Measurement of Radon Concentration and Exhalation Rates in Soil Samples of some districts of Haryana and Himachal in India

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Abstract— The radon Concentration and exhalation rates from samples of soil which were collected from the Shivalik foot hills of Haryana and Himachal Pradesh in India were experimentally measured using Canister technique. The study aims at assessing the contribution of soil in building materials in the form of bricks and for filling purpose in construction towards the total indoor radon exposure to the inhabitants of the study area. In this context, samples of soil were collected from different parts of the Shivalik foot hills of the two states. After processing, the samples were placed in plastic Canister and LR-115 type-II detectors were used to records the tracks of α-particles emitted by radon gas. After chemical etching process the tracks produced were counted and radon concentration & exhalation rates were calculated. The average level of radon concentration in soil samples from Haryana varies from 1254±53 Bq/m^3 to 3082 ±34 Bq/m^3, the average values of mass exhalation rate varies from 50±2 mBq/kg/hr to 122±1 mBq/kg/hr and the average values of surface exhalation rate varies from 1144±49 mBq/m^2/hr to 2811± 31 mBq/m^2/hr. Similarly, the average level of radon concentration in soil samples from Himachal Pradesh varies from 2265±84 Bq/m^3 to 3464 ±224 Bq/m^3, the average values of mass exhalation rate varies from 90±3 mBq/kg/hr to 143±6 mBq/kg/hr and the average values of surface exhalation rate varies from 2066±77 mBq/m^2/hr to 3159± 205 mBq/m^2/hr.

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I. INTRODUCTION

RADIUM is present everywhere in the earth's crust so radon is found everywhere in varying quantity. It can move freely from the place of its origin through pores in soil and cracks in walls. Radon transportation is mainly due to diffusion and forced flow. Radon continuously undergoes radioactive decay spontaneously into four solid short lived radio nuclides, viz., 218Po, 214Pb, 214Bi and 214Po, in which polonium isotopes are alpha emitters [1]. Radon ($_{222}$Rn) is an inert radioactive gas in the decay chain of uranium ($_{238}$U). Radon gas is produced from a radioactive solid element (a rock) and then the radioactive gas changes back into radioactive heavy metallic particles. This process and their atomic size (extremely small) makes the transport of radioactive atoms through a relatively static environment possible. In other words, radon's extended half-life (it takes about a month for a specific amount of it to decay to almost nothing) provides enough time for the gas to migrate through cracks and crevices in building foundations, then into the internal air volume where it changes into the more harmful radioactive heavy metals. It continuously emanates from soil to the atmosphere. Radon and its progeny are the major natural radioactive sources for the ambient radioactivity on Earth. A number of studies on radon were performed in recent decades focusing on its transport and movement in the atmosphere under different meteorological conditions as well as its impact to human health due to its carcinogenicity. The knowledge of the natural radioactivity of building materials is important for the determination of population exposure to radiations, as most of the residents spend about more than half of their time in indoor. Building materials contribute to natural radiation exposure by radon exhalation to an internal dose exposure due to deposition of radon decay products in the human respiratory tract. Elevated dose rates in indoor may arise from high activities of natural radio nuclides in building materials. In India dwellings are constructed with bricks mixed with nearly 80% soil, which may contain highly occurred concentrations of natural radio nuclides [2]. Radiation is present in every environment of the Earth's surface, beneath the Earth and in the atmosphere. According to UNSCEAR [3] about 87% of the radiation dose received by mankind is due to natural radiation sources and the remaining is due to anthropogenic radiation. It is well known that natural radioactivity is present in rocks, soils, sediments, water and fish. The human population is exposed to a natural background radiation level that is contributed by three components viz., cosmic rays, terrestrial radioactivity and internal radioactivity. The contribution from these components varies with location and altitude.

