Measurement of Radon Concentration in Urine using PM-355 Detector

Najeba F. Salih, Mohammed F. Sabri, Amera G. Baker

Department of Physics, Faculty of Science and Health, Koya University, Kurdistan Region – F.R. Iraq

Abstract–**The present study was performed to determine the concentration of radon (^{222}Rn) in the urine samples for human using PM-355 detector with polyvinyl chloride tube. This study was carried out on 30 urine samples from 30 persons of different ages (between 20 and 48 years), and they all have diabetes problems. The result showed that the highest concentration and the highest annual effect dose in 30 ml of urine samples were about 33.650 Bq/L and 0.8479 mSvy^{-1}, respectively, for the S19 (48 years). However, the lowest concentration and the lowest annual effect dose were about 10.285 Bq/L and 0.2591 mSvy^{-1}, respectively, for the S23 (20 years). In addition, the results showed that the concentration of radon gas was varied from person to another, depending on the allergy of that person to the radiation. The average absorption dose in this study was 0.3963 mSvy^{-1}, which is quite below the range (3-10 mSvy^{-1}) that was reported by the ICRP; therefore, there is no evidence of health problems and no evidence of the relationship between radiation and diabetes. In general, the obtained results were lower than the normal levels.**

Index Terms-Alpha particle, PM-355, Radiation, Radon concentration, Urine.

I. Introduction

In general, radiation plays a significant role in different fields such as life, life sciences, and medicine. Radiation can result in several types of biological effect, mainly depending on the irradiated part of the body [1]. Radiation and radioactive materials are both parts of our environment and are produced by many human activities. Nowadays, radiation is a common and valuable tool in medicine and industry researches. Radiation levels, on the other hand, have always been subject to the hazard of ionizing radiation. It is worth to mention that radon is the most important source of natural radiation that affects the human body [2]. Radon concentrations are usually determined by measuring the emitted alpha particles, which cause damage in the detector surface (latent track) [3]. There are different possible ways by which uranium can reach the human body. On one hand, through a direct way by inhaling uranium-bearing dust particles or by drinking water that been polluted by uranium. The indirect way, on the other hand, includes the fertile soil layer through the food chain [4]. Therefore, the radon progenies detected in biological systems arise from ingestion of these progeny from food and drinking water as well as from the inhalation of radon [5].

Inhalation is the primary exposure mode for gaseous radionuclide's (such as radon), and the fractional number of inhaled radionuclides is transferred from the lungs to the blood, where it distributes to other organs and the blood carries it throughout the body. If in the case, the blood contains a radiation, and it filters in the kidneys and then into the urine, as urine is a liquid and is secreted by the kidneys through a process called urination.

Accordingly, the urine contains the radiation after the process of filtration [6]. Urine is considered to be the best sample for the detection of the excessive intake of radon. Furthermore, urine is a part of an epidemiological survey to determine public exposure to natural radiation and to estimate radionuclide levels in the diet of residents in the high-level background radiation in Iraq. Urine assay is the preferred method for monitoring accidental or chronic internal intake of uranium into the human body, and physical studies were conducted to measure the levels of radon gas in the urine of humans [7]. Significant nuclear physic experiments were carried out after the discovery of track detectors. The SSNTDs have become a valuable tool in the investigation of the uranium exploration and the detection of radon gas environmentally. The increased importance of SSNTDs and their wide application rendered them necessary to study the tracks structure formation, their properties, and the extreme influence of environmental parameters on them [8]. In the present work, the technique of SSNTDs has been utilized for examining the samples of urine, especially PM-355 NTDs (a polyaillyl diglycol carbonate detector), which is an advanced version of the detector CR-39. The PM-355 detector has a high efficiency to record the tracks in comparison with other detectors, and it has some specifications as presented in Shaimaa [8].

II. Methodology

A. Samples Collection

Urine samples were collected from different persons (include both male and female) that had diabetes problem

Pure and Applied Science Conference | Koya University
Paper ID: ICAPS2018.NUS46, 4 pages
DOI: 10.14500/icpas2018.nus46
Received 28 February 2018; Accepted 25 March 2018
Conference paper: Published 01 August 2018
Conference track: Nuclear Structure (NUS)
Corresponding author's e-mail: najeba.farhad@koyauniversity.org

and for different ages between 20 and 48 years from Azadi Hospital in Kirkuk Governorate in Iraq using cleaned plastic tubes. For each patient, the volume of urine recorded in a 30 mL tubes. The samples were brought into the research clinic, labeled, and then kept and stored at 4°C [9] in the refrigerator.

