Praise Worthy Prize

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Uranium Concentration in Urine Using Fission Track Etch Technique

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Abstract – *In this research, the concentrations of uranium in the human urine samples from different radiation workers in different Iraqi government hospitals (x-ray, nuclear medicine) were measured using CR-39 nuclear track detectors. Different ages, gender and working years is considered as well. The results show that the average of uranium concentration for nuclear medicine workers 2.21 ppb , 2.048 ppb for X-ray workers and 2.404 ppb for the ministry of science and technology (MST) workers {previously known as the Iraqi Atomic Energy Commission}, while 1.486 ppb for control people. The average of uranium concentration for nuclear medicine , x-ray and MST (male only) workers was 2.212 ppb, 2.062 ppb, 2.404 ppb for male and 2.18 ppb, 1.987 ppb for female respectively, while for control people was 1.491 ppb for male and 1.478 ppb for female.*

Keywords*: Uranium, Urine, CR-39, NTDs, Workers*

I. Introduction

Health physics is a systematic organization of knowledge about the interaction between radiation and organic or inorganic matter. It is a versatile science that is based upon physics, chemistry, biology and medicine.

Radiation and radiation emitters (radio nuclides) can expose the whole body (direct exposure) or expose tissue inside the body when inhaled or ingested. Different types of radiation vary in their ability to damage different kinds of tissue.

All kinds of ionizing radiation can cause cancer and other effects. The main difference in the ability of alpha particles, beta particles, gamma-rays and x-rays to cause health effects is the amount of their energy. Their energy determines how far they can penetrate into tissue. It also determines how much energy they are able to transmit directly or indirectly to tissues and the resulting damage [1].

Alpha-emitters like uranium, for example, enter the bodies through the food we eat, or the water we drink and the air we breathe and also by absorption through the skin. The alpha emitting element may consist of small, fine particles and coarse, big particles. The big particles are caught in the nose, sinuses, and upper part of the lung where they are blown out or pushed to the throat and swallowed. The small particles are inhaled down to the lower part of the lung. If they do not dissolve easily, they stay there for years and cause most of the radiation dose to the lung [2].

Chakarvarti et al., 1980, determined the trace concentration of uranium in smokers and non-smokers normal human urine samples using fission track etching technique.

Results indicated heterogeneous distribution in both types with levels spread uniform ranging from (0.9–6.5) × 10^{-3} µg/l and in the non-uniform part (0.14–1.0) × 10^{-3} µg/l forming 10–52% of the overall contents of the order (1.2–7.1) × 10^{-3} µg/l [3].

Wrenn et al., 1992, found the lowest mean values were reported with ct spectrometry (mean of 23 ng/1 in 12 subjects) and thermal ion mass spectrometry (3.4 ng/1 in 1 subject). Even alpha spectrometry is not sufficiently sensitive at normal levels, so that techniques such as fission track analysis or mass spectrometry must be used to obtain results above the detection limit of the technique for individual samples [4].

Ahmed F. Saleh Al –Jobouri. 2012 determined the uranium concentration in urine of Tall Al-Ragrag residents (Iraq) are in the range of 0.410 ± 0.008 to 3.011 ± 0.072µg/l with mean value of 1.125 ± 0.001 µg/l, and for Al-Jesira residents (Iraq) are in the range of 0.552 ± 0.009 to2.925 ± 0.053 µg/l with mean value of 1.338 ± 0.003 µg/l. using fission track etching technique [5].

A small part of the alpha emitting elements swallowed will also be found in the blood, and the blood carries it throughout the body. Most of it leaves through the urine in a few days, but a little stays in the kidney and bones.

People can be exposed to ionizing radiation from natural and man -made sources of ionizing radiation outside the body.

Since 1991, when depleted uranium weapons were first used in conflict, exposure may occur to people working or living in areas where depleted uranium munitions were used and where they hit target and formed various oxides and uranium compound. Equipment contaminated with depleted uranium oxides

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can become a source of contamination when the oxides are re-suspended or otherwise dislodge during transit [6].

Ionizing particles passing through polymeric track detectors produce latent track, which are trails of radiation damage. The best means of observing the tracks is by etching the SSNTDs material with a chemical solution, which preferentially attacks the damaged material and enlarges the original track to a size, which is visible in the optical microscope [7].

In this research, we are collecting the samples of human urine from different radiation workers in different government hospitals and from workers of different high-risk factories. Different ages, gender and working years is considered as well.

