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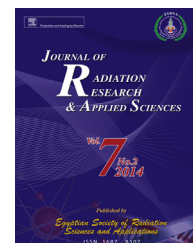


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Measurement of radon concentration in blood and urine samples collected from female cancer patients using RAD7

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ARTICLE INFO

Article history:

Received 21 December 2015

Received in revised form

20 January 2016

Accepted 3 February 2016

Available online xxx

Keywords:

Radon

RAD7

Blood

Urine

Cancer risk

ABSTRACT

The environmental monitoring of radon in the female blood and urine with the cancer problems has been carried out by using RAD7. This study has been undertaken for the purpose of health risk assessments. The significant of the results is this study indicate to the health risk assessments by showing association between radon concentration of blood and urine and cancers. The concentration of radon in blood samples varies from 417 to 714 Bq m⁻³ with an average of 570.25 Bq m⁻³ before irradiation and varies from 463 to 881 Bq m⁻³ with an average of 734.50 after irradiation. The concentration of radon in urine samples varies from 149 to 289 Bq m⁻³ with an average of 208.50 Bq m⁻³ before irradiation and varies from 239 to 1990 Bq m⁻³ with an average of 1062.62 Bq m⁻³ after irradiation. This study shows association between radon and cancers, also the results showed that the Rad7 particularly, has ability to measuring the concentration of blood and urine samples with higher levels of radon and correlation together.

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1. Introduction

Radon is a naturally occurring odourless, colourless, tasteless inert gas which is imperceptible to our sense. It is produced continuously from the decay of naturally occurring radionuclide such as U-238, U-235, and Th-232. The isotope Rn-222, produced from the decay of U-238, is the main source (approximately 55%) of internal radiation exposure to human life. Radon gas escapes easily from the ground into the air and disintegrates through short-lived decay products called radon

daughter or radon progeny. When radon gas itself is inhaled, most is exhaled before it decays, a small part of the inhaled radon and its progeny may be transferred from the lungs to the blood and transported throughout the body, where they can deliver a dose to other organs (Ali, 2013; Duggal, Rani, & Mehra, 2012). Kidney related diseases have also been observed in some people exposed to radon. The reason is that kidney receives the highest dose compared to other body organs after radon is transferred from the lung to the kidney by blood (Ahmad et al., 2014; Henshaw, Eatough, & Richardson, 1990). Radiation plays a significant role in life generally, and

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Peer review under responsibility of The Egyptian Society of Radiation Sciences and Applications.

<http://dx.doi.org/10.1016/j.jrras.2016.02.002>

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Please cite this article in press as: Salih, N. F., et al., Measurement of radon concentration in blood and urine samples collected from female cancer patients using RAD7, Journal of Radiation Research and Applied Sciences (2016), <http://dx.doi.org/10.1016/j.jrras.2016.02.002>

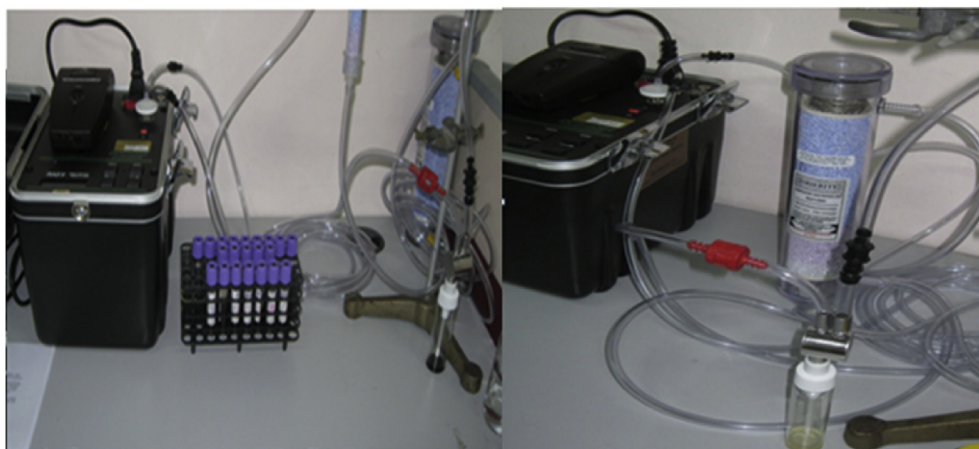


Fig. 1 – Measurement of radon concentration in blood and urine samples using RAD7.

