Measurement and Analysis of Radon Concentrations in Soil Gas Along Kurlok Fault Regions of Kolasib District, Mizoram India

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***Abstract*—In order to identify the distribution of radon concentrations in soil gas along Kurlok Fault, measurement was done on various fault regions of Kolasib District of Mizoram,India. Radon gas concentrations were measured on the ground at different depths of 60 cm, 90cm and 120 cm along the fault regions of Kurlok Fault lines using scintillation based detector Smart RnDuo device. Other fault lines were also studied for comparison purposes. The average values of radon concentration in soil gas of Kurlok Fault regions were 5.93 kBq/m3 at 120 cm depth, 2.93 kBq/m3 at 90cm depth and 0.13 kBq/m3 at 60 cm depth which were higher than the averages of other fault regions having values of 3.77 kBq/m3 at 120 cm depth, 1.9 kBq/m3 at 90 cm depth and 0.12 kBq/m3 at 60 cm depth. This shows that radon is more concentrated around Kurlok fault regions of the district. The results in the present work also indicate that value of radon concentrations increases with increase in depth. The grain size distribution of the soil samples were also analysed and were found to be sandy type of soil.**

Keywords— Fault regions, Grain size, Radon concentration, Soil gas, Smart RnDuo

I. INTRODUCTION

Radon is a colourless inert gas and is the heaviest noble gas having atomic radius of 1.34 Å. In the fourteen step sequence of ^{238}U radioactive decay series, this gaseous radon is formed and the sequence ends with the formation of ^{206}Pb which is stable and non-radioactive. Radon is fairly soluble in water and two are found in significant concentrations in human environment – Radon Rn222 and Thoron Rn220. This mobile radon isotope 222 has a half-life of 3.8 days, which is long enough to diffuse into the atmosphere through the solid rock or soil in which it is formed. Radon can enter the body through breathing causing damage to lug tissue and leading to lung cancer over the course of time. The long term exposure to radon especially in indoor places like closed rooms, caves or even mines cause about 10% of deaths from lung cancer. Radon in the soil is important because soil and rocks which are rich in uranium are the main sources of radon [1]. Radon concentration in soil gas is an important factor for evaluation indoor radon measurements. Concentrations of radon gas are much higher in the soil as compared to the environment. Radon concentration in soil gas can vary due to the geology of the area [2]. Radon being formed continuously in the soil and released in air is not an environmental hazard but it becomes an environmental hazard when it remains concentrated in enclosed places such as houses, caves and mines. Radon in the earth's crust can move freely around the pore spaces by diffusion process. The gases escape from the soil grain by emanation process and escape to the atmosphere by the process of exhalation. The top few meters of the ground are responsible for about 80% of radon emitted in the atmosphere [3]. The radon emanation varies from region to region depending upon parameters like moisture content, atmospheric pressure and grain size [4]. Fault lines are also responsible for movement of radon through rocks under the earth [5].

The purpose of this study is to identify the distribution of radon concentrations in soil gas along Kurlok Fault. This is the first investigation done in the areas for radon concentrations in soil gas. Radon gas concentrations are measured on the ground at different depths of 60 cm, 90cm and 120 cm along the fault regions of Kurlok using scintillation based detector Smart RnDuo device. For comparison analysis, other fault regions of Kolasib District are also measured each at different depths of 60 cm, 90cm and 120 cm. In order to identify the type of soil present in the areas of investigation, soil type analysis was also carried out to determine whether the soils in the study areas are of different types..

