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Assessment of uranium content in blood samples from kidney failure patients in Salah al-Din Governorate utilizing nuclear track detectors

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Abstract: This research use fission track analysis (FTA) using a CR-39 detector. Employed to determine uranium levels in the blood of patients with renal failure in Salah al-Din Governorate. The average uranium concentration in the patient samples ranged from 1.9447 ppb to 11.0293 ppb. The mean uranium concentration in the healthy cohort ranged from 0.4205 ppb to 2.4393 ppb. The results demonstrated increased uranium concentrations in the blood of patients with renal failure compared to healthy individuals.

1.INTRODUCTION:

Environmental pollution occurs when there are additional materials in the air, water, or food, which alter the natural structure of these materials quantitatively and qualitatively[1]. Radiation is energy conveyed through waves or a flow of particles. Radiation impairs the genetic material (DNA) within cells, which regulates cellular growth and division[2]. The biological effect of radiation depends on several factors, including the type of radiation, the method of exposure to it, whether external or internal, the sensitivity of the organ exposed to radiation, and its ability to store radioactive materials in the case of internal exposure[3].

Natural uranium is a lustrous, dense, and slightly radioactive element present in the natural environment. The majority of the uranium that humans absorb comes from the food, water, and air we regularly consume. The human body has around 66% of it in its skeletal structure, (16%) in its liver, (8%) in its kidneys, and(10%) in other tissues[4]. Uranium causes many health problems such as (cancer, kidney failure, leukemia, respiratory disorders, skin diseases and birth defects) as it is deposited in the bones and other organs and is released into the bloodstream causing all of the above health problems[5]. Blood is a connective tissue that carries oxygen, nutrients, hormones, and waste products from cells to other parts of the body, as well as specialized cells that cells need[6].

Prolonged exposure to uranium results in renal damage and may precipitate acute kidney failure, as elevated amounts of uranium are detrimental to human kidneys. Following the Gulf War (1991-2003) and military operations from 2014 to 2016, there was a notable rise in kidney failure cases, as reported by the Iraqi Ministry of Health. Consequently, numerous research projects were undertaken to ascertain the concentration of uranium in various contexts.

MATERIALS AND METHODS

Collection of sample

In the year 2024, samples were taken in July, August, September, and October. A healthy control group and a patient group were each given blood samples to analyze in the study of kidney failure. People living in Salah al-Din Governorate are part of the group of people with kidney failure. The dialysis center at Tikrit Teaching Hospital was the source of the patient samples. For the control group, we took blood samples from healthy residents of this governorate who do not have chronic renal disease Fig. (1).

Fig1: Geographical positions of the cities within Salah al-Din Governorate.

The main parts of this study showed in Table(1).

Table 1: The main parts of this study.

Blood	Type of disease	NO.Samples
	Patients with kidney failure	30
	Healthy Patients	23

2.2 Experimental work

A CR-39 detector track was employed to capture the traces of fission fragments. The detector plates were segmented into small pieces, and an americium-beryllium (241Am-9Be) source with a neutron flux of 5x10^3 (n/cm²/s) was employed to irradiate blood samples at the College of Education for Pure Sciences - Ibn Al-Haitham - University of Baghdad. Uranium-235 (235U) undergoes fission when subjected to thermal neutrons, resulting in the release of energy and several fast neutrons, as seen in the equation[15].

$$+ {}^{1}_{0}n \rightarrow {}^{236}_{92}U^{*} \rightarrow {}^{141}_{56}Br \ {}^{92}_{36}Kr + 3\,{}^{1}_{0}n \quad ......(1)\,{}^{235}_{92}U$$

Two 50μm drops of blood were pipetted onto a 1.5×1.5 cm² square section of CR-39 nuclear track detector. Subsequent to the sample drying at ambient temperature, an additional layer of detector was placed. Figure 2 illustrates the preparation of samples for irradiation using a neutron source.