Table 1 – Radon concentration (Bq m^{-3}) and relative humidity values in female blood samples before and after irradiation with Ra-226 sources using RAD7 at different temperature.

Test no.	Control							
	Before irradiation				After irradiation			
	Temp. °C	RH %	Activity Bq m^{-3}	Uncertainty	Temp. °C	RH %	Activity Bq m^{-3}	Uncertainty
1	26.4	6	648	451	28.3	4	835	497
2	27.7	5	417	386	25.8	5	602	439
3	27.1	4	603	440	26.8	4	834	497
4	27.1	4	417	386	26.4	5	463	400
5	25.2	5	714	474	28.9	4	881	508
6	25.5	4	649	463	28.3	4	881	508
7	25.5	4	556	427	28.3	5	685	300
8	26.8	4	558	426	27.4	4	695	463
Av.	26.41	4.5	570.25	431.62	27.52	4.37	734.50	451.50

in the fields of life sciences and medicine. Radiation can result in several different types of biological effect depending mainly on the part of the body irradiated (ICRP, 2003). The first case of radiation induced leukemia was reported in 1911. In particular with respect to the relative biological effectiveness of alpha-particles and the doses to the cells relevant to leukemia induction, which are probably much lower than that required for radon to be causative (Wolff and Stern, 1991).

Thereafter, there has been keen interest in the study of risks associated with radiation. Disparity in effects of radiation on human health is based on individual genetic makeup and susceptibility, which is discernible only in cases that correlates with exposure to radioactivity. This has been

demonstrated by studies on the survivors of atomic bomb explosions in Japan (Abu-Saleh et al., 2005). Radioactive radon gas is generally regarded as a health hazard, naturally because of its ability to produce several different types of biological effects (ICRP, 1969). High concentration of radon and its decay product is widely known to be dangerous to human health. It is possibly associated with different types of cancer and especially with lung cancer. It has very serious effects on human health due to large scale abundance of its parents and its longer half life. Radon has been considered as second leading cause of lung cancer after smoking (ICRP, 2004). A 2.4 mSv average annual dose has been estimated from natural radiation sources to the world population (Ahmad et al., 2014). One important advantage of solid state devices is the ability to electronically determine the energy of alpha particle (Duggal et al., 2012).

Table 2 – Variation of radon concentration (Bq m^{-3}) with age in female blood samples.

No. of samples	Age/Year	Δ Activity Bq m^{-3}
1	35	187
2	33	185
3	45	231
4	21	46
5	28	167
6	47	232
7	30	129
8	31	137

2. Methodology

Blood and urine samples were collected from 8 female cancer patients having age between 18 and 40 years. It should be noted that all female have problems with cancer (different types of cancer and they not exposed to radiotherapy). The samples were collected at clinic (Health Center) of Universiti Sains Malaysia (USM), Palau Penang, Malaysia. Each sample

Table 3 – Radon concentration (Bq m⁻³) and relative humidity values in female urine samples before and after irradiation with Ra-226 sources using RAD7 at different temperature.

Teat no.	Control							
	Before irradiation				After irradiation			
	Temp. °C	RH%	Activity Bq m ⁻³	Uncertainty	Temp. °C	RH%	Activity Bq m ⁻³	Uncertainty
1	26.4	5	198	99	28.6	4	306	110
2	27.7	4	215	105	25.5	4	1760	671
3	27.4	4	173	97	28.3	4	347	126
4	26.1	4	256	110	25.5	5	1990	708
5	26.8	4	173	93	26.8	4	289	116
6	27.7	4	289	116	25.8	4	1850	686
7	26.4	4	215	102	26.4	4	1720	665
8	27.1	4	149	88	28.6	4	239	107
Av.	26.95	4.1	208.50	101.25	26.93	4.1	1062.62	398.62

Table 4 – Variation of radon concentration (Bq m⁻³) with age in female urine samples.

