Vol: 6 | Issue: S3 | March 2013 | ISSN: 0974-6846

Indian Journal of Science and Technology

An international peer reviewed monthly research journal

A special issue containing the papers of the national conference, New Approaches of Basic Sciences Towards the Development of Engineering and Technology (NABSET)-2013, organized by Don Bosco College of Engineering and Technology, a constituent unit of Assam Don Bosco University.

Published by: Indian Society for Education and Environment
www.iseeadyar.org

Radon Activity in Soil-air Environment of Forest and Urban Residential Areas of Shillong, Meghalaya

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(**Note:** Please refer the Table.1,Table.2 and Fig.2 at end of the articles)

Abstract:

In this paper we have reported our findings of the value of Radon activity concentration in and around forested and urban residential areas of Shillong. Detectors are installed in 08 forested and 08 urban residential areas for two consecutive cycles of 14 days each. The average radon activity concentration in forested areas is found to be higher than the urban residential areas by a factor of 1.8.

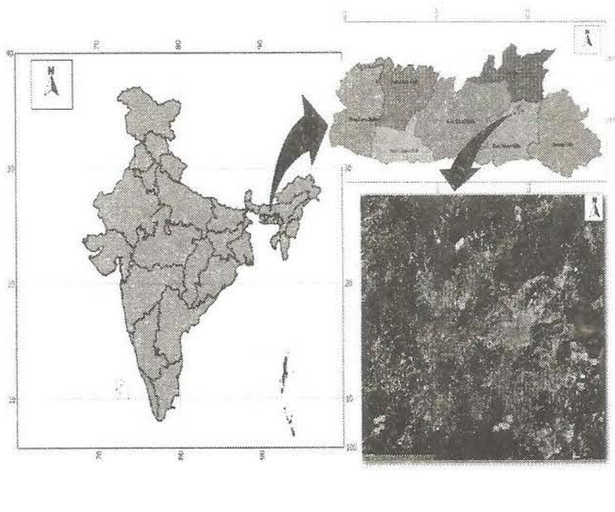
Keywords: *Radon, Soil-air, Forest area.*

1. Introduction

Radon is a noble gas isotope formed by the decay of Radium. Radium is one of the nuclides formed in the disintegration series from Uranium, the amount of radon formed in rocks and soils depends on their uranium content and the extent to which the radon atoms formed actually emanate from the mineral grains (Durrani and Ilic, 1997). Radon from soil is the prime source that enters houses and buildings mainly through cracks and/ or gaps in the building structures. Radon is transported from the soil into the atmosphere by diffusion or by transportation mechanisms or by both (Mogro-Campero & Fleischer, 1977, Abumurad, et al., 1997). The mechanisms of transportations are also determined by geological structures, underground water flow and meteorological conditions underneath the soil (Clement & Wilkening, 1974, Somogyi et al., 1986, Rogers & Nielson, 1988). The aim of our study is to find the value of radon activity concentration in the disturbed soil-air environment and an undisturbed soil-air environment.

In the present paper, radon activity concentration using PVC pipes for two cycles (one cycle consisting of 14 days) in the dry month of April '2012 and has been carried out in 16 sites including forested and urban residential areas of Shillong. In Shillong there are areas which are predominantly either undisturbed forest or urban residential and such patches were selected for study. The work has been undertaken to get an idea of radon activity concentration in Forested and Urban residential soil-air environments of Motinagar, NEHU, Nongrah and Upper Shillong which are located in Shillong. The area of the study which is covered by forest with constructions at least 30 meters away have been considered as an undisturbed forest areas and the area of the study which is closer to any constructions within 1-10 meters from houses have been treated as a urban residential areas. Eight sites were chosen for our study from each forested and urban residential areas of Shillong are shown in Fig1and locations are given in Table 1.

Fig.1 *Map showing the different Sites in Shillong*



2. Experimental Method

We have used the PVC pipe technique for the determination of Radon Activity concentration in the soil-air environments. 16

sites are chosen in the Shillong, Meghalaya. Solid State Nuclear Track Detectors, LR -115 Type II cellulose nitrate films (chemical composition $C_5H_8O_9N_2$, density of 1.52 g cm^{-1}) of size 2x2 sq.cm are fixed on the disposable cups which are fixed on one end of the pipe of 30 cm length. After making the detector unit air-tight the set-up is then placed in the soil dug up to 70 cm depth. The detector is placed in the respective sites for 14 days which constitutes one cycle and then cup with the detector is replaced with a new one, the process is repeated for 2 cycles. After retrieving the detector films, they are etched in 2.5 N NaOH at 60°C for 120 min. The tracks are then counted manually using an Optical Microscope at 150 magnifications. The observed tracks are then converted into Radon Concentration by using the following equation,

$C_R = \frac{\rho}{kT}$; where, ρ = track density (number of Tracks per sq.cm per day): k = Calibration Factor used 0.0312 tracks. cm^{-2} day^{-1} $(Bq.m^{-3})^{-1}$ (Ramola, 1996): T = number of days of exposure.

