Assessment of Uranium levels in workers urine samples for the Al-Kifl brick factories in Babil Governorate – Iraq

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KEYWORDS

Uranium concentration, CR-39 detector, Am-Be neutron source, workers urine samples, Nuclear Track Detectors (SSNTDs), Al-Kifl brick factories

ABSTRACT

This study aimed to determine the levels of "uranium" in human urine from 72 samples taken in the Babil Governorate of Iraq. The maximum value of uranium concentration (4.171 ± 0.054 ppb) was reached in the urine samples of workers of Al-Kifl brick factories, according to the results obtained with CR-39. The lowest value of uranium concentration was (1.359 ± 0.017 ppb). The average uranium concentration in urine samples taken from employees of Al-Kifl brick factories was (2.81 ± 0.69 ppb).

The control group's results indicated that the greatest uranium concentration was (1.429± 0.05 ppb), and the lowest uranium concentration was (0.215± 0.04 ppb). The control group's urine samples had an average uranium concentration of (0.81 ± 0.32 ppb). Ultimately, uranium concentrations were determined using a few parameters. It was discovered that uranium concentrations rise with increasing daily and cumulative working hours, rise in workers who smoke relative to those who do not, and rise with age.

1. Introduction

There are two main types of radiation that humans may be exposed to: radiation from man-made sources and from natural sources. Radiation from man-made sources is created when the nuclei of stable isotopes are bombarded with different nuclear particles. Radiation is basically the process of emitting energy in the form of waves or particles through a material medium and into space [1]. Uranium is one radioactive element that occurs naturally. In its pure form, it is a thick, glossy, silver-white metal that is slightly radioactive [2]. There are three isotopes of uranium that occur naturally: 234U, 235U, and 238U. These isotopes all decay by both alpha and gamma radiation [3]. While the isotopes 235U and 234U account for around (0.72% and 0.0054%) of the total, respectively, the isotope 238U is the most prevalent in terms of weight (99.28%) [4]. Because uranium metal and its compounds are used in both military and civilian purposes, such as nuclear weapons, energy production, and medicine, physicists and chemists are very interested in these materials [5]. Due to its application in the creation of nuclear energy, uranium is an element with significant commercial value [6]. Because the alpha particles released during uranium decay might have detrimental effects, uranium is categorised as radiotoxic [7]. Numerous factors, including the exposure route, particle dissolution, length of contact, and removal method, affect how poisonous uranium is [8]. Scientists have been urged to measure the quantity of alpha particles in urine samples since it's the most crucial biological sample for determining the amount of natural radiation to which humans are exposed. [9]. The age-related accumulation of radionuclides is explained by uranium consumption, which is not affected by sex. For this reason, measuring the amount of uranium in urine requires the use of very sensitive procedures. The same amount affects the variability in uranium release in a urine sample. The amount of uranium that a person consumes for himself depends on a variety of factors, including age, health, type of soluble uranium, duration of exposure, and environmental and behavioral differences. While some uranium is excreted in the urine, it also accumulates in the kidneys and bones. Humans are exposed to ionizing radiation from natural and anthropogenic sources of ionizing radiation outside the body. Absorption of radioactive materials can occur through inhalation, ingestion, and skin contact. When radioactive materials enter the human body, they are transported into the blood, which in turn carries them throughout the body. Most of them are excreted in the urine within a few days, but a small amount remains in the kidneys and bones. One of the most significant primordial radioisotopes in the crust of the Earth is uranium. It is present everywhere around us, including plants, animals, rocks, soil, water, and air. From regular food, water, and air intake, the human body typically includes about 90 micrograms of uranium. This uranium is distributed at a rate of roughly 66% in the skeleton, 16% in the liver, 8% in the kidneys, and 10% in various bodily tissues [10]. This study examined the calculation of naturally occurring radioactivity and the evaluation of worker exposure concerns in brick factories that are often used. Thus, fundamental instructions for the usage of these factories will be provided by information on the measurement of radioisotope content in workers' urine samples and the radiation hazards evaluated by the corresponding radiological.

2. Methodology

Collection Samples and Preparation

Urine samples were collected from workers in Al-Kifl brick factories in Babylon Governorate, Iraq. The study was conducted on 72 samples (i.e. 36 urine samples from workers and 36 urine samples from the control group) and their ages ranged from 20 to 60 years. Each sample was given a specific code to distinguish them from each other. All participants provided detailed information about their age, smoking habits and gender through a questionnaire.

