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# A PRELIMINARY STUDY ON INDOOR RADON MEASUREMENTS IN SOME MUD MADE HOUSES IN THE OUTSKIRTS OF DERA ISMAIL KHAN CITY OF PAKISTAN

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Indoor radon concentration measurements were carried out in 40 dwellings in the outskirts of Dera Ismail Khan, Pakistan, using CR-39 track detectors. The measurements were performed for a period of three months i.e. from 16th September to 14th December. The detectors were fixed in National Radiological Protection Board (NRPB) dosimeters and installed in the rooms of mud made houses. The results of indoor radon levels were found to vary from 70±16 to 222±29 Bq $m^{-3}$ with an average value of 139±23 Bq $m^{-3}$. The average value was within the International Commission on Radiological Protection (ICRP) recommended limits. However, 43% and 75% houses were found to have indoor radon concentration above the recommended levels set by United States Environmental Protection Agency (US-EPA) and World Health Organization (WHO), respectively.

**Keywords:** Mud houses, Radon survey, Indoor radon concentration, CR-39, NRPB dosimeters

## 1. Introduction

When radium ($^{226}Ra$) decays by alpha emission, it transmutes to its decay product radon ($^{222}Rn$) with a half life of 3.8 days. Radon is a noble gas, occurring as non polar, monatomic molecule and is an inert for practical purposes. When the parent radium decays in rock or soil, the resulting radon atom recoils. Some fraction of the recoiling atoms come to rest in geologic fluids, most likely water in the capillary spaces. A fraction of the radon in soil water enters soil gas, primarily by diffusion, and then becomes more mobile. Radon reaches the atmosphere when soil gas at the surface exchanges with atmospheric gas [1]. The basic factors limiting radon migration out of the soil and its consequent accumulation in a building are geophysical properties and chemical composition of the soil beneath the building, building foundation i.e. its type and nature, techniques used in construction, heights above the ground, the room's dimensions, the rate of ventilation, the seasonal and meteorological factors and the working and living conditions. The water used in house hold purpose such as in washing machines, showers, wash basins etc. having absorbed radon also contributes in the high radon levels in the homes. The dissolved radon in water is released into the home atmosphere via these activities [2]. It has been estimated that 1000 Bq $l^{-1}$ of radon in water will, on average, increase the radon concentration in indoor air by 100 Bq $m^{-3}$ [3]. Both the EPA and the committee on Risk Assessment of Exposure to Radon in Drinking Water has used a transfer factor of 1 x $10^{-4}$ for estimating the contribution of radon dissolved in water to the overall indoor radon concentration [4]. This ratio (10,000:1), while not to be considered a hard rule, has been verified through theoretical models and empirical evidence [5, 6].

Because radon is a noble gas with a lifetime that is long relative to breathing times, most of it that is inhaled is exhaled again rather than decaying, or becoming lodged in the lungs and later decaying [7]. In contrast, promptly decaying daughters ($^{218}Po$, $^{214}Pb$, $^{214}Bi$ and $^{214}Po$) of radon ($^{222}Rn$) tend to attach themselves to the dust particles, which can be inhaled and deposited on epithelial surfaces within the lung and shortly decay. The decay products of radon deliver a dose to the soft tissues of the whole body. Henshaw et al. (1990) claimed that indoor radon exposure is associated with the risk of leukemia and certain other cancers, such as melanoma and cancers of the kidney and prostate [8].

International Commission on Radiological Protection (ICRP), United States Environmental Protection Agency (US-EPA) and World Health Organization (WHO) has recommended an "action level" of 600 Bq $m^{-3}$, 150 Bq $m^{-3}$and 100 Bq $m^{-3}$, respectively for indoor radon [9- 11].

