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Soil-gas radon monitoring in Hamirpur District of Himachal Pradesh, NW-Himalaya, India

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ABSTRACT: The Tectonic features of Himalaya have been studied by various researchers by different transport mechanisms techniques, which includes active and passive soil gas radon monitoring. Keeping in view the ease of execution of passive technique, soil-gas measurement of radon- thoron concentration was performed by this method at Hamirpur district of North-West Himalayas, India. For this purpose LR-115 type-II detector films (SSNTD's) were used in radon-thoron discriminator at twenty different locations of the study area with an aim to set eventual correlation between radon-thoron anomalies and faults / fractured zone in lithology of area.

Keywords: Solid state nuclear track detector; radon; thoron.

INTRODUCTION: The Inert, radioactive radon which is formed by the decay of uranium present in earth crust can migrate through the soil and enter the atmosphere. The migration mechanism is two way process diffusion and convection. The second mechanism occurs only when a sufficient thermal gradient is available within the soil texture at different locations along upward movement. This type of process also depends on many other local factors such as radium contents, porosity, permeability or moisture contents. The convection of radon is caused by some carrier gases like carbon dioxide, helium, hydrogen and may be by methane. Once radon is free to move, when it has left its original matrix through the emanation process, it can give rise to different mechanisms of migration, until it arrives at the soil surface and exhales to the atmosphere. The dependency of radon migration on soil features leads the various researchers all around the India and world to study mechanisms like geothermal process, groundwater features, petrochemical studies, natural gases escapes, fault delineation, seismic studies and indoor radon for health hazard purpose both theoretically and experimentally [Etiope and Lombardi 1995, Igarashi et al. 1995, Ciotoli et al. 1998, Guerra and Lombardi 2001, Al-Tamimi and Abumurad 2001, Chyi et al. 2005, Fu et al. 2005, Singh et al. 2005, Kumar et al. 2009, 2012, 2013a, 2013b, Pereira et al. 2010, Singh et al. 2010, Sac et al. 2011, Yang et al. 2011, Li et al. 2013, Walia et al. 2013, Koike et al. 2014, Han et al. 2014, Jaishi et al. 2014, Jashank, 2014, Georgy et al. 2015, Piersanti et al. 2015]. Himalayas are tectonically and seismically very active, various geological formations in the Himalaya were measured by many researchers using soil gas leakage techniques using various active and passive techniques [Kumar et al. 2009, 2012, 2013a, 2013b, Walia et al. 2013]. The passive techniques using LR-115 type-II is a cost effective and reliable method to measure the radon thoron anomalies for seismic activities and fault delineation studies [Singh et al. 2006, Kumar et al. 2013]. The present study related to measure the radon –thoron using SSNTD film using LR-115 type –II detectors in radon-thoron discriminators in Hamirpur district of Himachal Pradesh, India at twenty sites.

Geology of Study Area: Himachal Pradesh located in the NW Himalayas with mountainous terrain between the river Ravi in the north-west and Yamuna in the south west. It lies between 75°45′55″ to 79°04′20″ east longitude and 30°22′40″ to 33°12′20″ north latitude. Hamirpur is one of the district of Himachal Pradesh which is situated between 76°18′ to 76°44′ East longitude and 31°25′ to 31°52′ North latitude. Geology of Hamirpur district comprises of mainly two formations

1. **Quaternary (Alluvium)**: which includes sand, Clay formations and Pebble.

They are of two types (a) Old Alluvium: which are distributed in the area of Naduan- sandhole and Hansi- Pattan along Beas rivers and Bhoraj tehsil along sir Khad. (b) Young Alluvium: They are formations along the central part of Hamirpur district.

2. Shiwaliks: They include conglomerates, boulders and pebbly sandstone, Micaceous sandstone, purple sand stone and shales.

Conglomerates are the major geological formations of the district, they are compact and hard in northern part, while in south-east parts they are fractured [Ground Water information booklet, 2013]. One part of MBT (main boundary thrust) i.e. Jawalamukhi Thrust also runs along the centre of district. The traces of some radioactive elements especially uranium are also reported in Hamirpur district of Himachal Pradesh [Geology and Mineral resources of Himachal Pradesh, 2011].