Experimental Method

Urine samples from Kafel brick plant workers have been examined using the fission track recording method to determine the amount of uranium present in them. The method for preparing urine samples was selected [11]. In order to keep urine samples from spoiling, hydrochloric acid was added before storage. The samples were subsequently stored in cold boxes with sample codes labelled on them and kept in the refrigerator until the study was finished. By using this technique, two droplets of urine with a known volume of 100 µl were dried for 24 hours at room temperature on a CR-39 detector piece (1 × 1 cm2) in a dust-free environment. A non-volatile substance was put on a thin film of the detector and covered by another piece of CR-39 to make it a pair as shown in Fig.1. Then , for seven days, each of these pairs was exposed to thermal neutrons from a neutron source (Am-Be) via a paraffin wax system at a distance of five centimeters, with a total flounce of (3.024×109) n cm-2 to cause latent damage to the detector owing to 235U (n, f) reaction as shown in Fig.2 [12-13]. After irradiation, the CR-39 detector was etched for 5 hours at 70 ± 1°C (NaOH) solution In the water bath, the solution normalcy was 6.25N . After that, distilled water was used to clean the detectors [14-15]. The chemical etching was done in a water bath. Track density, as measured by the CR-39 detector (track/cm2), was calculated using a 40X magnification optical microscope (Olympus Japan) Fig.3 [16]. Background was adjusted for by subtracting background from the alpha track density that was captured. The CR-39 detectors underwent chemical etching, then washed with distilled water and air dried [17].

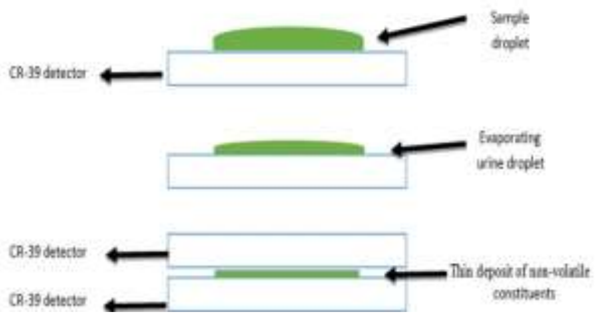

Figure 1 : Preparation of urine samples to determine the uranium content [2]

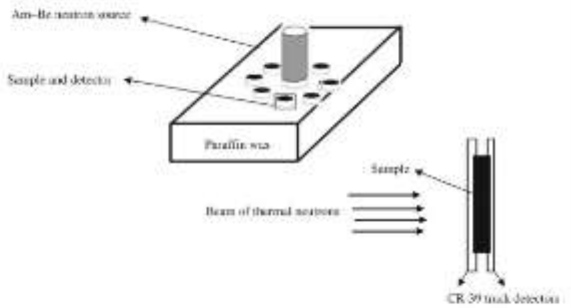

Figure 2 :The irradiation of the detectors and samples to the neutron source [18]

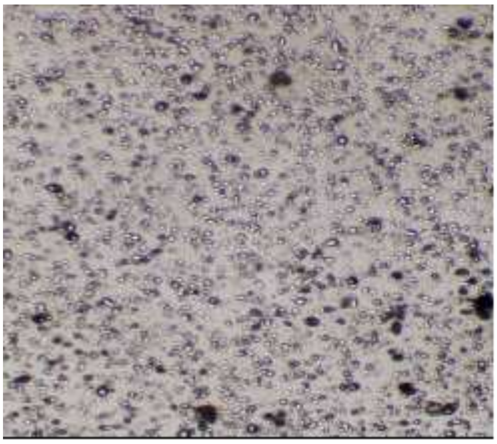

Figure 3: Density of tracks seen in the light microscope using the CR-39 detector

Calculations

The concentration of uranium present in the urine samples was determined by comparing the track densities recorded on the detectors of the urine samples with the standard samples (Equation 1)[19].

$$C_x = \rho_x \left(\frac{C_s}{\rho_x}\right) \dots \dots \dots (1)$$

Where and are the induced fission track density for unknown sample and standard sample in (tracks/mm2), and denote the uranium concentration for unknown sample and standard sample in (ppb). The slope of the linear relation between track density and uranium concentration for standard sample in Fig. 4 is equal to the reciprocal of the second term on the right-hand side of (Equation 2), the equation becomes.

$$C_x = \rho_x \ / \ slope \ \dots \dots . (2)$$

slope : is a ratio between the standard sample uranium concentration to the standard track density.

