SEASONAL VARIATION OF RADON - 222 CONCENTRATION IN SHOPS AND PHARMACIES OF ALZARQA TOWN- JORDAN

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Abstract

Seasonal variations in radon concentrations were measured in pharmacies and shops in Alzarqa town – Jordan, during: the summer, autumn, winter, and spring seasons of 1999 - 2000. In this survey, 202 measurements were collected using passive calibrated Solid State Nuclear Track Detectors (SSNTDs). The test results found that the seasonal radon concentration levels in pharmacies and shops, are minimum at summer (18.2 ± 6.7) Bq/m^3in pharmacies, and (16.6 ± 3.9) Bq/m^3 in shops, and maximum in winter season (50.0 ± 4.1) Bq/m^3in pharmacies, and (45.1 ± 4.2) Bq/m^3 in shops. These values of concentration are far below the radon action level (200- 600) Bq/m^3 as recommended by ICRP (ICRP, 1993), and lower than the world-wide, population weighted, average radon of 40 Bq/m^3 as reported by UNSCEAR (UNSCEAR, 2000).

Keywords

Radon; radon concentration; CR-39; seasonal variation; Pharmacies; Shops.

Introduction

Naturally occurring Radon and its decay products are significant sources of human radiological exposure (UNSCEAR, 2000). Radon is a noble gas, and is chemically inert in nature. It most common isotope, Radon 222 has a half-life of 3.8 days and comes from the alpha decay of Radium-226 (half-life 1600 years). Because measureable concentrations of Radium-226 (itself a daughter of Thorium-230) are commonly found in soil and rocks throughout the world, trace amounts of Radon (<10 Bq/m^3) in the atmosphere are found as well. However, within enclosed environments that are in contact with the soil or underlying rock, Radon can accumulate to levels orders of magnitude higher than the outdoor levels (Liendo *et* al., 1997). Epidemiological studies have shown that exposure to indoor radon and it progeny does increase the risk of contracting lung cancer in both homes and the work place (Lubin *et al.,*1994; Pershagen *et al.*, 1994; Lubin and Boice, 1997).

There are many sources of exposure of workers to radiation. Common man made sources include radioactive pharmaceuticals, and building materials (concrete and decorative stones). Whereas examples of work related exposures would include underground miners, nuclear energy cycles, scientific researches, and aircraft crewman. In conjunction with these exposures, workers could be exposed to elevated radon both at home and at work (Jacques, 1992). As for the radon component of this exposure, it had been clear that, long-term average measurements of radon concentrations are not an adequate indicator of inhalation risk in workplace (Solomon and Wang, 1994). Because radon exposure at the work place could be significant, steps should be taken to reduce it (Rimington, 1992). Recently the International Commission on Radiological Protection (ICRP) has considered the issue of workplace exposure to background radiation, in particular, exposure from elevated levels of radon and radon progeny (ICRP 60, 1990). The ICRP suggested an investigation level for radon exposures between 400 and 2000 Bq/m^3 and has proposed a conversion convection of 5 mSv/WLM for risk assessment from workplace exposure to radon progeny (ICRP 65, 1994).

This paper addresses the observed seasonal variation of indoor radon concentration in pharmacies and shops of Alzarqa town-Jordan collected from June 1999 to May 2000.

Measurement Technique

Radon was measured by using the passive closed-can technique (Elzain *et* al, 2008; Al-Bataina and Elzain, 2003; Hadad et al., 2007; Abumurad et al., 1994). About 202 detectors were distributed in pharmacies (114 detectors) and shops (88 dosimeters) in the town of Alzarqa. This detector consisted of a cup (7.00 cm in diameter and 4.6 cm in depth) containing a chip of CR-39 Track Etector. (1.5 cm $\times$1.5 cm $\times$500μm). A circular hole with a diameter of 1.5 cm was made in the lid, and was covered by a piece of membrane (sponge 2.00 cm $\times$2.00 cm $\times$0.5 cm), glued into the interior surface of the lid (Elzain *et* al, 2009; Al-Bataina, 1999). This configuration was necessary to prevent the entry of radon daughters and airborne particulate, but allowed for radon gas to readily diffuse into the cup. These detectors were exposed for 96 days during the summer of 1999 (June, July, September), 98 days during the autumn of 1999 (September, October, November, December), 100 days during the winter season of 1999 – 2000 (December, January, February, March), and 70 days during the spring of 2000 (March, April, May). The collected chips were chemically etched, using a 30% solution of Potassium Hydroxide (KOH), at a temperature of (70 $\pm$0.1)$^\circ$C for nine hours. An optical microscope was then used to count the number of track per cm^2 on each chip. To relate the density of the recorded tracks to radon concentration, the dosimeters were previously calibrated in the School of Physics and Space Research at Birmingham University, England (Al-Bataina, 1999). The indoor radon concentration in pharmacies and shops (C), in units of Bq/m^3, is then calculated using the following formula:

$$C = \frac{C_0 t_0 \rho}{\rho_0 t}$$

Where C_o is the radon concentration of the calibration chamber (90 kBq/m^3), t_o is the calibration exposure time (48 hours), ρ is the measured tracks number density per cm^2 on the CR-39 detectors inside the dosimeters used, $\rho_\circ$ is the measured track number density per cm^2 on the detectors of the calibrated dosimeters, t is the exposure time in days for pharmacies and shops.

