CPUH-Research Journal: **2015,** ***1(2)*****,** 23-27
ISSN (Online): 2455-6076
http://www.cpuh.in/academics/academic_journals.php

Radioactivity Measurements along Jwalamukhi Thrust in Himachal Pradesh, India

Naveen Thakur[1] *, Jitender Kumar[1], Babita Thakur[1], Reetika Bhadwal[1], K. C. Thakur[2] and Yachana Sharma[2]

[1]*Department of Physics, Career Point University, Hamirpur (H.P.) India*

[2]*Govt. College Sarkaghat, Mandi, Himachal Pradesh, India*

* *Correspondance Email: naveen.phy@cpuh.in*

ABSTRACT: The present work is devoted to measure radium concentration and radon exhalation rates of soil samples collected along Jwalamukhi Thrust in Himachal Pradesh, India. Radon is a colorless, odorless and tasteless gas. It can be found in the soil because of decay from the parent element Uranium and Radium, α-particles emitted by its short lived decay products can damage the cellular DNA. Various studies have established radon as a lung carcinogen. Thus radon and radium measurements are important form health point of view. Sealed can technique using LR 115 plastic track detectors has been used successfully to measure radium and radon exhalation rate. Highest activity was found with radium concentration $0.170X10^{-3}\ kg^{-1}h^{-1}$. The results reveal that radon gas is chemically unreactive with soil sample. Radium concentration was found with in safe limit.

Keywords: Radioactivity; Radon Exhalation rate; Radon Concentration and LR-115 and Detector.

INTRODUCTION: The largest contribution of ionizing radiation to the population is natural radioactivity. It is present everywhere within us and in surrounding environment in varying concentrations because of its natural presence. Radium, in the form of radium chloride was discovered by Marie Curie and Pierre curie in 1898 [1]. They extracted the radium compound from Uraninite and published the discovery at the French Academy of science after five years. We all know that Radon is a decay product of Radium, which decays after completing its half life directly into radon. Radon is produced continuously from the decay of naturally Occurring radionuclide such as U^{238}, U^{235} and Th^{323}.

Radon is a chemical element with symbol Rn and atomic number 86. It is a radioactive, colorless, odorless, tasteless noble gas, occurring naturally. Radon is one of the densest substance that remain a gas under normal conditions that only has radioactive isotopes and is considered a health hazard due to its radioactivity. The measurement of radon in man's environment is of interest because of its alpha emitting nature. Soil is the main source of continuous radiation exposure to the human beings [2-3]. The naturally occurring radionuclides present in the soil are mainly U^{238}, Ra^{236}, Th^{232} and K^{190}. These radio nuclides causes radiological hazard externally as well as internally due to their gamma ray emission and inhalation of radon and its progeny. The exposure of high concentration of radon and its daughter's to human beings for long periods leads to pathological effect like respiratory function changes and lead to lung cancer. The radiation dose received by human beings due to the inhalation of radon, thoron and their progeny present in the environment contribute about half of the average radiation dose from all natural sources of radiation. When radon inhaled, α-particles emitted by its short lived decay products can damage the cellular DNA mainly. Cellular mutagenesis studies, experimental research in animals and occupation epidemiologic studies have established radon as a lung carcinogen [4-5].

Keller *et. al.*, (1999) has investigated the Radon permeability and Radon exhalation of building materials. He observed that the application of conventional building materials contributes unessential to the whole radiation exposure of the population. The judgment of a resulting radiation influence of building materials only by their content of natural radioactive nuclides may lead to an incorrect valuation. For instance building materials like stones mixed with fly ashes and pumice or slag stones exhale less radon because of their closed surface structure than other very porous materials with a lower content of natural radionuclide [6].

Jelsch *et. al.*, (1999) has studied about the Radon (Ra222) level variations on a regional scale: influence of the basement trace element (U, Th) geochemistry on radon exhalation rate. They studied that influence of the basement geochemistry on the spatial distribution of radon level both at the soil/atmosphere interface and also in the atmosphere [7].