In Pakistan considerable data are available on indoor radon [12-23]; however, a few such studies have been performed in distant areas of the

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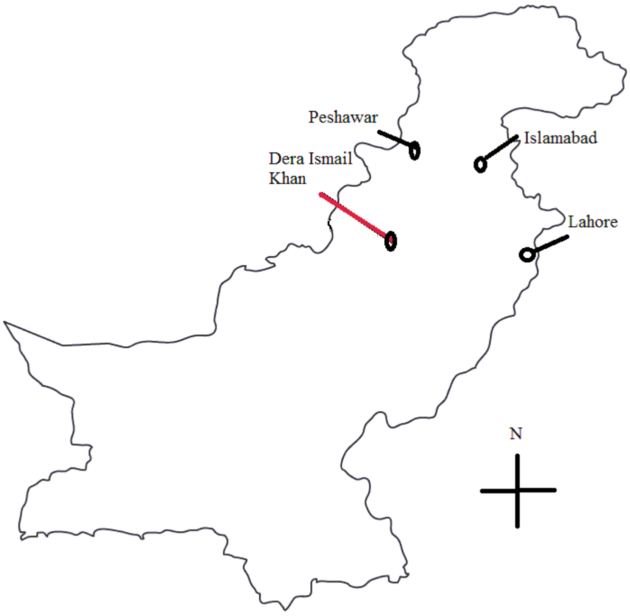


Figure 1. Map of Pakistan indicating location of Dera Ismail Khan.

country like Dera Ismail Khan [24, 25]. Since in the previous study [25], higher radon concentration was observed in some mud made houses as compared to cemented houses, it was regarded of vital interest to carry out a survey in mud made houses in the outskirts of Dera Ismail Khan city and to set up baseline data for the dwellers of such houses.

## 2. Area Under Study

Dera Ismail Khan is the southern-most district of the Khyber Pakhtunkhwa province of Pakistan situated on the west bank of River Indus and bounded on the north by Tank and Lakki Marwat districts, on the east by Mianwali and Bhakkar districts and on the south by Dera Ghazi Khan district of Punjab while on its west are the Tribal areas.

It is located at longitude of 70°55' E and latitude of 31°49' N and altitude of 165 m above the sea level. The total area of Dera Ismail Khan is 7, 326 $km^2$ (2, 829 sq mile) and its population is around 1,018,796. The location of Dera Ismail Khan is indicated in the Map of Pakistan (Figure 1).

## 3. Climate

Dera Ismail Khan district has extremes of climate. The months of May, June, July and August are extremely hot while December, January and February are the cold months. June is the hottest one in which the temperature shoots above 42 degree centigrade. In January the mean minimum temperature is 4 degree centigrade [26].

## 4. Type of Houses

In Dera Ismail Khan district only 15 per cent of population lives in urban areas and the rest 85 per cent lives in rural localities [26]. In rural areas majority of the houses are mud made. Therefore, for the present study mud made houses were selected in the outskirts of Dera Ismail Khan city. The mud houses are occupied by low-income population who are still using locally available building materials such as soil, sticks, straw and water which are easily affordable by the dwellers. Moreover, due to lack of basic amenities, the inhabitants prefer to live in such type of structures in order to withstand tough environmental condition (hot sunny days in summer and cold nights in winter) prevailing in Dera Ismail Khan.

The selected houses had their walls made of mud, and the roofs built of straw and sticks. The majority of the houses had one to two rooms with one door and with no windows and ventilators. Due to poor ventilation and direct coupling of the building and the soil, without having any sub-floor, such mud made houses attracted our interest to be investigated for indoor radon concentration levels. Because it is well known that the largest fraction of natural radiation exposure comes from radon, which is the decay product of radium contained in rocks and soil. A typical mud made house in the studied area is shown in Figure 2.

Figure 2: A typical mud made house in the studied area.

