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Potential Alpha Energy Concentration in Schools of Shillong, India

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(**Note:** Please refer all the figures and tables at the end of the article)

Abstract

The survey of seven schools located in Shillong City, has been carried out with an aim to assess the health risk of students and staffs in the schools due to Radon and its progenies. The survey is undertaken using the SSNTD method with LR-115 Type2 detectors in membrane with filter mode and in bare mode for two seasons, for winter '2011 and summer '2012. The Potential Alpha Energy Concentration (PAEC) obtained is in the range of 0.035 - 0.099 WL and 0.010 - 0.068 WL, respectively and the Radon Concentration ($Bq.m^{-3}$) ranges of 126.04 - 650.01 $Bq.m^{-3}$ and 31.90 -197.37 $Bq.m^{-3}$ respectively.

Keywords: PAEC, Schools, LR-115 Type2, Radon.

1. Introduction

Radon and its progenies in the atmosphere account for more than 50% of total natural radiation exposure to humans. Inhalation of the Radon progenies and their subsequent deposition along the walls of the various airways of the bronchial tree provide the main pathway for radiation exposure of the lungs. These exposures are mostly produced by the alpha particles emitted by the radio nuclides irradiating the secretory and basal cells of the upper airways and are responsible for reported lung cancer risks. Potential Alpha Energy Concentration (PAEC) evaluates the human exposure to radon and the decay products in the air that is breathed, in units of WL (Working Level) or Joule m^{-3} (UNSCEAR, 2000). Indoor radon levels can accumulate to harmful levels whereas in outdoor environment, radon is quickly diluted and is of no concern from radiological point of view (Munazza, and Matiullah, 2008). An indoor environment like schools can be a significant source of radon exposure for children and the staffs working there. As children (students) have smaller lung volumes and have higher breathing rates with their rapidly growing cells, hence higher radon concentration levels can serve as a risk for a higher radiation dose.

Shillong is situated in the North-eastern part of India, has a temperate climate, outskirts are rich in uranium deposits and commonly frequented by tremors. The summer months are warm accompanied by heavy showers and winter months are generally dry with mercury dropping close to 0^0C. Electric heating devices, coal fires etc are frequently used for warming the houses and ventilation is relatively poor during this period. Thus the burning of coal releases small amount of radionuclide and add up to the concentration of radon inside the building. Our study has been conducted at seven schools situated in different areas of Shillong which include Fire Brigade, Polo, Nongthymmai, Police Bazaar, Mawlai, and Laitumkhrah. The location of these schools is shown in the map (Fig 1) and the GPS locations of the schools are in Table 1.

2. Material and Methods

Radon concentration is measured in fifteen rooms of seven Schools situated in an area lying between N 25^0 33'47.0'' to N 25^0 36'25.1'' and E 091^0 52'56.2''to E 091^0 54'11.1'' of the Shillong city. About 2 to 3 rooms are chosen from each school in ground floors and the measurements are performed during winter '2011 in the month of November- December and summer '2012 in the month of April- May.

Solid State Nuclear Detectors, Kodak LR-115 Type2 cellulose nitrate films (chemical composition $C_5H_8O_9N_2$, density of 1.52 g cm^{-1}) of thickness 12 μ m are used in bare mode for our study in finding the PAEC levels (Srivastava, et al., 1996) and with filter and membrane for finding the Radon concentration. The films are cut into 2.5 x 2.5 cm^2 size and pasted on a cardboard of dimension 6 x 9 cm^2 at the centre and hanged with a thread for the bare mode. The cut films are paste in twin cup dosimeters and fixed with filter and membrane in the chambers. The detectors are kept at a distance of 10 cm away from the nearest wall and 2 meters above the ground. After the detectors are exposed for 60 days, they are retrieved and chemically etched in 2.5N NaOH solution at 60^o C for 120 min. With this etching condition 6.54 μm thick of the sensitive layer has been removed and the remaining sensitive layer thickness of the film 5.46 μm is left for counting (Nikezic & Yu, 2002). The perforated holes or tracks are then manually counted using an optical microscope at 150x magnification.