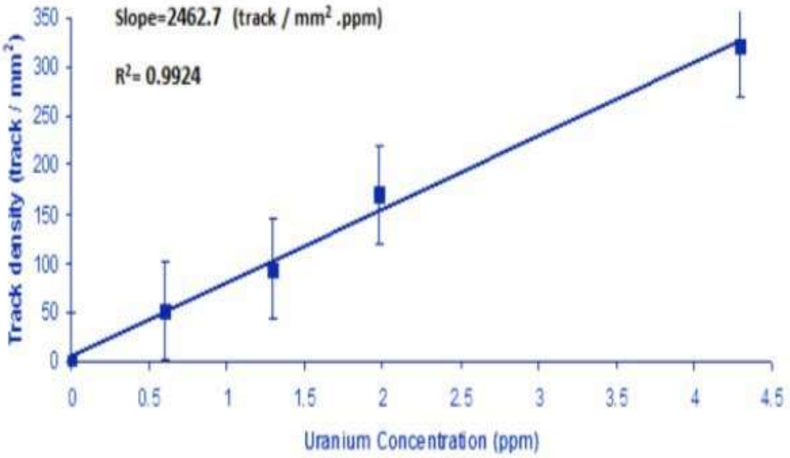

Figure 4: The relation between track density and uranium concentration in urine standard samples [20]

Statistical Analysis

An independent sample t-test was conducted for the data using SPSS version 26. to determine whether the results in our current work meet statistical significance at the probability (P) level (SPSS).

3. Result And Discussion

Table 1: Urine sample uranium concentrations statistically analysed for the following purposes: age, smoking habits, daily work period, and cumulative work period.

Table 1: Uranium concentrations in urine samples as following purposes age, habits of smoking , daily working period and cumulative work period and Statistical analysis

Characteristics workers urine samples	**Uranium concentration (^{235}U) level (ppb)**		***P value***
Age groups	**Mean ± SD**	**Range**	0.001 † S
20-29 years	1.69 ± 0.19	1.36- 1.92	
30-39 years	2.18 ± 0.27	2.02- 2.39	
40-49 years	2.89 ± 0.27	2.53- 3.32	
50-59 years	3.73 ± 0.23	3.42 – 4.17	
smoking habit	**Mean ± SD**	**Range**	**P**
Smoking	2.85 ± 0.86	1.60 – 4.20	0.733 † NS
Non Smoking	2.77 ± 0.73	1.36-3.85	
Daily working period	**Mean ± SD**	**Range**	**P**
< 8 hours	2.58 ± 0.81	1.36 – 3.42	0.484 † NS
≥ 8 hours	2.85 ± 0.80	1.60 – 4.20	
Cumulative work period	**Mean ± SD**	**Range**	**P**
< 10 years	1.91 ± 0.51	1.36 -3.05	0.001 † S
≥ 10 years	3.07 ± 0.67	2.02- 4.20	

control group			
Age groups	**Mean ± SD**	**Range**	**P**
20-29 years	0.375 ± 0.12	0.22- 0.58	**0.001 † S**
30-39 years	0.63 ± 0.20	0.36- 0.92	
40-49 years	0.83 ± 0.16	0.52- 1.03	
50-59 years	1.12 ± 0.21	0.80 – 1.44	
smoking habit	**Mean ± SD**	**Range**	**P**
Smoking	0.903 ± 0.28	0.32 – 1.43	**0.191 † NS**
Non Smoking	0.754 ±0.33	0.22-1.44	

Uranium content in urine can be determined using solid nuclear trace reagents, or (SNTDs). FTA, or the fission route technique, was proposed by Fleischer et al. This method works well for quantifying uranium in urine [21]. Solid State Nuclear Track Detectors (SSNTDs) and fission track technology were used in Al-Kifl brick factories the in Babil Governorate, and the CR-39 detector was used to determine the amount of uranium in the Al-Kifl brick factories workers.

From table1: it was found that the uranium concentrations in urine samples taken from Al-Kifl brick factories workers with a maximum value of (4.171 ± 0.054 ppb), and the minimum Concentrations of uranium are (1.359 ± 0.017 ppb), and urine sample means for uranium concentrations of Al-Kifl brick factories workers is (2.81±0.69 ppb). Uranium concentrations in control group urine samples, the values of uranium concentrations in the control group results are at a maximum value of (1.429± 0.05 ppb) and the minimum uranium concentration is (0.215± 0.04 ppb), and the average value of uranium concentrations in urine samples for control group is (0.81 ± 0.32 ppb).The mean uranium levels were higher in both Al-Kafl brick factories workers compared to the healthy control group and the difference was highly statistically significant (P>0.05).