In the present work the estimation of Radon concentration emanated from soil collected from the states Haryana and Himachal Pradesh in Shivalik foot hills of India. The aim of the study is the possible health risk assessment in the area. In this region the soil is the main constituent of brick material used in construction of the dwellings. The location of study area in Haryana and Himachal Pradesh near Shivalik foot hills in India's North West between latitude 8^0 –4' & 37^0-06' North and longitude 68^0 – 7' & 97^0 – 25' East. The study area is Southern part of Himachal Pradesh and Northern part of Haryana. It is also bounded by Punjab state in West and Utter Pradesh in East, through which Yamuna river passes. The sample collection sites are shown in the" fig (1)".

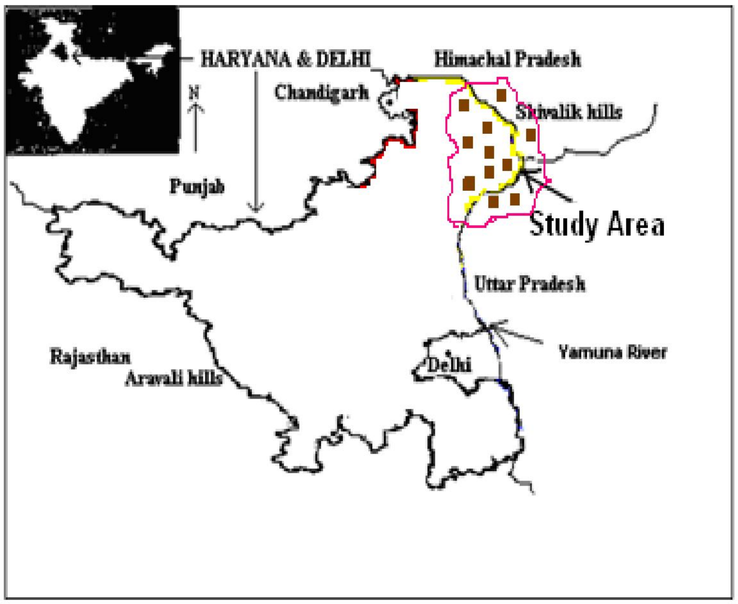


Fig-1 Geographical map of study area

II. Experimental Details

The Canister technique was used for the measurement of radon concentration and its exhalation rates in soil samples [4]. Samples of soil were collected from different sites of the study area.. A known amount of oven dried samples (200 gram each) were put in the plastic canister. LR-115 type-II plastic track detectors were fixed on the bottom of lid of each canister with tape such that sensitive side of the detector faced the samples "Fig-1". The canisters were tightly closed from the top and sealed. The size of the detectors was 1cm X 1cm and were exposed to samples for 100 days. The detector records the tracks of α-particles emitted by radon gas produced through α-decay of radium. 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 degree centigrade for 90 minutes. The detectors were washed and dried. The tracks produced by the alpha particles were observed and counted under an optical Olympus microscope at 600X. The measured track density was converted into radon concentration using a calibration factor (.021 tracks/cm^2/day = 1 Bq/m^3) as used by other workers. [4] - [7].

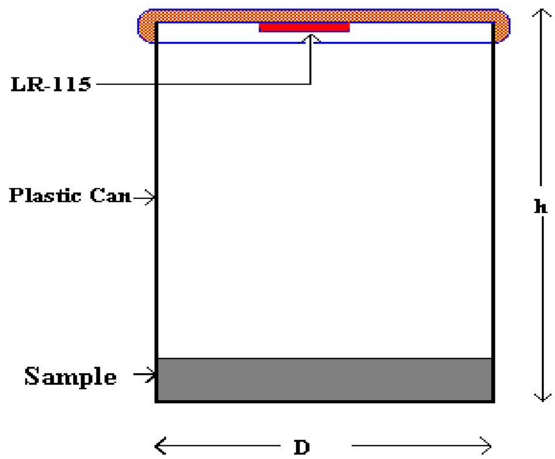
The surface and mass exhalation rates of radon have also been calculated using following formulae [8[-[9].

$$E_M = \frac{CV\lambda}{M[T + (1/\lambda)\{\exp(-\lambda T) - 1\}]}$$

(Bq Kg^{-1} h^{-1}) for mass exhalation rate

$$E_A = \frac{CV\lambda}{A[T + (1/\lambda)\{\exp(-\lambda T) - 1\}]}$$

(Bq m^{-2} h^{-1}) for surface exhalation rate
Where C is the Integrated radon exposure (Bq m^{-3} h^{1}), M is the mass of sample (Kg), V is the volume of air in



canister (m^3), T is the time of exposure (hrs), λ is the decay constant for radon (h^{-1}) and A is the area covered by the canister or Surface area of the sample (m^2).