The track density obtained in terms of tracks.cm^{-2} for the exposed film is converted into Potential Alpha Energy Concentration and Radon Concentration in terms of mWL and Bq.m^{-3} using the following equation,

$$C_{PAEC/R} = \frac{\rho}{kT} \qquad \text{................ (1)}$$

where ρ is the density of the tracks (tracks.cm^{-2}) or the number of tracks counted cm^{-2} area of the film, k is the calibration factor used which is k = 125 tracks $cm^{-2}d^{-1}$ $(mWL)^{-1}$ for the bare exposed films (Ramola et al., 1996) and k = 0.019 tracks cm^{-2} d^{-1} $(Bq.m^{-3})^{-1}$ (Mishra et al., 2004) and T is the number of days of exposure of the films.

3. Results and Discussions

The radon concentration of all the 7 schools obtained is expressed in terms of Potential Alpha Energy Concentration (PAEC) in WL, radon concentration in Bq.m^{-3} and Annual effective dose equivalent (AEDE) in mSv.y^{-1}. The data (as shown in Table 2) represent the concentration of radon in two cycles i.e., summer' 2012 and winter' 2011 season. The data is also shown in the form of graphical presentation (Fig 2, Fig 3 and Fig 4). The concentration of radon value range from 173.98 to 650.01 Bq^{-3} for winter cycle and 32.16 to 116.9 Bq.m^{-3} for summer cycle. The PAEC values in terms of Working level (WL) ranges between 0.035 - 0.099 WL in winter cycle whereas for the summer cycle its value ranges from 0.010 - 0.068 WL. As there is a change in meteorological parameters like temperature, pressure, humidity, rainfall etc., in different seasons of a year there is a significant variation in indoor radon concentration measured at different time or season of a year. The seasonal correction factor (scf) is applied to estimate the annual average radon concentration (Orlaith et al., 2010) and to improve the accuracy of predictions of long-term risks. The seasonal correction factor is comprised of a series of numerical multipliers, which convert one or three month radon activity concentration measurement, commencing in any month of the year, to an effective annual mean radon activity concentration (Denman et al., 2007). Seasonal correction factor for 1-month exposure suggested by Woods et al. (Woods et al. 2000) were used to calculate the appropriate factors to the measurement periods (Csaba et al., 2010). We have to multiply the radon activity concentration values in Bq.m^{-3} that we have obtained for two months exposure with the seasonal correction factors to obtain the annual Radon activity concentration values as shown in Table 3.

The AEDE value ranges from 0.15- 0.27 mSv.y^{-1} with the average value of 0.20 m Sv.y^{-1}. The highest annual effective dose is 0.27 mSv.y^{-1} in Brookside Adventist Secondary School and lowest 0.15 mSv.y^{-1} in Laitumkhrah Presbyterian Higher Sec. School.

From the study conducted in 7 schools located in Shillong city we have noticed that the radon activity concentration varies from one school to another and also from one room to the other room within the school. Since the buildings are all RCC structures, local building materials (e.g. bricks, cement, granite, tiles etc.) used for construction of school building might have also contributed to the radon activity concentration values and the PAEC values apart from the amount of ventilation, underlying soils or rock formation over which the building is located. It is also a well known fact that this region is rich in uranium deposits therefore the source from where the building materials are extracted can contribute a considerable amount to the concentration of radon. There are also certain cracks and fissures inside the building which could be the cause for high radon levels as radon can easily seep through these cracks and fissures. The study has been carried out mostly in ground floors of the school buildings.

The AEDE values obtained are less than the average annual effective dose limit for members of public prescribed by UNSCEAR, 1993 which is 1.2 mSv.y^{-1}. ICRP 65 also recommends that the action level of radon be in the range between 200 and 600 Bq.m^{-3} (ICRP, 1993). In 43% of the schools studied the average radon activity concentration values are found to be above the lower limit of the action level.

