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STUDY OF RADON LEVELS IN DWELLINGS OF NASIRIYA, THIQAR (IRAQ) AND DETERMINATION OF THE ANNUAL EFFECTIVE DOSE USING SOLID STATENUCLEAR TRACK DETECTORS (SSNTD) TECHNIQUE

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ABSTRACT

Radon is a cancer-causing, radioactive gas. It comes from the natural (radioactive) breakdown of uranium in soil, rock, and water and is released into the air we breathe. Radon is found in buildings, homes, offices, and schools - and can reach drastically high levels, causing a major health concern. Study of indoor radon has been carried out in some dwellings of Nasiriya district in Thiqar Governorate south of Iraq using LR-115 type II (SSYTDs). In the present study the value of concentration of radon ranges from 191.8 ± 8.7 to 38.3 ± 3.3 $Bq.m^{-3}$ Annual effective dose received by the human lunges varies from 0.66 ± 0.06 to 3.32 ± 0.15 $mSv.y^{-1}$.

KEYWORDS: Annual Effective Dose, Indoor Radon, LR-115 Type II (SSYTDs), Radon Concentration, PAEC

INTRODUCTION

Man is continuously exposed to ionizing radiation from Naturally Occurring Radioactive Materials (NORM) The origin of these materials is the Earth's crust, but they find their way into building materials, air, water, food and the human body itself. The worldwide average indoor effective dose due to gamma rays from building materials is estimated to be about 0.4 mSv per year (UNSCER 2000). In many parts of the world, building materials containing radioactive material have been used for generations.

As individuals spend more than 80% of their time indoors, the internal and external radiation exposure from building materials creates prolonged exposure situations (ICRP, 1999).

Radon is odorless, tasteless and chemically inert gases. At standard temperature and pressure, it is colorless but at low temperature (as cooled below freezing) it has brilliant phosphorescence which turns yellow as temperature lowered and Orange red at the temperature air liquefies (ICRP-65,1993).

Radon is a radioactive noble gas. It is the decay product of ^{226}Ra. ^{226}Ra is the sixth member of natural radioactive series of ^{238}U with half life 1620 years, it will decay in to radon by emission alpha particle. It found manly in soil and rocks and provide continuous source of ^{222}Rn (ICRP, 2009) As a result, radon is ubiquitous present everywhere but it's concentration vary from one location to another.

Current concern about acceptable level of indoor radon concentration and actual need of indoor radon gas monitoring has initially been derived from a clear evidence that occupational lung cancer strongly correlates with exposures to elevated radon concentrations (Grosche B et al, 2006).

As it was found in 70s and 80s that radon gas was an ubiquitous air pollutant in homes, additional studies were made to estimate lung cancer risk in case of exposure to low, comparing to those in mines, radon gas concentrations. The results of the studies were summarized in the National Council report (NRC, 1999). It was concluded by the report that around 4% death from lung cancer could be possibly avoided if indoor radon concentration was kept lower than 148 Bq/m^3 (action level guideline according to the Environmental Protection Agency, US). Further epidemiological studies and analyses, for example, presented in (D. Krewski et al, 2005), confirmed again a clear evidence that lung cancer can be caused by exposure to radon gas. Finally, World Health Organization summarized all knowledge about radon health effects, radon measurements, and mitigation and prevention techniques in a handbook on indoor radon, (WHO, 2009).

Although Radon was initially considered as a main contributor to the delivered dose to the lungs, then it was found that the dose is mainly delivered by α-particles released during decays of short-lived radon progeny ^{218}Po and ^{214}Po.

During recoil movement of alpha-particle that has enough energy to strip of the orbital electrons of the parent atom radon progeny become positively charged. At the end of the recoil movement a parent ionized atom slows down to the thermal velocity and so probability to capture electrons considerably increases. Therefore, about 88% of all polonium atoms are positively charged and remaining 12% are neutral. Due to the fact that polonium ions are positively charged they can attach to the dust particles and penetrate lungs with inhaled air.