Kumar *et. al.*, (2001) has investigated the Uranium, Radium and Radon exhalation in some soil samples from Una district, Himachal Pradesh, India by using track etching technique. They used experimental method in which soil sample were collected from different villages of Una district. These samples were chosen to understand particularly the migration and exhalation of radon in the naturally occurring soils. They observed that Uranium concentration in soil varies from village to village. The values of the radium concentration are much lower than those reported by Nageshwara Raw for the soil of Rajasthan area [8].
Ramola *et. al.*, (2003) has studied the measurement of radon exhalation rate from soil samples of Garhwal Himalaya, India. They found that soil-gas Radon concentration was somewhat higher than the normal value. The high value was mainly because of the Uranium deposited in the area [9].

Sun *et. al.*, (2004) studied the feasibility for mapping Radon exhalation rate from soil in china. They studied Radon exhalation rate in soil [10].

Singh *et. al.*,(2005) has analyzed Ra^{226} Th^{232} and K^{40} in soil samples collected from some area of Punjab and Himachal Pradesh, India by using gamma ray spectrometry. They found comparatively high value of Uranium in the soil of Palampur in Himachal Pradesh. The high values of Ra^{226} and Th^{232} in soil samples may be due to the presence of Uranium mineralization in Himachal Himalayas reported earlier by some workers due to the presence of the active faults in the area [11].
Mehra *et. al.*, (2006) has studied the Uranium, Radium, Radon exhalation rate and Indoor Radon in the environs of some areas of the Malwa Region, Punjab. They reported average Radon concentration levels and the standard deviation of the yearly values recorded in dweling of 34 villages of the Malwa region [12].

Sahoo *et. al.*, (2007) estimated the radon emanation factor in Indian building materials. They observed that fly ash samples, collected from Gujarat region, are having concentrations of natural radio nuclides higher than that was found in other building materials. Consequently, gamma dose was also high in these materials [13]].

Mahur *et. al.*, (2010) has investigated Radon exhalation rate and natural radioactivity in soil samples collected from east singhbhum shear zone in Jaduguha U-Mines area of Jharkhand, India and its radiological implication [14].

Zubair *et. al.*,(2011) has investigated the assessment of indoor Radon, Thoron and their decay products in the surrounding areas of Firozabad, Uttar Pradesh, India. All values obtained under the limit, depending on the type of house concentration, ventilation conditions and location [15].

Yanlin *et. al.*, (2013) measured Radon exhalation rate from the medium surface by tracing the radon concentration. Effective radium content and radon exhalation rates in soil samples have been measured by ‘‘Sealed Can Technique’’ using LR-115 type II plastic track detectors in Farrukhabad city of Utter Pradesh, India. All the values of radium content in soil samples of study area were found to be quite lower than the permissible value of 370 Bq kg^{-1} recommended by Organization for Economic Cooperation and Development [16].

Zubair *et,al.*,(2012) reported radium concentration and radon exhalation rates of soil samples collected from some areas of Bulandshahr district, Uttar Pradesh, India by using plastic track detectors. They studied that radon becomes airborne with the attachment of dust particle and pollution, after inhalation it becomes deeply trapped in the lung. Therefore the exposure of population to high concentration of radon and its daughters for a long period leads to pathological effects like the respiratory function changes. They also studied that the average values of radium content in the study area are comparable to the global average value of radium in soil. Strong positive co- relation has been observed between radium content, area exhalation rate and mass exhalation rate [17].

Hosoda *et.al*, (2015) has investigated the effect of soil Moisture content on Radon and Thoron exhalation. The measured exhalation rates decrease steadily. Both radon and Thoron exhalation rats decrease to approximately 1/5 with increase in the soil moisture content from 8-24% [18].

The present study area lies in high risk seismic zone IV. In light of seismic activities in Himachal Pradesh, this article focuses to measure radium concentration and radon exhalation rates of soil samples collected from Hamirpur area of Himachal Pradesh.

MATERIAL NAD METHODS: Soil sample were collected from different areas of Hamirpur by grab sampling method. The samples were further studied using Sealed Can Technique. In this technique dried samples (100gm) were placed at the bottom of the plastic Cans of size 7.5 cm height and 7 cm in diameter [17].

