Measurements of Radon Gas Concentration in Soil

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ABSTRACT
Radon and their decay products are the main contributors of total inhalation dose in the living environment. Concentration of radon soil gas is about thousand times higher as compared to environment. Thus, it is necessary to measure radon soil gas. Soil gas ^{222}Rn (radon) concentrations were measured at 5 locations in Sant Longowal Institute of Engineering and Technology (SLIET), Longowal, by using RAD7 (Durridge Company Inc., USA). Measurements were carried out at sampling depths of 30, 40 and 50 cm. The average concentrations for 30 and 40 cm varied from 298 Bqm^{-3} to 528 Bqm^{-3} and 1390 Bqm^{-3} to 3327 Bqm^{-3} for ^{222}Rn respectively. At 50 cm ^{222}Rn average concentrations ranged from 9685 Bqm^{-3} to 52958 Bqm^{-3}. At the location point 5 has the maximum Radon concentration for all the three depths compared with other locations. The high radon soil gas in any area leads to the chance of having lung cancer.

Keywords
Radon, RAD7, soil probe

1. INTRODUCTION
Radon is a radioactive, colorless, tasteless, toxic noble gas occurring naturally as an indirect decay product of uranium and thorium. It is monatomic gas. Its most stable isotope is ^{222}Rn, has a half life of 3.8 days. ^{222}Rn decays into radioactive products or progeny of ^{218}Po, ^{214}Pb, ^{214}Bi, and ^{214}Po until it reaches the final stable isotope ^{210}Pb. Radon comes from the soil, building and decoration materials, outdoor air etc. The world average soil radon concentration is 7400 Bq/m^3. People are not vigilant because Radon is invisible and intangible. Nazaroff and Nero [1] observed that radon enters the body through breathing and the short-lived radionuclide from decay of radon will be deposited in the bronchial, lung and kidney tissue, they release α-particle which produces radiation injuries from internal. This can damage lung tissue and lead to lung cancer over the course of lifetime. Kullab et al. [2] and report of UNSCEAR 1988 [3] gives information that thoron and their decay products contributes 55% of total inhalation doses to human population. Gupta et al. [4], Khatibeh et al. [5] and Patra et al. [6] described that radon– thoron comes from the soil and building materials, because the uranium and radium are uniformly distributed in these materials from the time of origination of earth. The indoor radon–thoron levels depend upon so many factors like geological setting of area, nature of soil, meteorological conditions, living style of the dwellers and type of building material used for the house construction [7-9]. Przylibski and Zebrowski, [10], and Przylibski et al. [11] have also measured radon concentrations in groundwater and its concentrations varied from 0.2 to 1645 Bq dm^{-3} and values exceeding 1000 Bq dm^{-3} constituted 3.9% of their results. A national residential radon survey was launched in April 2009 in Canada, this survey uses alpha track detectors used for a minimum of three months (Oct-April) with the objective of testing is of about 18,000 homes over a two year period [12]. Chauhan and Kumar [13] gave an idea that radon gas concentration inside the soil is 103–104 times higher than that of the environment.

The aim of the present work is to find out the radon concentration in soil gas at explicit depth within the soil. To do this, the air must be removed from the soil and delivered to a RAD7 (radon monitoring system) of Durridge Company (USA), without dilution by outside air. The volume of gas removed depends on the technique used to extract it and the porosity of the soil. In the present measurement we measured the dependence of radon concentration with depth in soil of Sant Longowal Institute of Engineering and Technology (SLIET) at different locations. The high radon soil gas in particular area leads to the chance of having lung cancer. Keeping this in mind the concentration of radon soil gas is measured.