When polonium decays, emitted α-particles can disrupt DNA of the lung cells making major genomic changes in a cell that can become one of the steps in a chain of events leading to the lung cancer. Moreover, existing studies show that there is no any particular level after which radon exposure becomes harmful to the health; there is clear evidence that any exposure to radon poses a risk for the health (UNSCEAR, 2000), in fact, the relation between cancer risk and radon exposure is linear. Taking into account that this relation is linear the health risks can be greatly decreased by radon prevention (in case of newly built dwellings) or mitigation (in case of existing old dwellings).In other words, radon monitoring should continuously be done in order to:

- Identify dwellings with higher than acceptable level of radon gas concentration.
- Determine effectiveness of radon prevention or mitigation methods (WHO, 2009).

METHODS

The method involved exposure of the film to the indoor environment for a known period of time, during which the alpha particles from radon and its daughters would leave tracks on the film. LR-115 type II solid state nuclear detectors (SSNTDs) were employed for measuring the radon concentration The detector films having a size of 1.5 cm x1.5 cm were fixed on glass slides and then these slides were mounted on the walls of different dwellings at a height of about 2m from the ground with there sensitive surface facing the air, in bare mode,taking due care that there was nothing to obstruct the detectors. After the exposure of detectors for 3 months these detectors were removed and etched in 2.5 NaOH for 2 h in a constant temperature bath ($60 \pm 1C^o$) and after a thorough washing they were scanned for track density measurements using optical microscope at a magnification of 400x. All α-particles that reach the LR- 115 type II SSNTDs with a residual energy between (1.6 - 4.7) MeV are registered as bright track holes. An unexposed film of the LR-115 was also etched and scanned for the determination of background track density of the film. This background track density was found very small and was subtracted from the observed value of the readings.

The Potential Alpha Energy Concentration (PAEC) was determined using the expression:

$$C_{p(WL)}=\frac{\rho}{k.t}$$

Where ρ is the track density (number of track per cm^2) obtained after subtracting the background, k is the sensitivity factor or calibration factor preferably found by a calibration experiment and t is the total time of exposure. Sensitivity factor was found by simulating the environmental condition in the Environmental Assessment Division of Bhabha Atomic Research Center (Shakir Khan et al, 2008).

A sensitivity factor of 625 tracks/cm^2 d per WL was used for evaluating the working level (WL) concentration of radon progeny. The radon concentrations in Bq/m^3 were calculated by using the relation :

$$C_{Rn(Bq.m^{-3})}=\frac{3700*WL}{F}$$

Where F is the equilibrium factor The value of F was taken to be 0.4 as recommended by (UNSCEAR, 2000).

The annual exposure to potential alpha energy E_p (effective dose equivalent) is then related to the average radon concentration C_{Rn} by following expression (Jyoti Sharma et al., 2012)

$$E_{p(WLM.y^{-1})}=\frac{T*n*F*C_{Rn}}{170*3700}$$

***T*:** Is the indoor occupancy time (24h*365=8760)

***n*:** Is the indoor occupancy factor (0.8)

The effective dose received by the bronchial and pulmonary regions of human lungs has been calculated using a conversion factor of 3.88 mSv/WLM and assuming an occupancy factor of 0.8 (ICRP-65, 1993).

RESULTS AND DISCUSSIONS

Table 1 gives a summary of the results of the track densities, indoor radon concentration levels, the annual effective dose rate and the annual dose equivalent rate measured in 20 different houses in Nasiriya district in Thiqar Governorate south of Iraq For the present study where the observation were taken from November 2012 to February 2013 The houses were selected at random situated at different areas. The average number of tracks per unit area was taken from the mean of the individual number of tracks per unit area.

The Table 1 present the measurement made for PAEC values of radon daughters in WL units, radon concentration in Bq.m^{-3}, and annual effective dose in mSv to the occupant of the dwelling of Nasiriya distract.