No.	Age/Year	Δ Activity Bq m ⁻³
1	35	108
2	33	1545
3	45	174
4	21	1734
5	28	116
6	47	1561
7	30	1505
8	31	90

Table 5 – Participants' age and their laboratory characteristics.

Variable	Mean (±SD)	Median
Age	29.38 ± 6.958	29.50
Temp blood control	26.413 ± 0.917	26.60
Temp blood after irradiation	27.525 ± 1.100	27.85
RH blood control	4.50 ± 0.756	4.00
RH blood after irradiation	4.375 ± 0.518	4.00
Activity blood control	570.25 ± 107.775	580.50
Activity blood after irradiation	734.50 ± 150.335	764.50
Uncertain blood control	431.625 ± 32.606	433.50
Uncertain blood after irradiation	451.50 ± 72.129	480.00
Temp urine control	26.95 ± 0.621	26.95
Temp urine after irradiation	26.938 ± 1.369	26.60
RH urine control	4.125 ± 0.354	4.00
RH urine after irradiation	4.125 ± 0.354	4.00
Activity urine control	208.50 ± 46.279	206.50
Activity urine after irradiation	1062.625 ± 824.614	1033.50
Uncertain urine control	101.25 ± 9.067	100.50
Uncertain urine after irradiation	398.625 ± 303.784	395.50
Change in activity of blood	164.25 ± 60.909	176.00
Change in activity of urine	854.125 ± 785.838	839.50
Number of participants = 8		

was kept separately in special tubes. The tubes were labeled with the respective numbers of the women. Later on, the blood (the blood was placed in tube contain the (EDTA) and urine samples were placed in an ice cool box (4 °C) and transferred to the laboratory for refrigeration until analysis begins. RAD7 was employed to analyze the level of radon concentration in both samples. RAD7 was inserted into the blood sample (1.5 ml volume) and urine sample (5 ml volume)

Table 6 – Correlation between participants' age and their laboratory results.

Variables	Age
Temp control blood	Spearman correlation –0.624
	p value 0.098
Temp after blood	Spearman correlation 0.638
	p value 0.089
RH cont blood	Spearman correlation 0.664
	p value 0.073
RH after blood	Spearman correlation –0.170
	p value 0.687
Activity cont blood	Spearman correlation 0.566
	p value 0.143
Activity after blood	Spearman correlation 0.572
	p value 0.138
Uncertain cont blood	Spearman correlation 0.614
	p value 0.105
Uncertain after blood	Spearman correlation 0.509
	p value 0.198
Temp control urine	Spearman correlation 0.056
	p value 0.932
Temp after urine	Spearman correlation –0.115
	p value 0.786
RH cont urine	Spearman correlation 0.332
	p value 0.522
RH after urine	Spearman correlation –0.249
	p value 0.552
Activity cont urine	Spearman correlation 0.267
	p value 0.526
Activity after urine	Spearman correlation –0.054
	p value 0.955
Uncertain cont urine	Spearman correlation 0.192
	p value 0.649
Uncertain after urine	Spearman correlation 0.052
	p value 0.978

to measure the concentration of radon in both samples. This process was carried out before irradiation (control) and after irradiation in the Medical laboratory Universiti Sains Malaysia (USM), by using radium source with activity 5 µCi to irradiate both samples (blood, and urine) for 5 min. This study is novelty to found out the association between radon concentration of blood and urine samples with cancers by using RAD7 and irradiation both samples, as showed in the Fig. 1. Radon concentration in those samples were measured using calibrated alpha spectrometer RAD-7 according to EPA protocol

Table 7 – Correlation between participants' age and changes in their blood and urine.