2. MATERIALS & METHODOLOGY
Present measurements of radon concentrations in soil gas were carried out using the RAD7 portable radon detector (Durridge Company Inc. USA). The experimental setup is shown in Fig 2. This system contains a solid-state ion-implanted planar silicon detector and a built-in pump with a flow rate of 1 L min^{-1}. Desiccant (CaSO4) tubes is used to absorb the moisture in the soil air, an infra-red HP8224OB alpha-numeric printer placed on the top of the RAD7 and nylon inlet filters (pore size 0.45 μm) that block fine dust particles and radon daughters from entering the RAD7 chamber. The RAD7's internal sample cell is a 0.7 L conducting hemisphere with an average potential of 2200 V relative to the detector that is placed at the center of the hemisphere. The detector operates in external relative humidity ranging from 0% to 99% and internal humidity of 0% to10%. The spectra are in 200 channels and the RAD7 groups them into eight windows of energy ranges. A, B, C, and D are the major windows and E, F, G, and H are the diagnostic windows. Window A covers the energy range from 5.40 to 6.40 MeV, showing the total counts from 6.00 MeV particles from the ^{218}Po decay. Window B covers the region 6.40 MeV to 7.40 MeV, showing the total counts of 6.78 MeV particles from the ^{216}Po. Window C represents total counts of the 7.69 MeV a particles from ^{214}Po, while the window D represents the total counts of the 8.78 MeV a particles from the decay of ^{212}Po. In other words, windows A and B represent ''new'' ^{222}Rn (radon) and ^{220}Rn (thoron), while windows C and D represent ''old'' ^{222}Rn and ^{220}Rn, respectively. The RAD7 separates radon and thoron signals by

their daughters products unique alpha particle energies with little cross-interference (Durridge Company Inc., 2000).

which means that the RAD7 calculates radon concentrations from the data in window A only and thoron concentrations from the data in window B, while the data from windows C and D are ignored. In this mode, the built-in pump runs continuously. The soil gas probe used in our study was made of stainless steel with length of 106cm. This probe has an inner rod inside a hollow tube and a sampling outlet. The probe was inserted into the In the present measurements sniff mode of the system is used, soil at depths of 30, 40, and 50cm. After inserting the probe at the specified depth, the sampling outlet was connected to the inlet of the RAD7 via a small drying tube. Before each measurement the detector was purged for at least 5 to 10min. After detecting high concentrations of radon, the purging time was much longer. In all the measurements the cycle time was 15min and three cycles were performed. Thus the total duration of a single run at a specified depth was 20min. The final result is an average from these 4 measurement cycles. The experimental results are shown in the table 1 and the variation of the radon concentration with the location points are shown in Fig. 1.

3. RESULTS AND DISCUSSION

An average value of Radon concentration was calculated for each location point in Bqm^{-3}. In Table-1 all the results were listed , and Fig. 1 shows the average Radon concentrations as a function of location point number .The radioactive level of ^{222}Rn for soil samples, as shown in Table-1, range from 9958±130 Bqm^{-3} for location No.1 at depth 50 cm underground surface, to 9430±40 Bqm^{-3} with the same depth. For depth 40 cm the concentration varied from 1850±590 Bqm^{-3} to 123±93 Bqm^{-3}. While in the depth 30 cm, the Radon concentration is varies from 614±58 Bqm^{-3} to 490±19 Bqm^{-3}.

For location No.2 at depth 50cm underground surface, Radon concentration varied from 11608±310 Bqm^{-3} to 10300±240 Bqm^{-3}. For depth 40cm the concentration varied from 3480±110 Bqm^{-3} to 2249±330 Bqm^{-3}. While in the depth 30 cm, the Radon concentration is varies from 610±87 Bqm^{-3} to 418±38 Bqm^{-3}.For location No.3 at depth 50 cm underground surface, Radon concentration varied from 27900±590 Bqm^{-3} to 25702±1300 Bqm^{-3}. For depth 40 cm the concentration varied from 1428±110 Bqm^{-3} to 1290±2804 Bqm^{-3}. While in the depth 30 cm, the Radon concentration is varies from 397±13 Bqm^{-3} to 319±90 Bqm^{-3}.

For location No.4 at depth 50 cm underground surface, Radon concentration varied from 14800±220 Bqm^{-3} to 11294±900 Bqm^{-3}. For depth 40cm the concentration varied from 2530±310 Bqm^{-3} to 2110±600 Bqm^{-3} While in the depth 30cm, the Radon concentration is varies from 297±42 Bqm^{-3} to 218±90 Bqm^{-3}. For location No.5 at depth 50 cm underground surface, Radon concentration varied from 54328±900 Bqm^{-3} to 52108±100 Bqm^{-3}. For depth 40cm the concentration varied from 3469±30Bqm^{-3} to 3158±30 Bqm^{-3}. While in the depth 30cm, the Radon concentration is varies from 407±30 Bqm^{-3} to 249±20 Bqm^{-3}.