4. Conclusion

The values of radon activity concentration and Potential Alpha Energy concentration obtained in the winter months are found to be more than the summer months. On the basis of the results obtained, it is suggested that the schools showing radon activity concentration above the lower limit should keep the rooms well ventilated especially during winter to lower the radon levels in the rooms, so as to avert to any risk posed by the higher radon activity concentration levels.

5. Acknowledgements: We are thankful to the Principal and Teachers of the Schools who have extended their co-operation and helped us in carrying out the survey successfully.

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Tables and Figures:

Table 1: *Location of the Schools studied.*

Code Name of the Site	Name of the Schools	Latitude	Longitude
A	Kendriya Vidyalaya –NEHU	N 25^0 36'25.1"	E 091^0 53'43.1"
B	Buddha Vidyalaya Niketan Upper Secondary	N 25^0 35'02.1"	E 091^0 53'21.6"
C	St. Xavier Secondary	N 25^{0}34'58.4"	E 091^{0}53'22.4"
D	Laitumkhrah Presbyterian Hr. Secondary	N 25^0 34'03.8"	E 091^0 53'59"
E	Brookside Adventist Secondary	N 25^0 33'59.6"	E 091^{0}54'02.2"
F	Nongthymmai Nepali Higher Secondary	N 25^0 33'47.0"	E 091^0 54'11.1"
G	R.B. Anoop Chand Hindi Secondary	N 25^0 34'30.6"	E 091^0 52'56.2"

Table 2: *Name of the Schools, Number of tracks observed in sq. cm area of the film for both bare mode and filter with membrane mode, Potential Alpha Energy Concentration (PAEC) values, Radon concentration values, Average Potential Alpha Energy Concentration in WL , Average Radon concentration in Bq.m^{-3} for Winter '2011 and Summer '2012.*

SCHOOLS	Winter '2011						Summer '2012					
	Track density (No. of tracks per sq.cm)		PAEC (WL)	C_R (Bqm^{-3})	Average PAEC (WL)	Average C_R (Bqm^{-3})	Track density (No. of tracks per sq.cm)		PAEC (WL)	C_R (Bqm^{-3})	Average PAEC (WL)	Average C_R (Bq.m^{-3})
	Bare	Filter+ Mem					Bare	Filter + Mem				
KV, NEHU	238.46	266.00	0.064	466.67	0.052	428.71	151.11	105.56	0.040	185.19	0.029	119.64
	149.44	222.73	0.040	390.75			84.00	39.06	0.018	54.10		
BVN, POLO	135.94	197.22	0.036	346.00	0.036	275.34	78.00	53.33	0.021	93.57	0.028	116.96