The mouth of the Can was sealed by a cover fixed with LR-115 type II plastic track detector in such a way that the sensitive surface of the detector faced the material. The detector records the track of α-particles emitted by radon gas produced. The etching is carried out to reduce the thickness of the LR-115 type detector about 5μm, which is obtained by 1.5 hours etching of the detector in 2.5 N, NaOH solution at 60^{o}C in a constant temperature water bath to reveal the tracks. Subsequently α- tracks at a magnification of 400x were recorded by microscope.

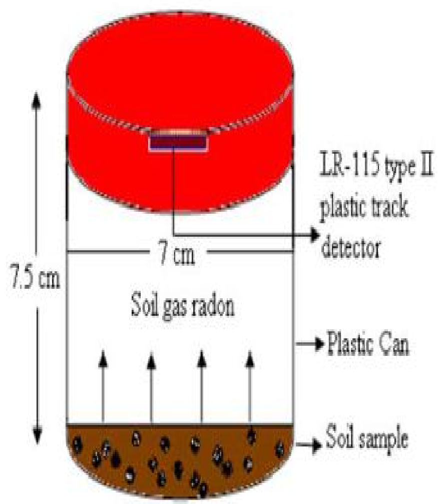

Figure 1: **Experimental setup for measurement of Radium concentration and Radon exhalation rates in soil sample.**

Formula used: The radium concentration was calculated by using formula which is given as under [17].

$$C_{Ra} = \frac{rhA}{KT_eM} \quad (1)$$

Where; r = 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 (which depend on the height and radius of the measuring Can)

Exhalation rates in terms of area and mass were calculated from the following equation which was earlier used by various researchers [17].

Area exhalation rate,

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

Mass exhalation rate,

$$E_m = \frac{CV\lambda}{M[T + \lambda^{-1}(e^{-\lambda T} - 1)]} \; BqKg^{-1}h^{-1}) \quad (3)$$

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)

Survey Area: Himachal Pradesh is situated in the western Himalayas. It extends from the latitudes 30°22'40" North to 33°12'40" North and longitudes 75°45' 55" East to 79°04' 20" East. It is located in the northern part of India, the state stands bordered by Uttar Pradesh in the southeast, Punjab in the west, , China in the east, Jammu and Kashmir in the north and Haryana in the southeast. The entire state of Himachal has altitude ranging from 350 meters to 7000 meters above sea level. The study area involves Jwalamukhi Thrust. Soil samples were collected along Jwalamukhi Thrust, from Ranital, Jwalamukhi, Naudan, Hamirpur and Bhota regions of Kangra and Hamirpur Districts of Himachal Pradesh.

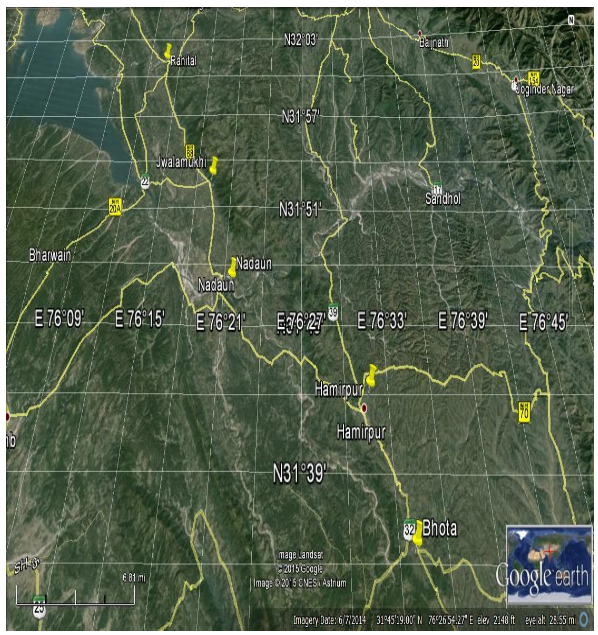

Figure 2: Study Area (www.googalearth.com) [19]

RESULTS AND DISCUSSION: Figure 3 show correlation between Area exhalation rate and Radon concentration. It is clearly evident from the plot that Area exhalation rate and Radon concentration are closely related with each other.