B. Sample Preparation

After the collection of the samples, the sample preparation was then performed in the ambient temperature [10]. The samples were prepared by weighing about 30 g/30 ml of each urine sample using an electronic balance, and then, each sample was separately transferred into the polyvinyl chloride (PVC) tube (PVC tube is a long-cylindrical plastic tube made from PVC) [11] with a length of about 11 cm [12] and a volume of about 84.78 cm^3. This technique was used to determine ^{222}Rn levels in the samples. The calibration of this technique was discussed in more details in the study of Salih *et al*.[12]. Each sample was placed in the bottom of the tube, and the PM-355 detectors of the size of 15 × 20 × 0.9 mm^3 were placed on the end of the top inside the radon dosimeters at 10.5 cm [12] from the surface of the samples (urine) to register the track of the α-particles from the radioactivity during the time of exposure. After the installation of the detectors in the position and sealing the tube properly, the samples were then stored in the refrigerator and left stably at 4°C during the 60 days [13] of exposure time**.** After this period [13,14], all the detectors were collected and brought to the research laboratory. Later, the process of track visualization was carried out by chemical etching. All the detectors were etched chemically in a 6.25N NaOH solution at 70 ± 0.5°C for about 6 h [15] by using a water bath to display and enlarge the latent alpha tracks due to the radon decay. Furthermore, an optical microscope of ×400, 100 fields was used for scanning each detector [16], (Fig. 1).

After the four steps of the process of etching and scanning, the track densities (ρ) in the samples were determined according to the following equation [17].

$$\text{Track density } (\rho)\,\frac{\text{Average of the total pits}}{\text{Area of the field view}} \qquad (1)$$

The measurement of the radon concentrations was based on the track densities, the calibration factor of the track density to the radon concentration (0.24 ± 0.04 track·cm-2 per Bq·m-3·day) [18], and the exposure time (60 days). Equation 2 was used and adapted from the studies of Saad and Abdalla, Shashikumar *et al*.[15,19]

$$C_{Rn}\,\frac{\rho}{k.t} \qquad (2)$$

Where C_{Rn} is the radon concentration ($Bq.m^{-3}$), ρ is the track density ($track.cm^{-2}$), k is the calibration factor ($track.m^{-3}$)/(cm^{-2}. Bq.day), and t is the exposure period (day).

The annual effective dose of ^{222}Rn of the urine samples due to the exposure to the radon decay products was calculated using the following formula [20].

$$E \text{ (annual effective dose)} = A_{Rn} \times F \times O \times DCF \qquad (3)$$

Where E is the annual effective dose, A_{Rn} is the radon concentration in urine, F is the equilibrium factor between radon and its decay products (0.4), O is the average indoor occupancy time per person (7000 h y^{-1}), and DCF is the dose conversion factor for the radon exposure (9.0 nSv h^{-1} [Bq. m^{-3}·h^{-1}]).

III. Results and Discussion

The current results showed that the concentration level of radon in the urine for the tested samples was calculated depending on the number of tracks per unit area (track/ cm^2) using Equation 1. For the purpose of estimating the annual effective dose rate received by the person, it is important to take into account the conversion coefficient from the absorbed dose and the indoor occupancy factor. The annual effectiveness has been calculated from the measured radon concentration in all samples using the equation that is described in more details in the study of Rahman *et al*. [20,21].

The maximum and minimum value concentrations of ^{222}Rn in 30 ml of urine were found to be about 33.650 Bq/L in S19 and about 10.285 Bq/L in S23, respectively, as shown in the Table I. In addition, the results showed that the concentration of radon gas was varied from one patient to another, and this large variation of the radon concentration can be explained depending on the allergic reaction of the body to the radiation and the response of the body to the radiation and also on the age of the person. In the case of age increasing, the exposure time to the radiation increases as well and this leads to the increase in the accumulated dose. Knowing of these concentrations is extremely important, as it reveals whether urine has received such doses of radioactive materials. It is worth mentioning that the issues in this research are very important in strengthening the link between radon and urine.