Results of urine sample uranium concentrations of Al-Kafl brick factories workers indicate that they are very high. These results show that workers in Al-Kifl brick factories are exposed to high levels of uranium through swallowing and inhaling polluted air resulting from fumes emitted from the site. These factories are also characterized by the lack of environmental requirements in terms of using poor fuel in the production process, and the lack of means to control gas emissions, and thus the emission of toxic gases. As is known, the worst type of fuel is black oil due to its high sulfur content, which leads to the release of gases loaded with dangerous pollutants containing carbon dioxide, nitrogen, sulfur, and unburned hydrocarbons in addition to water vapor and fluorine gas resulting from fluoride salts originally present in the clay used as a raw material in brick production. In addition, the release of dense black smoke containing gaseous and solid waste through chimneys directly into the air surrounding the factories will lead to the deposition of solid particles in the lands surrounding the factories, which form what is called SOOT, which is a heavy black carbon material that is difficult for the air to carry. Gaseous wastes that are released directly into the air without treatment cause the appearance of a dark black cloud that clearly covers the sky of the area in the early morning hours as a result of the activity and work of these factories. At night, the continuous daily work of these factories for decades has led to the appearance of a type of fog surrounding the work area, mostly brown in color, called smog, which appears in the early morning hours and results from the reaction of nitrogen oxide with hydrocarbons.

High levels of uranium appear as a result of drinking water contaminated with uranium and eating contaminated food. Environmental pollution in Iraq is due to radioactive uranium as a result of the use of weapons containing depleted uranium, which led to the accumulation of uranium inside the bones and various organs until it eventually returns to the bloodstream, causing many health problems, starting with most types of cancer resulting from kidney failure, skin diseases, respiratory disorders, and other unknown diseases. The average uranium concentration values obtained are higher than the average reference values of the International Commission on Radiological Protection, which amount to 0.5 micrograms/liter [12].

The comparison of Urine Uranium (235U) level of Al-Kifl brick factories workers according to age groups was . The mean urine Uranium (235U) level was (1.69 ± 0.19 ppb), (2.18 ± 0.27 ppb), (2.89 ± 0.27 ppb) and (3.73 ± 0.23 ppb) in the Al-Kafl brick factory workers 20-29 years age group, Al-Kafl brick factory workers with 30-39 years age group, Al-Kafl brick factory workers with 40-49 years age group and Al-Kafl brick factories workers with 50-59 years age group, the mean level was higher in workers with more than 50 years age groups in compared with workers and the differences was significant (p = 0.001). Also, the comparison of urine samples Uranium (235U) level of Al-Kafl brick factories workers. The mean of urine samples Uranium (235U) level was (2.85 ± 0.86 ppb) and (2.77 ± 0.73 ppb) in Al-Kafl brick factories workers smoking and non-smoker Al-Kafl brick factories workers, the mean level was higher in smoker workers in compared with non-smoker workers but the differences was non- significant (p = 0.733). As for the level of uranium (235U) in the urine samples of Al-Kafl brick factories workers according to the daily working period. The average level of uranium (235U) in the urine was (2.58 ± 0.81ppb) and (2.85 ± 0.80 ppb) in Al-Kafl brick factories workers with less than 8 hours daily working and Al-Kafl brick factories workers with more than 8 hours daily working, the mean level of uranium (235U) was higher in workers with more than 8 hours daily working in compared with workers with less than 8 hours daily working but the differences was non-significant (p = 0.484).