The values of radon exhalation rate in terms of area, mass and radium concentration have been calculated from track density of collected soil samples from different areas of Hamirpur, Himachal Pradesh. In the present investigation, the area exhalation rate for radon ranges from 2.03197E-06 to 4.93881E-07 Bqm^{-2}h^{-1} with an average of 3.564976E-06 Bqm^{-2}h^{-1} and standard deviation of 458.84. The values of mass exhalation rate for radon ranges from 1.02417E-07 to 7.24148E-08 $Bqkg^{-1}h^{-1}$ with an average of 2.648556 $Bqkg^{-1}h^{-1}$ and standard deviation of 32.43. The value of radon exhalation rate in soil samples observed with in safe limit of the global value of radon exhalation rate from soil which is in the range of 0.02-0.05$Bqm^{-2}h^{-1}$.

Table 1: Radium concentration and radon exhalation rate in soil sample. (Soil-1: Hamirpur, Soil-2: Ranital, Soil-3: Nadaun, Soil-4: Jawalamukhi, Soil-5: Bhota)

Sr. No.	Sample code (Longitude, Latitude, Elevation)	Radon Exhalation Rates		Radium concentration $(Bqkg^{-1})$
		$E_A \times 10^{-3}$ $(Eqm^{-2}h^{-1})$	$E_M \times 10^{-3}$ $(Bqkg^{-1}h^{-1})$	
1	Soil-1 (N 31°41′54″, E 76°30′43″, 793m)	2.03197	1.30943E-07	0.115
2	Soil-2 (N 32°52′30″, E 76°13′12″, 530m)	2.69518	1.02417E-07	0.090
3	Soil-3 (N 31°36′46″, E 76°28′20″, 478m)	3.44588	7.72148E-08	0.068
4	Soil-4 (N 31°52′42″, E 76°19′23″, 511m)	4.93881	1.87675E-08	0.170
5	Soil-5 (N 31°36′32″, E 76°34′20″, 870m)	4.99988	1.79095E-08	0.015
Minimum		2.03197	1.02417E-07	0.159
Maximum		4.99988	7.24148E-08	0.068
Mean		3.56497	2.648556	0.0613
S.D.		458.84	32.43	0.9388

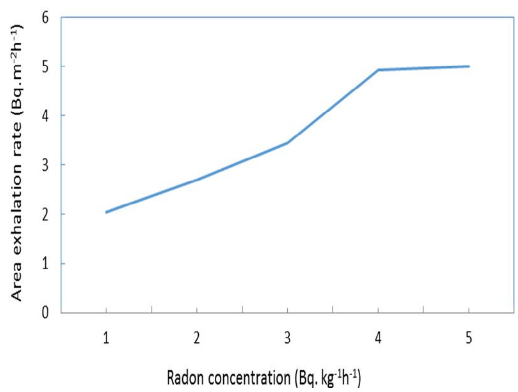

Figure 3: Plot between radium concentration and area exhalation rate.

The observed values of radium concentration in soil samples in the present study are within the recommended action level 370 $Bqkg^{-1}$ and also within the average global value of 35 $Bqkg^{-1}$. The soil of this area is advisable to use in building construction. The correlation between the radium concentration and the radon emanation potential of the source material is required for radon risk. A positive correlation has been observed between radium concentration and area exhalation rate in soil of the study area.

CONCLUSION: The average values of radium content in the study area are within the global average value of radium in soil.

The values of radon exhalation rate in soil samples of the study area are quit lower than the areas known for Uranium mineralization is within the global value. Therefore the use of soil of this area in Brick manufacturing for building construction is considered to be safe.

Highest activity was found in soil number 4. The results reveal that radon gas is chemically unreactive with soil sample. Radium concentration was found with safe limit. The result also reveals that the area is safe for as the health hazard effects of radium and radon exhalation rate are concerned.

Strong positive correlation has been observed between radium content, area exhalation rate and mass exhalation rate.

