International Journal of Research in Management, Science & Technology (E-ISSN: 2321-3264)
Vol. 5, No. 1, 7-12, April 17
Available at www.ijrmst.org

Indoor radon measurements and estimation of inhalation doses in Amritsar and Gurdaspur districts of Punjab, India

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Abstract: Radon (^{222}Rn) is the most important source of natural radiation and is responsible for approximately half of the received dose of the totality of the sources. Most of this dose comes from the inhalation of the progeny of ^{222}Rn, and this happens particularly in closed atmospheres. Due to this, the measurement of indoor radon is important to assess the threat it may pose in human environment as it is considered potential health hazardous. Keeping this in view, indoor radon measurements were carried out in dwellings of different locations belonging to the Amritsar and Gurdaspur districts of Punjab using the LR-115 type II cellulose nitrate films. The annual average radon concentration was measured in the range from 16.8 Bqm^{-3} to 465.6 Bqm^{-3} in Amritsar district and from 9.6 Bqm^{-3} to 398.4 Bqm^{-3} in Gurdaspur district. The levels of radon activity were found to be within the action level recommended by International Commission on Radiological Protection (ICRP). The average annual effective dose was found to vary from 0.28mSv to 7.94mSv in Amritsar district and from 6.8mSv to 0.16mSv in Gurdaspur district.

Key words: Radon, radioactive, cancer, environmental.

I. INTRODUCTION:

Radon is a colourless, odourless and chemically inert radioactive gas existing in variable quantities throughout the world. It is rare in nature because its isotopes are all short-lived and radium, its source, is a scarce element. The atmosphere contains traces of radon near the ground as a result of seepage from soil and rocks, all of which contain minute quantities of radium. By the late 1980s, naturally occurring radon gas had come to be recognized as a potentially serious health hazard. Because of the effects of the wind and temperature, the air pressure in the houses is usually lower than the air pressure in the soil beneath it. The gas, arising from solid and rocks, seeps through the foundations, basements, or piping of buildings and can accumulate in the air of houses that are poorly ventilated. Exposure to high concentrations of this radon over the course of many years can greatly increase the risk of developing lung cancer. Indeed, radon is now thought to be the single most important cause of lung cancer among non-smokers in the United States. It was not until the 19th century that lung cancer was identified as the primary cause of death for 75% of all miners in the Schneeberg region (Rahman et al., 2006). Radon has now been classified as a human carcinogen by the International Agency for Research on Cancer (IARC, 1988).

Radon levels are highest in homes built over geological formations that contain uranium mineral deposits. The gas is a source of penetrating gamma radiation, which comes mainly from one of radon's decay products, bismuth-214. Radon emanates from the materials carrying uranium and thorium. Initially, it fills the space in the host material (soil, sand, rocks, gravel etc.). Being a gas it responds to temperature and pressure gradients. Being relatively long lived, it may succeed in escaping out of materials and get mixed with air. If it escapes to a confined space such as a basement of a building or a room with limited ventilation, the concentration may be fairly high (Nazaroff & Nero, 1988; Sextro et al., 1987).

Radon is present everywhere in our atmosphere in variable concentrations. The confined space are fairly rich in radon and hence its decay products. People breathing in such an atmosphere inhale air, which may be fairly rich in radon and its daughters. The inhaled stuff contains relatively long-lived gaseous atoms of radon and short-lived metallic atoms of radon daughters. The metallic radon daughter products, which are electrostatically charged at the time of their birth in a room atmosphere, are not usually in a free state and at once stick to dust and smoke particles and water vapours, present in the space (Bodensky et al., 1987).The main sources of radon are soil, ground water, building material, natural gas, dwelling engineering, occupant life style and meteorological parameters such as moisture, pressure and seasonal variations etc. Other data on sensitivity to cancer-inducing effects of radiation comes from studies of uranium miners, who have an increased risk of lung cancer (EPA, 1999).The measurement of radon and its daughters in houses is important to determine whether or not the particular living place needs to have action against possible higher levels of radon and its daughters. In USA the Environment Protection Agency has recommended 4pCi/l (148Bq/m^3) as action level (Jamil et al., 1997).