II. Experimental

To determine uranium concentration, CR-39 Nuclear Track Detectors (NTDs) are prepared at suitable size ($1.5\times1.5cm^2$). Materials and the equipments are installed according to the urine sample size. Urine samples collected from the workers in the hospitals (x-ray, nuclear medicine). The samples classification is shown in Tables I and II. Uranium concentration in urine samples has been determined using the fission track registration technique.

In this technique two drops of urine of known volume (100) µl were dried on a square CR-39 piece in a dust free atmosphere at normally room temperature as shown in Figure 1. The non-volatile residuals formed thin layers on one side of the detector. The layer was then covered with a second piece of the detector. The uranium standard solution was prepared by using urinal acetate $(CH_3COO)_2.UO_2$.

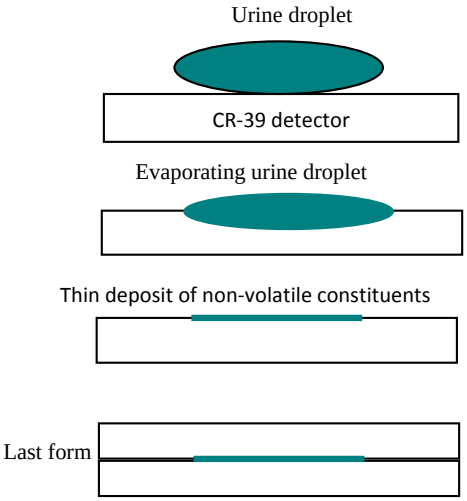

Fig. 1. Evaporation of the sample droplet and the formation of a thin deposit [8]

Subsequently, samples were exposure a beam of thermal neutrons (flux of 5×10^3 n cm^{-2} s^{-1}), and with a total fluence of 3.024×10^9 n cm^{-2} was employed using Am-Be neutron source as shown in Fig. 2.

This figure shows the irradiation setup of detectors with samples to the neutron source.

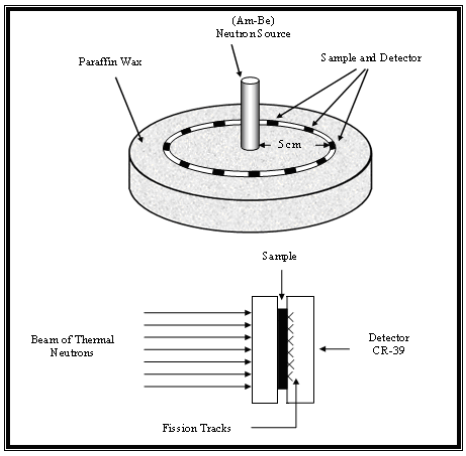

Fig. 2. The irradiation of the detectors and samples to the neutron source

The induced fission fragments were obtained according to the (n,*f*) reaction as in Eq.(1) [9]:

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

After irradiation the base detectors were etched in 6.25 N NaOH at 60°C for five hours.

The etched detectors were then rinsed in distilled water.

The induced fission tracks densities were recorded using an optical microscope at a magnification of (400x).

The fission track density (ρ) was calculated according to the following Eq. (2) [10]:

$$Track\ Density(\rho) = \frac{Average\ number\ of\ total\ track}{Area\ of\ field\ view} \quad (2)$$

III. Results and Discussion

Uranium concentration in urine samples was measured by comparison between track densities registered on the detector of urine samples and that of the standard solutions by Eq. (3) such that[4]:

$$C_x = (\rho_x / \rho_s) \cdot C_s \quad (3)$$

where ρ_x and ρ_s are the induced fission track density for unknown sample and standard solution (in tracks/mm^2), C_x and C_s denote the uranium concentration for unknown sample and standard solution in (ppb).

The slope of the linear relation between track density and uranium concentration for standard samples, as show in (Fig. 3), is equal to the reciprocal of the second term on the right-hand side of Eq. (4) then:

$$C_x = \rho_x / slope \quad (4)$$

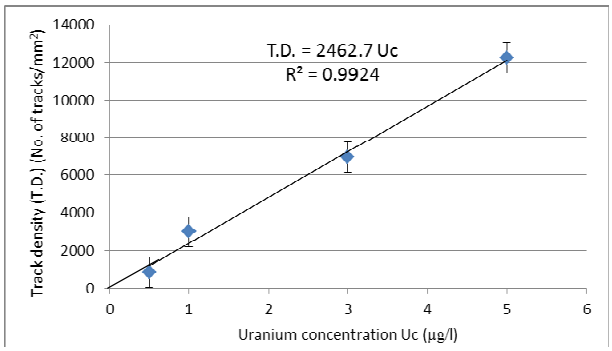

Fig. 3. The relation of uranium concentration and track density in standard samples

Uranium concentration in urine samples from nuclear medicine workers was shown in Table I, the results ranged from 1.62 ppb, male, 31 years old, 17 years work to 2.64 ppb, male, 60 years old and 35 years work, with average 2.21 ppb. Uranium concentration in urine samples from x-ray workers in was shown in Table II, the results ranged from 1.31 ppb, male, 24 years old and 1 years work to 2.60 ppb, male, 59 years old and 40 years work, with average 2. 048 ppb.