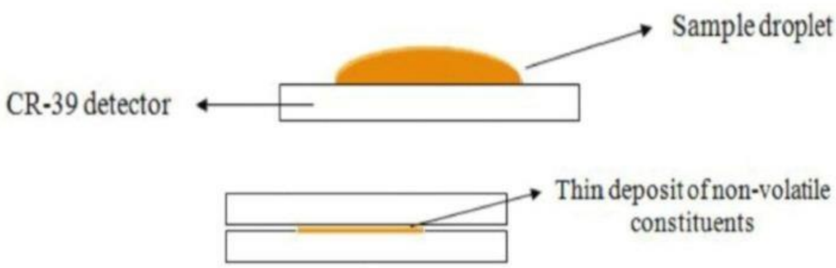

Fig 2: Blood samples on the detector.

After irradiation, the reagents were scraped in NaOH solution (6.25N) at 60˚C for (5) hours. The scraping solution was prepared using a graduated volumetric flask, as shown in the following equation[16].

$$\mathbf{W = W_{eq} \cdot N \cdot V} \quad \text{......(2)}$$

Where **W:** denotes the weight of NaOH, and $\mathbf{W_{eq}}$**:** refers to the equivalent weight of NaOH. **N:** is the normality(equals6.25) and **V:** defines the volume of distilled water (250 ml)

The reagents were recovered from the skimming solution after five hours and subsequently rinsed with distilled water for purification. The observation method was thereafter conducted utilizing a light microscope at a magnification of 40X. The fission track density (ρ) was determined using the subsequent equation:

$$\textbf{Track density } (\rho_x) = \frac{\boldsymbol{Av.of\ total\ track(Nave)}}{\boldsymbol{Area\ of\ field\ view(A)}} \quad \text{......(3)}$$

Where $\boldsymbol{\rho_x}$**:** the density of Track (Tracks/mm^2). $\mathbf{N_{ave}}$: Average of total effects with in area (A). **A:** Area (mm^2).

Results and discussion

To find the uranium concentrations in blood samples, we compared the densities of traces recorded for standard blood samples with those from blood samples taken with the CR-39 nuclear trace detector. The correlation between uranium concentration in standard blood samples and trace density is illustrated in Fig. (3):

$$C_x = C_s \cdot (\rho_x / \rho_s) \quad \text{.......(4)}$$

Where C_x and **Cs:** show the uranium concentrations in parts per billion for the control and unknown samples, respectively. $\boldsymbol{\rho_x}$ and $\boldsymbol{\rho_s}$: The induced fission track density for standards and unknown samples, respectively, is measured in units of Tracks/mm^2.

The conclusive equation utilized to quantify the content of uranium in blood samples of indeterminate concentration is articulated as follows:

$$C_x = \frac{\rho x}{\text{slope}} \quad \text{......(5)}$$

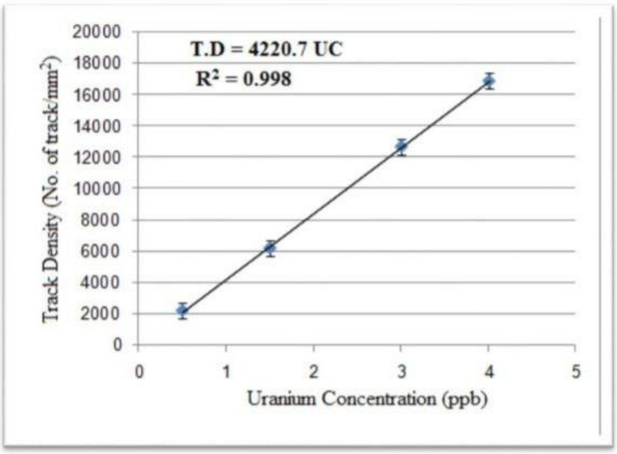

Fig 3: The correlation between trace density and uranium concentration in normal blood specimens.

Thirty healthy volunteers with renal failure participated in the research; 19 of them were men (M-Male) and 11 were female (F-Female). By analyzing the concentrations of uranium in patients with kidney failure, the result found that the highest concentration of uranium (11.0293ppb) was in a 60-year-old male from Samarra who was a smoker. While the second place was occupied by the concentration of uranium (6.3188ppb) for male, 34 years old, from the city of Tikrit, who was also a smoker. While lowest concentration of uranium in blood samples was (1.9447ppb)for female, 44 years old, from the city of Baiji, as shown in table(2). Comparison of results between patients group and healthy group with regard to the highest and lowest uranium concentration. We note that the average concentration of uranium in people with renal failure is (4.6596ppb), while in healthy people it is (1.0590ppb), which indicates a clear relationship between increased concentrations of uranium in the blood and an increased incidence of kidney failure. This is due to environmental pollution resulting from the use of depleted uranium weapons in conflicts, as depleted uranium can enter the human body through inhaling dust, consuming contaminated water or food, or through direct skin contact. Once in the body, uranium accumulates in bones and organs, and may later return to the bloodstream, leading to a range of health problems, including leukemia, kidney failure, respiratory disease, and birth defects[18].