3. Results and Discussion

The density of tracks which is the number of tracks observed per square cm of the exposed film for forested and urban residential soil for 2 cycles is given in Table 2. And for the first cycle in 8 forested areas Radon Activity Concentration values vary from 4.49 -16.16 $kBq.m^{-3}$ with the geometric mean value as 8.59 $kBq.m^{-3}$ and in 8 urban residential areas the values vary from 1.53 – 11.67 $kBq.m^{-3}$ with the geometric mean value as 4.24 $kBq.m^{-3}$. For the second cycle, radon activity concentration values for the forested area vary from 3.09- 14.84 $kBq.m^{-3}$ with the geometric mean value of 7.21 $kBq.m^{-3}$ and for the urban residential areas varies from 1.44 -9.74 $kBq.m^{-3}$ with the geometric mean value of 4.69 $kBq.m^{-3}$. The overall geometric mean value of the Forested area and Urban Residential area is found to be 8.02 $kBq.m^{-3}$ and 4.47 $kBq.m^{-3}$ respectively, as shown in Table 3.

The average radon activity concentration value in Forested area is found to be highest in Site No. 2 which is in Motinagar and lowest in Site No. 8 which is in Upper Shillong. And the average radon activity concentration value in urban residential areas is found to be highest in Site No. 16 which is in Upper Shillong and lowest in Site No. 9 which is in Motinagar. Shillong had received a mean total rainfall of 128.3 mm in 13 days during the month of April' 2012, period of our study (World Weather Information Service-Shillong, 2012). Radon in soil is believed to be the main source of radon in homes, measurements of soil-gas radon concentrations can be used to estimate the variation in radon potential of indoor environments (Akerblom, & Mellander, 1997). It has been estimated that soil-gas radon activity concentration as low as 10 $kBq.m^{-3}$ can produce an indoor concentration above the UK action level of 200 $Bq.m^{-3}$ (Varley & Flowers, 1998). From our study the average radon activity concentration in soil-air is found to be 7.02 $kBq.m^{-3}$ and an estimate of 140.4 $Bq.m^{-3}$ is found as an average indoor radon concentration in the study area. The estimated indoor radon concentration for the forested and urban residential study sites is found to be more than 172.4 $Bq.m^{-3}$ and more than 106.6 Bqm^{-3} respectively. The annual effective dose (calculated using the parameters given by UNSCEAR, 1993) for the estimated indoor radon concentration in the forested and urban residential areas is found to be around 0.16 $mSv.y^{-1}$ and around 0.10 $mSv.y^{-1}$ respectively (as shown in Table 2).

The higher radon activity concentration in an undisturbed forested soil-air environment may be because the production, migration and exhalation of radon are approximated by diffusion and other processes whereas; in the urban residential sites the presence of a building dramatically changes the system. The soil environment is modified by excavation, grading and fill. The building itself interrupts the diffusive flux to the atmosphere while creating pressure differences that transport soil-gas through cracks, joints and service penetrations (Harry E. Rector, 1991).

4. Conclusion

The eight locations in the forested areas chosen for our study are found to have more radon activity concentration values compared to the 8 locations in urban residential area by a factor of 1.8. And the estimated radon activity concentration in the urban residential areas is found to be 106.6 $Bq.m^{-3}$ and Average Effective dose calculated using the parameters given by UNSCEAR, 1993 is found to be 0.10 $mSv.y^{-1}$ which is below the action limit 1.2 $mSv.y^{-1}$ prescribed by UNSCEAR, 1993.

Tables

Table.1. *Location and soil-gas radon activity concentration in $kBq.m^{-3}$ in coal mining areas and its neighbouring residential sites.*