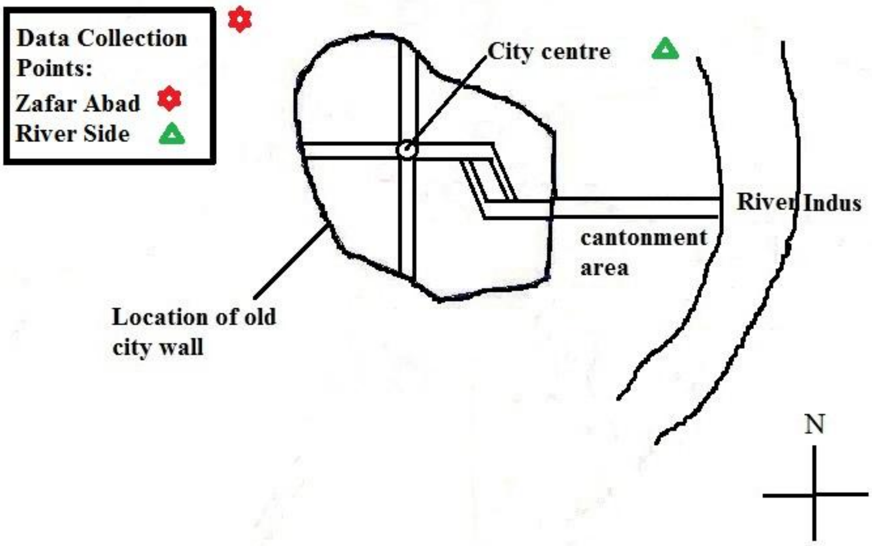


Figure 3. Locations of data collection points in the outskirts of Dera Ismail Khan city.

## 5. Experimental Details

Forty mud made houses were selected at two locations in the outskirts of Dera Ismail Khan city. Twenty such houses were selected along river side and twenty in Zafarabad in North-West of Dera Ismail Khan city (Figure 3).

Small pieces of CR-39 track detectors of size 1.5× 1.5 $cm^2$ were fixed in NRPB (National Radiological Protection Board) radon dosimeters and the dosimeters were installed in the rooms of mud made houses at a height of 6ft from the ground level in order to keep them in breathing zone. After three months exposure to indoor environment i.e. from $16^{th}$ September to $14^{th}$ December, the detectors were chemically etched in 6M NaOH solution at 70ºC for 16 hours. The etched detectors were studied under optical microscope and track densities were measured.

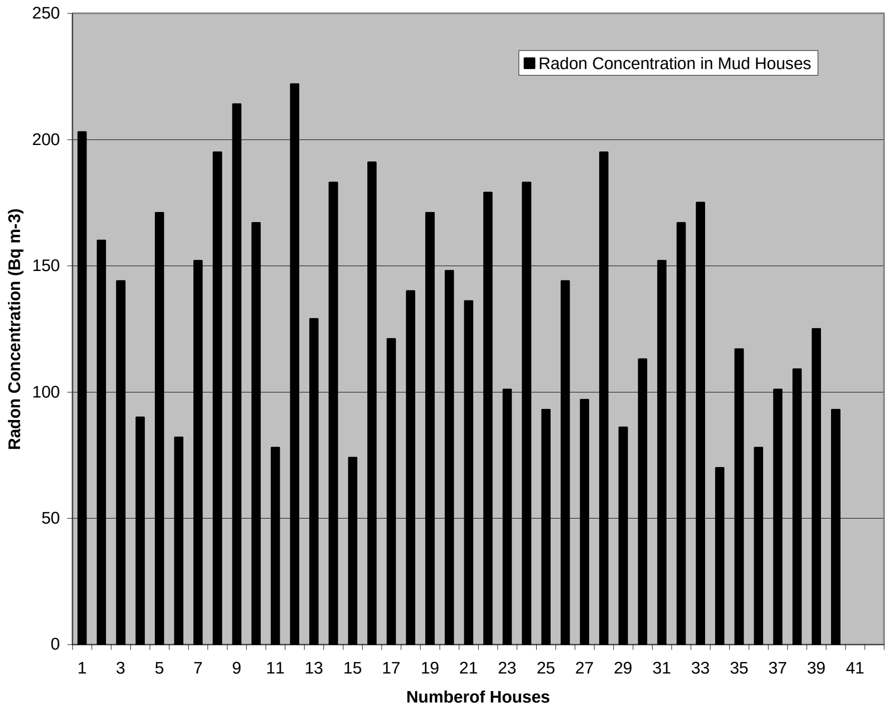


Figure 4. Indoor radon levels in mud made houses.

In order to convert track density into radon concentration a calibration factor of 2.7 tracks/cm²/hr = 1 KBq/m³ = 1 Bq/L was used [27].