In the present study, indoor radon measurements were carried out in the dwellings of 20 locations belonging to Amritsar and Gurdaspur districts of Punjab. The latitude and longitude of Amritsar and Gurdaspur are 31.6340° N, 74.8723° E and 32.0419° N, 75.4053° E, respectively. The area surveyed in the present investigation is shown in Figure 1. The houses monitored were chosen so that dwellings constructed with different types of building materials and in different localities of the districts were covered. The annual exposure to occupants, the annual effective dose received by the population and the life time fatality risk estimates were assessed in the light of guidelines given by the International Commission on Radiological Protection .

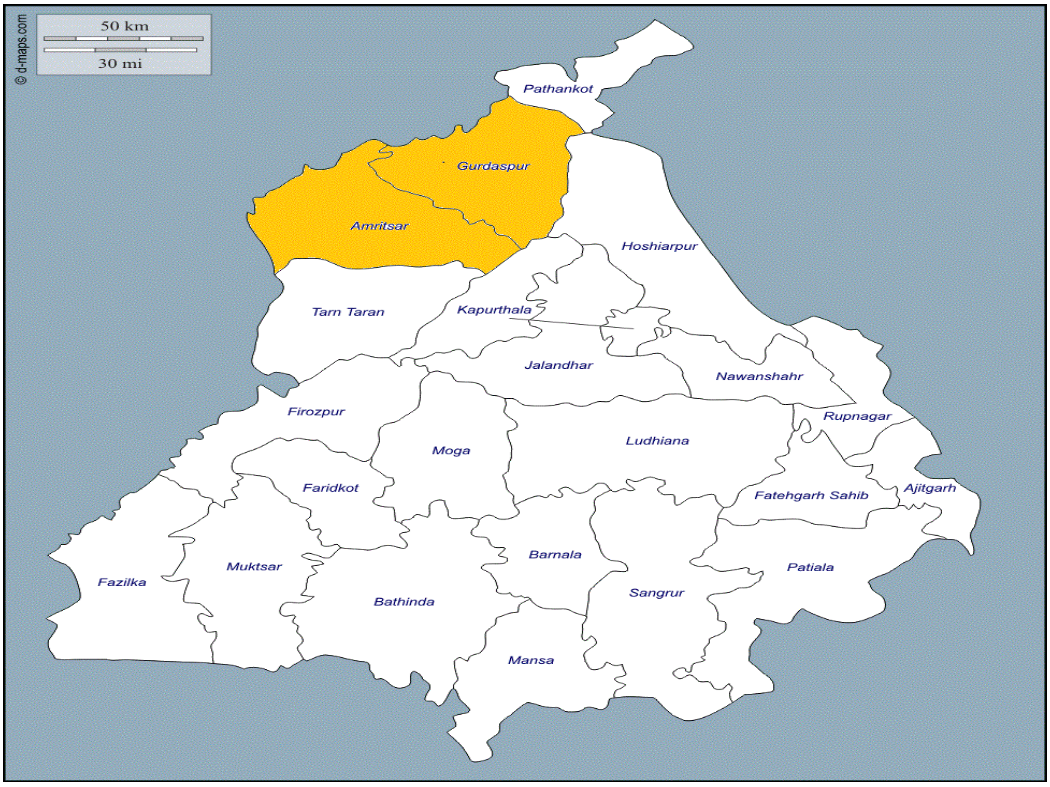

Fig1: Map Showing the Amritsar and Gurdaspur districts of Punjab

II. EXPERIMENTAL TECHNIQUE

The plastic track detector films (LR-115 type II) and the bare mode technique (Mishra et al., 1997; Ramola et al., 1998; Singh et al., 2004, 2005, 2006), was employed for indoor radon measurements in the dwellings belonging to Amritsar and Gurdaspur districts of Punjab for the estimation of annual average radon concentrations. These plastic track detectors of size 2cm x 2cm were fixed on glass slides and then these slides were mounted on the walls of different dwellings at a height of about 2 m from the ground with their sensitive surface facing the air, taking due care that there was nothing to obstruct the detectors. After a fixed duration of exposure, detector films were removed and etched in 2.5 N NaOH solution at 60^0 C for 90 minutes in a constant temperature bath. Then these films were washed, dried and counted using spark counter for track density measurements. Background track density of an unexposed detector has also been counted. The corrected track density is then obtained by subtracting the number of tracks on an unexposed detector from the exposed detector. The track density so obtained was converted to radon concentrations (Bqm^{-3}) using the calibration factor 0.020±0.002 tracks cm^{-2}day^{-1} per Bqm^3 (Eappen et al., 2001) being used for the bare mode. The calculations were made under using the conversion factors given elsewhere (ICRP, 1993; Raghavayya, 1994) according to which the exposure of an individual to the radon decay products of 1 WLM is equivalent to 3.54 mJhm^{-3}. The conversion factor of 3×10^{-4} WLM^{-1} and 3.88 mSv WLM^{-1} was used for calculating the lifetime fatality risk and the annual effective dose respectively.

III. RESULTS AND DISCUSSION

