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Radiation Doses due to Indoor Radon Concentration in Tafila District, Jordan

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ABSTRACT

In this study, measurements of the indoor radon concentration level using solid state nuclear track detectors inside dwellings were performed in the fall 2008. Fifty two detectors (type CR-39) were distributed in four sites in Tafila district, Jordan. The study sites were located in an area that has the most important phosphate mines and hot spa springs. After three months of the detector exposure, the detectors were etched in a 30% KOH solution at 70°C for 9 h. The Alpha track density was determined by means of an optical microscope. Radon concentrations were found to vary from region to region, ranging from 23.85 to 29 Bq m^{-3} with a mean value of 27.30 Bq m^{-3}. Tafila city region was found to have the highest and the lowest radon concentration with a mean value of 28.77 Bq m^{-3}. According to the findings of this study, the residents of the four sites may receive on the average an annual radon effective dose 0.665 mSv y^{-1}, which is below the annual effective dose recommended by the International Commission on Radiological Protection (ICRP).

Key words: Radon gas, annual effective dose, radon concentration, CR-39 detector, exposure time

INTRODUCTION

During the last decades, it has been well established that exposure to radon (^{222}Rn) causes lung cancer (Samet, 1989), and it has been recognized as one of the most important environmental pollutants to which humans are exposed. Radon is a naturally occurring radioactive gas from the decay of radium-226, uranium-238 and radium-226 (Kaplan, 1963). The radioisotope ^{222}Rn, produced from the decay of ^{238}U, is the main source of internal radiation exposure to human life (ICRP, 1993). The natural decay of uranium in building stones, bricks, soils and bed rocks produces the radioactive radon gas, therefore radon seeps into and accumulates inside buildings. Moreover, the cracks, fissures, joints and faults in bed rocks provide passages for migration of radon gas to the surface. The detection and radon concentration measurements are one of the most important procedures in environmental protection. Radon is identified as one of the public health concerns due to the facts that it is widespread and due to the health risks associated with it (Harley and Harley, 1990). The existence of radon has been known since the beginning of previous century and the health effects associated with it have been studied for several decades. Outdoors, where radon is diluted to low concentrations in the air, radon poses significantly less risk than indoors therefore studying the indoor radon concentration inside the dwellings has received numerous concerns and intensive research interest. Indoor radon concentration depends primarily on the building's construction, the materials used in the building, the amount of radon in the underlying soil, air temperature, direct or indirect ventilation (Chao *et al.*, 1997).

Worldwide, measurements of radon concentration in the indoor air of the dwellings are continuously presented (Celik *et al*., 2007). Measurements of the indoor radon concentration in different seasons and locations in Jordan were presented by different authors. In Al-Ruseifa, an average value of 273.7 Bq m^{-3} was obtained by Kullab *et al*. (2001), this high value was attributed to the fact that the land of the dwellings in the studied area was used to be phosphate mines. A survey of radon levels in different cities in Jordan was conducted by Abumurad *et al*. (1997) where the highest average value of 99.68 Bq m^{-3} was found in Karak and the lowest value of 29.36 Bq m^{-3} was found in Aqaba. Similar study in some cities of Jordan has been made by Khatibeh *et al*. (1997) where the obtained values were ranging from 33 Bq m^{-3} in Zarqa up to 105 Bq m^{-3} in Karak. Recently, Abumurad and Al-Omari (2008) and Yaqoub *et al*. (2009) have been measured the indoor radon concentration in dwellings of Irbid and As-Salt cities, respectively. The average radon concentrations obtained in these studies were 44 Bq m^{-3} in Irbid and 111 Bq m^{-3} in As-Salt, respectively. In addition, Ya'qoub *et al*. (2009) have found that As-Salt dweller is exposed annually to 0.49 Working Level Month (WLM) from radon gas and its short-lived daughters. Moreover, very recently Abu-Haija *et al*. (2010) have been only measured the radon concentrations in three different sites of Tafila province in Jordan (Ayma, Aina Al-Badah and Al'is) during winter season. They found the overall average of radon concentration level inside dwelling of the three locations to be 26.28 Bq m^{-3}.