Also, the urine samples uranium (235U) level of Al-Kafl brick factories workers was compared according to the cumulative working time. The mean of urine Uranium (235U) level was (1.91 ± 0.51ppb) and (3.07 ± 0.67ppb) in Al-Kafl brick factories with less than 10 years cumulative work and Al-Kafl brick factories workers with more than 10 years cumulative work, the mean level was higher in workers with more than 10 years cumulative work in compared with workers with less than 10 years cumulative work and the differences was significant (p = 0.001) . The comparison of Urine Uranium (235U) level of control group according to age groups was . The mean urine Uranium (235U) level was (0.375 ± 0.12ppb) , (0.63 ± 0.20 ppb), (0.83 ± 0.16 ppb) and (1.12 ± 0.21ppb) in control group with 20-29 years age group, control group with 30-39 years age group, control group with 40-49 years age group and control group with 50-59 years age group, the mean level was higher in control group with more than 50 years age groups in compared with workers and the differences was significant (p = 0.001). The comparison of urine Uranium (235U) level of control group according to smoking was. The mean urine Uranium (235U) level was (0.903 ± 0.28 ppb) and (0.754 ± 0.33 ppb) in smoker control group and non-smoker control group, the mean level was higher in smoker control group in compared with non-smoker control group but the differences was non- significant (p = 0.191).

Comparison with other results, in this study, uranium concentrations in urine samples of both groups appeared, where uranium concentrations in urine samples of workers of Al-Kafl brick factories ranged with a maximum value of (4.171 ± 0.054 ppb), the minimum value of uranium concentrations was (1.359 ± 0.017 ppb), the average amount of uranium found in urine samples of workers of Al-Kafl brick factories was (2.81 ± 0.69 ppb). While the results of the control group showed that the maximum value of uranium concentration was (1.429 ± 0.05 ppb), while the minimum the uranium concentration value was (0.215 ± 0.04 ppb), the uranium concentrations on average in urine samples of control group (0.81 ± 0.32 ppb) Uranium concentrations in urine samples have varied in other studies in different regions. In a study conducted in Iraq on workers in ceramic factories, the results showed the maximum value concentration of uranium in the urine samples of workers (1.34 ± 0.35 μg/L) and minimum value the concentration of uranium (1.89 ± 0.35 μg/L) with a mean value of (1.58 ± 0.42 μg/L), In the same study, the concentrations of uranium in urine samples collected from glasses factory workers the maximum value (1.89±0.32 μg/L) and minimum value the concentration of uranium (1.35±0.38 μg/L) with an average value of (1.57 ± 0.46 µg/L), also the concentration of uranium in urine samples of Phosphate factories workers the maximum value (3.39±0.43 µg/L) minimum value the concentration of uranium (1.68±0.31)µg/L with a value averaging (2.73 ± 0.40 µg/L), while for control group, the maximum uranium concentration was (1.82±0.44 µg/L) and minimum concentration was (1.26±0.43 µg/L) with an average value (1.49±0.53 µg/L) [14] .

Another, study was conducted in Iraq, where the results of the concentration of uranium in urine samples taken from workers in flooring materials factories showed a maximum value of (1.7 µg/L) while the minimum value was (0.96 µg/L). As for the control groups, the maximum of uranium concentration was (1.49 µg/L) while the minimum of uranium concentration was (0.91 µg/L)[20]. The present study found that the concentrations of uranium in urine samples of Al-Kafl brick factories workers were higher compared to the in a study conducted in Iraq, uranium concentrations were measured in urine samples collected from workers in the field of radiation (radiology, nuclear medicine) in the hospital, the results showed that the uranium concentration for workers in the field of nuclear medicine reached a maximum of (2.64±0.63ppb) and a minimum of (1.62±0.47ppb),the average uranium concentration for workers in the field of nuclear medicine was (2.21±0.47 ppb),while the results of uranium concentrations for workers in X-rays showed a maximum of (2.60±0.72 ppb) and a minimum of (1.31±0.24 ppb),the average uranium concentration for workers was (2.05±0.40 ppb). As for the uranium concentrations for workers in the Ministry of Science and Technology (MST) {formerly known as the Iraqi Atomic Energy Commission}, the maximum value appeared (2.96±0.49 ppb) and the minimum value (1.73±0.63 ppb) and the average uranium concentration was (2.40±0.56 ppb), while the uranium concentrations of the control group were maximum (1.82±0.44 ppb) and minimum (1.26±0.43ppb), while the average uranium concentration was (1.49±0.53 ppb)[22].

4. Conclusion and future scope

The average amounts of uranium found in urine samples of workers in Al-Kafl brick factories were higher than those of the control group samples. These results were highly statistically significant (P>0.05) due to workers being exposed to high uranium content through ingestion and inhalation of air polluted with gases and due to fumes emitted from sites resulting from combustion. Urine sample uranium concentration results revealed an increase with the increase in the number of daily working hours and the number of cumulative years of work. The values increase among smoking workers compared to non-smokers and its rates increase significantly with age.

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