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INDOOR RADON LEVELS AND THE ASSOCIATED EFFECTIVE DOSE RATE DETERMINATION AT THE SHATT-ALARAB DISTRACT IN THE BASRAH GOVERNORATE, IRAQ

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ABSTRACT

Study of indoor radon has been carried out in some dwellings of shatt alarab distract in Basrah Governorate, using LR-115 type II solid state nuclear track detectors (SSNTDs). The monitoring of radon has become a global phenomenon due to its health hazard effects on population. Lung cancer risk depends upon the concentration of radon and their decay products in air above recommendation level. In the present study the value of concentration of radon ranges from 19.7 to 195.2 Bqm^{-3} with an average value of 75.1 Bqm^{-3}. The Potential of Alpha Energy Concentration (PAEC) in terms of m WL ranges from 2.1 to 21.1 with an average value of 8.1. The annual exposure in terms of WLM ranges from 0.09 to 0.87 with an average value of 0.3. The annual effective dose ranges from 0.34 - 3.37 mSv.y^{-1} with an average value of 1.3 mSv.y^{-1}.

KEYWORDS: Indoor Radon, Annual Effective Dose, LR-115 Type II Detector, Radon Concentration, PAEC

INTRODUCTION

Radon is a naturally occurring odourless, colourless, tasteless and chemically inert gas and radioactive in all of its isotopes, which is imperceptible to our sense. Radon-222, is produced continuously from ^{226}Ra in the decay series of ^{238}U, being the most important radon isotope in terms of radiation exposure, is measured in different environments to determine its contribution to human radiation exposure. Rn-222 contributes about 55% of the annual radiation dose to the general population (ICRP, 1993). The measurement of radon in man's environment is of interest because of its emitting nature of alpha particles. Radon decays with a half-life of 3.825 days into a series of short-lived daughter produced out of which ^{218}Po and ^{214}Po emit high-energy alpha particles which are highly effective in damaging tissues. Inhalation of these radionuclide's represents the main source of exposure to ionizing radiation for population in most countries (Jonsson, 1988). Nationwide measurements of radon activities in the indoor air of dwellings are continuously presented all over the world. As gases the isotopes are mobile and carry messages over significant distances within the earth and in the atmosphere, but, on the other side, inhalation can be a problem to health (Banjanac1 et al., 1988).

The fact that radon, when inhaled during breathing, can cause lung cancer in human beings is known since a long time ago. Studies on underground miners have shown an increased risk of lung cancer after exposure to high doses of radon and radon daughters (Wichmann et al., 2005).

At sufficiently high concentrations, radon and its a particle-emitting decay products (polonium-214, polonium-218) have been shown to cause lung cancer among underground miners, especially those who smoke cigarettes. There is concern that residential exposures might be responsible for a considerable number of lung cancer deaths in the general population (Jay et al., 1994).

Long-term exposure to elevated indoor radon concentrations has been determined to be the second leading cause of lung cancer in adults after tobacco smoking (WHO, 2009).

Radon exposure variability seems to be affected by several factors: soil temperature, soil permeability, moisture state, temperature differences between the interior and exterior of buildings, air pressure variations, materials used for building constructions and the degree of ventilation of closed environments, among the most important. The concentration of indoor radon also depends on the ventilation rate of the dwellings. It is important to note that a reduced ventilation rate helps enhance the concentration of radon and its progenies in the air (Rohit Mehra and Pankaj Bala, 2013).

The sources of indoor radon are soil adjacent to house, earth-based building materials, domestic water, outdoor air and natural gas. However, the soil and building materials are considered as mainly responsible for indoor concentration as other sources generally contribute only a fraction of total indoor activity (Sharma and Virk, 2001).

The radon gas can enter the body via respiring, drinking and eating. The alpha particles emitted by radon gas and other radiations emitted by its daughter products increase the absorbed dose in respiratory and digestion systems. Since people spend so much of their time indoors, indoor air is the predominant source for exposure to pollutants. More than half of the body’s intake of airborne material during a lifetime is the air inhaled in the home. Thus, most illness related to environmental exposures stem from indoor air exposure (Komal et al., 2012).

