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Uranium Concentration in Human Blood using Fission Track Etch Technique

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Abstract
The technique of fission track etch has been applied to determine concentration of uranium in human blood samples for exposed group and control group, male and female, using CR-39 track detector that is employed for registration of induced fission tracks. The blood samples of exposed group were collected from three key southern Iraqi governorates (Basrah, Muthanna and Dhi-Qar). These governorates were the center of intensive military activities during the 1991 and 2003 Gulf wars. The blood samples of the control group were taken from individuals who live in Babil governorate. This governorate, which is considered environmentally uncontaminated, is located north-west of the study area. The results showed that the uranium concentrations in human blood of exposed group ranged from 0.78 ppb (male, 3 years old, from Dhi-Qar) to 2.47 ppb (female, 65 years old, from Basrah). For the control group, the uranium concentration ranged from 0.32 ppb (male, 4 years old) to 1.47 ppb (female, 52 years old). It has also been found that the uranium concentrations in blood samples of exposed group are higher than those of the control group, and the uranium concentrations for female exposed group and control group are higher than those for male exposed group and control group.
Keywords: uranium concentration, human blood, CR-39, fission track, Iraq

1. Introduction

Human technological activities influence the environment in many ways. Some of these activities result in pollution of the environment; radioactive pollution plays an important role. One source of man-made radioactive pollution is uranium (Bersina et al. 1995).

Uranium is widespread in nature, being present in a wide variety of solid, liquid, and gaseous compounds. It readily combines with other elements to form uranium oxide, silicates, carbonates, and hydroxides (Banks et al. 1995)

Uranium is used as fuel in nuclear power plants and is present, in the different steps of the nuclear industry, in different forms with different isotopic compositions (natural, depleted, and enriched). Depleted uranium (DU) is a byproduct of the nuclear industry. Its specific activity is approximately 40% lower than that of naturally occurring uranium. Because of its high density and metallurgical properties, DU is used in the manufacture of armor and armor piercing shells in several countries (Mould 2001; Monleau et al. 2006). The first use of DU was in the Gulf war in 1991(McDiarmid et al. 2004). In the south of Iraq, DU was and still an environmental pollution problem because its levels raised after both Gulf wars I and II in 1991 and 2003 respectively (IAEA 2010).

There are different possible ways by which uranium can reach the human body either in a direct way by inhaling uranium-bearing dust particles or by drinking water which is polluted by uranium, or in an indirect way from the fertile soil layer via the food chain (Bersina et al. 1995). Solubility of uranium varies depending on the particular compounds and the solvent, and this solubility determines how quickly and efficiently the body absorbs them through the lungs and the intestines, respectively (ATSDR 2013). Uranium deposited in the bones and other organs is subsequently released back into the blood stream, which causes several health problems ranging from cancer to kidney failure, leukemia, respiratory disorders, congenital abnormalities, skin diseases, and other obscure unknown diseases (Briner 2010; Tawfiq et al. 2012; Segovia et al. 1986).

Solid-state nuclear track detectors (SSNTDs) are normally used to determine the uranium concentration in human blood. The fission track technique was suggested by Fleischer (Fleischer et al. 1975), who proposed the method of using thermal neutron irradiation of solid-state track-recording materials that are in contact with both films and pressed together to dry the blood. This technique appears particularly suitable for quantitative determination of uranium in the blood.

The aim of this study is to determine the concentration of uranium in the blood samples for the exposed and control group using CR-39 nuclear track detector, and to study the relationship between the type of human gender.

2. Material and method

2.1 Sample collection

In this study, 42 blood samples of volunteers, males and females, were collected from two groups. The first group included the exposed group by which 30 blood samples were collected from Basrah, Muthanna and Dhi-Qar. While the second group involved the control volunteers and the samples were gathered from 12 volunteers who live in the Babil governorate as shown in Figure1. The volunteers from these groups had no previous history of occupational exposure to uranium .They completed a comprehensive questionnaire about demographic information such as age, gender, and medical history. The ratio between the genders for these groups was more balanced.

2.2 Experimental method

The experimental technique of uranium concentration in blood samples is the same as reported elsewhere (Tawfiq et al. 2012; Segovia et al. 1986; Durakovic 1999).