Uranium concentration in urine samples from MST workers in was shown in Table III, the results ranged from 1.73 ppb, male, 36 years old and 5year work to 2.96 ppb, male, 58 years old and 32 years work, with average 2.404 ppb. The uranium concentration in urine samples for control people was shown in Table IV, the results ranged from 1.26 ppb, male, 17 years old to 1.82 ppb, male, 46 years old, with average 1.491 ppb. The average of uranium concentrations according to number of working years are presented in Table V and (Figs. 4, 5 and 6) which show that the concentrations increase with increasing the number of working years for nuclear medicine, x-ray and MST workers.

The average of uranium concentrations in urine samples for workers and control peoples according to the gender, sick, addicted was shown in Table V and (Fig. 7), the uranium concentration for healthy peoples are lower than that for sick peoples and we also noticed that the concentration for smokers higher than that for non smokers due to heavy smoking.

TABLE I
SAMPLES CLASSIFICATIONS AND URANIUM CONCENTRATION IN URINE SAMPLES FOR NUCLEAR MEDICINE WORKERS

No.	Age (year)	No. of working years	Gender	Smoking or Alcohol	Diseases	Uranium concentration (ppb)
1	43	20	M	S	Non	2.45±0.45
2	31	11	M	Non	Non	2.01±0.48
3	49	21	M	S	Non	2.52±0.49
4	41	21	M	Non	Non	2.58±0.60
5	41	23	M	Non	Non	2.01±0.53
6	24	1	M	Non	Non	2.50±0.38
7	42	21	M	S	Hypertensive	2.52±0.37
8	60	34	M	Non	Non	2.57±0.52
9	31	8	F	Non	Non	2.33±0.40
10	46	29	F	Non	Non	2.22±0.46
11	36	7	F	Non	Non	1.73±0.34
12	37	6	F	Non	Non	2.10±0.55
13	40	12	M	Non	Non	2.34±0.40
14	60	35	M	Non	Hypertensive	2.64±0.63
15	60	33	M	Non	Non	2.42±0.55
16	48	10	F	Non	Non	1.95±0.53
17	33	1	M	Few S	Non	1.77±0.47
18	55	33	F	Non	Non	2.61±0.53
19	48	21	F	Non	Non	2.33±0.51
20	53	20	M	S	Hypertensive , Diabetes	2.52±0.69
21	23	4	M	Non	Non	2.21±0.29
22	35	5	M	Non	Non	2.31±0.37
23	62	30	M	S	Non	2.55±0.59
24	63	35	M	S	Hypertensive , Diabetes	2.54±0.60
25	40	15	M	S	Non	2.37±0.43
26	21	1	M	Non	Non	2.12±0.20
27	25	4	M	Non	Non	1.64±0.44
28	37	17	M	Non	Non	1.62±0.47
29	33	1	M	S	Non	1.95±0.41
30	27	1	M	Non	Non	1.95±0.41
31	28	1	M	S	Non	1.67±0.24
32	62	39	M	Non	Non	2.55±0.31
33	40	4	M	S	Non	1.76±0.35
34	36	2	M	S	Non	2.00±0.39
35	40	15	M	Non	Non	1.92±0.35
36	26	6	M	S	Non	2.12±0.36
			Average			2.21±0.47