II. MATERIALS AND METHODS

Mizoram lies in the seismic zone V of seismic zonation map of India. The state of Mizoram is a hilly area and a tropical region with moderate climate and the temperature varies from 11ºC to 24 ºC during the winter season and 18 ºC to 29 ºC during summer. The study areas of Kolasib lie in the northern parts of Mizoram sharing its borders with Assam. Kurlok fault regions lie on the junctions of Rengtekawn and is also called Rengtekawn fault. The study area extends 24° 11' 08.93" to 24° 20' 58.15"latitude and 92° 40' 32.85"to 92° 48' 34.25"longitude and having elevation ranges of 36 m to 568 m above sea level. The areas of investigation consists of several fault lines as shown in figure 1.Kurlok fault consists of fault lines covering a few kilometers and covers the largest area among the faults in Kolasib District. The area is significant because in theory movement of radon is expected to be more

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 11 Issue 09, September 2022

abundant around the areas as it is considered to consist of more than one fault line.

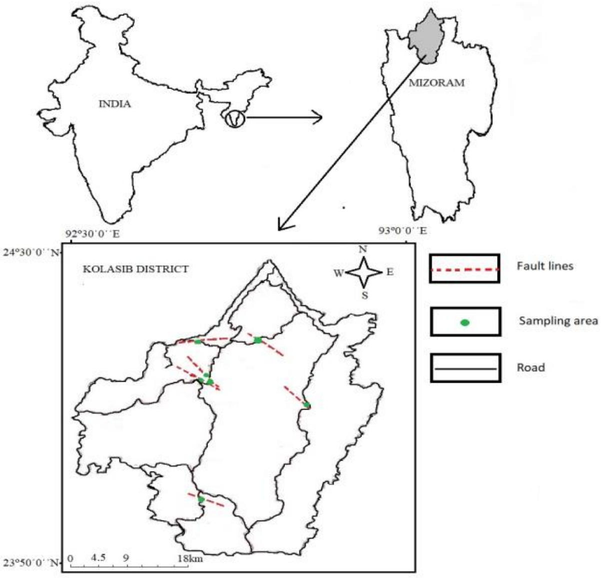

Figure 1: Geological map of the study area

Radon concentrations in soil gas were measured at different fault regions using a scintillation based detector Smart RnDuo as shown in figure 2. The RnDuo consists of a scintillation cell which is coated by ZnS:Ag on the inside. This is connected to a photomultiplier tube. Radon measurements are based on detection of alpha from radon and its decay products inside the scintillation cell. This is counted by the photomultiplier tube and the associated counting electronics. The results are then displayed on the display screen. The upper detection limit is 50 MBq/m3 and minimum detection limit of 8 Bq/m3 at 1σ and 1 h cycle for radon and 15 Bq/m3 at 1σ and 1 h cycle for thoron.

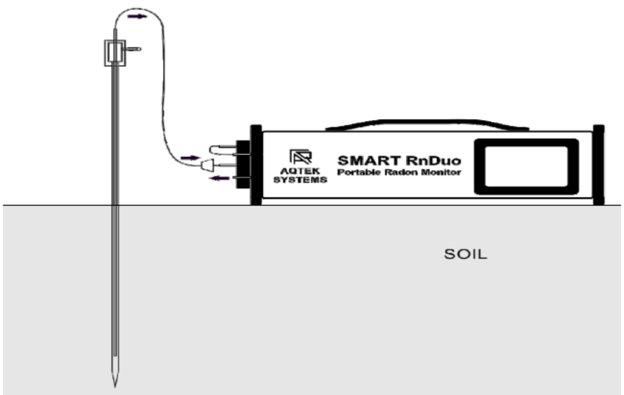

Figure 2: Smart RnDuo

A soil probe of suitable length is inserted on the ground which is connected to the Smart RnDuo device by means of pipes connected at different ends. For each location, measurement is taken at a cycle of 15 minutes for about 1 hour each accumulating to 4 to 5 readings each. The average of the readings obtained is calculated. Measurement is taken at different depths of 60 cm, 90cm and 120 cm along the Kurlok fault regions as well as the other fault regions of Kolasib District for comparison. Global Positioning System (GPS) device was used to determine the exact geographical coordinate.