The PAEC obtained values vary from 20.73 to 4.14 mWL with an average value of 9.73 mWL. The significant value of radon activity varies from 191.8 to 38.3 Bq.m^{-3} with an average value of 9.04 Bq.m^{-3}. Annual effective dose varies from 0.66 to 3.31 mSv.y^{-1} with an average value of 1.55 mSv y^{-1}.

Results show higher indoor radon levels and radon effective dose especially in kitchen as compared to other locations. High values of radon activity may be due to use of water and cooking gas in kitchen. Gas whether natural or form oil, comes from ground and contain so many radioactive elements, also its may be attributed to poor ventilation. Radon concentration was found to be lowest in waiting room.

The main object of this measurement was to see indoor radon level and its daughters. The worldwide average background Radiation dose of 2.4 mSv/yr and hence a cause of concern (UNSCEAR, 2000).

Table 1: Values of Indoor Radoon Concentration in Dwellings

House		P (T.Cm-^{2}.D^{-1})	PAEC (Mwl)	Radon Activity (Bq.M^{-3})	Annual Exposure WLM	Annual Effective Dose (Msv.Y^{-1})
kitchen	1	4.101±0.2	6.7±0.30	62.1±3.1	0.28±0.01	1.07±0.05
	2	11.02±0.5	17.6±0.85	163.1±7.5	0.72±0.03	2.81±0.12
	3	6.810±0.4	10.1±0.60	93.1±6.0	0.41±0.03	1.61±0.10
	4	5.832±0.4	9.3±0.62	86.3±5.7	0.38±0.03	1.49±0.10
	5	3.241±0.2	5.2±0.40	47.9±3.2	0.21±0.02	0.83±0.06
	6	9.131±0.4	14.6±0.70	135.1±6.5	0.61±0.03	2.34±0.11
	7	12.96±0.6	20.7±0.92	191.8±8.7	0.85±0.04	3.32±0.15
	8	5.184±0.4	8.3±0.57	76.7±5.3	0.34±0.02	1.32±0.09
	9	5.765±0.3	9.2±0.56	85.3±5.2	0.38±0.02	1.48±0.85
	10	5.832±0.4	9.3±0.62	86.3±5.8	0.38±0.03	1.49±0.10
	11	12.58±0.6	20.1±0.92	186.2±8.5	0.83±0.04	3.22±0.15
	12	5.831±0.3	9.3±0.56	86.3±5.2	0.38±0.02	1.49±0.09
	13	9.722±0.5	15.5±0.76	143.9±7.2	0.64±0.03	2.48±0.13
	14	12.31±0.5	19.7±0.91	182.2±8.5	0.81±0.04	3.15±0.15
	15	4.602±0.4	7.4±0.55	68.1±5.3	0.31±0.02	1.18±0.09
	16	7.128±0.4	11.4±0.64	105.5±5.8	0.47±0.03	1.82±0.10
	17	6.812±0.4	10.9±0.63	100.8±5.7	0.45±0.03	1.74±0.10
	18	11.02±0.6	17.62±0.89	163.1±8.1	0.72±0.04	2.82±0.14
	19	3.241±0.3	5.2±0.46	47.9±4.2	0.21±0.02	0.83±0.07
	20	9.722±0.5	15.6±0.79	143.9±7.3	0.64±0.03	2.48±0.13
Waiting room	1	7.131±0.4	11.4±0.64	105.5±5.8	0.47±0.03	1.82±0.10
	2	3.242±0.3	5.2±0.45	47.9±4.2	0.21±0.02	0.83±0.06
	3	4.704±0.4	7.5±0.56	69.8±5.3	0.31±0.02	1.21±0.09
	4	4.531±0.4	7.2±0.53	67.13±5.1	0.30±0.02	1.16±0.09
	5	7.128±0.4	11.4±0.63	105.5±5.5	0.47±0.03	1.82±0.10
	6	4.711±0.4	7.5±0.56	69.8±5.3	0.31±0.02	1.21±0.09
	7	11.66±0.6	18.6±0.90	172.6±8.2	0.77±0.04	2.98±0.14
	8	3.888±0.3	6.2±0.4	57.5±4.2	0.25±0.02	0.99±0.07
	9	9.621±0.5	15.4±0.79	142.2±7.3	0.64±0.03	2.47±0.13
	10	5.832±0.4	9.3±0.57	86.3±5.5	0.38±0.02	1.49±0.09
	11	3.851±0.2	6.2±0.32	57.2±3.0	0.25±0.01	0.99±0.04
	12	5.242±0.4	8.4±0.62	77.6±5.8	0.35±0.03	1.34±0.10
	13	5.184±0.4	8.3±0.59	76.7±5.6	0.34±0.02	1.32±0.10
	14	2.592±0.2	4.1±0.36	38.3±3.3	0.17±0.01	0.66±0.06
	15	2.991±0.2	4.8±0.25	44.3±2.3	0.21±0.01	0.77±0.04
	16	10.37±0.5	16.6±0.79	153.4±7.3	0.68±0.03	2.65±0.13
	17	6.282±0.4	10.1±0.65	93.1±6.0	0.41±0.03	1.61±0.10
	18	3.888±0.2	6.2±0.40	57.5±3.7	0.25±0.02	0.99±0.06
	19	3.241±0.2	5.2±0.32	47.9±3.0	0.21±0.01	0.83±0.04
	20	5.184±0.4	8.3±0.6	76.7±5.9	0.34±0.03	1.32±0.10