The maximum and minimum values of the annual effective dose of ^{222}Rn in 30 ml of urine were found to be 0.8479 $mSvy^{-1}$ in S19 and 0.2591 $mSvy^{-1}$ in S23, respectively, as shown in Table I. The intensity of the annual effective dose, on the other hand, was also varied from one

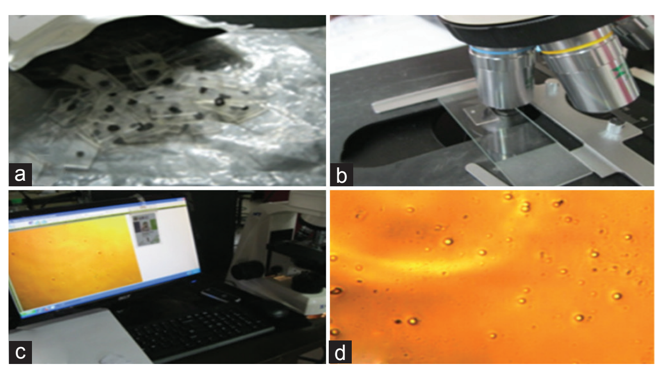

Fig. 1**.** (a) PM-355NTDs, (b) the detector under the optical microscope, (c) scanning and couting tracks with the camera, and (d) Track density as a function of chemical etching.

DOI: http://dx.doi.org/10.14500/icpas2018

person to another, depending on the exposure period to the radiation [22].

Fig. 2. shows that the relationship between the concentration of radon and the annual effective dose is linearity because when the radon concentration is increased, the annual effective dose is also increased.

From the obtained results, the radon concentration in urine samples was lower than the global permissibility limiting of exposure to radon (200 Bq/L). In general, radon gas has more effects than another radiation. This is due to the fact

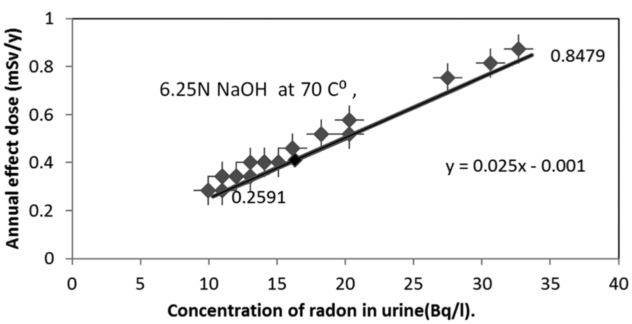

Fig. 2. Relationship between the concentration of ration in urine and the dose absorbtion in urine in female.

TABLE I
EVALUATION THE RADON CONCENTRATION AND THE ANNUAL EFFECTIVE DOSE IN URINE

N	Samples	Age (Years)	Density (Track/cm²)	Concentration (Bq/L)	AED (mSvy−m)
1	S1	41	188.112	14.788	0.3697
2	S2	34	161.219	12.679	0.3169
3	S3	44	183.091	14.394	0.3598
4	S4	42	143.128	11.252	0.2813
5	S5	41	190.926	15.010	0.3750
6	S6	30	261.408	20.551	0.5137
7	S7	28	207.522	16.314	0.4111
8	S8	34	243.449	19.139	0.4823
9	S9	33	263.431	20.709	0.5218
10	S10	35	186.739	14.680	0.3699
11	S11	45	164.319	12.918	0.3195
12	S12	34	150.283	11.815	0.2977
13	S13	42	145.871	11.467	0.2889
14	S14	29	193.823	15.237	0.3839
15	S15	36	189.574	14.908	0.3756
16	S16	33	173.514	13.641	0.3437
17	S17	31	172.155	13.534	0.3410
18	S18	30	168.726	13.264	0.3342
19	S19	41	426.034	33.650	0.8479
20	S20	36	165.794	13.034	0.3284
21	S21	35	232.794	18.301	0.4611
22	S22	32	195.716	15.386	0.3877
23	S23	27	130.832	10.285	0.2591
24	S24	26	136.644	10.742	0.2707
25	S25	32	216.611	17.029	0.4291
26	S26	43	145.861	11.467	0.2889
27	S27	38	211.881	16.657	0.4197
28	S28	39	356.871	28.056	0.7070
29	S29	27	392.763	30.877	0.7781
30	S30	28	149.877	11.782	0.2969

that the former has the ability to produce biological damage more than any other radiation by a factor of 100 times [14]. In addition, radon has high LET values and it gives alpha when the body absorbs it by inhalation and ingestion.