The results of our investigation of indoor radon activity in dwellings of different locations belonging to Amritsar and Gurdaspur districts of Punjab, where radon concentration was recorded were summarized in Table1. The annual exposure, the annual effective dose and average lifetime fatality risk for each of the locations were also calculated. It can be seen from Table 1 that the average indoor radon concentration in the locations surveyed in Amritsar varied from 16.8 Bqm^{-3} in the location Majitha Road to 465.6 Bqm^{-3} in the location Kot Khalsa. Also the average indoor radon concentration in the locations surveyed in Gurdaspur varied from 9.6 Bqm^{-3} in the location Batala Road to 398.4 Bqm^{-3} in the location Govt College Road. These values are in the range of intervention level (200-600 Bqm^{-3}) as recommended by the International Commission on Radiological Protection (ICRP, 1993). The overall average value in Amritsar was 201.8 Bqm^{-3} while in Gurdaspur was 108.4 Bqm^{-3}, which are much more than the world average of 40 Bqm^{-3} (UNSCEAR, 2000). The annual effective dose received by the residents of the study area was found to vary from 0.28mSv to 7.94mSv in Amritsar and from 6.8mSv to 0.16mSv in Gurdaspur district. In all the villages surveyed, the annual effective dose received by the residents lies in the range of action level (3-10 mSv $year^{-1}$) recommended by ICRP. The lifetime fatality risk of the residents of the study area was found to vary from 2.21×10^{-4} to 61.45×10^{-4} in Amritsar and from 52.58×10^{-4} to 1.26×10^{-4} in Gurdaspur.

The variation of radon concentration between different dwellings may be explained due to different ventilation rates, the nature and type of building material used during construction and the variation of radioactive levels in soil beneath the dwellings. It had been established that the radon in soil is highly variable changing as much as 30 times over a domain of 10m (Toth et al., 1997). As a consequence, the radon levels are highly variable in dwellings, varying by a factor of 10 in different rooms of the same house, the maximum concentration being recorded in underground cellars. The indoor radon values obtained in the present investigations were comparatively lower than those reported in some dwellings of Hamirpur (660-1060 Bq m^{-3}, Kumar et al., 1994), Kullu (156-635 Bq m^{-3}, Singh et al., 2001a) and Una (235-970 Bq m^{-3}, Singh et al., 2002) districts of Himachal Pradesh. The higher indoor radon values in these areas were explained due to the presence of uranium mineralization in the area (Kaul et al., 1993).

Fig 2 and 3 shows the frequency distribution of the annual average radon concentration among 10 dwellings each of Amritsar district and Gurdaspur district respectively.