The knowledge of radon levels in dwellings is important in assessing population exposure. Indoor radon concentrations are almost always higher than outdoor concentrations. Once inside a building, the radon cannot easily escape. The sealing of buildings to conserve energy reduces the intake of outside air and worsens the situation. Radon levels are generally highest in cellars and basements because these areas are nearest to the source and are usually poorly ventilated. Radon can seep out of the ground and build up in confined spaces, particularly underground, e.g. in basements of buildings, caves, mines, etc., and ground floor buildings. High concentrations can also be found in buildings because they are usually at slightly lower pressure than the surrounding atmosphere and so tend to suck in radon (from the soil) through cracks or gaps in the floor.

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 track detectors (SSNTDs) were employed for measuring the radon concentration. The detector films having a size of 1.5 cm × 1.5 cm were fixed on glass slides and then these slides were mounted on the walls in different dwellings at a height of about 2m from the ground with their 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±1 C◦) and after a thorough washing they were scanned for track density measurements using optical microscope at a magnification of 400×. 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 to be very small and was subtracted from the observed value of the readings.

The potential alpha energy concentration (PAEC) was determined using the expression:

$$C_p(\mathrm{WL}) = \frac{\rho}{k.t}$$

Where ρ is the track density (number of tracks 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 conditions in the Environmental Assessment Division of Bhabha Atomic Research Centre (Shakir Khan et al., 2008).

A sensitivity factor of 625 $tracks/cm^2.d^{-1}$ 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:-

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

Where F is the equilibrium factor. The value of F was taken to be 0.40 as recommended by (UNSCEAR, 2000).

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

$$E_p[\mathrm{WLM.y^{-1}}] = \frac{T \times n \times F \times C_{Rn}}{170 \times 3700}$$

T: Is the indoor occupancy time (24h×365 = 8760 $h.y^{-1}$)

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 3.88mSv/WLM (ICRP-65, 1993).

RESULTS AND DISCUSSIONS

Table 1 presents the measurements made for PAEC values of radon daughters in WL units, radon concentration in Bqm^{-3}, Annual exposure in WLM and annual effective dose in mSv.y-1 to the occupant of the dwellings of Shatt-Alarab distract in Basrah Governorate. For the present study where the observation were taken from October to December, 2013. The houses were selected at random situated at different areas. The PAEC obtained values vary from (2.1 to 21.1) mWL with an average value of 8.1 mWL. The significant value of radon activity varies from 19.7 to 195.2 Bqm^{-3} with an average value of 75.1 Bqm^{-3}. Annual exposure varies from 0.09 to 0.87 WLM with an average value of 0.3 WLM. Annual effective dose varies from 0.34 to 3.37 $mSv.y^{-1}$ with an average value of 1.3 $mSv.y^{-1}$. Results show higher indoor radon levels and radon effective does 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 from oil, comes from ground and contain so many radioactive elements. Radon concentration was found to be lowest in bed room. High values of radon activity in other rooms in some dwellings may be due to ventilation conditions or the type of building materials.

The main object of this measurement was to see indoor radon level and its daughters. The International Commission on Radiation Protection (ICRP, 1993) has recommended that remedial action against radon and its progeny is justified above a continued effective dose of 3-10 $mSv.y^{-1}$ has been proposed. The action level for radon activity should be in the range 200-300 $Bq.m^{-3}$ (ICRP, 2009). The measured values are below the recommended ICRP action levels.