Blood samples were heated at 37 °C for 24 h using an electric heating incubator to dry and to oxidize organic material. The powders collected in the form of 0.5 g of dried powder blood were mixed with 0.1 g of methylcellulose (C6 H10 O5) used as a binder. The mixture was pressed into a pellet of 1 cm diameter and 1.5 mm thickness. The pellets were covered with CR-39 track detector on both sides and were put in a plate of paraffin wax at a distance of 5 cm from Am-Be neutron source, with a thermal flounce equal to (3.02×10^9 n cm-2) for 7 days, to cause latent damage to the detector due to ^{235}U (n, f) reaction. After the irradiation, the CR-39 detectors were etched in (NaOH) solution with normality (N= 6.25) at a temperature of 60 °C for 5 h. The induced fission tracks densities were recorded using Olympus optical microscope with magnification of 400×. The fission track densities were measured on surfaces showing uniform distribution of uranium.

2.3 Calculations of uranium concentrations

Uranium concentration in the blood samples was measured by comparison between track densities registered on the CR-39 detectors around the sample pellet and that of the standard samples pellet, from the following relation (Tawfiq et al. 2012).

$$C_x\,(\text{sample}) / \rho_x\,(\text{sample}) = C_s\,(\text{standard}) / \rho_s\,(\text{standard}) \qquad (1)$$

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

$$C_x = C_s\,\rho_x / \rho_s \qquad (2)$$

2.4 Statistical analysis

The obtained results were statistically processed using Statistical Package of the Social Sciences (SPSS) and the significance of the probability level (P) was estimated by independent sample T-Test.

Figure 1. The location of the four governorates involved in the study

3. Results and discussion

Uranium concentrations in blood samples of individual volunteers in exposed group and control group are summarized in tables 1and 2, from Table1 the uranium concentration in blood samples of exposed group ranged from 0.78 ppb which belongs to a male (3 years old, and living in Dhi-Qar governorate) to 2.47 ppb which belongs to a female (65 years old, and living in Basrah governorate).

The average value of uranium concentration of this group is 1.84 ppb, and this finding is higher than reported data of other researchers (Tawfiq et al. 2012; Romero et al. 1984).

Table .1 Uranium concentration (ppb) in blood sample of the exposed group

Sample NO.	Gender	Age (Year)	Location	Uranium concentration in (ppb) ± S.D
1	Male	30	Basrah	1.86 ± 0.11
2	Male	55	Basrah	1.97 ± 0.22
3	Male	35	Basrah	1.99 ± 0.22
4	Female	65	Basrah	2.47 ± 0.18
5	Male	23	Basrah	1.92 ± 0.24
6	Male	25	Basrah	1.81 ± 0.21
7	Male	36	Basrah	2.05 ± 0.17
8	Male	27	Basrah	1.97 ± 0.15
9	Male	34	Basrah	1.75 ± 0.19
10	Female	50	Basrah	2.01 ± 0.15
11	Male	62	Muthanaa	2.18 ± 0.11
12	Female	50	Muthanaa	2.06 ± 0.19
13	Male	26	Muthanaa	1.52 ± 0.14
14	Female	25	Muthanaa	2.26 ± 0.23
15	Male	37	Muthanaa	1.62 ± 0.18
16	Male	55	Muthanaa	1.82 ± 0.15
17	Female	50	Muthanaa	1.91 ± 0.25
18	Female	61	Muthanaa	2.28 ± 0.1
19	Female	33	Muthanaa	1.48 ± 0.11
20	Female	45	Muthanaa	1.81 ± 0.11
21	Female	46	Dhi-Qar	1.7 ± 0.18
22	Male	70	Dhi-Qar	1.97 ± 0.18
23	Female	52	Dhi-Qar	1.98 ± 0.16
24	Male	30	Dhi-Qar	1.69 ± 0.20
25	Male	59	Dhi-Qar	1.9 ± 0.12
26	Male	6	Dhi-Qar	0.97 ± 0.18
27	Male	50	Dhi-Qar	1.89 ± 0.2
28	Female	47	Dhi-Qar	1.82 ± 0.23
29	Male	47	Dhi-Qar	1.77 ± 0.21
30	Male	3	Dhi-Qar	0.78 ± 0.18
Mean ± Std Error				1.84 ± 0.06

Table 2 represents the mean value of uranium concentration in the blood samples of control group. From this table the uranium concentration in blood samples ranged from 0.32 ppb which belongs to a male 4 years old to 1.47 ppb which belongs to a female 52 years old. The average value of uranium concentration of this group is 0.88 ppb.