MATERIALS AND METHODS: Radon and thoron have been measured with the SSNTDs using track etch technique (Solid State nuclear track detectors) in area of Hamirpur district, Himachal Pradesh, India at twenty locations. This technique is discussed in literature by various researchers [Kumar et al., 2013; Kumar et al., 2016]. The radon detector is a discriminator for the Radon –Thoron. A rectangular aluminum strip was slipped into the discriminator on which SSNTDs were fixed .The SSNTD films were cut in to the pieces of size of 1.5cm x 1.5cm and were placed one at the bottom of the discriminator and other at the top. Upper detector was used to record alpha particle tracks due to Radon and lower was used record tracks due to both radon and Thoron. The SSNTDs (LR-115 Type -2 Films) are deep red colored cellulose nitrate films, with 100μm thick polyester base and 12 μm thick sensitive portion. The important thing is that the energy limit for LR-115 type II detector is 4Mev and the energy of the alpha particle emitted by decay of radon and thoron is more than the 5Mev, moreover this type of films are less influenced by moderate moisture, heat and light. The detectors were placed at the monitoring locations at depth of about 50-70 cm deep, the tracks that were created on the films due the alpha particles of radon-thoron were etched with 10M NaOH solution at (60 ±1)℃ for 90 minutes there after the film was washed with water and dried for some time. The track densities on films were obtained by counting the tracks under optical microscope of 400× , after then tracks were converted into equivalent radon-thoron concentrations by using relation discussed by Eappen and Mayya, [2004].

RESULTS AND DISCUSSION: The values of radon and thoron concentrations as measured in the study area are listed in Table 1.

The radon concentrations is the study area varies from 1400 Bq/m^3 – 6530 Bq/m^3.The average value of radon concentration in the study area is 1598 Bq/m^3 whereas the standard deviation in the measurement of radon concentration is found to be 1108 Bq/m^3. The thoron concentrations in the study area vary from 127 Bq/m^3 - 861 Bq/m^3 with average value of 313 Bq/m^3 and standard deviation value of 222 Bq/m^3. The radon –thoron anomalies can be calculated by any of the statistical methods as discussed by by different authors in the past (Guerra et al. 2001, Walia et al. 2005, Fu et al. 2005 Kumar et al. 2013). Here these anomalies are fixed at average (μ) plus one standard deviation (σ). Fig. 5 and 6 shows the variation of radon and thoron concentration (Bq/m^3) at different sampling locations in comparison to average (μ) and average+standard deviation value (μ+σ). The anomaly value for radon must be greater than 2706 Bq/m^3, whereas this value for thoron must be greater than 535 Bq/m^3. The radon anomaly is reported only at one station that is at serial no. 2 Bharoli with value of 6530 Bq/m^3. Thoron anomalies were reported at serial no. 4 Bhoopal, sr. no. 2 Bharoli and serial no. 6 at Ropa. With anomaly values of 861 Bq/m^3, 861 Bq/m^3 and 600 Bq/m^3. The study performed by the researchers in this area was near to Jwalamukhi thrust. The similar study was also conducted by the Kumar et al. [2013] in the Dharamshala region in the vicinity of MCT (Main central thrust) and MBT (main boundary thrust) they reported the high value radon-thoron values at this area.

CONCLUSIONS:

1. Very less anomalies were reported in this study area.

2. The area is very less active than the MCT and MBT of nearby area.

3. The area is suitable for big structures as compared to other areas of Himachal Pradesh.

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Table1: Radon/ Thoron concentrations at twenty locations in Hamirpur District of Himachal Pradesh, India

Sr. No.	Places	Longitude	Latitude	Altitude	Radon concentration (Bq/m^3)	Thoron concentration (Bq/m^3)
1	Hamirpur	E 76°31′344″	N 31°41′587″	753m	1430	400
2	Bharoli	E 76°20′189″	N 31°47′468″	422m	6530	861
3	Nadaun	E 76°20′707″	N 31°47′003″	434m	3030	230
4	Bhoopal	E 76°22′885″	N 31°44′342″	465m	1400	861
5	*Rangas	E 76°26′427″	N 31°43′732″	498m	2100	261
6	Ropa	E 76°33′268″	N 31°40′345″	769m	2200	600
7	Lambloo	E 76°35′259″	N 31°40′189″	768m	1400	161
8	CPU	E 76°37′402″	N 31°37′300″	953m	1530	200
9	Balokhar	E 76°36′345″	N 31°35′911″	936m	2030	230
10	Karwi	E 76°36′897″	N 31°39′533″	852m	2123	132
11	Bhota	E 76°34′053″	N 31°36′488″	726m	1673	243
12	Masoui	E 76°33′610″	N 31°37′262″	725m	1564	176
13	Didwi	E 76°33′689″	N 31°37′413″	722m	1743	178
14	Tikar	E 76°33′729″	N 31°37′709″	736m	1750	180
15	Kohli	E 76°33′657″	N 31°38′286″	710m	1900	143
16	Mattan	E 76°33′166″	N 31°38′671″	704m	1782	298
17	Kadru	E 76°32′886″	N 31°39′351″	725m	2187	127
18	Taropka	E 76°32′510″	N 31°39′666″	730	1865	198
19	Dugha	E 76°32′474″	N 31°39′801″	737	1987	154
20	Dosadka	E 76°31′953″	N 31°40′495″	706	1765	226

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