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Health Risk Assessment Based on Radioactivity Measurement in Soil Samples Collected from Some Areas of Mandi District in Himachal Pradesh

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ABSTRACT: ***Background:*** **Radon is primary cause of Lung Cancer in non-smokers; it is formed in decay chain of Uranium. The measurement of Radon has been carried out in Talali region in Mandi district of Himachal Pradesh, to assess the Health Risk in the study area.** ***Materials and Methods:*** **Soil samples have been collected by using Grab Sampling Technique and further tested for radioactivity by Sealed Can Technique.** ***Results:*** **Radium concentration and Radon Exhalation Rates has been measured and Strong positive correlation is observed between radium concentration, area exhalation rate and mass exhalation rate. Parameters calculated form collected data have been presented graphically and discussed.** ***Conclusion:*** **The results reveal that area is safe as far as health hazards effects of radium and radon exhalation rate are concerned.**

Keywords: Lung Cancer; LR-115 Type II Detector and Sealed Can Technique

INTRODUCTION: Radon is naturally occurring radioactive inert gas. It occurs in the radioactive decay of radium, which is formed in the radioactive decay series of natural uranium. Radium acts as a permanent source of radon and is found in small quantities in all solids, rocks and materials although the amount varies from place to place. Lung cancer is the principal health concern associated with radon exposure. Radon itself is only partially responsible for health hazards, but the primary concern is associated with decay products of radon. Decay products are chemically reactive and may get deposited on respiratory tissues when inhaled. Radon is cause of lung cancer among non-smokers. It is responsible for about 2900 deaths of those people yearly, who have never smoked in the world[1]. According to several researchers, breathing low level of radon may increase the possibility of lung cancer[2 & 3.] Therefore measurement of radium and radon in samples are important from public health point of view.

Radon can migrate from soil into groundwater, which can become another route of exposure, if the groundwater is used as a water supply source. Being present in the soil, uranium and radium accumulate in food in very small amounts. Radon can be found in the air or dissolved in water, but it is not generally present in food. Radon is not found at any appreciable concentration in surface water.

Most radon in homes comes from radon in the soil that seeps into homes through cracks in the foundation or slab. The amount of radon in the soil varies widely and depends on the chemical makeup of the soil. There can be a large difference in radon concentrations in the soil from house to house. The only way to know is to test.

Radon is the second leading cause of lung cancer and can also cause damaging effects to the human DNA structure. Radon gas decays into radioactive particles that can get trapped in our lungs when we breathe. As they break down further, these particles release small bursts of energy. This can damage lung tissue and lead to lung cancer over the course of our lifetime. When radon decay products decay, they release alpha, beta and gamma radiation. The alpha particles that come from the decay of radon decay products will impact the sensitive lung tissue. In most cases they will kill the lung tissue cell, which can be replaced by the body. However, the alpha particles can impact the DNA, or create a chemical reaction that will affect the DNA. When this occurs the cell can become mutated. This is the mechanism by which prolonged exposure to radon and radon decay products can increase the potential of lung cancer. When radon decay products are inhaled they stick to sensitive lung tissue. Being short-lived, they will break down while they are in the lungs. This exposes the lung tissue to radiation.

Narayan Dass in 1979 *et al.,* has investigated the Geology structure or uranium mineralization in Kullu region of Himachal Pradesh and measured radon concentration and exhalation rates of soil samples from these area[8]. Kaul in 1993 *et al.,* has studied the uranium concentration in soil samples from Siwalik range of north western Himalayan in India[9]. Nageswara Rao in 1996 *et al.,* has studied the natural radioactivity and radiation levels in soil samples collected from some areas of Rajasthan[10]. Sharma *et al.,* in 2003 *et al.,* has investigated the radium concentrations and radon exhalation rates in soil samples of Kangra in Himachal Pradesh[11]. Singh in *2005 et al.,* reported the activity concentrations of radon and radon exhalation rates in Bathinda district of Punjab India[12]. Walia *et al.,* in 2008 has investigated soil gas activity in the vicinity of neo-tectonic fault near Dharamshala region of NW Himalayas, India, using active detectors[13].

