

The increase in uranium concentration in urine samples from the village of Ishtar can be attributed to several possible reasons, including water pollution, food type, inhaling polluted air, and living near nuclear test sites, which expose individuals to internal and external radiation. The Tuwaitha Nuclear Research Center in Baghdad can be considered a highly radioactive pollution site with a higher average dose than other areas, as it was heavily bombed during the wars in 1991 and 2003. More environmental and epidemiological studies are desperately needed to identify possible causes.

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تحديد تراكيز (^{238}U) في الادرار البشري في بغداد، العراق

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الموبايل:

الخلاصة:

تم قياس تركيز اليورانيوم في15 عينة ادرار من سكان قرية عشتار (ذكور وإناث) (تتراوح أعمارهم بين 57-20 سنة) ومقارنتها بـ 15 عينة من أفراد يعيشون في منطقة أخرى من بغداد بعيدة عن موقع التويثة النووي (تتراوح اعمارهم بين 60-20 سنة). أجريت هذه الدراسة في شهري أكتوبر وديسمبر2023 باستخدام كاشف المسار CR-39. أظهرت النتائج أن تراكيز اليورانيوم تراوحت من 0.175 ميكروغرام/لتر إلى 0.836 ميكروغرام/لتر بمتوسط 0.523±0.05 ميكروغرام/لتر في قرية عشتار ومن 0.112 ميكروغرام/لتر إلى 0.930 ميكروغرام/لتر بمتوسط 0.285±0.05 ميكروغرام/لتر في منطقة التحكم، مع وجود فروق ذات دلالة إحصائية بين النتائج لكلا المنطقتين. نستنتج أن مستوى تركيز اليورانيوم في قرية عشتار أعلى من تركيزه في منطقة السيطرة، متجاوزاً الحد المسموح به من قبل منظمة الصحة العالمية وهو µg/L0.3. وفيما يتعلق بالجنس، فقد وجد أن الذكور أكثر تلوثاً باليورانيوم من الإناث، وتزداد تركيزات اليورانيوم مع تقدم العمر.