Engineering and Technology Journal
Journal homepage: engtechjournal.org

Assessment of Uranium in Urine Samples of Primary School Students

Sahar A. Amin [a*] **and Azhar M. Haleem** [b]
[a] Environmental Research Center, University of Technology, Baghdad, Iraq. saharamin53@yahoo.com
[b] Environmental Research Center, University of Technology, Baghdad, Iraq. amhjanabi74@gmail.com
*Corresponding author.

Submitted: 14/09/2019 Accepted: 23/11/2019 Published: 25/04/2020

K E Y W O R D S

urine; uranium; CR-39

A B S T R A C T

The environmental monitoring of radon in the children urine has been carried out by using solid state nuclear track detector CR-39. This study has been undertaken for the purpose of health risk assessments. The concentration of uranium values excreted with the boy's urine samples ranged from 0.203 Bq.L^{-1} (1.246 ng/L) and 2.201 Bq.L^{-1} (13.486 ng/L) with an average value of 0.698 Bq.L^{-1} (4.007 ng/L). While the concentration of uranium values excreted with the girl's urine samples ranged between 0.290 Bq.L^{-1} (1.777 ng/L) and 0.675 Bq.L^{-1} (4.135 ng/L), with an average value of 0.474 Bq.L^{-1} (2.901 ng/L). The amount of uranium deposited in the kidneys, according to ICRP's biokinetic model, and the annual radiation dose were also calculated. All values of the study samples were within the normal range and do not indicate any health hazard.

How to cite this article: S. A. Amin and A. M. Haleem, "Assessment of uranium in urine samples of primary school students," Engineering and Technology Journal, Vol. 38, Part B, No. ٠1, pp. 41-46, 2020.
DOI: https://doi.org/10.30684/etj.v38i1B.581

1. Introduction

Uranium is naturally occurring radioactive element which is found everywhere in the earth's crust. Uranium concentration in the soil depends on geological formation of the soil. The uranium levels in the soil are about 0.001 g/kg – 0.010 g/kg of soil weight net with a mean value of ~ 0.003 g/kg [1]. Thus, as a result of this, plants, animals, humans, nourishment items and water contain distinctive levels of uranium depending upon its solubility. Hence, every individual ingests a specific measure of radioactive materials consistently which is later discharged. Usually, the human body contains about 56 µg of uranium which is equal to 0.690 mBq 238U in non-exposed subjects [2].
Radioactive materials can enter enter human body through ingestion, inhalation or through the skin, hence, uranium can be found in different biological samples such as urine, blood etc. [3]. The biggest quantity of ~ 0.010 to 0.200 Bq/kg net weights comes from legume, grain products and particular types of fish [4]. Moreover, substantial quantity of uranium ranged from 0.001 to 500 mBq/L comes from certain types of mineral water [5], which may be regarded as the main part of uranium intake if consumed regularly. Insoluble uranium oxides enter the body by inhalation, stays long time within long and little dissolvable amount will consumed by blood and appropriated to different organs like