Bedroom	1	5.184±0.4	8.29±0.59	76.7±6.0	0.34±0.03	1.32±0.10
	2	7.776±0.4	12.44±0.61	115.1±5.9	0.51±0.03	1.99±0.10
	3	5.243±0.3	8.41±0.53	77.6±4.9	0.35±0.02	1.34±0.09
	4	7.128±0.4	11.40±0.63	105.5±5.9	0.47±0.03	1.82±0.10
	5	3.881±0.2	6.22±0.40	57.5±3.7	0.25±0.02	0.99±0.06
	6	4.110±0.3	6.71±0.43	62.1±4.1	0.28±0.02	1.07±0.07
	7	7.776±0.4	12.44±0.62	115.1±6.1	0.51±0.03	1.99±0.10
	8	3.242±0.2	5.18±0.40	47.9±3.6	0.21±0.02	0.83±0.06
	9	4.601±0.2	7.42±0.34	68.1±3.1	0.30±0.01	1.18±0.05
	10	3.881±0.3	6.22±0.45	57.5±4.2	0.25±0.02	0.99±0.07
	11	2.873±0.2	4.61±0.25	42.6±2.6	0.19±0.10	0.74±0.04
	12	3.241±0.2	5.18±0.40	47.9±3.8	0.21±0.02	0.82±0.06
	13	3.242±0.2	5.18±0.40	47.9±3.4	0.21±0.02	0.83±0.05
	14	9.072±0.5	14.52±0.77	134.3±7.1	0.59±0.03	2.32±0.12
	15	2.781±0.2	4.52±0.35	41.2±3.3	0.18±0.01	0.71±0.06
	16	3.888±0.3	6.22±0.42	57.5±4.2	0.25±0.02	0.99±0.07
	17	9.722±0.4	15.55±0.70	143.9±6.5	0.64±0.03	2.48±0.11
	18	4.536±0.3	7.26±0.53	67.1±4.7	0.29±0.02	1.16±0.08
	19	2.592±0.2	4.15±0.36	38.3±3.3	0.17±0.01	0.66±0.06
	20	6.48±0.4	10.37±0.65	95.9±6.1	0.42±0.03	1.66±0.10

CONCLUSIONS

The calculated of radon levels in running factory having maximum and minimum values in room. In present work most of the radiation dose are not higher than the world wide average back ground dose of 2.4 mSv/yr (UNSCEAR, 2000), and hence they does not pose any serious threat to the occupants. Our results have been found close to that's of other authors (Isa Jasem AL-khalifa & Hussam Nejam Abood, 2014).

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