For classification of soil type United States Department of Agriculture (USDA) textural soil classification was used in which soil type is classified based on particle size distribution. These particle sizes can be categorized as sand (2.0 – 0.05 mm), silt (0.05 – 0.002mm) and clay (smaller than 0.002mm) which can further be refined to 12 classes [6]. The grain size of soil is an important factor that contributes to radon concentration in soil [7]. Soil samples were collected from the fault lines and were dried up. A mechanical sieve shaker consisting of different sieve sizes with different mesh number was used to sieve the soil samples. Sieves of sieve mesh number 60 (grain size 0.25 mm sand), 120 (grain size 0.125 mm sand), 230 (grain size 0.0625 mm very fine sand), 325 (grain size 0.044 mm silt/mud) and >325 (grain size smaller than 0.044 mm clay) was used to identify the grain size distribution. Percentage of the grain size distribution was then plotted.

III. RESULTS AND DISCUSSION

The values of radon concentration in soil gas as well as the coordinates are shown in table 1. The average values of radon concentration in soil gas of Kurlok Fault regions denoted by K1, K2 and K3 were 5.93 kBq/m3 at 120 cm depth, 2.93 kBq/m3 at 90cm depth and 0.13 kBq/m3 at 60 cm depth. On the other hand, the average values of radon concentration in soil gas in the other regions were 3.77 kBq/m3 at 120 cm depth, 1.9 kBq/m3 at 90 cm depth and 0.12 kBq/m3 at 60 cm depth. We can see that the average concentration in soil gas is greater in the Kurlok fault regions when compared with the other regions of the district. This may be due to the fact that Kurlok fault consists of a larger or longer fault line passing through the junctions. Since movement of radon through rocks under the earth depends on faults, it is expected to have a larger concentration in areas of larger faults.

TABLE I. MEASUREMENT OF RADON CONCENTRATIONS IN SOIL GAS ALONG KURLOK FAULTS AS WELL AS OTHER FAULT REGIONS OF KOLASIB DISTRICT

Name	Loaction	GPS Coordinate	Concentration		
			120cm depth	90cm depth	60cm depth
K1	Kurlok 1	Elevation 351 m N 24° 15' 11.15" E 092° 40' 37.48"	5.36	2.66	0.12
K2	Kurlok 2	Elevation 410 m N 24° 14' 59.27" E 092° 41' 34.60"	9.37	4.62	0.18
K3.	Kurlok 3	Elevation 552 m N 24° 14' 55.2" E 092° 41' 12.6"	3.06	1.51	0.11
K4.	Chemphai	Elevation 38 m N 24° 20' 57.5" E 092° 45' 23.5"	0.83	0.48	0.11
K5.	Buhchangphai	Elevation 36 m N 24° 20' 58.15" E 092° 40' 32.85"	6.29	3.09	0.15
K6.	Thingthelh	Elevation 587 m N 24° 11' 08.93" E 092° 48' 34.25"	6.13	3.13	0.13
K7.	New Khamrang	Elevation 313m N 23° 57' 19.59" E 092° 41' 04.06"	1.84	0.91	0.1

The measured values of radon concentration from all the different locations are shown in figure 3,4 and 5 and lies between the range of 0.83 kBq/m3 to 9.37 kBq/m3 with an average value of 4.70 kBq/m3 at 120cm depth; from 0.48 kBq/m3 to 4.62 kBq/m3 with an average value of 2.34 kBq/m3 for 90cm depth and from 0.1 kBq/m3 to 0.18 kBq/m3 with an average value of 0.13 kBq/m3 for 60cm depth. The highest value of radon concentration for all the different depths lies in K2 having a value 9.37 kBq/m3 at 120cm, 4.70 kBq/m3 at 90cm and 0.18 kBq/m3 at 60cm depth Bq/m3 while the lowest value for 120cm and 90cm lies in K4 with values of 0.83 kBq/m3 and 0.48 kBq/m3 respectively.The lowest value for 60 cm is on K7 with values of 0.1 kBq/m3.