## 6. Results and Discussion

The calculated values of radon concentration are given in Table 1.

Graphical representation of indoor radon levels in mud made houses is shown in Figure 4.

Table 1 and Figure 4 indicates that the radon concentration levels of all the surveyed houses were found within ICRP recommended limit of 600 Bq $m^{-3}$. However, radon concentration levels of 17 houses (43%) were found above US-EPA Action Level 150 Bq$m^{-3}$ and of 30 houses (75%) were found above the Action Level of 100 Bq $m^{-3}$ set out by WHO. It means that radon concentration levels of 57% houses were within US-EPA limits and only 25% were found within WHO recommended limits. This may be attributed to poor ventilation conditions of these mud made houses. Most of the rooms in the study area have single door and there are no windows or ventilators. Very few rooms are such that there is small hole in a wall for ventilation.

Minimum, maximum and arithmetic mean of radon concentration (Bq $m^{-3}$) are given in Table 2. Mean value of radon concentration in mud houses was 139±23 Bq $m^{-3}$ with minimum and maximum of 70±16 and 222±29 Bq $m^{-3}$, respectively. Minimum value was found in a house along river side while maximum value was in a house of Zafarabad. All the houses in the studied area have no sub-floor and the rooms are constructed on the soil. For this reason, radon emits directly into the rooms. The minimum value of indoor radon in mud house along river side can be attributed to relatively higher level of ground water because the presence of layers of ground water, wet clay or other non-permeable soils means that the radon gas is more or less prevented from going upwards [7].

## 7. Conclusions

Average values of indoor radon concentration in the mud made houses were found below the action level set by ICRP and US-EPA but it was above WHO recommended limits. Possible reasons for high radon concentration in mud made houses are construction materials and poor ventilation conditions. At least one or two windows for fresh air and a floor made of baked bricks to eliminate direct coupling of building with soil can reduce the high indoor radon concentration.

Table 1. Radon concentration (Bq m$^{-3}$) in mud made houses.

| House No. | House location | Indoor radon Concentration (Bq m$^{-3}$) |
|---|---|---|
| 1 | Zafarabad | 203±28 |
| 2 | -do- | 160±25 |
| 3 | -do- | 144±24 |
| 4 | -do- | 90±19 |
| 5 | -do- | 171±26 |
| 6 | -do- | 82±18 |
| 7 | -do- | 152±24 |
| 8 | -do- | 195±27 |
| 9 | -do- | 214±30 |
| 10 | -do- | 167±25 |
| 11 | -do- | 78±17 |
| 12 | -do- | 222±29 |
| 13 | -do- | 129±22 |
| 14 | -do- | 183±27 |
| 15 | -do- | 74±17 |
| 16 | -do- | 191±27 |
| 17 | -do- | 121±22 |
| 18 | -do- | 140±23 |
| 19 | -do- | 171± 26 |
| 20 | -do- | 148±24 |
| 21 | River Side | 136±23 |
| 22 | -do- | 179±26 |
| 23 | -do- | 101±20 |
| 24 | -do- | 183±27 |
| 25 | -do- | 93±19 |
| 26 | -do- | 144±24 |
| 27 | -do- | 97±19 |
| 28 | -do- | 195±27 |
| 29 | -do- | 86±18 |
| 30 | -do- | 113±21 |
| 31 | -do- | 152±24 |
| 32 | -do- | 167±25 |
| 33 | -do- | 175±26 |
| 34 | -do- | 70±16 |
| 35 | -do- | 117±21 |
| 36 | -do- | 78±17 |
| 37 | -do- | 101±20 |
| 38 | -do- | 109±21 |
| 39 | -do- | 125± 22 |
| 40 | -do- | 93±19 |

Table 2. Minimum, maximum and arithmetic mean of radon concentration (Bq m$^{-3}$) in mud made houses.

| Indoor radon Concentration (Bq m$^{-3}$) | | |
|---|---|---|
| Minimum | Maximum | Arithmetic Mean |
| 70±16 | 222±29 | 139±23 |

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