Table 2 : Statistics for the results of the studied blood samples.

Statically Value	Patients Group	Healthy Group
No.Sample	30	21
Max	**11.0293**	**2.4393**
Min	**1.9447**	**0.4205**
Mean	**4.6596**	**1.0590**

Fig (4) also shows a chart of the average uranium concentration in both groups: patients and healthy individuals.

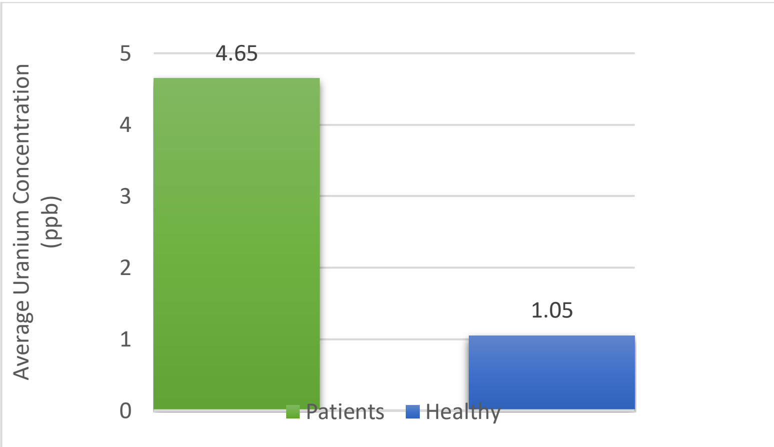

Fig 4: Uranium concentration in both groups: patients and healthy individuals.

Table (3) displays the mean uranium amounts in male and female contaminated blood samples. According to the data in the table, among kidney failure patients, females typically had a lower average uranium content than males. Fig. (5) shows that, among healthy individuals, female blood samples typically had a lower uranium concentration than male ones. Reasons for this include the fact that female blood volume is approximately four to five liters, whereas male blood volume ranges between five and six liters, the nature of men's work in industrial facilities, and their involvement in past wars, all of which contribute to a lower percentage of blood in females compared to males [19].

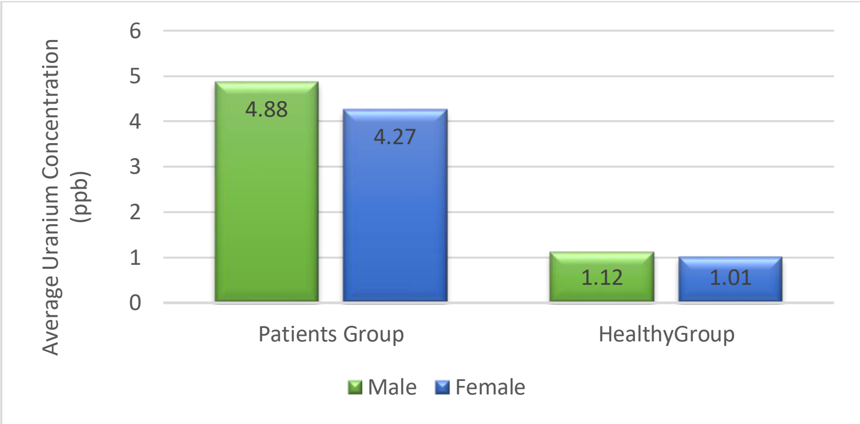

Fig 5: Displays a graph depicting the average uranium content in relation to gender (male and female).

CONCLUSIONS

The results showed that patients with kidney failure had higher uranium concentrations (ppb) than healthy individuals (ppb). The study also showed that age also affects uranium levels, as older people were found to have higher uranium concentrations than younger people. In addition, as well as gender, uranium concentrations were higher in males than in females.

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