Table 1: Values of Indoor Radon Concentration in Dwellings

House		P ($T.cm^{-2}.d^{-1}$)	PAEC (mWL)	Radon Activity ($Bq.m^{-3}$)	Annual Exposure ($WLM.y^{-1}$)	Annual Effective Dose ($mSv.y^{-1}$)
1	kitchen	2.353 ± 0.2	3.8 ± 0.25	34.8 ± 2.3	0.16 ± 0.01	0.60 ±0.04
	Reception room	1.711 ± 0.1	2.7± 0.22	25.3± 2.0	0.11± 0.01	0.44±0.03
	Bedroom	2.139 ±0.2	3.4± 0.24	31.7± 2.2	0.14± 0.01	0.55±0.04
2	kitchen	3.851± 0.2	6.2± 0.32	57.0± 3.0	0.25± 0.01	0.99±0.04
	Reception room	2.995± 0.2	4.8± 0.29	44.3± 2.6	0.20± 0.01	0.77±0.05
	Bedroom	2.781± 0.2	4.5± 0.28	41.2± 2.6	0.18± 0.01	0.71±0.04
3	kitchen	2.540± 0.1	4.1± 0.20	37.6± 1.8	0.17± 0.01	0.65±0.03
	Reception room	1.814± 0.1	2.9± 0.17	26.9± 1.6	0.12± 0.01	0.46±0.03
	Bedroom	1.451± 0.1	2.3± 0.15	21.5± 1.4	0.10± 0.01	0.37±0.02
4	kitchen	2.493± 0.2	4.0± 0.25	36.9± 2.3	0.16± 0.01	0.64±0.04
	Reception room	4.602± 0.2	7.4± 0.34	68.1± 3.1	0.30± 0.01	1.18±0.05
	Bedroom	2.876± 0.2	4.6± 0.27	42.6± 2.5	0.19± 0.01	0.74±0.04
5	kitchen	4.193± 0.3	6.7± 0.43	62.1± 4.0	0.28± 0.02	1.07±0.07
	Reception room	3.494± 0.2	5.6± 0.40	51.7± 3.7	0.23± 0.02	0.89±0.06
	Bedroom	3.494± 0.2	5.6± 0.40	51.7± 3.7	0.23± 0.02	0.89±0.06
6	kitchen	6.289± 0.4	10.1± 0.65	93.1± 6.0	0.41± 0.03	1.61±0.10
	Reception room	6.813± 0.4	10.9± 0.68	100.8± 6.3	0.45± 0.03	1.74±0.11
	Bedroom	4.717± 0.4	7.5± 0.56	69.8± 5.2	0.31± 0.02	1.21±0.09
7	kitchen	12.58± 0.6	20.1± 0.92	186.2± 8.5	0.83± 0.04	3.22±0.15
	Reception room	5.765± 0.4	9.2± 0.62	85.3± 5.8	0.38± 0.03	1.48±0.10
	Bedroom	12.58± 0.6	20.1± 0.92	186.2± 8.5	0.83± 0.04	3.22±0.15
8	kitchen	4.193± 0.3	6.7± 0.53	62.1± 4.9	0.28± 0.02	1.07±0.08
	Reception room	4.717± 0.4	7.5± 0.56	69.8± 5.2	0.31± 0.02	1.21±0.09
	Bedroom	5.241± 0.4	8.4± 0.59	77.6± 5.5	0.35± 0.02	1.34±0.09
9	kitchen	9.13± 0.5	14.6± 0.77	135.1± 7.1	0.60± 0.03	2.34±0.12
	Reception room	9.637± 0.5	15.4± 0.79	142.6± 7.3	0.64± 0.03	2.47±0.13
	Bedroom	13.19± 0.6	21.1± 0.93	195.2± 8.6	0.87± 0.04	3.37±0.15
10	kitchen	4.492± 0.3	7.2± 0.51	66.5± 4.7	0.30± 0.02	1.15±0.08
	Reception room	6.289± 0.4	10.1± 0.60	93.1± 5.6	0.41± 0.02	1.61±0.10
	Bedroom	8.535± 0.4	13.7± 0.70	126.3± 6.5	0.56± 0.03	2.18±0.11
11	kitchen	5.169± 0.3	8.3± 0.53	76.5± 4.9	0.34± 0.02	1.32±0.09
	Reception room	7.754± 0.4	12.4± 0.65	114.8± 6.0	0.51± 0.03	1.98±0.10
	Bedroom	7.323± 0.4	11.7± 0.64	108.4± 5.9	0.48± 0.03	1.87±0.10
12	kitchen	4.793± 0.4	7.7± 0.57	70.9± 5.3	0.32± 0.02	1.23±0.09
	Reception room	4.764± 0.4	7.6± 0.56	70.5± 5.2	0.31± 0.02	1.22±0.09
	Bedroom	4.694± 0.3	7.5± 0.53	69.5± 4.9	0.31± 0.02	1.20±0.08
13	kitchen	6.594± 0.4	10.5± 0.65	97.6± 6.1	0.43± 0.03	1.69±0.10
	Reception room	5.072± 0.4	8.1± 0.57	75.1± 5.3	0.33± 0.02	1.30±0.09
	Bedroom	6.086± 0.4	9.7± 0.63	90.1± 5.8	0.40± 0.03	1.56±0.10
14	kitchen	4.043± 0.3	6.5± 0.48	59.8± 4.5	0.27± 0.02	1.03±0.08
	Reception room	2.246± 0.2	3.6± 0.36	33.2± 3.3	0.15± 0.01	0.57±0.06
	Bedroom	5.391± 0.3	8.6± 0.56	79.8± 5.2	0.36± 0.02	1.38±0.09
15	kitchen	5.765± 0.4	9.2± 0.62	85.3± 5.8	0.38± 0.03	1.48±0.10
	Reception room	6.289± 0.4	10.1± 0.65	93.1± 6.0	0.41± 0.03	1.61±0.10
	Bedroom	3.145± 0.3	5.0± 0.46	46.5± 4.2	0.21± 0.02	0.80±0.07

