A STUDY ON THE INDOOR RADON CONCENTRATION IN HOSPITALS IN THE SHILLONG REGION, MEGHALAYA

Yubaraj Sharma[1], Deveshwori Maibam[1], Priya P. Ram[2], Atul Saxena*[1] and Devesh Walia[2]
[1]*Department of Physics, North-Eastern Hill University, Shillong-793022*
[2]*Department of Environmental Studies, North-Eastern Hill University, Shillong-793022*
*For correspondence. (atulnehu@yahoo.co.in)

Abstract: In this paper, we report our findings on indoor radon survey at 8 major hospitals in the Shillong region and also present estimates on the associated annual effective doses and life-time fatality risks. The survey was undertaken using LR-115 Type2 detectors. The measured radon activity concentration values were found to range from 65.66 Bq.m^{-3} to 783.77 Bq.m^{-3} with an arithmetic mean value of 260.4 ± 138.3 Bq.m^{-3} and a geometric mean value of 228.4 ± 1.67 Bq.m^{-3}. Of the total rooms surveyed, 60% have radon concentration more than the ICRP prescribed lower limit of 200 Bq.m^{-3}; about 4% of the rooms had values higher than the upper limit of 600 Bq.m^{-3}. Distribution analysis of the radon activity concentration measured at the hospital rooms is carried out. Floor-wise variation was studied and a decrease in radon concentration with increase in floor-number has been observed.

Keywords: SSNTD; radon; annual effective dose; life time fatality risk; statistical distribution

PACS: 87.55N- and 02.50.-r

1. Introduction:

Radon has become a topic of considerable attention and concern in recent years as the single most significant source of natural radiation exposure to humans. It is present ubiquitously in varying amounts in our living environment, which necessitates its accurate and reliable monitoring for the assessment of radiological health risk arising from it [1]. The association of lung cancer to radon has been known since decades, and although the initial study focused on underground miners exposed to high radon levels, several studies conducted since the early 1980's in homes and buildings have concluded that sufficient indirect evidence exists which link significant lung cancer risk in the general population to the radon levels found commonly in buildings [2].

Radon concentration was measured in 105 rooms of 8 major hospitals located in the Shillong region of East-Khasi Hills District, Meghalaya *viz*. Supercare, Robert, Ganesh Das, Nazareth, Woodland, Bethany, Civil and NEIGRIHMS. About 10 to 16 rooms located at different floors were chosen from hospital building which consists of OPD (Out Patient Department), Emergency, Pharmacies, X-ray rooms, CT-scan rooms, Medicine ward - both male and female, OT (Operation Theatres), General Surgical Wards, Baby rooms, Post Operative wards, Pediatrics Department, Nurse rooms, Plaster rooms etc. The location of the study sites are given in table 1.

2. Materials and Methods:

Solid State Nuclear Track Detectors, namely LR-115 Type2 films are used for our study. The films are cut into small sizes of about 2.5x2.5 cm^2, pasted onto a cardboard of dimension 6x9 cm^2, and hung in the selected rooms such that the detectors are at a distance of at least 10 cm away from the nearest wall and about 2 meters from the ground. The detectors are retrieved after an exposure period of about 60 days; these exposed films are then chemically etched in 2.5N NaOH solution at 60ºC for 90 minutes. The perforated holes or etched tracks formed by the alpha particles (mostly from radioactive decay of radon) appear as bright spot in reddish background; these tracks are counted manually using an optical microscope at 150x magnification.

The track density obtained are then converted into radon activity concentration using the following equation:

$$C_{RN} = \frac{\rho}{kT} \quad (1)$$

where, ρ is the density of the tracks (number of tracks per square cm of the film); k is the calibration factor and a value of 0.0312 tracks.cm^{-2} d^{-1} (Bq.m^{-3})$^{-1}$ [3] is used; and T is the duration (in days) for which the detectors were exposed.