By observing data from the table-1, one can see that in the majority of locations there is linearity between the radon concentrations and the depth for the same location point. However large variation of Radon concentration in soil gas with depth. At the location point 5 has the maximum Radon concentration for all the three depths compared with other locations. The average Radon concentration in depth 50cm is 22763±418 Bqm^{-3}, in depth 40cm is 2322±253Bqm^{-3}, in depth 30cm is 412±36 Bqm^{-3}.The average radon concentration level in areas with higher depth may be due to the presence of Uranium prospect beneath the soil.

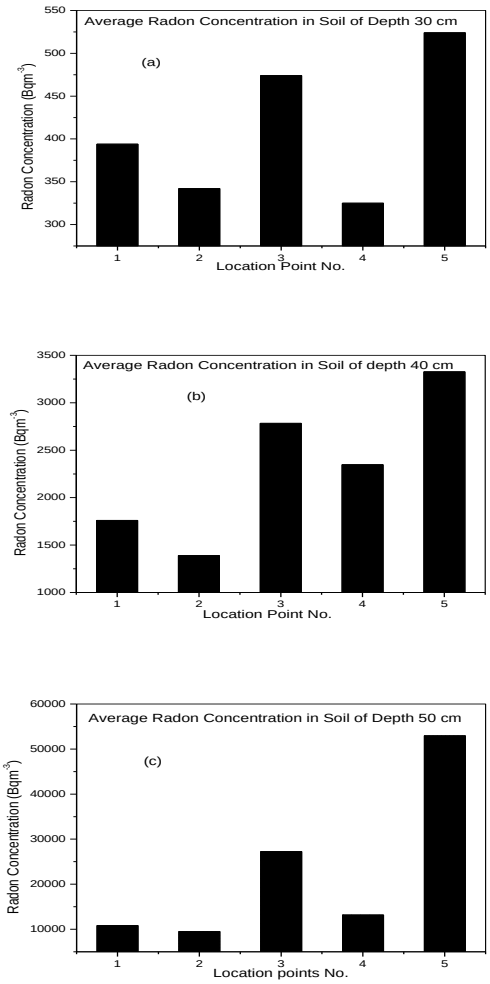

Fig. 1. Radon concentration as a function of the location point number: (a) at depth 30cm, (b) at depth 40cm, and (c) at depth 50 cm

Table 1. Radon Concentrations in different depths for the five location points in SLIET

Location Point	Radon gas Concentrations in Soil measured in Bqm^{-3} for different depth from ground surface		
	30 cm	40 cm	50 cm
1	394±35	1760±252	10852±418
2	342±34	1390±254	9548±419
3	474±36	2783±253	27253±516
4	325±36	2348±253	13205±450
5	524±37	3327±252	52958±556

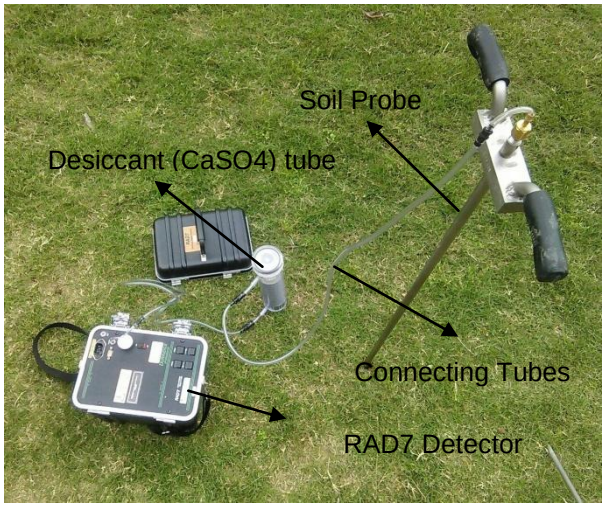

Fig 2: Experimental setup of RAD7 for measuring soil radon gas at SLIET, Longowal

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