It is important to mention that Tafila district, which is located in the southern part of Jordan (Fig. 1), has a special situation where the most important phosphate mines, the most extensive source of natural radioactivity in Jordan, and the hot spa springs are situated (Ajlouni *et al*., 2009, 2010). This fact encouraged researchers to have more interest in studying the radon levels in this district in different seasons and locations. In the present work, indoor radon concentrations inside the dwellings of some Tafila sites namely, Busayra, Arwim, Wadi-Zeid and Tafila city in fall

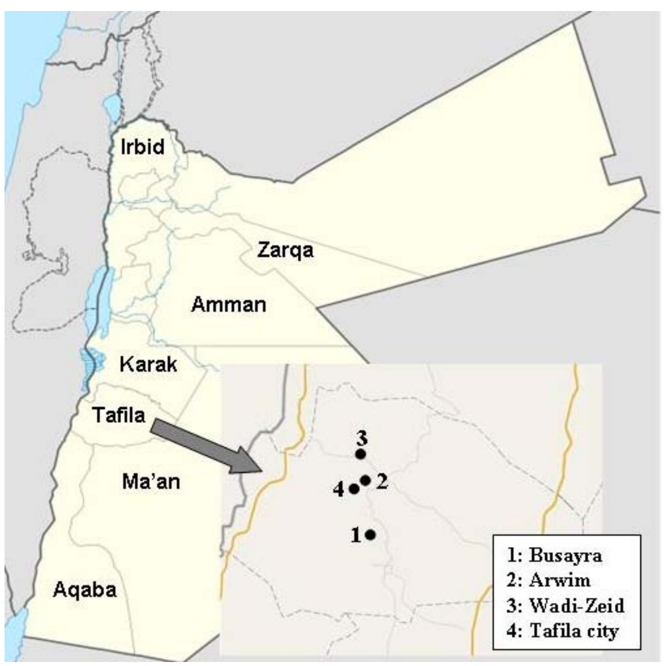

Fig. 1: Jordan map showing Tafila district with four investigated locations

2008 are reported and the collected data are discussed in the light of recommendation of the International Commission on Radiation Protection (ICRP). Furthermore, the annual effective dose received by the residents of the four sites will be presented. So, this study is considered as a continuation of previous study (Abu-Haija *et al.*, 2010) for the purpose of radon survey in Tafila province.

MATERIALS AND METHODS

In this study radiation doses due to indoor radon concentrations were measured in different areas of Tafila district in the southern part of Jordan in 2008 (Fig. 1). Passive diffusion radon dosimeters containing CR-39 solid state nuclear track detectors, which are very sensitive to á-particles, were used. The detector of dimensions 2×2 cm was inserted in the internal bottom of nearly cylindrical plastic cub and fixed using a small piece of adhesive tape. The top of the cub was covered and drilled as shown in Fig. 2. The houses under study were chosen so that the construction does not vary significantly. The dwellings were built using cement, sand, stones, bricks, iron structure, marble and concrete as the construction materials. Each house having from three to five rooms with size approximately (4×4×3) m^3 with one or two windows and a door in each room. Fifty two detectors were installed in different compartments (living room, bedroom, bathroom, and kitchen) of chosen houses in four locations such that 11 detectors were distributed in Busayra, 5 in Arwim, 8 in Wadi-Zeid and 28 in Tafila city (Fig. 1). Detectors were placed between one to two meters above ground level, except in few cases in which the height was less than a meter. The exposure time for the detectors was 90 days during the fall months of 2008 (September, October and November). After exposure, the dosimeters were retrieved and the collected plastic detectors were etched chemically using 30% KOH solution at 70°C for 9 h. The detectors were mounted vertically in a stainless steel spring and then immersed in the etching solution inside a water bath. At the end of the etching process, the detectors were washed thoroughly with distilled water and then left to dry. An optical microscope with a magnification of 150x was used to count the number of tracks per cm^2 (track density) in each detector. The tracks were counted randomly all over the detector surface at least 30 fields of view to obtain an average and representative value of track density for each dosimeter. The standard deviation of the track density was taken as the experimental error in this work. The radon concentration was calculated as explained previously (Abu-Haija *et al.*, 2010).