Fig .2 The Canister used for the measurement of radon concentration and exhalation rates from different samples

III. Results and Discussions

The average level of radon concentration in soil samples from Shivalik foot hills in Haryana varies from 1254±53 Bq/m^3 to 3082 ±34 Bq/m^3, the average values of mass exhalation rate varies from 50±2 mBq/kg/hr to 122±1 mBq/kg/hr and the average values of surface exhalation rate varies from 1144±49 mBq/m^2/hr to 2811± 31 mBq/m^2/hr. Similarly, the average level of radon concentration in soil samples from Shivalik foot hills in Himachal Pradesh varies from 2265±84 Bq/m^3 to 3464 ±224 Bq/m^3, the average values of mass exhalation rate varies from 90±3 mBq/kg/hr to 143±6 mBq/kg/hr and the average values of surface exhalation rate varies from 2066±77 mBq/m^2/hr to 3159± 205 mBq/m^2/hr.

It is clear from the results that radon concentration varies appreciably from sample to sample. It is due to the fact that soil samples collected from different places may have different Uranium contents. The level of Radon concentration were found to be higher in hilly area like Mornil hills , Kalka and Taje Wala than in plane area places like Barwala, Sadhora and Naraingarh as shown in table-I of Haryana. Similar trend was observed in the soil samples collected from Himachal Pradesh as shown in table-II where Lal Dhang (peak) area situiated on Haryana & Himachal border in National reserve forest Kaleser has highest value of radon concentration.

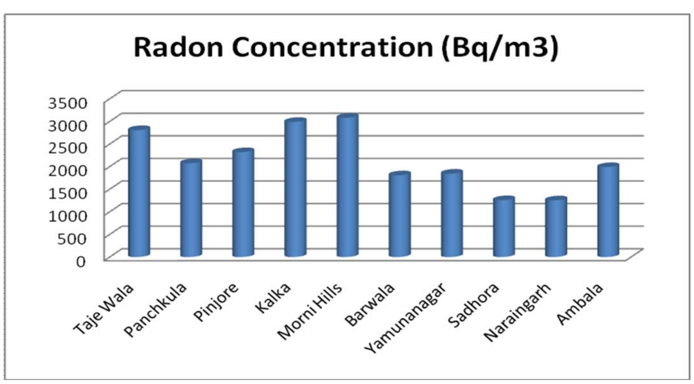


Fig. 3 Radon Concentration of soil samples collected from Various places of Haryana State near Shivalik foot hills

TABLE I. Radon Concentration and Exhalation rates from soil samples collected Various places of Haryana State near Shivalik foot hills

S No	Place	Radon Concentration (Bq/m3)		MassExhalationRate (mBq/kg/hour)	Surface Exhalation Rate (mBq/m2/hour)
		Min- Max	AM±SE	AM±SE	AM±SE
1	Taje Wala	1646-3474	2809±237	111 ±9	2562±216
2	Panch Kula	1767-2788	2075±122	83 ±5	1892±111
3	Pinjore	2072-2575	2321 ±55	92 ±2	2118±50
4	Kalka	2407-3779	2990±192	118 ±7	2728±175
5	Morni Hills	2910-3215	3082 ±34	122 ±1	2811±31
6	Barwala	1188-2209	1809±133	71 ±5	1650±121
7	Yamuna Nagar	1584-2209	1845 ±79	73 ±3	1683±73
8	Sadhora	1158-1371	1259 ±32	50 ±1	1149 ±29
9	Narain garh	1066-1356	1254 ±53	50 ±2	1144 ±49
10	Ambala	1660-2209	1991 ±64	79 ±2	1816±58

TABLE II. Radon Concentration and Exhalation rates from soil samples collected various places of Himachal Pradesh State near Shivalik foot hills