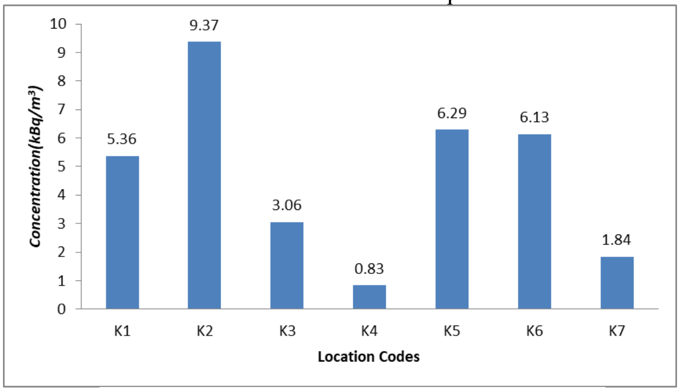

Figure 3: Radon concentrations in soil gas at 120cm depths

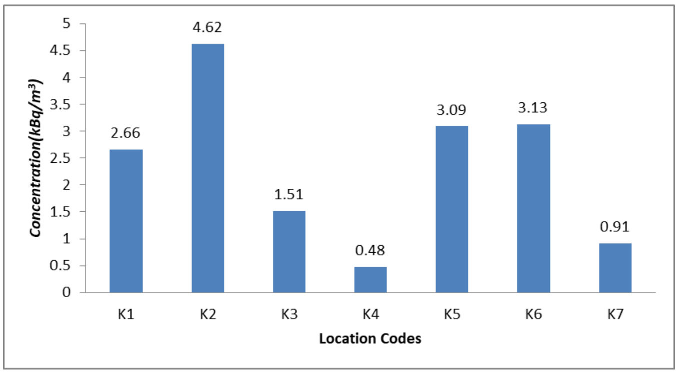

Figure 4: Radon concentrations in soil gas at 90cm depths

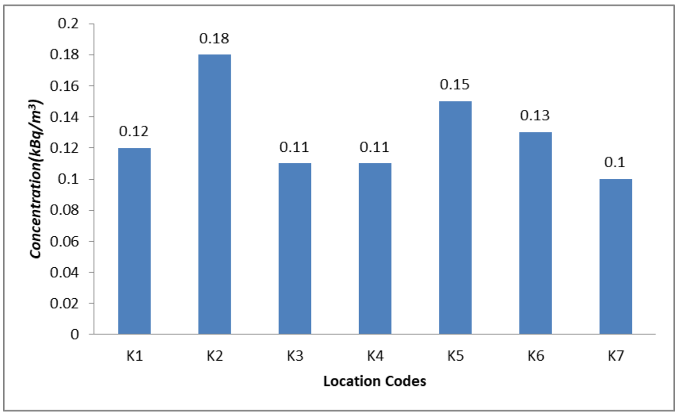

Figure 5: Radon concentrations in soil gas at 60cm depths

The average values of radon in soil gas at different depths are shown in figure 6. The results show that the average concentration is greater at depths of 120cm when compared with the other depths. The lowest average concentration is on 60cm depth. The results indicate that value of radon concentrations varies with the different depths. It was seen that the value of radon concentrations increases with increase in depth. The variation in concentration may be due to soil moisture content with increasing depth of the soil. This trend follows the same trend as measurements done by Duggal et al., Hasan et al. and Kaur et al. [8-10].