3. Results and Discussion:

The measured indoor radon activity concentration values in rooms of the 8 studied hospitals in Shillong Region are tabulated in table 2. We have also estimated annual radon activity concentration, annual exposure, annual effective dose (AED) using the parameters given by UNSCEAR, 2000 as well as lifetime fatality risks; these measures give an idea of the amount of radon in the given environment as well as the associated hazards posed by it (a detailed discussion is available in reference [5]). The measured indoor radon activity concentration values are found to vary from 65.66 (Supercare Hospital) to 783.77 Bq.m^{-3} (Bethany Hospital) with the overall arithmetic mean (AM) value of 260 ±138.3 Bq.m^{-3} and geometric mean (GM) value of 228.36 ± 1.67 Bq.m^{-3}. Figure 1 shows the average radon activity concentration measured in the eight hospitals with Bethany Hospital having the maximum value with AM of 530.29 ± 112.32 Bq.m^{-3} and GM of 520.38 ± 1.2 Bq.m^{-3} and Woodland Hospital having the minimum value with AM of 151.41 ± 62.83 Bq.m^{-3} and GM of 139.52 ± 1.5 Bq.m^{-3}. Figure 2 shows the plot of radon activity concentration corresponding to different floor level; the error bars represent the variations in the radon activity concentration values obtained in different rooms in the same level of the building. A decrease in the radon concentration has been found with increase in floor level, except in case of the fourth level where only two data points were available for Bethany Hospital, which had relatively higher values.

Table 1: Location of the study sites.

Name of the Hospital	Latitude			Longitude		
Supercare	25	34	5	91	53	56
Robert	25	35	8	91	52	29
GaneshDas	25	35	3	91	53	2
Nazareth	25	34	16	91	53	53
Woodland	25	33	57.38	91	53	11.91
Bethany	25	33	58	91	54	4
Civil	25	34	2	91	52	52
NEIGRIHMS	25	35	29	91	56	28

Table 2: List of the Hospitals where the detectors were exposed with the number of detectors exposed Radon activity concentration obtained in minimum, maximum, arithmetic mean, standard deviation, geometric mean, geometric standard deviation values, estimated annual radon activity concentration, annual exposures, annual effective dose and estimated Life time fatality risks.

Name of the Hospital	No. of detectors studied	Radon Activity Concentration (Bq.m^{-3})						Annual Radon Activity Conc. (Bq.m^{-3})	Annual Exposure		AED (mSv. y^{-1})	Life Time Fatality Risk x 10^{-4}
		Min	Max	AM	SD	GM	GSD		WLM	mJhm^{-3}		
Supercare	11	65.7	385.5	209.8	99.6	188. 7	1.6	186.77	0.60	2.1	4.9	1.80
Robert	13	99.2	313.6	191.1	59.1	178.6	1.4	170.11	0.55	2.0	4.5	1.64
Ganesh Das	15	83.5	418.6	235.4	101.0	213.7	1.5	209.51	0.67	2.4	5.5	2.01
Nazarath	16	132.7	432.9	255.4	90.4	240.3	1.4	227.33	0.38	2.6	6.0	2.06
Woodland	10	82.6	225.6	153.7	58.3	143.3	1.5	136.82	0.44	1.6	3.6	1.10
Bethany	13	395.2	783.8	530.3	112.3	520.4	1.2	471.96	1.51	5.3	12.5	4.54
Civil	13	121.6	382.3	253.9	91.8	237.1	1.5	225.94	0.72	2.6	6.0	2.17
NEIGRIHMS	14	83.6	391.8	228.4	97.6	207.0	1.6	202.51	0.21	0.8	5.3	0.64

(Min=Minimum: Max=Maximum: AM=Arithmetic Mean: SD=Standard Deviation: GM=Geometric Mean: GSD= Geometric Standard Deviation)