Age correlation	Change activity blood	Change activity urine
Pearson correlation	0.126	0.029
p value (2 tailed)	0.767	0.945

test (Ahmad, Jaafar, & Alsaffar, 2015). RAD7 (Radon detector) is a highly versatile device that can form the basis of a comprehensive radon measurement system (RAD7 is a device manufactured by the Durrige Company, Model 711. Serial 00512, Calib 21-MAY-99- from the original company), but normal calibrate carry in 2012) (Al-Nafey, Jaafar, & Bauk, 2014). RAD7 has an air pump and a solid state alpha detector which consists of semiconductor material. Silicon is usually used as semiconductor material which directly converts alpha radiation to an electrical signal. Bq m⁻³ was used as a standard unit in this study (Ahmad et al., 2014).

3. Result and discussion

After determining the concentration of radon in both samples, irradiation was subsequently carried out at room temperature using ²²⁶Ra as irradiation source. The irradiation procedure was conducted in the Biophysics laboratory for 2 sample types at different exposure times of the ²²⁶Ra to surface samples; initial 10 min exposure to blood, after then to urine. Radon concentration (Bq m⁻³) was detected in the blood and urine samples of women in the location under study using RAD7 at

different temperature and relative humidity values, as shown in Table 1.

And the result showed the change of activity Bq m⁻³ of blood samples for the women under study explained that the radiation affects on the blood (Table 2).

Also same procedure with the urine as shown in the Tables 3 and 4.

3.1. Statistically analysis for radon after irradiation by using RAD7

1- Participants' demographic and their laboratory data with the age

There were eight participants in current study with mean age 29.38 ± 6.958 years. The participants' laboratory characteristics were found in Table 5.

2- Correlation between participants' age and their laboratory data

Non-parametric tests were used to analyze the current results. Spearman correlation coefficient showed no significant correlations between participants' age and their laboratory data for both control and radiation positions because all data results of p value were more than 0.05 were found in Table 6.

3- Correlation between participants' age and change of activity

Table 8 – Difference in participants' laboratory results between control and after irradiation.

Variables		N	Mean rank	Z value	p value
Temp blood after radiation – Temp blood control	Negative Ranks	3	2.83	1.334	0.182
	Positive Ranks	5	5.50		
	Ties	0			
RH blood after radiation – RH blood control	Negative Ranks	2	3.00	0.378	0.705
	Positive Ranks	2	2.00		
	Ties	4			
Activity blood after radiation – Activity blood control	Negative Ranks	0	0.00	2.521	0.012
	Positive Ranks	8	4.50		
	Ties	0			
Uncertain blood after radiation – uncertain blood control	Negative Ranks	1	8.00	1.400	0.161
	Positive Ranks	7	4.00		
	Ties	0			
Temp urine after radiation – Temp urine control	Negative Ranks	3	3.50	0.000	1.00
	Positive Ranks	3	3.50		
	Ties	2			
RH urine after radiation – RH urine control	Negative Ranks	1	1.50	0.000	1.00
	Positive Ranks	1	1.50		
	Ties	6			
Activity urine after radiation – Activity urine control	Negative Ranks	0	0.00	2.521	0.012
	Positive Ranks	8	4.50		
	Ties	0			
Uncertain urine after radiation – uncertain urine control	Negative Ranks	0	0.00	2.521	0.012
	Positive Ranks	8	4.50		
	Ties	0			

Wilcoxon Signed Rank test.

The parametric test, Pearson correlation, used to find the correlation between parametric results. No significant correlation found between participants' age and changes in the blood and urine because the result of p value was more than 0.05, as shown in Table 7.

3.2. Differences in laboratory results between radiation and control states

Non-parametric Wilcoxon Signed Rank test was used to find the differences between laboratory test in control and after irradiation. Significant difference found in activity of blood and urine, i.e. the activities of blood and urine after irradiation was significantly higher than found in control because the result of p value was less than 0.05, as shown in Table 8.