liver, kidney where 98% from soluble uranium will discharged by kidney, while 2% will deposited in bones, organs and abdomen organs which causes damage to the immune system [6, 7].
Many investigations conducted in many countries have discovered that the daily rate of 238U intake is ranged from 11 to 18 mBq per day; which equal to an amount of 0.9 - 1.5 µg of U [8]. Around 2 percent of the intake quantity is really exchanged from the gut to the blood stream and thus to different organs where it creates little amount of residues, while the rest go through the gut without being absorbed and is discharged with urine and stool during a couple of days [9]. Absorbed uranium in the inner organs of the body is generally excreted through the renal system within a short time, while the rest, which is kept in various organs, will also be excreted through urine but within long half-life [10]. The highest dose of uranium and its progeny is received by the kidney compared by other organisms [11, 12]. Thus, the amount of uranium excreted by urine and stool can be assumed that it is proportional to the uranium concentration within the body.
Radiation can lead to various sorts of biological effects depends on the irradiated organism of the human body [13]. Urine can be considered as the best biological sample in order to assess human exposure to naturally occurring radiation and to evaluate its concentration as well as to determine the excessive intake of uranium [14]. This stimulates many scientists to estimate the concentration of alpha emitters in urine samples [15, 16]. The scientific studies on uranium levels which excrete in the urine of not exposed people show that renal uranium excretion/ day is independent on gender but it increases with age this explains the cumulative nature of radioactive elements (3, 18, 19, and 20). The other long-lived radionuclides like radium-226 and thorium-232 as well as the non-radioactive heavy metals conduct as the same behavior as uranium [1]. Uranium concentrations particularly in drinking water, which dominate the uranium concentrations in urine, vary to a large degree in magnitude from one place and another [9]. For example, biokinetic model for uranium given by ICRP (the intake, uptake, distribution, excretion of a substance and its behavior in the human body), shows that the continued uptake of 0.001 mg/L of uranium with drinking water at a consumption rate of 1.4 L/d causes a maximum uranium level in urine of approximately 0.020 µg/L for adults [17]. An amount of 1 mBq of 238U per kg of drinking water, which is equal to 81 ng of natural uranium per liter of drinking water, causes an approximately 1.6 ng/L of uranium level in urine as given as a reference value by UNSCEAR [18]. In the present work, urine samples were collected from primary school students study at various locales of Baghdad city. The samples were collected from boys and girls and with age ranged between 6 and 12-year-old. Long term method using CR-39 detectors was carried out. This study was conducted to determine the present concentration of uranium and its health risks for primary school students.

2. Materials and Methods

Twenty-five milliliter of morning urine samples from 41 primary school students with age group 6-12 years old have been collected from various primary schools within Baghdad city. They were 27 boys and 14 girls. All samples were stored in the refrigerator [19]. An amount of 10 µg/mL of amoxicillin is added to each urine sample and kept in clean plastic containers. The amoxicillin was used in order to prevent any bacterial growth. 10 µg/mL of water – amoxicillin solution was prepared as a standard sample. CR-39 detectors, size of (1.5 × 1.5) cm2, were immersed in the urine samples and stored for 2 months. After the end of exposure time, CR-39 detectors were taken out from urine samples and etched chemically in 6.25N NaOH solution at 70 oC for 5 hours. After etching, the detectors were washed first with tap water then with distilled water and later with alcohol. Thereafter, the detectors were scanned using optical microscope at 400x and hence, alpha track density / cm2 was determined.
Uranium concentrations in the urine samples were calculated by the following equation [20]:

$$C_U(Bq/m^3) = \frac{\rho}{CF\,T} \qquad (1)$$

Where, ρ is the measured α-track density (Track cm^{-2}), *T* is the exposure time, and *CF* is the calibration factor which is determined using equation mentioned in [20].

$$W_U = \frac{N_U W_{mol}}{N_{av}} \qquad (2)$$

Where,

$$N_U = \frac{C_s\,V}{\lambda_U} \qquad (3)$$

$$C_U(ng/L) = \frac{W_U}{W_s} \qquad (4)$$

Then, uranium concentration excreted in the urine samples (ng/L) and uranium concentration deposited in the kidneys (ng/g) according to ICRP biokinetic model for uranium [17].
Total Dose (mSv/y) was calculated using equation (2) [21].
Equation 1 is used to calculate radionuclide concentration C_R [13]:

$$D(mSv/y) = A \times C_{Sp} \times W \times 10^3 \qquad (5)$$

Where, A= activity (Bq/L) of the respective radionuclide, C_{sp} = specific dose coefficient of the respective radionuclide and the age group = $6.8x10^{-8}$Sv/Bq of ^{238}U for (7-12) age group and W = average water consumption of the age group (Ly^{-1}) assuming consumption of 1 liter/day.