Table 1: Contd.,

16	kitchen	3.431± 0.3	5.5± 0.50	50.8± 4.6	0.23± 0.02	0.88±0.08
	Reception room	3.316± 0.3	5.3± 0.49	49.1± 4.6	0.22± 0.02	0.85±0.08
	Bedroom	3.202± 0.3	5.1± 0.48	47.4± 4.5	0.21± 0.02	0.82±0.08
17	kitchen	4.523± 0.3	7.2± 0.55	66.9± 5.1	0.30± 0.02	1.16±0.09
	Reception room	4.431± 0.3	7.1± 0.55	65.6± 5.0	0.29± 0.02	1.13±0.09
	Bedroom	4.021± 0.3	6.4± 0.52	59.5± 4.8	0.27± 0.02	1.03±0.08
	Reception room	4.632± 0.3	7.4± 0.56	68.6± 5.2	0.31± 0.02	1.19±0.09
	Bedroom	4.965± 0.4	7.9± 0.58	73.5± 5.3	0.33± 0.02	1.27±0.09
19	kitchen	6.202± 0.4	9.9± 0.65	91.8± 6.0	0.41± 0.03	1.59±0.10
	Reception room	5.431± 0.4	8.7± 0.60	80.4± 5.6	0.36± 0.02	1.39±0.10
	Bedroom	5.072± 0.4	8.1± 0.58	75.1± 5.4	0.33± 0.02	1.30±0.09
20	kitchen	6.121± 0.4	9.8± 0.64	90.6± 5.9	0.40± 0.03	1.57±0.10
	Reception room	4.693± 0.4	7.5± 0.56	69.5± 5.2	0.31± 0.02	1.20±0.09
	Bedroom	5.932± 0.4	9.5± 0.63	87.8± 5.8	0.39± 0.03	1.52±0.10

CONCLUSIONS

The values of radon concentration, inhalation dose and annual effective dose do not show major concern. Our results have been found lower when compared to the other authors (Ammar and Hana, 2010). From the present work it has been concluded that the radon levels in running dwelling having maximum and minimum in bedroom. The values are found to be lower than the action levels (3-10 mSv.y^{-1}) recommended by (ICRP, 1993).

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