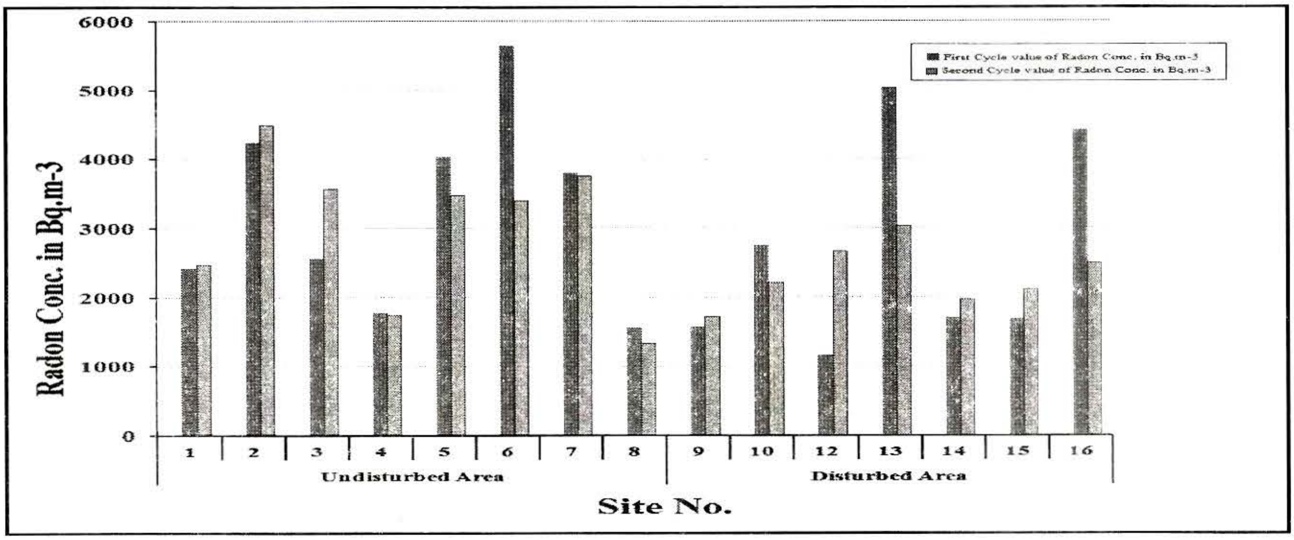
	Site Code	Latitude	Longitude	Elevation in meters	Radon Activity Conc. in $kBq.m^{-3}$		Average Radon Activity Conc. in $kBq.m^{-3}$
					1st cycle	2nd cycle	
Coal Mining Areas	M1	N 25° 20' 56"	E 92° 21' 26.5"	1115	28.66	x	28.66
	M2	N 25° 20' 48.3"	E 92° 21 '32.8"	1111	40.05	39.81	39.93
	M3	N25° 20' 43.6"	E 92° 21' 33.1"	1104	28.22	22.56	25.39
	M4	N 25° 20' 48"	E 92° 21' 39"	1111	47.99	46.69	47.34
	M5	N 25° 20'46.4"	E 92° 21' 21.4"	1114	37.87	33.88	35.88
	M6	N 25° 20' 30.1"	E 92° 21' 19.3"	1097	42.46	39.69	41.07
	M7	N 25° 20' 31.1"	E 92° 21' 13.2"	1108	39.26	38.17	38.71
	M8	N 25° 20' 45.1"	E 92° 21' 15.8"	1119	42.57	45.31	43.94
	M9	N 25° 20' 34.1"	E 92° 21' 40"	1094	55.13	42.59	48.86
	M10	N 25° 20' 26"	E 92° 21' 35.3"	1097	61.19	59.49	60.34
Residential Areas	R1	N 25° 21' 34.5"	E 92°22' 11.4"	1093	41.35	39.57	40.46
	R2	N 25° 21' 48.5"	E 92° 21' 59.8"	1114	39.81	39.57	39.69
	R3	N 25° 21' 50.4"	E 92° 21' 56.6"	1129	40.09	38.76	39.43
	R4	N 25° 21' 44.8"	E 92° 22' 10.2"	1123	17.73	9.00	13.37
	R5	N 25° 21' 29.8"	E 92° 22' 14.7"	1110	14.17	13.37	13.77
	R6	N 25° 21' 42.1"	E 92° 21' 35.5"	1126	23.30	35.62	29.46
	R7	N 25° 21' 33.7"	E 92° 21' 32.2"	1127	37.60	39.04	38.32
	R8	N 25° 21' 26.4"	E 92° 21' 34.8"	1146	23.36	23.47	23.41
	R9	N 25° 21' 22.2"	E 92° 21' 41.7"	1121	15.62	24.28	19.95
	R10	N 25° 21' 20.5"	E 92° 21' 54.4"	1099	32.36	x	32.36

Table.2. *Estimated Indoor Radon Activity Concentration in the coal bearing sites and its neighbouring residential areas (in $Bq.m^{-3}$) and the Dose calculated (in $mSv.y^{-1}$).*

	Site Code	Estimated Indoor Radon Activity Conc. in $Bq.m^{-3}$	Dose calculated in $mSv.y^{-1}$	Average Dose in $mSv.y^{-1}$
Coal Mining Areas	M1	573.27	0.52	0.74
	M2	798.69	0.72	
	M3	507.81	0.46	
	M4	946.82	0.85	
	M5	717.51	0.65	
	M6	821.44	0.74	

	M7	774.28	0.7	
	M8	878.77	0.79	
	M9	977.15	0.88	
	M10	1206.82	1.09	
Residential Areas	R1	809.23	0.73	0.52
	R2	793.89	0.71	
	R3	788.52	0.71	
	R4	267.31	0.24	
	R5	275.45	0.25	
	R6	589.17	0.53	
	R7	766.33	0.69	
	R8	468.23	0.42	
	R9	399.01	0.36	
	R10	647.24	0.58	

Fig.2. *Bar graph showing the Radon Activity Conc. in Bq.m^{-3} in two cycles for forested (Undisturbed) and urban residential (Disturbed) areas.*



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