3. Results and Discussion

Uranium concentrations were determined for 41 primary school student's urine samples using passive detector CR-39. Table 1 and Figure 1 show Uranium concentrations excreted in the urine, its concentrations deposited in the kidneys and annual radiation dose for the boy's urine samples. The results reveal that the values of uranium concentrations excreted with the urine were ranged between 0.203 Bq.L-1 (1.246 ng/L) and 2.201 Bq.L-1 (13.486 ng/L) with an average value of 0.698 Bq.L-1 (4.007 ng/L). Uranium concentrations deposited in the kidneys, according to biokinetic model given by ICRP are also given in Table 1. The highest value of deposited uranium concentration was 0.200ng/g while the lowest value was 0.018ng/g with an average value of 0.059ng/g. However, girl's urine samples were analyzed and the results are given in Table 2 and shown in Figure 2. The results present that the uranium concentration values excreted in the girl's urine samples extend between 0.290 Bq.L-1 (1.777 ng/L) and 0.675 Bq.L-1 (4.135 ng/L), with an average value of 0.474 Bq.L-1 (2.901 ng/L).

Table 1: Uranium concentrations, CU deposited in the kidneys and annual radiation dose in boy's urine samples

Sample No.	Age (Year)	Tr/mm^2	C_U Bq.L^{-1}	C_U in urine (ng/L)	C_U in kidneys (ng/g)	ARD mSv/y
1	7	12.49	0.426	2.607	0.039	0.011
2	7	10.50	0.358	2.192	0.033	0.009
3	7	18.78	0.640	3.921	0.058	0.016
4	7	10.74	0.366	2.242	0.033	0.009
5	8	18.85	0.642	3.935	0.058	0.016
6	8	27.21	0.927	5.680	0.084	0.023
7	8	11.14	0.380	2.326	0.035	0.009
8	8	19.89	0.678	4.152	0.062	0.017
9	9	14.08	0.480	2.939	0.044	0.012
10	9	14.96	0.510	3.123	0.046	0.013
11	9	12.73	0.434	2.658	0.039	0.011
12	9	31.50	1.073	6.576	0.098	0.027
13	9	9.55	0.325	1.994	0.030	0.008
14	9	8.35	0.285	1.743	0.026	0.007
15	10	8.75	0.298	1.827	0.027	0.007
16	11	64.60	2.201	13.486	0.200	0.055
17	11	13.37	0.456	2.791	0.041	0.011
18	11	39.78	1.356	8.305	0.123	0.034
19	11	42.56	1.450	8.885	0.132	0.036
20	11	12.33	0.420	2.574	0.038	0.010
21	11	20.21	0.689	4.219	0.063	0.017
22	11	19.25	0.656	4.019	0.060	0.016
23	11	16.63	0.567	3.472	0.051	0.014
24	12	22.75	0.775	4.749	0.070	0.019
25	12	5.97	0.203	1.246	0.018	0.005
26	12	23.31	0.794	4.866	0.072	0.020
27	12	13.29	0.453	2.774	0.041	0.011
Min		5.97	0.203	1.246	0.018	0.005
Max		64.60	2.201	13.486	0.200	0.055

Average	18.91	0.698	4.007	0.059	0.016

Table 2: Uranium concentrations, CU deposited in the kidneys and annual radiation dose for the girl's urine samples

Sample No.	Age (Year)	Tr.mm^{-2}	C_U Bq.L^{-1}	C_U in urine (ng/L)	C_U in kidneys (ng/g)	ARD mSv/y
1	6	19.809	0.675	4.135	0.061	0.017
2	6	13.206	0.450	2.757	0.041	0.011
3	6	19.252	0.656	4.019	0.060	0.016
4	7	09.865	0.336	2.059	0.031	0.008
5	7	13.047	0.445	2.724	0.040	0.011
6	8	12.888	0.439	2.691	0.040	0.011
7	8	10.581	0.361	2.209	0.033	0.009
8	8	14.002	0.477	2.923	0.043	0.012
9	8	14.558	0.496	3.039	0.045	0.012
10	9	17.582	0.599	3.670	0.054	0.015
11	11	10.183	0.347	2.126	0.032	0.009
12	11	08.512	0.290	1.777	0.026	0.007
13	11	10.740	0.366	2.242	0.033	0.009
14	12	19.809	0.675	4.135	0.061	0.017
Min		8.512	0.290	1.777	0.026	0.007
Max		19.809	0.675	4.135	0.061	0.017
Average		13.897	0.474	2.901	0.043	0.012