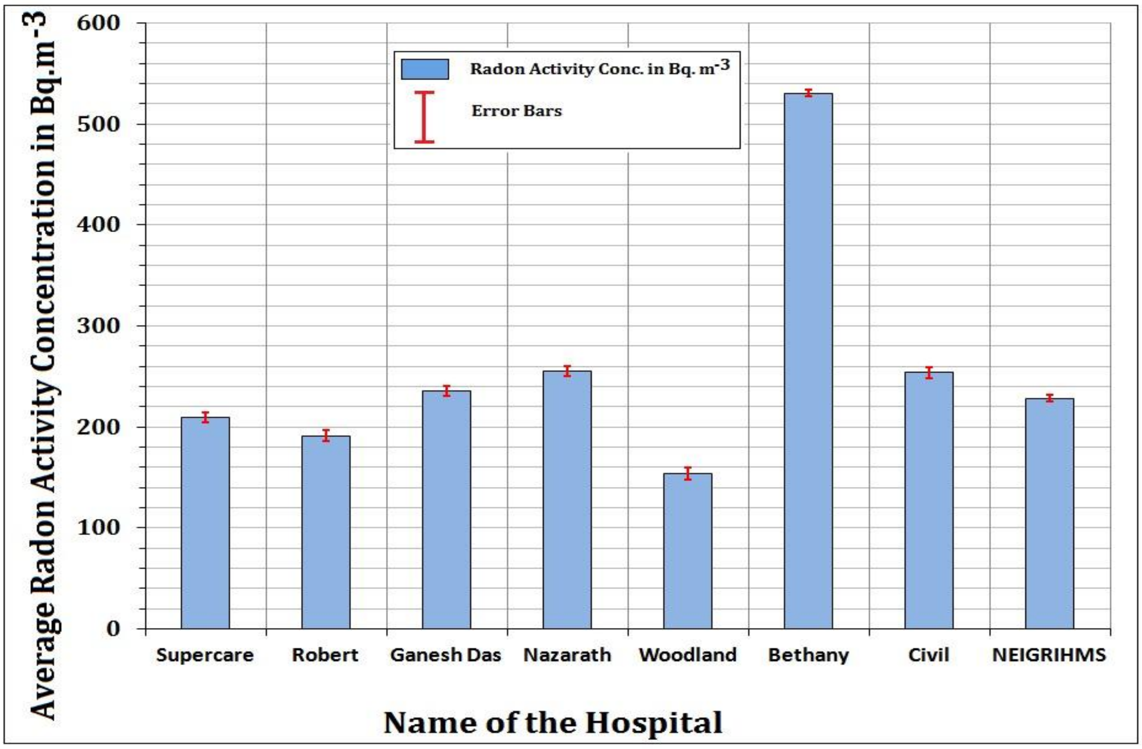

Figure 1: Average radon activity concentration measured in the 8 studied hospitals with error bars representing counting errors.