Singh in *2010 et al.,* has monitored soil gas and ground water for earthquake prediction in North West Himalayas, India [14]. They monitored soil gas radon at Sarol. The daily monitoring of radon concentration in water at Banikhet was carried out in Chamba valley of North West Himalayas, India “a well-known seismic zone”. Chauhan et al., in 2011 has investigated the radon exhalation rates from stone and soil samples of Aravalli hills in India[15]. Kumar et al., in 2011 has studied radon in soil gas and natural radionuclide in soil, rock and ground water samples[16]. They observed concentration of radon in soil was higher near Chamundi hills and Karighatta village in rainy season. Sharma et al., in 2013 has studied the Remote sensing satellite data to recognize structures having tectonic significance[17].

In the present work, radon exhalation rate and radon concentration from soil samples have been measured through “Sealed Can technique” using LR-115 type II plastic track detector. Six samples were studied from some areas of Mandi District in Himachal Pradesh.

Survey Area: Area of Mandi district in Himachal Pradesh was under observation. Six soil samples were collected randomly from different places near to Sundernagar in Mandi district. The soil was collected from Murari Devi, Talali, Chaye ka Dora and Trifalghat in Sundernagar region of Mandi district by grab sampling method. The collected soil was packed and sealed in airtight dry polyethylene bags. The collected samples were converted in powdered form and sealed Can technique was applied for the measurement.

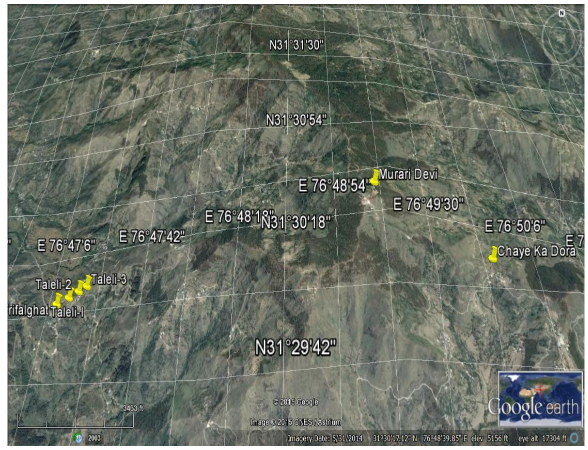

Figure 1: Satellite picture of Study Area (www.googleearth.com)[18].

MATERIAL NAD METHODS: There are many methods of radioactivity analysis and measurement of radon concentration. The types of detectors for the measurement of radioactivity are numerous. The detectors and the instrumentation associated with detectors will perform with different efficiencies to radiation detection depending on many factors. In the present work, radon exhalation rate and radium concentration from soil samples have been measured through “Sealed Can technique” using LR-115 type II plastic track detectors[6]. Cylindrical plastic “Can” of 7.5 cm height and 7.0 cm diameter was sealed to the individual samples. In each can a LR-115 type II detector was fixed at the top inside of the Can such that the sensitive surface of the detector faces the material and is freely exposed to the emergent radon so that it could record the tracks of alpha particles resulting from the decay of radon. The cans were sealed for 90 days. After the exposure for 90 days, the film detectors were etched in NaOH at 60˚C for a period of 90 minute in a constant temperature water bath instrument.

Experimental arrangement is shown in figure 2. The tracks were observed and counted by using microscope with a magnification of 400×. The track density and radon activity was obtained through calibration factor of 0.056 tracks $cm^{-2}d^{-1}(Bqm^{-3})$[7].