Annual radiation dose (ARD) were also calculated using equation (2) and the obtained results show that the lowest and the highest ARD values for 238U for the boys were 0.005 mSv/y and 0.055 mSv/y, respectively with an average ARD value of 0.016 mSv/y. while, ARD for 238U for the girls were 0.007 mSv/y and 0.017 mSv/y, respectively with an average ARD value of 0.012 mSv/y.
The results present that the concentration of uranium is higher in boy's urine samples than in girl's urine samples this may be due to the nature of urinary tract of females differ from that of male and repeat of urination reduces the concentration of excreted uranium. The variations in the uranium concentrations in the study urine samples depend on how extent the body is sensitive to the radiation, gender, age and the exposure time. The deposited uranium in the body represents the most health risks. Hence, it is exceptional required to maintain the environment protected and as safe as possible. The uranium level in urine acquired from a laboratory research is not itself adequate to evaluate the related hazardous risk. The health hazard varies widely depending on the exposure situation that resulted in such a value.

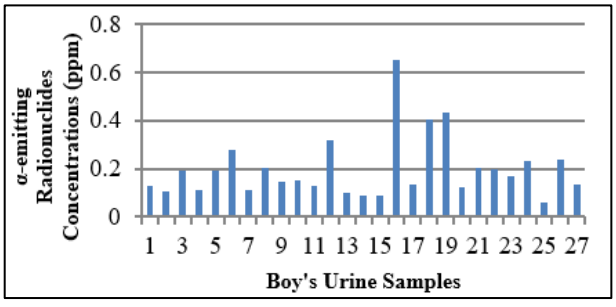

Figure 1: Concentration of uranium for boy's urine samples

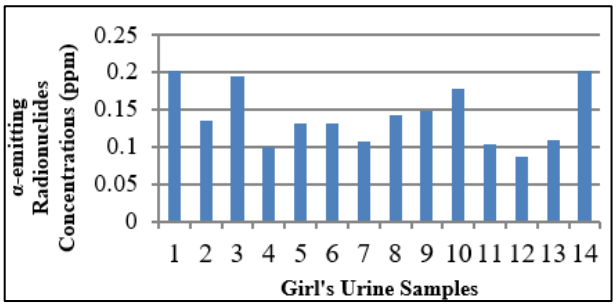

Figure 2: Concentration of uranium for girl's urine samples

4. Conclusions

This study was conducted to determine the amount of urinary uranium excretion and the health hazard associated with it. The results were performed by long term method using CR-39 SSNTDs. The urine samples were obtained from primary school students. A total of 41 students were examined. All the obtained results for uranium concentration excreted in urine of the studied urine samples does not indicate high radiation hazard. Even though, the environment should be kept as secure and safe as possible.

References

[1] P. Roth, E. Werner, H.G. Paretzke,"A study of uranium excreted in urine - An assessment of protective measures taken by the German Army KFOR Contingent," Research report prepared for the Federal Ministry of Defense; GSF - National Research Center for Environment and Health, Institute of Radiation Protection, Neuherberg, GSF Report 3/01, 36, January 2001. http://www.nato.int/du/docu/ge010229a.pdf

[2] I.M. Fisenne, P.M. Perry, N.H. Harley, "Uranium in humans," Radaition Protection Dosimetry. Vol. 24, No. (1-4), pp.127-131, 1988. https://doi.org/10.1093/oxfordjournals.rpd.a080256

[3] G. Zhu, M. Tan, Y. LI, X. Xiang, H. Hu, S. Zhao, "Accumulation and distribution of uranium in rats after implantation with depleted uranium fragment. Journal of Radiation Research. Vol.50, No.3, pp.183-192, 2009.

[4] I.M. Fisenne, P.M. Perry, K.M. Decker, H.K. Keller, "The daily intake of 234,235,238 U, 228,230,232 Th, and 226,228 Ra by New York city residents," Health Physics. Vol. 53, pp. 357- 363, 1987.

[5] E. Werner, P. Roth, U. Heinrichs, P. Schramel, I. Wendler, J. McAughey, R. Hearn, M.C. Cantone, "Uranium concentration in tap water, mineral water and urine of unexposed subjects in Britain, Italy and Germany," Proc. IRPA Regional Congress on Radiation Protection in Central Europe, Budapest, 1999.