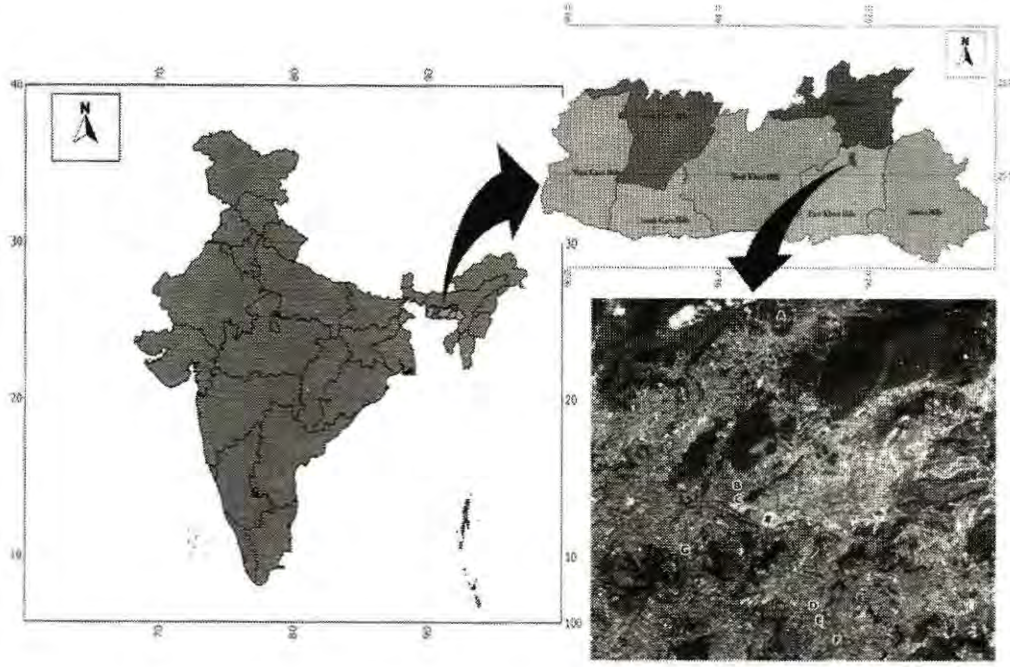
	131.25	116.67	0.035	204.68			134.69	80.00	0.036	140.35		
ST.XAVIER	231.54	99.17	0.062	173.98	0.062	173.98	148.33	x	0.040	x	0.052	178.95
	x	x	x	x			240.00	102.00	0.064	178.95		
PRES.HR.SC	240.28	120.83	0.047	155.11	0.057	233.74	203.17	112.50	0.054	197.37	0.030	94.29
	348.33	243.33	0.068	312.37			74.29	18.18	0.020	31.90		
	334.17	98.18	0.065	126.04			63.64	30.56	0.017	53.61		
BROOKSIDE	382.72	270.83	0.099	459.82	0.088	554.92	148.96	26.79	0.040	46.99	0.039	51.27
	295.45	382.86	0.076	650.01			140.26	31.67	0.037	55.56		
NEPALI, NTHM	338.02	270.31	0.071	374.39	0.078	367.25	171.88	82.22	0.046	144.25	0.057	150.10
	403.08	260.00	0.085	360.11			256.57	88.89	0.068	155.95		
RBA, PB	255.63	241.82	0.064	397.73	0.072	343.95	62.00	18.33	0.017	32.16	0.013	47.41
	316.67	176.43	0.079	290.18			38.18	35.71	0.010	62.66		

Table 3: *Name of the Schools with the Winter and Summer Radon Activity concentration in Bq.m^{-3} with the Annual Radon activity concentration for Winter and Summer seasonal corrected values and the Annual effective dose eq uivalent (in mSv.y^{-1}) and Corresponding dose due to Decay products in this case ^{222}Rn decay products (in mSv.y^{-1}).*

Name of the School	Winter Radon activity conc. in Bq.m^{-3}	Annual Radon Activity conc with scf*in Winter Readings	Summer Radon activity conc. in Bq.m^{-3}	Annual Radon Activity conc with scf*in Summer readings	Average Annual Radon Activity conc. in Bq.m^{-3}for two seasons with scf*	Annual effective dose equivalent (AEDE) in mSv.y^{-1} (UNSCEAR,1993)	Corresponding dose due to progenies in mSv.y^{-1}
KV, NEHU	428.71	338.68	119.64	125.63	277.17	0.25	5.24
BVN, POLO	275.34	217.52	116.96	122.81	199.07	0.18	3.77
ST.XAVIER	173.98	137.44	178.95	187.89	180.94	0.16	3.42
PRES.HR.SEC	233.74	184.65	94.29	99.01	166.37	0.15	3.15
BROOKSIDE ADVENTIST	554.92	438.38	51.27	53.84	304.38	0.27	5.76
NEPALI, NTHM	367.25	290.13	150.10	157.60	262.43	0.24	4.97
RBA, PB	343.95	271.72	47.41	49.78	196.87	0.18	3.73

scf* denotes seasonal correction factor

Fig.1. *A map showing location of the study sites*



Location A: Kendriya Vidyalaya -NEHU
Location B: Buddha Vidyalaya Niketan Upper Sec.
Location C: St. Xavier Sec.
Location D: Laitumkhrah Presbyterian Hr Sec.
Location E: Brookside Adventist Sec.
Location F: Nongthymmai Nepali Higher Sec.
Location G: R.B Anoop Chand Hindi Sec.