The average annual effective dose in the studied samples was about 0.3963 $mSvy^{-1}$, and this is quite below the range of 3–10 $mSvy^{-1}$ that reported by the ICRP [23]. Therefore, there is no evidence of health problem and the human urine is safe. The average annual effective dose intake corresponds to a very small component of the total effective dose from natural sources (2.4 $mSvy^{-1}$) [24]. As a result, there is no evidence of health problems in this case as well. EPA noted that the radon levels were less than 4 pCi/L and still pose a health risk but can be reduced [25]. However, the concentration of radon in our samples is very less than this value. The EPA has suggested that the immediate intervention is required only if the concentration of radon (^{222}Rn) level is above 190 Bqm^{-3} (the standard level of the radon is between 40 and 190 Bqm^{-3}), and if the concentration is below 40 Bqm^{-3}, no intervention is required. Therefore, the person is safe from the hazard of the radon and no danger is present in his/ her life, as the concentration of radon in all our samples is <4 pCi/L and 190 Bqm^{-3} [26].

IV. Conclusion

The current study was conducted to determine the concentration of radon in a biological sample (urine). Knowing of radon concentration is extremely important because it reveals if a person has received high doses of radioactive. The tested samples were of the low level of radon concentration (less than risk level), and therefore, the person is safe from hazard. The concentration of radon and the effective dose were estimated to ascertain the health risk level of radiation on biological samples. In addition, the SSNTDs appeared to be useful for the experimental analysis of biological samples and a benefit detector for radiation estimation, and therefore, the passive method of PM-355 detector is simple and reliable analytical method.

Acknowledgment

The authors thank the academic support provided by the School of Physics at the University Sains Malaysia and also thank all those who helped us throughout this study in Iraq.

References

[1] N. F. Salih and M. S. Jaafar, “WBC, PLT of women’s blood affects by alpha deposition into the body,” *American Journal of Thoracic and Cardiovascular Surgery*, vol. 2, no. 2, pp. 25-28, 2017.

[2] D. Nan, X. Yongjun, X. Xilin, Z. Zhiyuan and I. Yingwu, “Determination of radon using solid state nuclear tracks wireless sensing method,” *Analytica Chimica Acta*, vol. 686, pp. 121-125, 2011.

[3] P. C. Marcia and W. M. Elaine, “Calibration of the solid state nuclear track detector CR-39 for radon measurements,” *International NUC Atlanta Conference - INAC ASSOCIAÇÃO BRASILEIRA DE ENERGIA NUCLEAR Instituto de PesquisasEnergéticas e Nucleares* (IPEN/CNEN - SP), 2007.

DOI: http://dx.doi.org/10.14500/icpas2018

[4] A. H. Anees, M. S. Jaafar, F. T. Nada and N. F. Salih, "Uranium concentration in human blood using fission track etch technique,'' *Journal of Natural Sciences Research*, vol. 13, pp. 176, 2013.

[5] A. S. Hussein, "Radon in the environment: Friend or foe", *Proceedings of the 3rd Environmental Physics Conference Aswan, Egypt Nuclear Power Plants Authority, Cairo, Egypt*, pp. 19-23, 2008.

[6] A. Nsiah, J. J. Fletcher, O. C. Oppon and A. B. Andam, "Indoor radon levels and the associated Effective dose rate determination at dome in the greater Accra region of Ghana," *Research Journal of environmental and EA Sciences,* vol. 3, pp. 124-130, 2011.

[7] C. Jewel, F. Obaid, W. Jewell, T. L. Fernando, G. Kristina and J. P. Sari, *Toxicological Profile for Phenol U.S. Department of Health and Human Services,* Atlanta, GA: Public Health Service Agency for Toxic Substances and Disease Registry, 2008.

[8] T. A. Shaimaa, "Determination of alpha emitters concentration in human urine via PM-355 SSNTDs detector,'' *MSc. Thesis in Physics, Al-Nahrain University,* 2009.

[9] M. Tsivou, D. Livadara, D. G. Georgakopoulos, M. A. Koupparis and P. J. Atta, "Stabilization of human urine doping control samples: II. Microbial degradation of steroids," *Analytical Biochemistry,* vol. 388, pp. 146-154, 2009.