Results and Discussion.

In general the buildings tested had similar designs, resided on the same geology and were tested on the ground floor. The radon test results, listed in Tables 1 and 2, and illustrated in Figures 1 and 2, shows the radon concentrations as a function of season and building use in Alzarqa town. As can be seen in Figures 1 and 2, radon levels in the shops and pharmacies clearly exhibited seasonal variation (radon levels were highest in the winter and lowest in the summer). A partial explanation of this finding is the local custom of keeping buildings well ventilated during the summer months either naturally (e.g. open doors) or by using fans during the summer months. Presumably, this custom increases the building's ventilation rates and may play a role in reducing the radon concentrations in the building. This correlation between indoor radon concentration and ventilation has also been reported by the US EPA (EPA, 1993) and by Abu-Jarad where air turbulence was found to reduce the working level concentration of radon daughters (Abu-Jarad and Sextro, 1988; Abu-Jarad and Frimlen, 1982). Conversely, during the winter months, the buildings windows and doors tend to be closed for longer period of time in particular at night when the ambient outdoor temperature drops. Presumably this would result in a lower average ventilation rate and thus would allow for a corresponding increase in the indoor radon concentration. This conclusion is consistent with other reports (Narayana et al.,1998; Ramachandran et al., 1990).

As for the autumn season, the radon concentrations were found to be relatively higher in shops than those in pharmacies. This may possibly be attributed to the higher humidity inside shops vs. the pharmacies during this season. During this season, the shops doors were usually closed for long periods of time due to the seasonal heavy rainfall. This increase in rain fall increases the outdoor humidity which induces the workers to keep the doors closed. This observation is consistent with other reports as well (Islam *et al*., 1989; Merrill and Khanzadeh, 1998).

As for the spring season, the radon levels were consistently lower than autumn and winter for both the pharmacies and the shops but higher than in the summer. As before it is suspected that the prevailing climate may play an important role. The spring in Alzarqa town is typically low humidity as a result of significantly lower rain fall with a significant number of sunny days. However, the nights are cooler than those in the summer and may result in the closing of windows and doors. Therefore, because of the more palatable daytime weather, the workers would presumably leave the windows and doors open more than the autumn or winter but keep them closed more at night than in the summer. This in turn would help reduce the radon indoor radon levels when compared to the autumn and winter but slightly higher than the summer. This phenomena has also been observed and reported by Oufni (Oufni *et* al**.** 2005).

Conclusions

In summary, a comparison of our results with the suggested reference values by the International Commission on Radiological Protection: 500 Bqm^3 for workplaces (ICRP, 1993), shows that the annual averages of radon concentrations are relatively low for both pharmacies and shops in Alzarqa town. These reported concentrations (Tables 1 and 2) are far below the radon action level (200- 600) Bq/m^3 as recommended by ICRP (ICRP, 1993), lower than the world-wide, population weighted, average radon of 40 Bq/m^3 as reported by UNSCEAR (UNSCEAR, 2000), and lower than the arithmetic mean obtained in autumn-winter period of 117 Bq/m^3 in Italy (Friuli-Venezia Guilia) (Malisan *et al.,* 1991). In addition, our findings support others that have reported seasonal radon concentrations linked to meteorological factors (Moses *et* al. 1963; Ikebe, 1970) as well. This study also shows that the radon levels are not a serious radiation risk to the workers in either the pharmacies or shops in Alzarqa town.

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Table 1. Statistical summary of radon concentration with seasons inside pharmacies of Alzarqa Town.