*Non= non smoker and non alcohol or not sick.
S= Smoker.
C= Addicted to alcohol

TABLE II
SAMPLES CLASSIFICATIONS AND URANIUM CONCENTRATION IN URINE SAMPLES FOR X-RAY WORKERS

No.	Age (year)	No. of working years	Gender	Smoking or Alcohol	Diseases	Uranium concentration (ppb)
1	50	38	M	Non	Non	2.45±0.61
2	48	30	M	Non	Hypertensive	2.10±0.80
3	31	5	M	S	Non	1.77±0.63
4	59	40	M	S	Non	2.60±0.72
5	28	7	M	Non	Non	1.98±0.92
6	29	5	M	S , C	Non	1.94±0.56
7	48	30	M	S	Non	2.18±0.52
8	54	32	M	Non	Non	2.34±0.43
9	42	22	M	Non	Non	2.12±0.49
10	45	23	M	Non	Non	2.12±0.27
11	27	1	F	Non	Non	1.88±0.43
12	20	1	M	Non	Non	2.04±0.23
13	22	1	M	Non	Non	1.89±0.18
14	24	1	M	Non	Non	1.31±0.24
15	23	1	M	Non	Non	1.91±0.36
16	21	1	M	Non	Non	1.62±0.47
17	55	34	M	S	Non	2.24±0.35
18	45	20	F	Non	Non	2.19±0.19
19	27	6	M	Non	Non	2.07±0.54
20	28	6	M	Non	Non	2.07±0.31
21	24	3	M	Non	Non	2.04±0.24
22	20	1	F	Non	Non	1.86±0.24
23	20	1	F	Non	Non	1.82±0.18
24	20	1	F	Non	Non	2.03±0.23
25	41	14	F	Non	Non	2.15±0.25
26	26	4	M	S	Non	2.04±0.55
27	58	37	M	Non	heart disease	2.25±0.22
28	52	22	M	Non	Non	2.21±0.64
29	25	4	M	Non	Non	2.04±0.24
30	23	1	M	Non	Non	2.03±0.26
31	55	30	M	Q 15 Y*	Non	2.24±0.24
32	39	12	M	Non	Non	2.03±0.36
			Average			2.05±0.40

*Quit smoking X years ago
Non= non smoker and non alcohol or not sick.
S= Smoker.
C= Addicted to alcohol

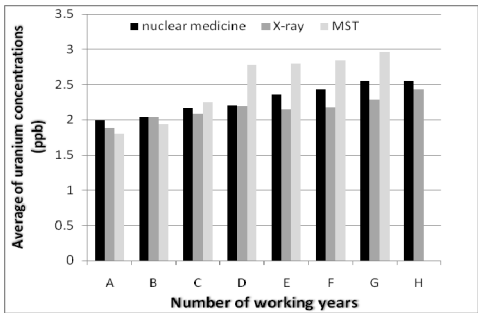

Fig. 4. Average of uranium concentrations in urine samples for workers according to the number of working years

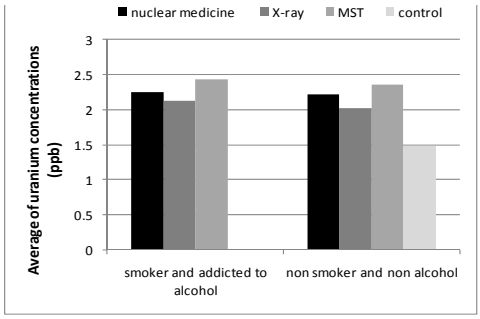

Fig. 5. Average of uranium concentrations in urine samples for control and workers according to the (smoker and addicted) and (not smoker and not addicted)

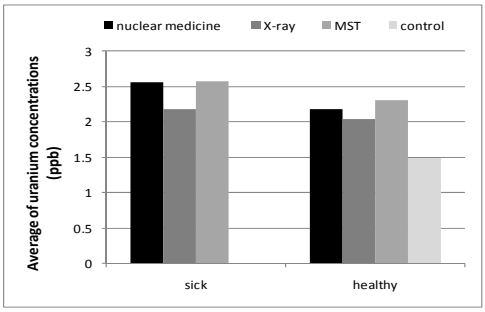

Fig. 6. Average of uranium concentrations in urine samples for workers according to the sick and healthy peoples

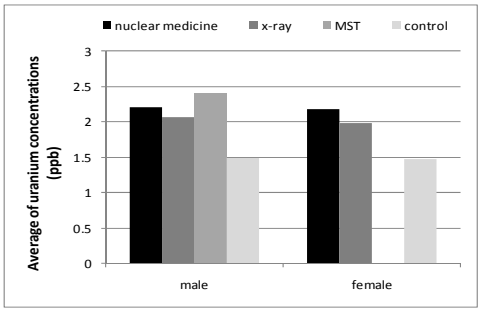

Fig. 7. Average of uranium concentrations in urine samples for workers according to the gender