[10] M. Biljana, N. Dragoslav and S. A. Nenad, "Simulation of neutron interaction from Ame Be source with the CR-39 detector," *Radiation Measurements*, vol. 1338-1341, pp. 45, 2010.

[11] M. R. Yousuf, M. M. Husain and A. L. Najam, "Measurement of radon concentration levels in spring water in Iraq,'' *Jordan Journal of Physics*, vol. 2, pp. 89-93, 2009.

[12] N. F. Salih, M. J. Zubir and M. S. Jaafar, "Investigation of distribution of radioactivity with effects of heavy metals in toothpastes from Penang markets," *Environmental Science and Pollution Research.* DOI 10.1007/ s11356- 016- 7388- 4.

[13] N. F. Salih and M. S. Jaafar, "Novel method to assessing and the impact of alpha emitter's concentration of the uterus on women fertility in Iraqi Kurdistan region," *Journal of Radioanalytical and Nuclear Chemistry*. DOI: 10.1007/ s10967-013-2583-y.2013.

[14] M. I. Sersawi, "Study of the chronic radiation exposure situation in Gaza," *MSc. Thesis in Physics. Islamic University of Gaza*, 2007.

[15] A. F. Saad, Y. K. Abdalla, N. A. Hussein and I. S. Elyaseery, "Radon exhalation rate from building materials used on the Gar Younis University, Benghazi, Libya,'' *Turkish Journal of Energy and Environmental Science,* vol. 34, pp. 67, 2010.

[16] R. D. Joris, T. K. Timo, R. H. Andreas, H. P. Kurt, G. G. Walter and L. Andreas, "The role of automated urine particle flow cytometry in clinical practice,'' *Clinica Chimica Acta*, vol. 30, pp. 11-18, 2000.

[17] A. H. Gil and J. Kilee, "Construction of an environmental radon monitoring system using CR-39 nuclear track detectors,'' *Nuclear Engineering and Technology*, vol. 37, pp. 395-340, 2005.

[18] M. S. Al-Nafiey, M. S. Jaafar, S. B. Bauk and N. F. Salih, "Design and fabrication of new radon chamber for radon calibration factor of measurement,'' *International Journal of Scientific and Engineering Research,* vol. 10, pp. 1-6, 2012.

[19] T. S. Shashikumar, M. S. Chandrashekara and L. Paramesh, "Studies on the radon in the soil gas and natural radionuclides in soil, rock and ground water samples around Mysore City,'' *International Journal of Environmental Science,* vol. 5, pp. 786-797, 2011.

[20] UNSCEAR, *Report of the United Nations Scientific Committee on the Effects of Atomic Radiation to the General Assembly,* United Nations, New York: ANNEX B: Exposures from Natural Radiation Sources, 2000.

[21] S. U. Rahman, F. Malik, F. M. Matiullah, T. Nasir and J. Anwar, "Monitoring of indoor radon levels around an oil refinery using CR-39-based radon detectors,'' *Indoor and Built Environment*, vol. 21, no. 3, pp. 452-457, 2011.

[22] R. Muhammad, S. U. Rahman, R. Said, Matiullah, S. M. Ikram, A. Navid, J. Iqbal, B. Ahmed, T. Ahmed and N. Akhtar, "Assessment of indoor radon doses received by the students in the Azad Kashmir schools, Pakistan,'' *Radiation Protection Dosimetry,* vol. 142, no. 2-4, pp. 339-346, 2010.

[23] ICRP (International Commission on Radiological Protection), "Protection against ^{222}Rn at home and work Publication 65," *Ann of ICRP*. vol. 2, pp. 23- 29, 1993.

[24] B. Salameh, O. A. Haija, A.W. Ajlouni and M. Abd elsalam, "Radiation doses due to indoor radon concentration in Tafila district, Jordan," *Research Journal of Environmental Toxicology,* vol. 5, pp. 71-75, 2011.

[25] Public Health Statement (PHS) Radon CAS #14859-67-7 Division of Toxicology and Environmental Medicine September. Department of Health and Human Services, Public Health Service Agency for Toxic Substances and Disease Registry. Available: www.atsdr.cdc.gov/2008.

[26] EPA, "Toxicological review of zinc and compounds," In *Support of Summary Information on the Integrated Risk Information System (IRIS)*, vol. 66. Washington, DC: EPA, 2005.

DOI: http://dx.doi.org/10.14500/icpas2018