S. No	Place	Radon Concentration (Bq/m3)	Mass Exhalation Rate (mBq/kg/hour)	Surface Exhalation Rate (mBq/m2/hour)
		Min - Max AM±SE		
			AM±SE	AM±SE
1	Lal Dhang	2377-4502 3464±224	143±6	3159±205
2	Ponta Sahib	1615-3337 2633 ±179	108±9	2402 ±163
3	Dhola Kuan	2301-3626 2905 ±180	115 ±7	2650 ±164
4	Nahan	1980-2560 2265 ±84	90 ±3	2066 ±77
5	Kala Amb	2179-2545 2309 ±53	91±2	2106 ±48

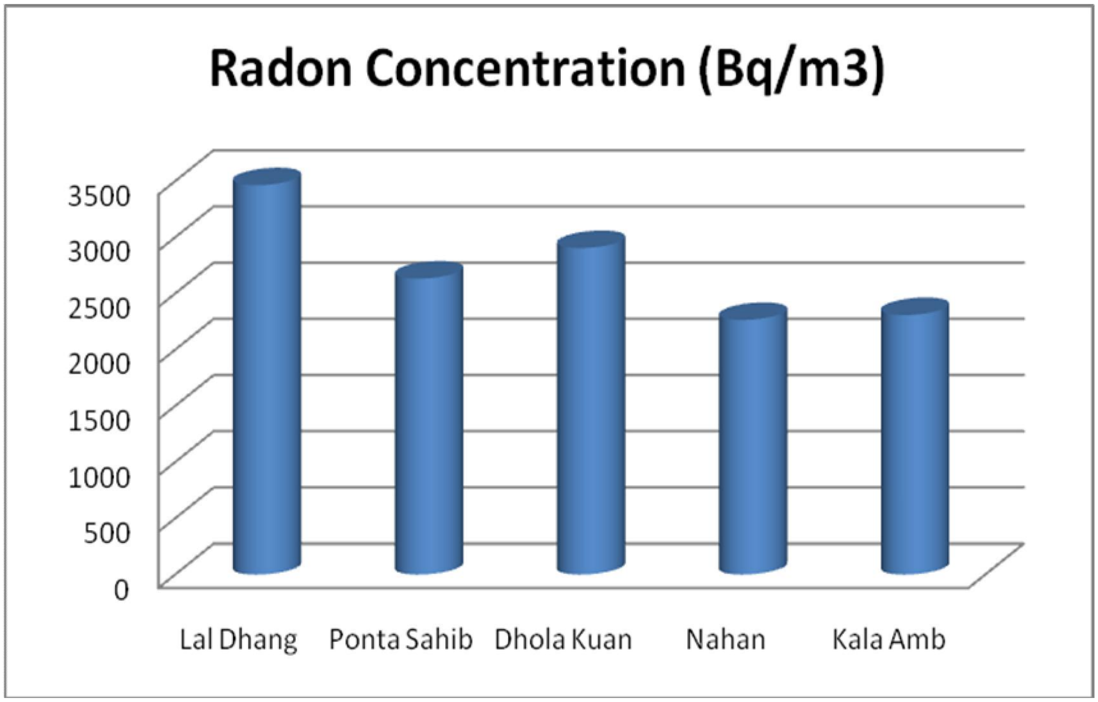


Fig. 4 Variation of Radon Concentration of soil samples collected from various places of Himachal Pradesh State near Shivalik foot hills

IV. CONCLUSION

The following conclusion can be drawn from the present investigation:

The values of radon concentration and exhalation rates are higher in soil samples collected from hilly areas than in plane area of Haryana. The values of radon concentration and exhalation rates are higher in all soil samples collected from Himachal Pradesh than samples collected from Haryana. The highest value of radon concentration and exhalation rate was observed from the sample collected from Lal Dhang peak. It may be due to higher uranium contents in the underground soil of hilly area [10]-[11]. Another reason for higher values in this area may be due to the fact that northern part of India is having high geochemical distribution of 238u as revealed by the radioactivity profile map of India [12].

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