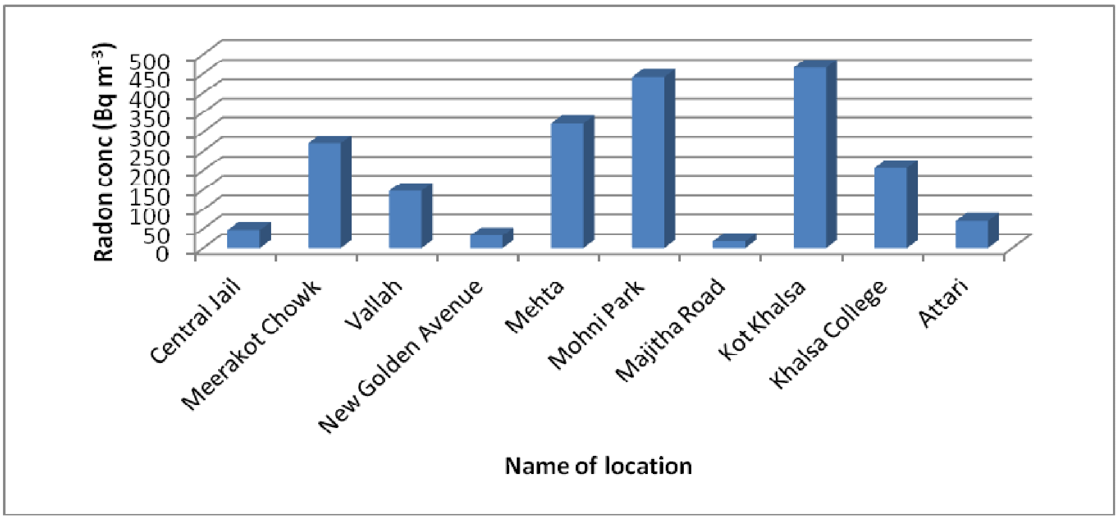

Fig 2: Frequency distribution of the annual average radon concentration among 10 dwellings of Amritsar district.

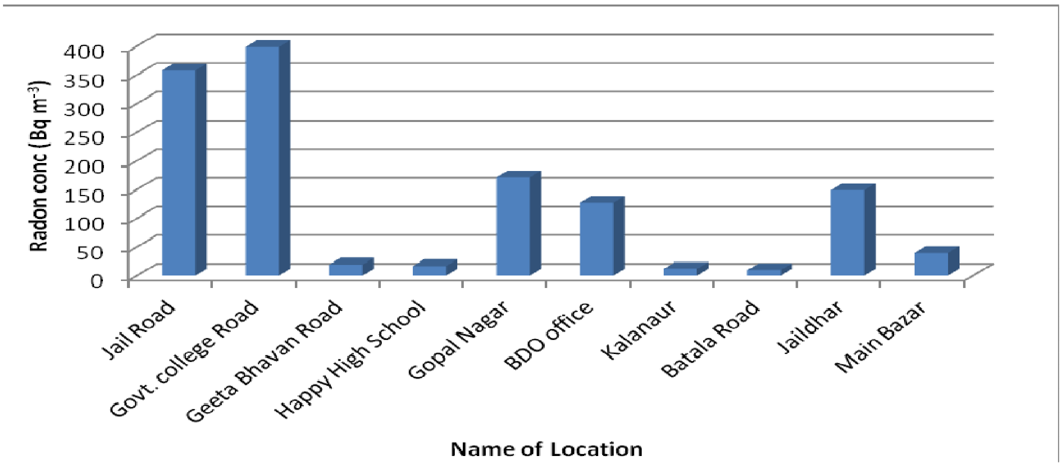

Fig 3: Frequency distribution of the annual average radon concentration among 10 dwellings of Gurdaspur district.