Exhalation rate of Radon: Radium is a decay product of uranium in the naturally occurring uranium series. When radium decays in soil grains, the resulting atoms of radon isotopes must first escape from the mineral grains to air filled pores. The rate at which radon escapes or emanates from solid into the surrounding air is known as Radon Exhalation rate of solid. This may express by either per unit mass or per unit surface area of solid[3].

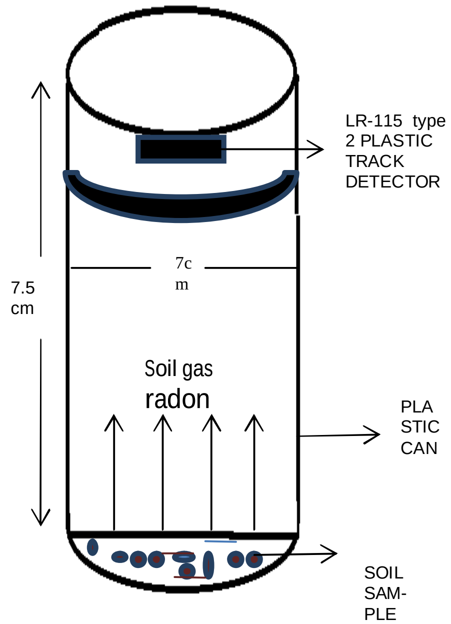

Figure 2: Experimental setup for measurements of radium concentration and radon exhalation rates in soil sample

Exhalation rates in terms of area and mass were calculated from the following equations which were earlier used by various researchers[4 & 5].

Area exhalation rate:

$$E_A = CV\lambda / A\left[T + \lambda^{-1}\left(e^{-\lambda T} - 1\right)\right]\ (Bqm^{-2}h^{-1}) \quad (1)$$

Mass Exhalation rate:

$$E_M = CV\lambda / M\left[T + \lambda^{-1}\left(e^{-\lambda T} - 1\right)\right]\ (Bqkg^{-1}h^{-1}) \quad (2)$$

Where;

C = radon exposure ($Bqm^{-3}h$)
T =Time of exposure (hrs)
λ =decay constant for radon (h^{-1})
V =Volume of Can (m^3)
M = Mass of sample (kg)

Radium Concentration: The radium concentration can be calculated by using formula:

$$C_{Ra} = \rho hA\ /\ KT_e M \quad (3)$$

Where;

ρ = track density (track/cm^2)
A = surface area of sample in cm^2
h = distance between detector and top of the sample in cm.
K = sensitivity factor (tracks $cm^{-2}d^{-1}$ per Bq m^{-3})

Almost all measurements of radon levels in the home or outdoors are expressed as the concentration of radon in units of picocuries per liter of air (pCi/liter), or in SI units as Becquerel per cubic meter (Bq/m^3).

RESULTS AND DISCUSSION: The values of radon exhalation rate in terms of area and mass and radon concentration in soil samples from region of Sundernagar in Mandi district of Himachal Pradesh are depicted in table 1. The soil of this area is commonly used in construction work and in some cases making of cement also. In the present investigation the area exhalation rate for radon ranges from 14.76 to 141.33 $Bqm^{-2}h^{-1}$ with an average of 105.82 $Bqm^{-2}h^{-1}$ and a standard deviation of 42.67.

Table 1: Values of radium concentration and radon exhalation rate in soil samples (S1: Chaye ka Dora, S2: Murari Devi, S3: Talali-I, S4: Talali-II, S5: Talali-III, S6: Trifalghat).