The indoor effective dose rate in units of mSv y^{-1} (H_E) is calculated using the formula (UNSCEAR, 2000):

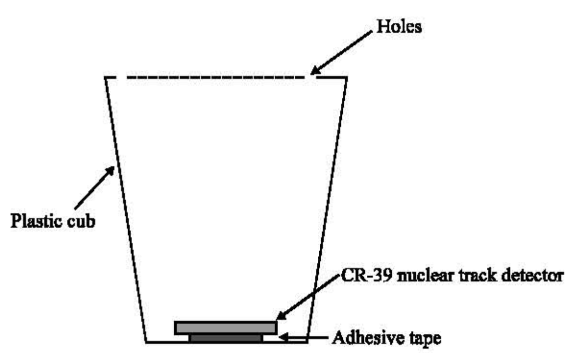

Fig. 2: The radon detector

Table 1: Number of collected dosimeters (No.) from each area, the minimum, maximum and the mean value (C) of radon concentrations in each area and H_E is the indoor effective dose

Region	No.	Min. Conc. (Bqm^{-3})	Max. Conc. (Bqm^{-3})	C (Bqm^{-3})	H_E ($mSv\ y^{-1}$)
Busayra	11	11.30	49.09	23.85±2.69	0.60
Arwim	5	16.40	45.39	29.00±4.24	0.73
Wadi-Zeid	8	16.20	39.55	27.56±3.89	0.70
Tafila city	28	9.95	68.15	28.77±3.99	0.72

$$H_E = C_{Rn} \cdot F \cdot T \cdot D \tag{1}$$

where, C_{Rn} is the measured radon concentration in Bqm^{-3}, F is the equilibrium factor (0.4), T is the dwellings occupancy time (0.8×24 h×365.25 day = 7010 hy^{-1}) and D is the dose conversion factor (9×10^{-6} mSv h^{-1}/Bq m^{-3}) (ICRP, 1993).

RESULTS AND DISCUSSION

The indoor radon concentrations and the annual effective dose received by people in several dwellings in four locations in Tafila district were measured. Table 1 summarizes the obtained results of the minimum, maximum, mean value of the indoor radon concentration along with the calculated indoor effective dose rate for investigated areas in Tafila region, the results of our study indicate that there is no clear appreciable difference in the indoor radon concentration between the different studied areas; this is due to the similarities in the buildings design, the materials used in the building construction, the ventilation rate of the dwellings and even the life style of people. It can be seen that the lowest average value of concentration was found in Busayra, 23.85 Bq m^{-3}, whereas the highest value was found in Arwim, 29.00 Bq m^{-3}. The overall average value was found to be 27.57 Bq m^{-3}, which is much lower than the recommended ICRP action level of (200-600) Bq m^{-3} (ICRP, 1993). Comparing the results obtained here with the results obtained by Abu-Haija *et al.* (2010), we see that the average radon concentration obtained in the present work is nearly equal despite seasonal variations and locations. In addition, our obtained results in the dwellings of the studied areas are lower than the average radon concentration in all other Jordanian regions (Abumurad *et al.*, 1994). This difference can be attributed to several factors like the high ventilation rate of the dwellings in Tafila district due to large houses with many openings, occupied by big families. Another factor which can explain our results is the relatively large distances between the houses in Tafila district due to the low population density; this can increase the ventilation rate of the houses.

The annual effective dose has been calculated from the measured radon concentration in the different areas using Eq. 1. Comparing our results with the annual effective dose recommended by the ICRP (1993), we found that (assuming 80% occupancy) the average exposure to radon in the studied area was in the range of about 0.69 mSv y^{-1}, which is below the range (3-10 mSv y^{-1}) reported by the ICRP (1993) for the same period of occupancy.

