Estimation Of Annual Effective Dose Due To Low-Level Radiation Exposure In Dwellings Of Some Districts Of Haryana

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Abstract: All organisms (e.g. bacteria, plants or animals including humans) are exposed everyday to varying amounts of ionizing radiation emitted from radon and its progeny in general environment and in the dwellings. These radiations are spontaneously emitted by naturally occurring radioactive material like ^{238}U and ^{232}Th, ever since their existence on earth. The exposure to alpha radiation emitted from radon poses health hazards not only to workers at industrial units like thermal power plants, coal fields and oil fields but also to the dwellers in normal houses in their surroundings. Radon being an inert gas can easily disperse into the atmosphere immediately on its release. The solid alpha active decay products of radon like ^{218}Po and ^{214}Po become airborne and get themselves attached to the aerosols, dust particles and water droplets suspended in the atmosphere. When inhaled during breathe, these solid decay products along with air may get deposited in the tracho-bronchial and pulmonary region of lungs resulting in the continuous irradiation of the cells which may be the cause of lung cancer. In the present work, we report on the estimation annual effective doses received by the residents living in different types of dwellings. For these measurements we have used the alpha sensitive solid-state nuclear track detectors (SSNTD). The concentration of radon and annual effective doses have been calculated using recommendations from by International commission on radiological protection (ICRP). The results indicate higher radiation dose received by the residents residing in mud and fly ash brick dwellings compared with the residents of cemented and other dwellings.

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1 Introduction

The effect of low-level ionizing radiations on human population has been a concern to the scientific community and the public at large, for a long time. The study of health effects of exposure to low-level-exposure to alpha radiation emitted from radon in dwellings and general environment has received continuing attention as the radon has been found to be a ubiquitous indoor radioactive air pollutant to which all persons are exposed [1,2]. Through various epidemiological studies, researches and investigations, it is established that exposure to ^{222}Rn in mines has caused excess lung cancer in several groups of miners. All exposures except those from the direct cosmic radiations are produced by the radioactivity of the natural radionuclides present in the environment [3]. Exposure due to natural radiation is of great importance due to its largest contribution (nearly 53%) to the total collective radiation dose to the world population [4]. Major contribution of doses from normal background regions arises from the inhalation of ^{222}Rn, ^{220}Rn and their short lived progeny. At sea level about 80% of the ionization is caused by natural radioactivity, mainly by the emission of alpha particles from air borne radionuclides [5]. Apart from external exposure, there is an internal exposure due to the ingestion of ^{238}U, ^{232}Th and the radionuclides produced by the decay of these nuclides as well as ^{40}K through dietary intake.

Radon mainly comes from grantic and volcanic subsoil as well from certain construction materials. In general, there are three main mechanisms of radon entry into a building [6].

1. Convection via utility access points, cracks and openings.
2. Diffusion from soil via the pore space of the building material and earthen foundations.
3. Emanation from building materials.

High radon concentration indoors is usually due to penetration from the surrounding soil via mechanism 1 & 2. Radon levels in a home can fluctuate from day to day, depending upon the level of radon in the soil, type of soil, airflow through the soil, openings to buildings and ventilation. Underground water may also be contaminated with radon gas, which is released during showers and other household uses. Outdoor radon concentrations are low but indoors this gas may accumulate in high concentrations emitted from the soil and from building materials when the room is not properly ventilated. Radon emanation from the soil depends upon its radium content but also upon mineralogy, porosity, grain size, moisture content and permeability of host rock and soil [6,7].

Radon gas decays overtime into radioactive particles that can be inhaled and trapped in the lungs as these daughter products remain air borne for a long time. When radon decays it forms its progeny ^{218}Po and ^{214}Po, which are electrically charged and can attach themselves to tiny dust particles, water vapours, oxygen, trace gases in indoor air and other solid surfaces. These daughter products (aerosols) remain air-borne for a long time and can easily be inhaled into the lung and can adhere to the epithelial lining of the lung, thereby irradiating the tissue. Bronchial stem cells and secretion cells in airways are considered to be the main target cells for the induction of lung cancer resulting from radon exposure. The exposure of population to high concentrations of radon and its daughters for a long period lead to pathological effects like the respiratory functional changes and the occurrence of lung cancer [8]. Based upon current knowledge about health effects of inhaled radon and its progeny, ICRP has made recommendations for the control of this exposure in dwellings and work place [9].

However, controversy exists regarding the health effects of exposure to low level alpha radiation emitted from radon in dwellings and general environment [10]. The exposure response to miners is generally linear. In the published literature, data and reports regarding the health effects of low-level-exposure to alpha radiation emitted from radon there are two schools of thought. First one favours the linear no-threshold (LNT) hypothesis and states that exposure to alpha radiation emitted from radon is potentially harmful, no matter how small be its level. The exposure to alpha radiation emitted from radon poses grave health hazards not only to uranium miners but also to people living in normal houses, buildings and work place like thermal power plants, coal fields and other related industries [11,12]. The second school of thought (Hormesis hypothesis) believes that such a low-level-exposure to alpha radiation emitted from radon may not be harmful after all or may even have beneficial effects i.e., low-level-exposure to alpha radiation emitted from radon can stimulate repair mechanisms which mitigate the effect of subsequent high exposures leading to a decrease in the lung cancer incidences. Radiation Hormesis is the stimulatory or beneficial effect of low doses of ionizing radiation. The term refers to a process whereby low doses of ionizing radiation may result in beneficial or stimulatory effects. The underlying property is a physiological effect that cannot be anticipated by linear downward extrapolation from the toxic levels of exposure [13,14]. Both schools quote epidemiological studied on human beings as well as the laboratory research using experimental animals.