[6] A. Bleise, P.R. Danesi, W. Burkart, "Properties, Use and health effects of depleted uranium (DU)," Journal of Environmental Radioactivity. Vol. 64: pp.93-112, 2003.

[7] D.S. Barber, M.F. Ehrich, B.S. Jortner, "The effect of stress on the temporal and regional distribution of uranium in rat brain after acute uranyl acetate exposure," Journal of Toxicology and Environmental Health A. Vol. 68, No.2, pp. 99-111, 2005.

[8] J.H. Harley, "Naturally occurring sources of radioactive contamination. radionuclides in the food chain," M.W. Carter, ed., International Life Sciences Institute Monographs, Heidelberg: Spinger-Verlag. pp. 58-71, 1988.

[9] WISE Uranium Project - FAQ, "Depleted Uranium in Urine of Soldiers," Peter Diehl, Am Schwedenteich 4, 01477 Arnsdorf, Germany first published: August 10, 2004 last revised: June 17, 2005. www.wise-uranium.org/pdf/duusfaq.pdf

[10] D.M. Taylor, S.K. Taylor, "Environmental uranium and human health," Reviews on Environmental Health. Vol.12, pp.147-157, 1997.

[11] N. Ahmad, M.S. Jaafar, S.A. Khan, T. Nasir, S. Ahmad, M. Rahim, "Measurement of radon exhalation rate, radium activity and annual effective dose from bricks and cement samples collected from Dera Ismail Khan," American Journal of Applied Science. Vol.11, No.2, pp.240-247, 2014.

[12] D.L. Henshaw, J.P. Eatough, and R.B. Richardson, "Radon as a causative factor in induction of myeloid leukaemia and other cancers," Lancet. 335, 1008e1012, 1990. http://dx.doi.org/10.1016/0140-6736(90)91071.

[13] [ICRP] International Commission on Radiological Protection, "Biological effects after prenatal irradiation (Embryo and Fetus)," Pergamon: ICRP Publication 90, 2003.

[14] Z.S. Žunić, N.R. Miljevic, "Environmental and health impact assessment of ammunition containing transuranic elements," Handbook of Environmental Chemistry, pp.209–251, 2009.

[15] A.S. Hussein, "Radon in the environment friend or foe. Proceedings of the 3rd Environmental Physics Conference, Nuclear Power Plants Authority, Cairo, Egypt, 2008.

[16] N.F. AL-Talbany, M.S. Jaafar, M.S. Al-Nafiey, "Measurement the Concentration of Alpha Emitters in the Urine in Vitro, Natural Exposure," Journal of Natural Sciences Research, Vol.3, No.3, 2013. ISSN 2224-3186 (Paper) ISSN 2225-0921.

[17] [ICRP] International Commission on Radiological Protection, "Human respiratory tract model for radiological protection," ICRP Publication 66. Annals of the ICRP 24(1-3). Oxford Glasgow. Pergamon Press Ltd., 1994.

[18] [UNSCEAR] United Nations Scientific Committee on the Effects of Atomic, "Radiation Sources and Effects of Ionizing Radiation," UNSCEAR Report to the General Assembly, with Scientific Annexes, 2 volumes, New York, 2000. http://www.unscear.or

[19] N. Tsivou, D. Livadara, D.G. Georgakopoulo, M.A. Koupparis, j. Atta-Politou, C.G. Georgakopoulos, "Stabilization of human urine doping control samples," Science Direct Analytical Biochemistry, Vol.388, pp.146–154, 2009.

[20] S.A. Amin, "Assessment of naturally occurring radioactive material (NORM) in the oil drilling mud of Az Zubair oil field, Basra, Iraq," Environmental Earth Science, Vol.75, 769, 2016.

[21] M. Küsters, W. Schraven, "Determination and differentiation of 226Ra and 222Rn by gamma-ray spectrometry in drinking water," Journal of Radioanalytical and Nuclear Chemistry, Vol.280, No.3, 475–480, 2009.