No	Season	N	Min. C Bq/m^3	Max. C Bq/m^3	Mean C Bq/m^3	S.D Bq/m^3
1	Summer	23	6.9	58.8	18.23	4.06
2	Autumn	28	16.5	68.3	32.54	8.00
3	Winter	33	37.2	86.3	49.96	4.08
4	Spring	30	14.7	55.2	27.13	4.15
All types		114	6.9	68.2	31.97	5.07

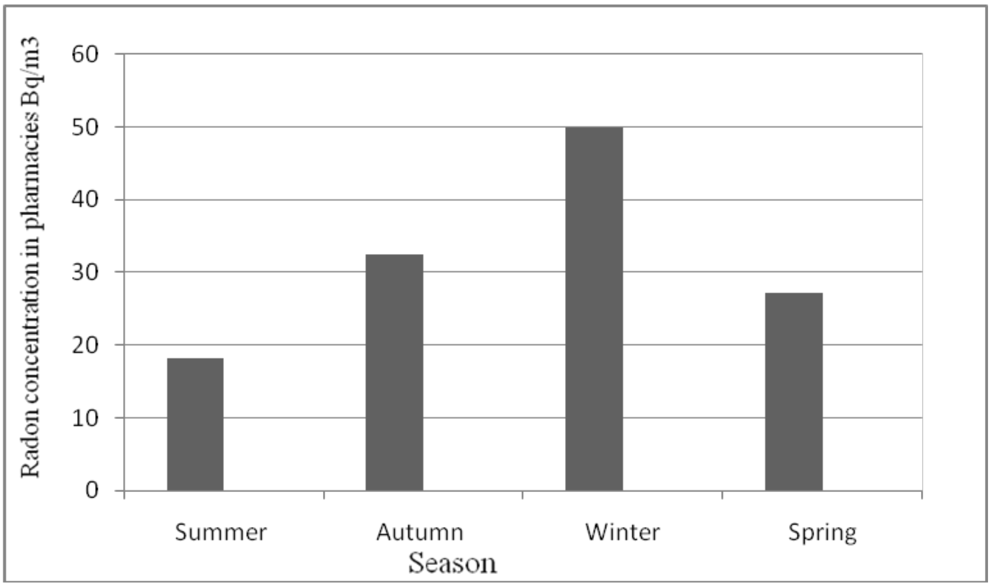

Figure 1. Measurements of radon concentrations with seasons inside pharmacies of Alzarqa Town.

Table 2. Statistical summary of radon concentration with seasons inside shops of Alzarqa Town.

No	Season	N	Min. C Bq/m^3	Max. C Bq/m^3	Mean C Bq/m^3	S.D Bq/m^3
1	Summer	24	10.2	38.7	16.63	3.94
2	Autumn	20	16.7	113.1	42.57	9.67
3	Winter	23	34.8	63.7	45.04	4.21
4	Spring	21	17.0	27.1	22.04	3.92
All types		88	10.2	113.1	31.66	5.44

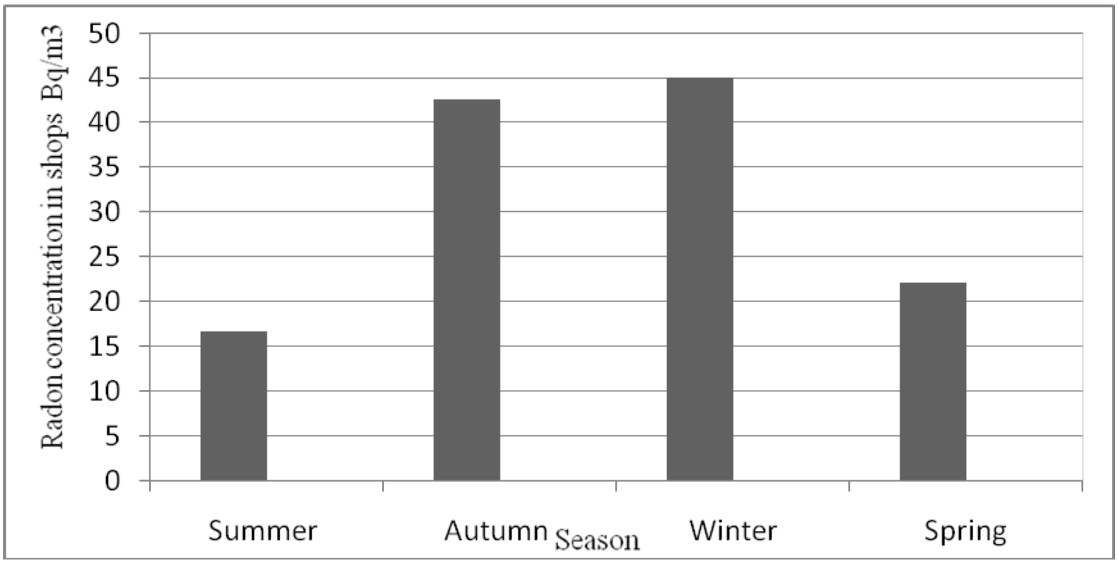

Figure 2. Measurements of radon concentrations with seasons inside shops of Alzarqa Town.