Sr. No.	Sample code (Longitude, Latitude, Elevation)	Radon Exhalation Rates		Radium concentration $(Bqkg^{-1})$
		$E_A \times 10^{-3}$ $(Bqm^{-2}h^{-1})$	$E_M \times 10^{-3}$ $(Bqkg^{-1}h^{-1})$	
1	S1(N 31°30′07″, E 76°49′14″, 1301m)	14.76	6.31	3.50
2	S2(N 31°30′09″, E 76°49′07″, 1508m)	101.60	43.42	24.30
3	S3(N 31°29′17″, E 76°47′12″, 954m)	115.66	49.43	27.71
4	S4(N 31°29′20″, E 76°47′14″, 974m)	128.68	54.99	30.79
5	S5(N 31°29′25″, E 76°47′17″, 971m)	132.89	56.80	31.80
6	S6(N 31°29′23″, E 76°47′17″, 810m)	141.33	60.40	33.82
Minimum		14.76	6.31	3.50
Maximum		141.33	60.40	33.52
Mean		105.82	45.22	25.32
S.D.		42.67	18.23	10.21

The values of mass exhalation rate in soil samples observed with in safe limits and higher than the global value of radon exhalation rate from soil is in the range of 0.02-0.05 $Bqm^{-2}h^{-1}$. Radium concentration ranges from 3.50 to 33.52 $BqKg^{-1}$ with an average of 25.32 $BqKg^{-1}$ and a standard deviation 10.21. The observed values of radium concentration in the present study less than the recommended action level 370 $BqKg^{-1}$ and lower than the average global value of 35 $BqKg^{-1}$.The soil of this area is available for manufacturing work for building construction. A positive correlation has been observed between radium concentration and area exhalation rate in soil of study area. The graphs are as:

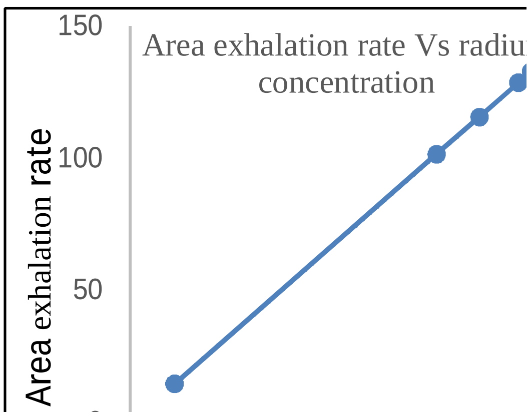

Figure 3: Showing the correlation between radium concentration and area exhalation rate.

Figure 3 is a plot between area exhalation rate and radium concentration. Plot is linear, which shows strong correlation between radium concentration and area exhalation rate.

Figure 4 is a graph between radium concentration and mass exhalation rate. Graph shows strong correlation between radium concentration and mass exhalation rate.

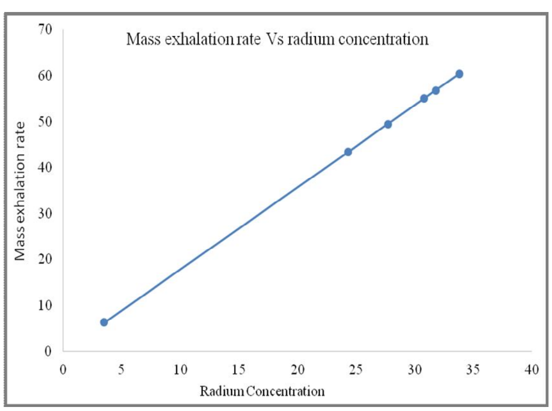

Figure 4: Showing the correlation between radium concentration and mass exhalation rate.

CONCLUSION:

- The average value of radium content in the study area is comparable to the global average value of radium in soil.
- The values of radon exhalation rate in soil samples of observed area are lower than the areas known for uranium mineralization nevertheless is higher from the global value. Therefore the use of soil of this area in manufacturing for building construction is considered to be safe.
- Highest activity was found in soil number sample no. 6.
- Lowest activity was found in soil sample no. 1.
- These results reveal that radon gas is chemically uncreative with soil sample.
- Radium concentration was found within the safe limits. Strong positive correlation has been observed between radium concentration, area exhalation rate and mass exhalation rate.
- The results reveal that area is safe as far as health hazards effects of radium and radon exhalation rate are concerned.

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