The aim of present work is the estimation of radon and annual effective doses received by the residents in some dwellings of North India. The study will help in detecting the areas with higher radiation exposure and the possible causes of enhanced dose received by the residents.

2 Geology of the Area under Study

As a geographical unit, Haryana is situated in India's northwest between 27^0 37′and 30^0 35′ Northern Latitude and 74^0 28′ to 77^0 36′ East Longitude. Haryana can be subdivided into two natural areas, sub-Himalayan terrain and the Indo-Gangetic planes. The plane is fertile and height above sea level is 700-900 ft. The slope is from north to south. The climate of Haryana is of pronounced character, very hot in summer and markedly cold in winter. The maximum temperature is recorded in the month of May and June when it goes upto 46^0C. The state is bounded north by Himachal Pradesh, east by Uttar Pradesh, south and west by Rajasthan and northwest by Punjab. The locations under study are the parts of the districts of Panipat, Faridabad, Ambala, Panchkula, Yamunanagar and Kurukshetra as shown in fig.-1. The districts of Panchkula and Yamunanagar of northern Haryana are adjacent to Shivalik hills of Himalayas while Panipat and Faridabad are industrial towns having one coal fired thermal plants each.

3 Experimental Methods

For the measurement of radon concentration, in each dwelling LR-115 type- II detectors (1 cm x 1 cm size) were exposed for 100 days in bare mode. The height of detectors was kept about 1.5 m from ground in most of the cases. The sensitive side of the bare detectors was exposed to the environment facing down so that dust may not settle on it. At the end of the exposure time, the detectors were removed and subjected to a chemical etching process in 2.5N NaOH solution at 60^0C for 90 minutes. The detectors were washed and dried and the tracks produced by the alpha particles were observed and counted under an optical Olympus microscope at 600X. A large number of graticular fields of the detectors were scanned to reduce statistical errors.

The measured track density (Track/cm^2/day) was converted into radon concentration in Bq/m^3 using calibration factor from [15, 16]. The equilibrium factor is 0.4 [4]. The annual effective dose from radon was calculated according to ICRP Publication [9].

D = (C × K × H) / (3700 Bq/m^3 × 170 h), where

D – Annual effective dose (mSv/Yr)

C – Equilibrium Equivalent Concentration, EEC_{Rn} (Bq/m^3)

K – ICRP dose conversion factor (3.88 mSv WLM^{-1} for general public, 5 mSv WLM^{-1} for occupational workers)

H = Annual Occupancy at location (7000 hours for residents), i.e. 80% of total time.

170, is taken as exposure time in hours for WLM.

4 Result and Discussion

The calculated values of radon concentration in different dwellings varied from 66 ± 9 Bq m^{-3} to 97 ± 10 Bq m^{-3} (table-1). In case of dwellings the radon levels are found to be higher in industrial towns like Panipat and Faridabad compared with other towns as shown in table-1. It may be due to enhancement of levels by the industries using coal as fuel like thermal power plants. The annual effective dose received by the residents in dwellings varied from 1.1 to 1.6 mSv. The radon concentration levels in dwellings are within the recommended safety limits of [9]. The comparison of present study with some other studies of the region is shown in table-2. The radon levels are found to be increased in case of dwellings of industrial towns compared with other towns.

Table-1: Radon concentration and annual effective doses received in some dwellings of Haryana, India.

Location	Number of dwellings	Radon concentration (Bq m^{-3}) AM ± SE*	Annual dose received (mSv) AM ± SE*
Panipat (Haryana)	6	92 ± 12	1.6 ± 0.5
Faridabad (Haryana)	6	97 ± 10	1.7 ± 0.3
Kurukshetra (Haryana)	8	66 ± 9	1.1 ± 0.2
Ambala (Haryana)	8	76 ± 10	1.3 ± 0.4
Panchkula (Haryana)	10	89 ± 12	1.5 ± 0.5
Yamuna Nagar (Haryana)	8	78 ± 14	1.3 ± 0.7

* SE (standard error) = σ/√ N, where σ is SD (standard deviation), and N is the number of observations.

Table 2. Comparison of indoor radon levels with some other Indian studies of the Area

Values from literature (Bq m^{-3})	Regions from India	References
58-240	Punjab	Singh et al., 2005 [17]
40-134	Haryana	Kant et. al. 2004 [18]
37 - 134	Rajasthan	Kumar et al., 1994 [19]
145 - 165	Himachal Pradesh	Virk, 1999 [20]
42-168	Palampur (H.P.)	Kumar et al., 2003 [21]
13.5 - 143	All India	Ramchandran, 1998 [22]
66-97	Northern Haryana	Present study

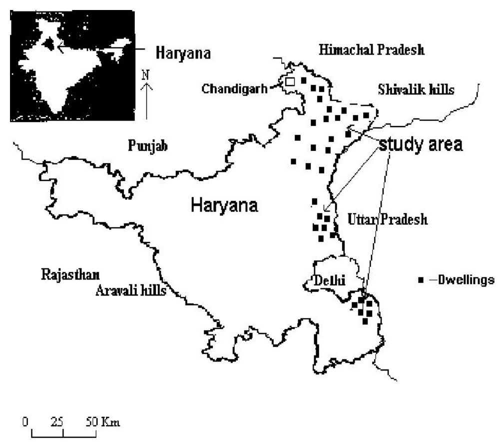

Fig: 1 Geographical map of the locations under study in northern Haryana (India).

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