TABLE III
SAMPLES CLASSIFICATIONS AND URANIUM CONCENTRATION
IN URINE SAMPLES FOR MST WORKERS

No.	Age (year)	No. of working years	Gender	Smoking or Alcohol	Diseases	Uranium concentration (ppb)
1	50	30	M	S	Diabetes	2.93±0.67
2	43	11	M	Non	Non	2.39±0.48
3	51	20	M	S	Hypertensive	2.79±0.70
4	48	27	M	S	Hypertensive	2.91±0.64
5	53	28	M	S	Hypertensive	2.88±0.73
6	42	17	M	S	Non	2.79±0.71
7	34	4	M	S	Non	1.79±0.56
8	44	14	M	S	Non	2.09±0.46
9	30	9	M	S	Hypertensive	1.89±0.62
10	42	16	M	S	Non	2.81±0.67
11	51	31	M	S	Non	2.94±0.66
12	43	13	M	Non	Non	2.24±0.29
13	39	20	M	S	Colon	2.57±0.59
14	60	32	M	S	Hypertensive	2.96±0.49
15	60	30	M	Non	stone in kidney	2.64±0.71
16	42	12	M	Non	Non	2.27±0.60
17	35	19	M	Non	Hypertensive	2.82±0.71
18	46	25	M	Q 1 Y*	Non	2.70±0.31
19	21	2	M	Non	Non	1.79±0.43
20	23	2	M	S	Non	1.83±0.35
21	45	21	M	Non	Non	2.90±0.71
22	27	6	M	Non	Non	1.89±0.38
23	30	11	M	Non	Non	2.18±0.44
24	40	9	M	S	Diabetes	1.94±0.36
25	45	18	M	Non	Non	2.90±0.74
26	40	14	M	S	Non	2.30±0.49
27	36	5	M	S	Non	1.73±0.63
28	33	12	M	Non	Non	2.39±0.60
29	48	17	M	Non	Hypertensive	2.85±0.54
30	36	18	M	Non	Non	2.73±0.64
31	48	10	M	Non	Diabetes	2.01±0.64
32	35	15	M	S	Hypertensive	2.18±0.63
33	19	3	M	Non	Non	1.85±0.48
34	34	3	M	Non	Non	1.86±0.53
			Average			2.40±0.56

*Quit smoking X years ago
Non= non smoker and non alcohol or not sick.
S= Smoker.
C= Addicted to alcohol

TABLE IV
SAMPLES CLASSIFICATIONS AND URANIUM CONCENTRATION
IN URINE SAMPLES FOR CONTROL PEOPLE

No.	Age (year)	Gender	Smoking or Alcohol	Diseases	Uranium concentration (ppb)
1	28	M	Non	Non	1.44±0.69
2	26	M	Non	Non	1.43±0.47
3	32	F	Non	Non	1.46±0.62
4	20	F	Non	Non	1.31±0.39
5	17	M	Non	Non	1.26±0.43
6	39	M	Non	Non	1.64±0.53
7	38	F	Non	Non	1.62±0.44
8	33	M	Non	Non	1.50±0.59
9	46	M	Non	Non	1.82±0.44
10	25	M	Non	Non	1.37±0.67
11	40	F	Non	Non	1.65±0.70
12	41	M	Non	Non	1.74±0.52
13	24	F	Non	Non	1.35±0.42
14	34	M	Non	Non	1.58±0.77
15	21	M	Non	Non	1.34±0.39
16	18	M	Non	Non	1.28±0.45
		Average			1.49±0.53

Non= non smoker and non alcohol or not sick.

TABLE V
AVERAGE OF URANIUM CONCENTRATIONS (PPB) IN URINE SAMPLES FOR WORKERS ACCORDING TO THE NUMBER OF WORKING YEARS

Group	Number of working years	nuclear medicine	x-ray	MST
A	1 - 5	1.99	1.88	1.81
B	6 - 10	2.05	2.04	1.93
C	11 - 15	2.16	2.09	2.25
D	16 – 20	2.20	2.19	2.78
E	21 – 25	2.36	2.15	2.80
F	26 – 30	2.43	2.17	2.85
G	31 – 35	2.56	2.29	2.96
H	36 - 40	2.55	2.43	
	Average	2.29	2.16	2.483

TABLE VI
AVERAGE OF URANIUM CONCENTRATIONS (PPB) IN URINE SAMPLES FOR WORKERS AND CONTROL ACCORDING TO THE GENDER, SICK, ADDICTED

Average	nuclear medicine	x-ray	MST	control
Over all	2.21	2.048	2.404	1.486
male	2.212	2.062	2.404	1.491
female	2.18	1.987		1.478
sick	2.557	2.177	2.569	
healthy	2.174	2.04	2.303	1.486
smoker and addicted to alcohol	2.248	2.127	2.433	
non smoker and non alcohol	2.218	2.022	2.357	1.486

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