Fig.2. *Bar graph showing the Average Radon Concentration (in Bq.m^{-3}) of the Schools in the Winter of 2011 and Summer of 2012 with the name of the schools.*

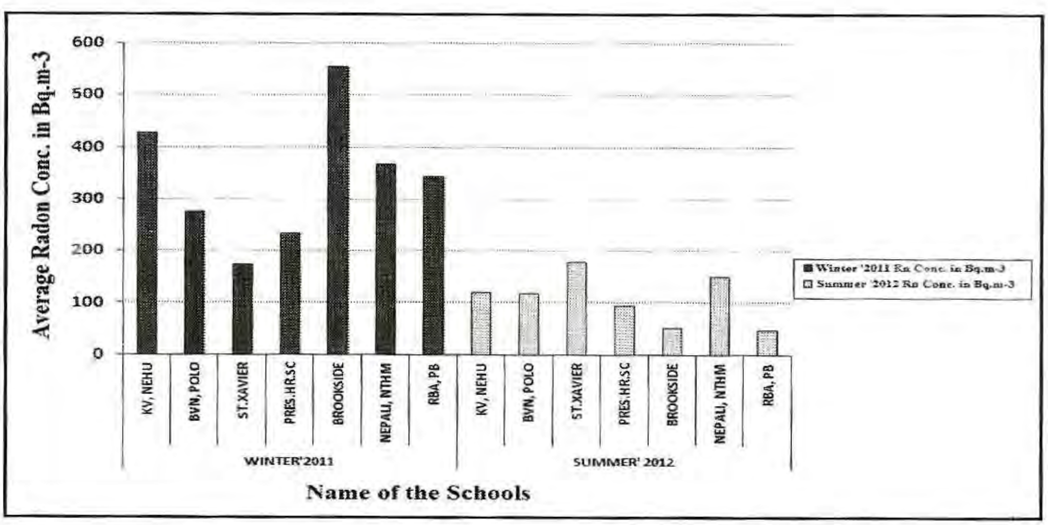


Fig.3. *Bar graph showing the Average Potential Alpha Energy Concentration (in WL) of the Schools in the Winter of 2011 and Summer of 2012 with the name of the schools.*

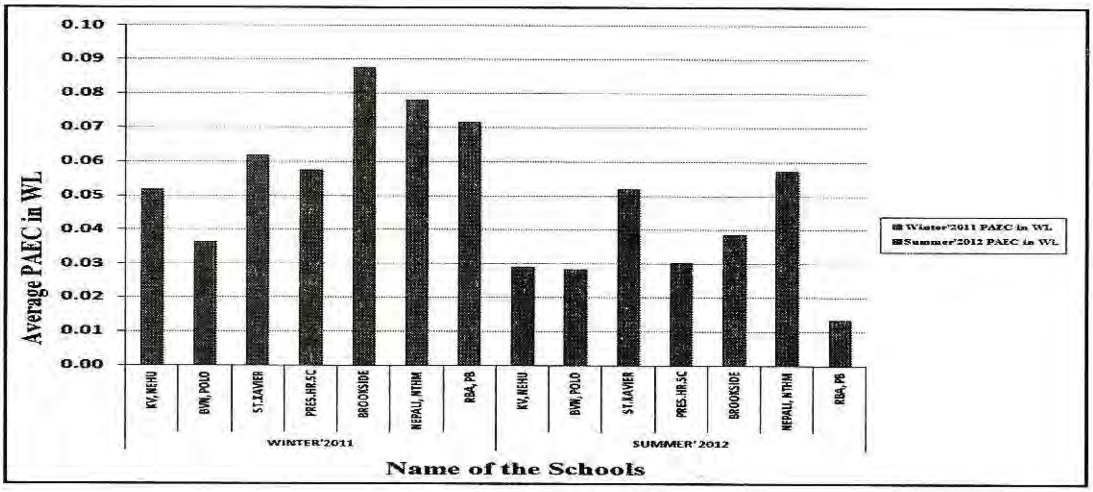


Fig.4. *Bar graph showing the Annual Effective Dose in mSv.y^{-1} with the name of the Schools.*