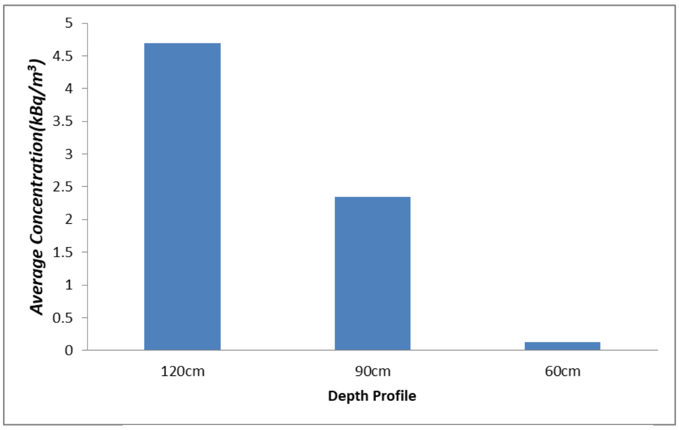

Figure 6: Average radon concentrations in soil gas at different depths

Figure 7 shows the triangular plot of USDA textural soil classification. The results obtained from the soil samples indicate that most of the soil particle size is distributed to mostly sandy type of soil. Usually the concentration decreases with sand content in the soil and increases with clay content in soil. The results from the figure indicates that majority of the particles are distributed among 60,120 and 230 mesh sizes indicating that most of the soil lies in the sandy region. Thus we can conclude that there is no variation among the soil in the investigation as they are all sandy type of soil.

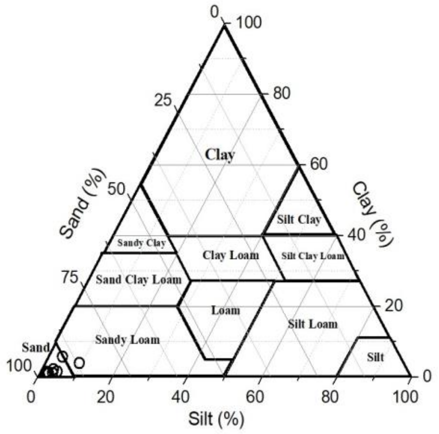

Figure 7: USDA triangular plot for soil samples from Kolasib District

The results from this present investigation is compared with results from recent work done by other investigators and is shown in table 2. The results from this investigation is well within the ranges of results from Prasad et al. (1.10–31.80 kBq/m3), Bourai et al.(0.01–2.33 kBq/m3) and Vikas Duggal et al. (0.09–10.40 kBq/m3) [11-12]. The differences in variation of concentration may be due to differences in geology of the different areas of investigations. The type of soil in different regions may be different and also the soil moisture content may vary depending on the location.

TABLE II. COMPARISON TABLE OF RADON CONCENTRATION IN SOIL GAS WITH RESULTS FROM OTHER INVESTIGATORS

Investigators	Radon concentration range (kBq/m^3)	Year	Area of investigation
Prasad *et al.*	1.10–31.80	2008	Budhakedar,Tehri Garhwal, India
Bourai *et al.*	0.01–2.33	2013	Garhwal Himalaya, India
Vikas Duggal *et al.*	0.09–10.40	2014	Sri Ganganagar district, Rajasthan, India
Present investigator	0.1 – 9.37	-	Kurlok fault regions, Kolasib District, Mizoram, India

IV. CONCLUSIONS

The average values of radon concentration in soil gas of Kurlok Fault regions at 120 cm depth, 90cm depth and 60 cm depth were each found to be higher than the averages of other fault regions from Kolasib District indicating that radon soil gas are more concentrated around Kurlok fault regions in comparison. This shows that radon gas concentrations are more abundant around Kurlok fault regions of the district.

Comparing the depths of 120 cm, 90cm and 60 cm, each reading shows that the radon gas concentrations are highest in the 120 cm depths. This indicates that radon concentration in soil gas increases with depth of the soil.

The results of soil type analysis shows that most of the soils are of sandy type. More than 90% of the particles were distributed among sand and the rest are silt and clay. From this we can confirm that all of the soil analysed are of the same type of soil i.e. sand. Therefore for this particular analysis there is no variation of soil type.

ACKNOWLEDGEMENT

The authors are thankful to the Board of Research in Nuclear Sciences, Department of Atomic Energy sanction number 36(4)/14/67/2014-BRNS/36016, Government of India, for providing financial assistance through the Research Project..

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