REFERENCES:

1. Barooah, D. Barman, S. and Phukan, S. 2013. Study of environmental radon exhalation, radium and effective dose in Dillijepore coalfield, India using LR 115(II) Nuclear track detectors. *Journal of pure and applied physics.* 51: 690-695.
2. Sonkawade, R.G. Kant, K. Muralithar, S. Kumar, R. and Ramola, R.C. 2008. Natural Radioactivity in common building construction and radiation shielding materials. *An atmospheric Environment.* 42: 2254-2259.
3. US Environmental Protection Agency 2004. A citizen's guide to radon, fourth edition Washing-

ton DC, US Government Printing office: 402-K02-006.

4. Khan, M., Zubair, M., Verma, D., Naqvi, A. H., Azam, A. and Bhardwaj, M. K. 2011. The study of indoor radon in the urban dwelling using plastic track detectors. *Environ Earth Sci.* 63: 279-282.

5. Sahoo, B. K., Nathwani, D., Eappen, K. P., Ramachandran, T. V., Gaware, J. J. and Mayya, Y. S. 2007. Estimation of radon emanation factor in Indian building materials. *Radiation measurement* 42: 1422-1425.

6. Keller, G., Hoffmann, B. and Feigenspan, L. 1999. Radon permeability and Radon exhalation of building materials. *Institute of biophysics.*

7. Jelsch, G. Thieblemont, D., Labeld, V. and Richon, P. 1999. Radon ($^{222}R_n$) Level variations on a regional scale: influence of the basement trace element (U, Th) Geochemistry on Radon exhalation rates. *Journal of environmental Radio activity*. 53: 75-90.

8. Kumar, A., Singh, B. and Singh, H. 2001. Uranium and Radon exhalation studies in some soil sample from Una Distt. Himachal Pradesh, India using track etching technique. *Journal of pure and applied physics*. 39: 760-764.

9. Ramola, R. C. and Choubey, V. M. 2003. Measurement of Radon exhalation rate from soil samples of Garhwal Himalaya, India. *Journal of Radio analytical and nuclear chemistry*. 256: 219-223.

10. Sun, K., Guo, Q. and Zhuo, W. 2004. Feasibility for mapping Radon exhalation rate from soil in China. *Journal of nuclear science and technology*. 41: 86-90.

11. Singh, S., Rani, A. and Kumar, R. 2005. Ra^{226}, Th^{232}, K^{40} analysis in soil samples from some areas of Punjab and Himachal Pradesh, India using gamma ray spectrometry. *Journal of radiation measurements*. 39: 431-439.

12. Mehra, R., Singh, S. and Singh, K. 2006. A study of Uranium, Radium, Radon exhalation rate and Indoor Radon in the environs of some areas of the Malwa region, Punjab. *Journal of applied science.* 40: 740-748.

13. Sahoo, B. K., Nathwani, D., Eappen, K. P., Ramachandran, T. V., Gaware, J. J. and Mayya, Y. S. 2007. Estimation of radon emanation factor in Indian building materials. *Radiation measurement.* 42: 1422-1425.

14. Mahur, A., Kumar, K. and Mishra, M. 2010. Study of radon exhalation rate and natural radioactivity in soil samples collected from east Singhbhum Shear John in Jaduguda U-Mines area Jharkhand, India and its radiological implications. *Journal of pure and applied physics*. 48: 486-492.

15. Zubair, M., Khan, M. and Verma, D. 2011. Assessment of Indoor Radon, Thron and their decay products in the surrounding areas of Firozabad ,utter Pradesh , India. *Archives of applied science research*. 3: 77-82.

16. Yanlian, Y. and Xiao, D. 2013. Measurements of the Radon exhalation rate from the medium surface by tracking the Radon concentration. *Journal of Radio analytical and nuclear chemistry*. 295: 2295-2299.

17. Zubair, M., Shakir khan, M. and Verma, D. 2012. Measurement of radium concentration and radon exhalation rates of soil samples. *Iran. J. Radiate. Res.* 10: 83-87.

18. Hosoda, M., Shmo, M. and Sugino, M. 2015. Effect of soil moisture content on Radon and Thoron exhalation. *Journal of nuclear science and technology* 44: 664-667.

19. www.googalearth.com