CONCLUSIONS

Most of the studied areas show, in general, low radon concentration levels. There are no significant variations in radon levels among the different areas. Arwim is characterized by the highest average of radon concentration level (29 Bq m^{-3}), while Busayra is characterized by the lowest one (23.85 Bq m^{-3}). The overall average radon concentration obtained in this work in Tafila region of 27.30 Bq m^{-3} is much less than (almost half) the obtained values in other Jordanian cities. In accordance with these results the average annual effective dose received by the dwellers of Tafila region is 0.665 mSv y^{-1} which is much less than the recommended value by the International Commission on Radiological Protection (ICRP). For future work, it is recommended to extend the survey during other periods of the year in order to have a better representative value for the annual average. It is also recommended to study the radon concentration levels in soil and water in the same region of the study.

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REFERENCES

Abu-Haija, O., B. Salameh, A.W. Ajlouni, M. Abdelsalam and H. Al-Ebaisat, 2010. Measurement of radon concentration inside houses in Tafila Province, Jordan. Int. J. Phys. Sci., 5: 696-699.

Abumurad, K., M. Kullab, B. Al-Bataina, A. Ismail and A. Lehlooh, 1994. Estimation of radon concentration inside houses in some jordanian regions. Mutah J. Res. Stud., 9: 9-21.

Abumurad, K., B. Al-Bataina, A. Ismail, M. Kullab and A. Al-Eloosy, 1997. A survey of radon levels in jordanian dwellings during an autumn season. Radiat. Protect. Dosim., 69: 221-226.

Abumurad, K.M. and R.A. Al-Omari, 2008. Indoor radon levels in irbid and health risk from internal doses. Radiat. Measure., 43: S389-S391.

Ajlouni, A.W., M. Abdelsalam, O. Abu-Haija and B. Joudeh, 2009. New findings: A very high natural radiation area in Afra hot springs, Jordan. Radiat. Proton. Dosim., 133: 115-118.

Ajlouni, A.W., O. Abu-Haija, M. Abdelsalam and Y.S. Almasaefah, 2010. Radiation doses due to natural radioactivity in afra hot Spring, Jordan. Int. J. Low Radiation, 7: 48-52.

Celik, N., A. Poffijn, U. Cevik and L. Schepens, 2007. Indoor radon survey in dwellings of the Kars Province, Turkey. Radiat Prot. Dosim., 128: 432-436.

Chao, C.Y.H., T.C.W. Tung and J. Burnett, 1997. Influence of ventilation on indoor radon level. Build. Environ., 3: 527-534.

Harley, N.H. and J.H. Harley, 1990. Potential lung cancer risk from indoor radon exposure. Cancer J. Clin., 40: 265-275.

ICRP, 1993. Protection Against Rn-222 at Home and at Work International Commission on Radiological Protection Publication 65. Ann. ICRP 23 (2). Peramon Press, Oxford.

Kaplan, I., 1963. Nuclear Physics. Addison-Wesly, Reading, MA. USA.

Khatibeh, A.J.A.H., N.A. Matiullah, M.A. Kenawy, K.M. Abu-Murad, M. Kullab and B.A. Al-Bataina, 1997. Measurements of indoor radon concentration levels in some cities of Jordan. Radiat. Measure., 28: 589-590.

Kullab, M.K., B.A. Al-Bataina, A.M. Ismail and K.M. Abumurad, 2001. Seasonal variation of Radon-222 concentrations in specific locations in Jordan. Radiat. Measure., 34: 361-364.

Samet, J.M., 1989. Radon and lung cancer. J. Nat. Cancer Inst., 81: 745-758.

UNSCEAR, 2000. Effects and Risks of Ionizing Radiations. United Nations Scientific Committee on the Effects of Ionizing Radiation, New York.

Yaqoub, M.M., I.F. Al-Hamarneh and M. Al-Kofahi, 2009. Indoor radon concentrations and effective dose estimation in dwelling of as-salt region in Jordan. Jordan J. Phys., 2: 189-196.