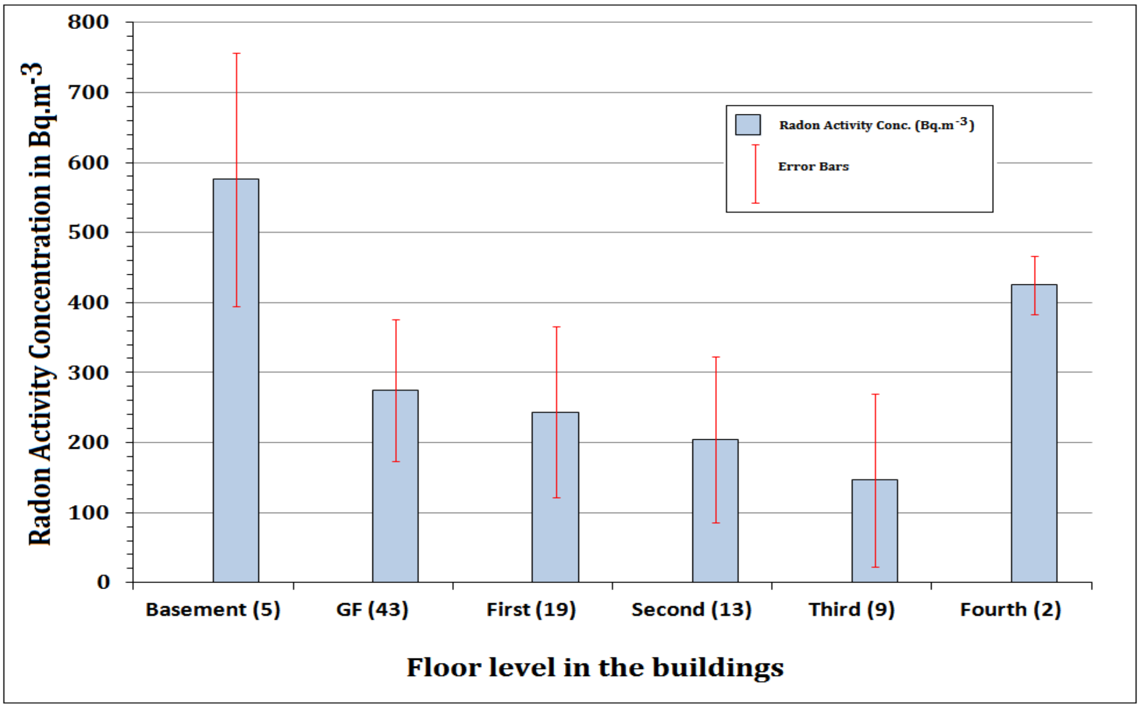

Figure 2: Average radon activity concentration grouped floor-wise of the surveyed hospitals with standard deviation of the values given by the error bars; numbers in the parenthesis represent number of rooms studied for the given floor level (GF= Ground Floor).