IV. CONCLUSIONS

1. The radon concentration values in all the locations were lower than the recommended action level.
2. The annual effective dose received by the residents in the study area lies within the range of recommended action level (3–10mSv per year) recommended by ICRP.

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Table 1. Values of indoor radon concentration in dwellings of different villages in district Amritsar and Gurdaspur of Punjab.

S.No.	Location	Construction Material	Ventilation conditions	Radon Conc. (Bq m^{-3})	Annual Exposure		Annual effective dose (mSv)	Life time fatality risk ($\times 10^{-4}$)
					WLM	mJ h m^{-3}		
Amritsar District								
1	Central Jail	Floor: Marble Roof: cemented Walls: cement Doors: Two Windows: Two	Well ventilated	46.8	0.20	0.72	0.79	6.17
2	Meerakot Chowk	Floor: Marble Roof: cemented Walls: cement Doors: One Windows: one	Partially ventilated	270	1.18	4.20	4.60	35.64
3	Vallah	Floor: Marble	Well ventilated	147.6	0.64	2.29	2.51	19.48
4	New Golden Avenue	Roof: cemented Walls: cement	Well ventilated	32.4	0.14	0.50	0.55	4.27
5	Mehta	Floor: Marble Roof: cemented Walls: cement Doors: One Windows: one	Partially ventilated	321.6	1.40	5.00	5.49	42.45
6	Mohni Park	Floor: Marble Roof: cemented Walls: cement Doors: One Windows: Nil	Poorly ventilated	441.6	1.90	6.87	7.53	58.29
7	Majitha Road	Floor: Marble Roof: cemented Walls: cement Doors: Two Windows: Two	Well ventilated	16.8	0.07	0.26	0.28	2.21
8	Kot Khalsa	Floor: Marble Roof: cemented Walls: cement Doors: One Windows: Nil	Poorly ventilated	465.6	2.04	7.25	7.94	61.45
9	Khalsa College	Floor: Marble Roof: cemented Walls: cement Doors: One Windows: one	Partially ventilated	206.4	0.90	3.21	3.52	27.24
10	Attari	Floor: Marble Roof: cemented Walls: cement Doors: Two Windows: Two	Well ventilated	69.6	0.30	1.08	1.18	9.18
Gurdaspur District								
1	Jail Road	Floor: Marble Roof: cemented Walls: cement Doors: One Windows: Nil	Poorly ventilated	357.6	1.57	5.56	6.10	47.20

2	Govt. college Road	Floor: Marble Roof: cemented Walls: cement Doors: One Windows: Nil	Poorly ventilated	398.4	1.75	6.20	6.80	52.58
3	GeetaBhavan Road	Floor: Marble Roof: cemented Walls: cement Doors: Two Windows: Two	Well ventilated	19.2	0.08	0.29	0.32	2.53
4	Happy High School	Floor: Marble Roof: cemented Walls: cement Doors: Two Windows: Two	Well ventilated	16.8	0.07	0.26	0.28	2.21
5	Gopal Nagar	Floor: Marble Roof: cemented Walls: cement Doors: One Windows: one	Partially ventilated	171.6	0.75	2.67	2.92	22.65
6	BDO office	Floor: Marble Roof: cemented Walls: cement Doors: One Windows: One	Partially ventilated	127.2	0.55	1.98	2.17	16.74
7	Kalanaur	Floor: Marble Roof: cemented Walls: cement Doors: Two Windows: Two	Well ventilated	12	0.05	0.18	0.20	1.58
8	Batala Road	Floor: Marble Roof: cemented Walls: cement Doors: Two Windows: Two	Well ventilated	9.6	0.04	0.14	0.16	1.26
9	Jaildhar	Floor: Marble Roof: cemented Walls: cement Doors: One Windows: Two	Partially ventilated	148.8	0.65	2.31	2.54	19.66
10	Main Bazar	Floor: Marble Roof: cemented Walls: cement Doors: Two Windows: Two	Well ventilated	39.6	0.17	0.61	0.67	5.22