Table 2. Uranium concentration (ppb) in blood sample of the control group

Sample NO.	Gender	Age (Year)	Location	Uranium concentration in (ppb) ± S.D
31	Male	23	Babil	0.79 ± 0.15
32	Male	7	Babil	0.51 ± 0.2
33	Male	45	Babil	1.26 ± 0.19
34	Female	15	Babil	0.73 ± 0.18
35	Male	51	Babil	1.34 ± 0.2
36	Male	36	Babil	1.03 ± 0.19
37	Male	16	Babil	0.6 ± 0.13
38	Female	32	Babil	1.1 ± 0.17
39	Female	52	Babil	1.47 ± 0.14
40	Male	4	Babil	0.32 ± 0.11
41	Female	5	Babil	0.55 ± 0.15
42	Female	25	Babil	0.85 ± 0.19
Mean ± Std Error				0.88 ± 0.09

From tables 1 and 2, the mean value of uranium concentration in blood samples of the exposed group was two times higher than those of the control group. The independent sample T-Test confirmed statistically significant

difference in the uranium concentration in blood samples between the exposed group and control group (P< 0.001). The reason behind such results can be attributed to the fact that the area of the current study (southern Iraq) was the center of intensive military activities during the Gulf wars I and II, and the discarded weapons are still lying around in this region. This explains reasons behind the high concentration of uranium in the blood samples of the exposed group.

Figure 2 represents the mean value of uranium concentration in the blood samples of male and female exposed group and control group. From this figure, the mean value of uranium concentration of male and female exposed group is 1.76 ppb and 1.98 ppb respectively, while the mean value of uranium concentration of male and female control group is 0.84 ppb and 0.95 ppb respectively.

The results showed that the average values of uranium concentration for female exposed group and control group are higher than those for male exposed group and control group. This is because the total blood volume in females is 4-5 L, while in males is 5-6 L (Fox 2003).

Results showed no statistically significant difference in the uranium concentration with regard to gender in both groups (P>0.05).

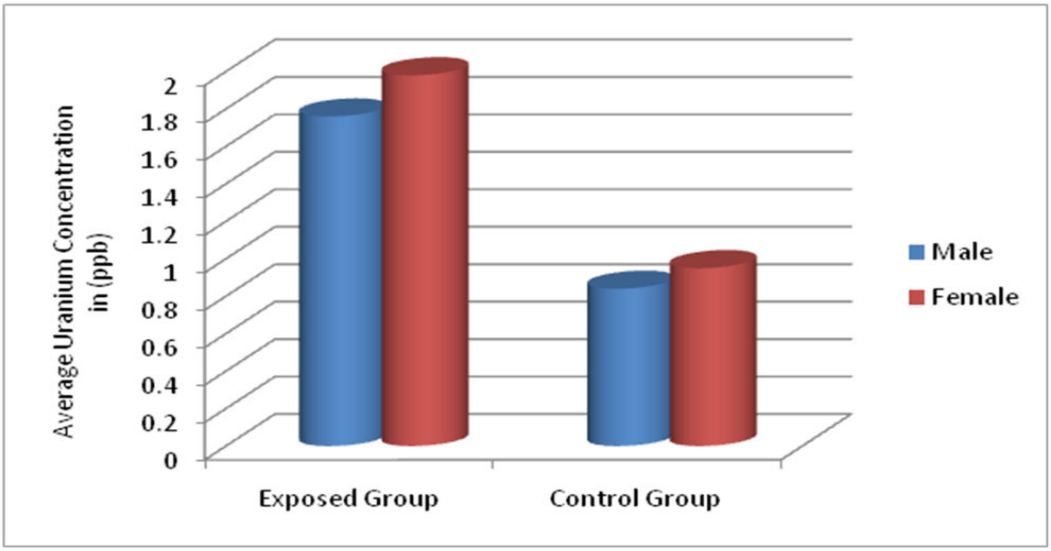

Figure 2. Uranium concentration in the blood samples as a function of gender

4. Conclusion

Results obtained show that uranium concentration in human blood samples of exposed group is higher than those of control group. This indicates that the people living in (southern Iraq) exposed to high levels of uranium. Also uranium concentration in blood samples of females is larger than that in blood samples of males.

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