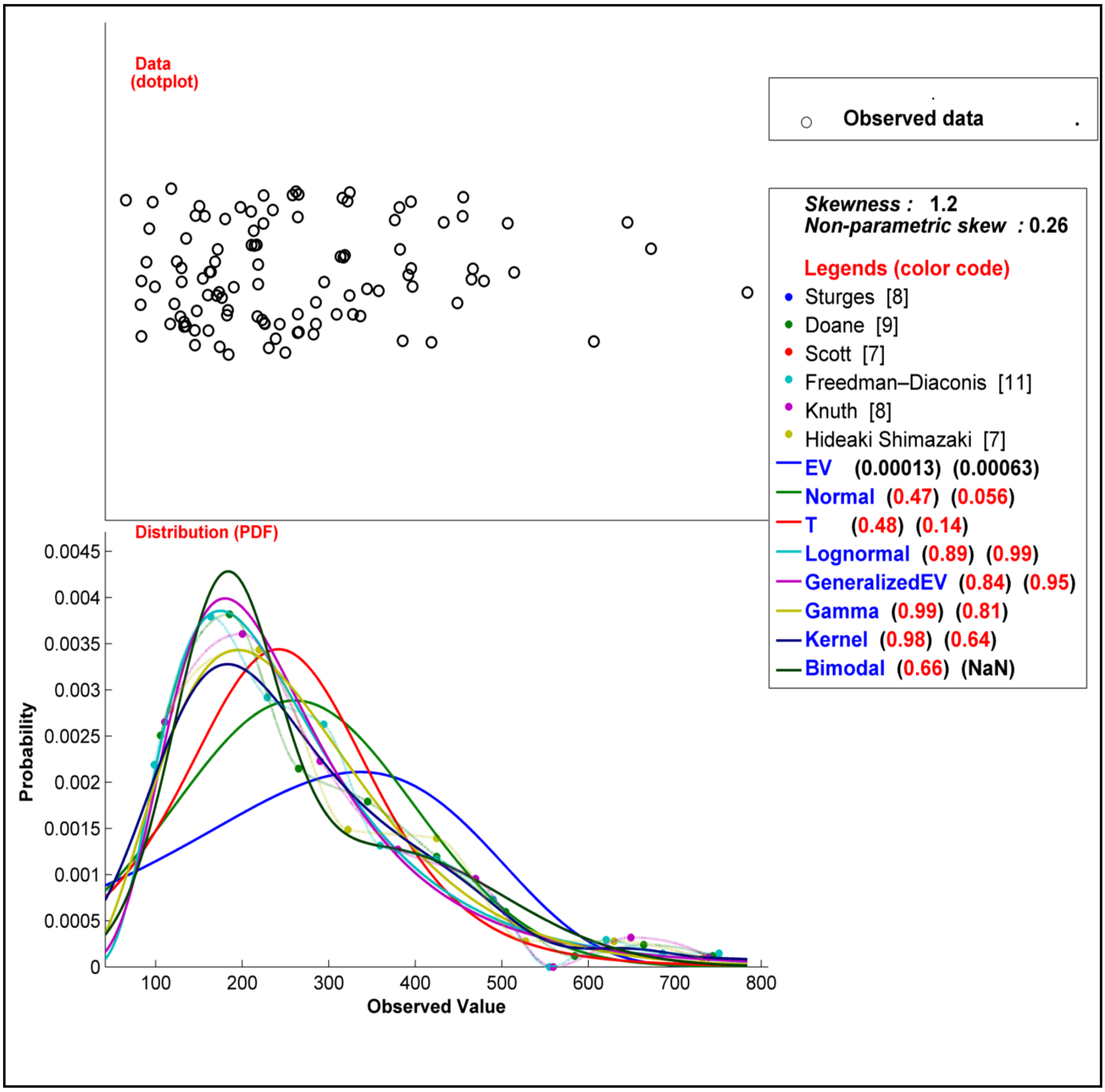

Figure 3: Distributional analysis of spread of indoor radon activity concentration values obtained from the hospital rooms. The legend gives details on the studied distributions (including various methods of histogram binning), skewness measures and the results of the p-values of the χ^2 and Anderson-Darling goodness-of-fit tests given in the parenthesis [5].

The distributional analysis of indoor radon activity concentration is shown in **Figure 3**; it is observed that most of the data are concentrated between values 100 to 300 Bq.m^{-3}. From visual inspection as well as from computed values of skewness, the distribution appears right skewed. The goodness-of –fit test (GOF) results is shown within parenthesis against the name of distribution that is tested. The χ^2 GOF test and AD (Anderson-Darling) test unequivocally rejects the Extreme Value (EV) distribution **[5]**. The student's *t*, normal, lognormal, generalized extreme value, gamma, kernel and bimodal distributions seem to fit our data. Since kernel density is a non-parametric distribution, it obviously fit the data well. The generalized extreme value distribution is a three parameter distribution and fits the data well so does the four parameter Gaussian bimodal distribution (the AD test is not performed in this distribution). The test also fails to reject the null hypothesis in the case of two-parameter distribution family *viz.* lognormal and gamma distribution. Given the rule of parsimony, we find the lognormal distribution and normal distribution both are good candidates for describing the distribution of the indoor radon activity concentration in the hospital buildings.

4. Conclusions:

Workplaces at hospitals are generally well ventilated but a few rooms in the basements, particularly those housing instruments, are likely to produce high radon concentration, which necessitates its measurement. About 60% of the rooms surveyed have radon concentration more than the ICRP prescribed lower limit 200 $Bq.m^{-3}$ and about 4% of the rooms have values more than the upper limit given as 600 $Bq.m^{-3}$; though these values are not excessively high to warrant any immediate action, but a few precautionary and mitigation measures like regular ventilation is suggested. Lifetime fatality risk estimates at the hospital with highest radon activity concentration shows that out of 10,000 people exposed to the amount of radon level in their lifetime (~30 years), 2 persons have the probability of fatality due to lung cancer.

References:

[1] UNSCEAR, Exposures from natural sources of radiation. Report to General Assembly with Annexes,1988.
[2] World Health Organization WHO handbook on indoor radon: A public health prespective: World Health Organization, 2009.
[3] R.C.Ramola, R.B.S. Rawat, M.S. Kandari, T.V. Ramachandran, K.P. Eappen and M.C. Subba Ramu Indoor Built Environ: 5: 364-366, 1996.
[4] UNSCEAR, Sources and effects of ionizing radiation, Report to the General Assembly with Annexes, 2000.
[5] D. Maibam, Studies on Radon activity in soil-air, indoor and in water at selected locations in Meghalaya. Ph.D Thesis, North-Eastern Hill University, Shillong-22, 2014.
[6] ICRP Protection against radon-222 at home and at work. A report of a task group of the International Commission on Radiological Protection. Ann ICRP, 23(2): p. 1-45, 1993.