The environmental monitoring of radon in the blood and urine for women has been carried out. This study has been undertaken for the purpose of health risk assessments. The concentration of radon in blood samples varies from 417 to 714 Bq m⁻³ with an average of 570.25 Bq m⁻³ before irradiation and varies from 463 to 881 Bq m⁻³ with an average of 734.50 after irradiation. The concentration of radon in urine samples varies from 149 to 289 Bq m⁻³ with an average of 208.50 Bq m⁻³ before irradiation and varies from 239 to 1990 Bq m⁻³ with an average of 1062.62 Bq m⁻³ after irradiation. The results of the study showed that the radon levels were higher than the acceptable ICRP limits and IAEA (200 Bq m⁻³) (Salih, 2014), therefore, the level of radon in blood is higher than the safe mean value of 0.5 µg/L for ICRP (ICRP, 1975) and the average concentration of alpha emitters is also higher than the safe the allowable limits of ICRP agency 0.115 (ppm) (Karim, Hasan, & Abd-alkadr, 2010).

4. Conclusion

Results obtained show that radon concentration in women blood and urine samples of exposed group is higher than those of control group. Also radon concentration in urine samples is larger than that in blood samples. The significant of the results is this study indicates to the health risk assessments by showing association between radon concentration of blood and urine and cancers.

REFERENCES

- Abu-Saleh, R. M. (2005). *Measurement of radiation in soil in the middle of Gaza* (MSc. thesis). Islamic University of Gaza.
- Ahmad, N., Jaafar, M. S., & Alsaffar, M. S. (2015). Study of radon concentration and toxic elements in drinking and irrigated water and its implications in Sungai Petani, Kedah, Malaysia. *Journal of Radiation Research and Applied Sciences*, 8, 294–299.
- Ahmad, N., Jaafar, M. S., Khan, S. A., Nasir, T., Ahmad, S., & Rahim, M. (2014). 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 Sciences*, 11(2), 240–247.
- Al-Nafey, M. S., Jaafar, M. S., & Bauk, S. (2014). Measuring radon concentration and toxic elements in the irrigation water of the agricultural areas in Cameron Highlands, Malaysia. *Sains Malaysiana*, 43(2), 227–231.
- Ali, A. Al-H. (2013). Determining the concentrations of radon and the rate of annual effective dose in some types of drinking water available in the Iraqi markets. *Iraqi Journal of Physics*, 11(20), 75–80.
- Duggal, V., Rani, A., & Mehra, R. (2012). Indoor radon level measurements in the dwellings of Northern Rajasthan, India. Pelagia Research Library. *Advances in Applied Science Research*, 3(6), 3956–3960. ISSN: 0976-8610.
- Henshaw, D. L., Eatough, J. P., & Richardson, R. B. (1990). Radon as a causative factor in induction of myeloid leukaemia and other cancers. *Lancet*, 335, 1008–1012. [http://dx.doi.org/10.1016/0140-6736\(90\)91071](http://dx.doi.org/10.1016/0140-6736(90)91071).
- ICRP. (1969). *Radiosensitivity distribution and spatial of dose*. International commission on radiological protection. 70-78961, London: Oxford Glasgow. Pergamon Press Ltd.
- ICRP. (1975). *Report of the task group on reference man* (vol. 23). ICRP Publication.
- ICRP. (2004). *Biological effects after prenatal irradiation (Embryo and Fetus)*. Pergamon: ICRP. Publication 90 for the International Commission on Radiological Protection.
- Karim, M. S., Hasan, M. H., & Abd-alkadr, M. A. (2010). Determination of alpha particles concentrations in blood Samples taken from area situated in Anbar governorate by using nuclear track detector (CR-39), Al-Mustansiriyah University. *Journal of Education*, 6, 101–109.
- Salih, F. N. (2014). *Impact of radioactivity in tissue, blood, urine and hormones on women infertility* (PhD. Thesis). Malaysia: Radiation Protection/Medical Physics. University Science Malaysia (USM).
- Wolff, S. P., & Stern, G. S. (1991). Geographical associations between radon and cancer: is domestic radon level a marker of socioeconomic status? *Journal of Radiological Protection*, 11(4), 225–230.