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RADON ACTIVITY IN NONGKHLAW VILLAGE OF WEST-KHASI HILLS DISTRICT, MEGHALAYA

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ABSTRACT

The relatively recent realisation of the harmful consequences of radon exposure on human health, particularly its carcinogenic effects, had led to a spurt in the assessment of radon in the living environment around the world. In the current paper, we present our results on the measurement of radon activity, radon exhalation rates, radium content (in soil) and other derived parameters in Nongkhlaw village of West-Khasi Hills, Meghalaya, which lies in close proximity to reported uranium deposits. Contrary to expected results, measurements show that no significantly harmful build-up of radon is present in the study area.

INTRODUCTION

Radon is theresult of alpha decay of radium, which is a naturally occurring radioactive element released in the uranium decay series.Radon has been extensively studied because of its unique nature of being (a) agas, which allows it to be mobile and travel over significant distances within the structures, (b) noble, which meansit is not immobilized by chemically reacting with the medium it permeates, (c) radioactive, which allows it to be detectedwith high precision andalso poses a health hazard particularly if inhaled and lastly (d) its half-life (of the isotope Rn-222) is significant enough for long-distance transportation and accumulation **[1]**. Studies on radon is generally perceived from two general perspectives one from hazard aspect and other as a help, of which we will study the formeraspect in this paper.

The importance of indoor radon studyfrom this aspect is evident from the interest shown by reputed health organisations such as United States Environmental Protection Agency (US-EPA), World Health Organisation (WHO), United Nations Scientific Committee on Effects of Atomic Radiation (UNSCEAR), National Council on Radiation Protection and Measurements (NCRP), International Commission on Radiological Protection (ICRP) to name a few. Initial studies on underground miners exposed to high radon levels have shown its association to lung cancer**[2]**. However, several studies, since the early 1980's have investigated radon concentrations in homes and other buildings, have concluded that sufficient indirect evidence exists to link lung cancer in the general population on radon levels commonly found in buildings **[3]**. Following these inferences, many countries have set guidelines and regulations to address the radon problem in construction of new buildings (for prevention) and in existing buildings (for mitigation or remediation)**[4, 5]**.

In this paper, we have reported radium content and indoor radon activity concentration in the Nongkhlawvillageof West-Khasi Hills district of Meghalaya. We have presumed that the localisation of coal, iron, granite, etc., around the study area and the uranium deposits in Kylleng-Pyndensohiong Mawthabah(KPM) area(at ~112 km from Nongkhlaw) in the district might show peculiar distribution of radon in the area. Atomic Mineral Division (AMD), Government of India, has established a reserve of about 9.22 metric tons of higher grade 0.104% U_2O_3 at Domiasiat (KPM), West-Khasi Hills District **[6]**. Although it is hard to perceive a direct functional relationship between radon in indoors and the radium content of the soil samples due to other compounding variables like ventilation, exhalation rate etc., indisputably radium content is an important variable determining radon concentration, so we have attempted to estimate any possible correlation between the two.

EXPERIMENTAL TECHNIQUE

1.For radium content study: The 'Can Technique' **[7]**has been used for the measurement of radium content in 20 soil samples collected from different location of Nongkhlaw area respectively. The dried soil samples from different location were finely powdered and sieved through 90 micron mesh sieve. The finely powdered soil sample (100g) from each location was placed and sealed in different bottles for 30 days so as to attain secular equilibrium, LR-115 type2 plastic track detectors were then fixed inside the lid of these bottles (1 litre capacity acting as emanation chambers), sealed and left undisturbedagain for 90 days. After the exposure period, the films areretrieved from the emanation chamber and etched in 2.5N NaOH solution at 60°C for 120 minutes using a constant temperature water bath. The resulting alpha tracks are then counted using an optical microscope at magnification of ~650x.

The exhalation rates are estimated using the relations,

$$E_M = \frac{CV\lambda}{M(t+1/\lambda(e^{-\lambda t} - t)} \text{……..} (1)$$

$$E_A = \frac{CV\lambda}{A(t+1/\lambda(e^{-\lambda t} - t)} \text{……..} (2)$$

where, E_M and E_A are the radon exhalation rate in terms of mass (Bq.kg^{-1} h^{-1}) and area (Bq.m^{-2} .h^{-1}), *C* is the integrated radon concentration (Bq.m^{-3}.h^{-1}), *V* is the effective volume of the can (m^3), λis the decay constant for radon (h^{-1}), *t* is the exposure time (h), Mis the mass of the soil sample and A is the area of cross-section of the bottle.

The radium concentration in soil samples is computed using the relation

$$C_{Ra} = \frac{\rho h A}{K T_e M} \text{………..} (3)$$

where, C_{Ra} is the effective radium content of the soil sample (Bq.kg^{-1}), Mis the mass of the soil sample, Ais the area of cross section of the bottle (5.9×10^{-3} m^2), h is the distance between the detector and the top of the soil sample and T_e is the effective exposure time, ρis the background corrected track density (tracks.cm^{-2}) and K is the sensitivity factor (0.0245 tracks.cm^{-2} d^{-1} (Bq.m^{-3})$^{-1}$**[8]**.

The Alpha index value is calculated using the relation**[9]**;

$$I_\alpha = \frac{C_{Ra}}{200\,Bq\ kg^{-1}} \text{……….} (4)$$

2.For Indoor radon study: Solid State Nuclear Track Detectors, namely LR-115 Type2 films are used for our study. The indoor sites are chosen at close proximity (about 1- 2 meters) from where soil samples are collected for radium content analysis. The films are cut into small sizes about 2.5x2.5 cm^2 sizes, pasted onto a cardboard of dimension 6x9 cm^2, and hung at centre of the rooms. The detectors are placed about 10 cm away from the nearest wall and about 2 meters from the ground. The detectors are retrieved after a period of exposure of about three months; these exposed films are then chemically etched in 2.5N NaOH solution at 60°C for 120 minutes. The perforated holes or tracks that appear as bright spot in reddish background 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,

$$C_{RN} = \frac{\rho}{kT} \text{…………...} (5)$$

where ρ is the density of tracks (number of tracks counted per area of the film), k is the calibration factor used with a value of 0.02 tracks.cm^{-2} d^{-1} (Bq.m^{-3})$^{-1}$**[10]**and T is the duration in days for which the detectors were exposed.

RESULTS

The value of radium content of the soil samples collected from 20 locations along with the radon exhalation rates in terms of mass and area as well as the calculated alpha index value under the study area are given in **table 1.**The radium content in the soil samples were found to vary from 14.05 to 61.77Bq.kg^{-1} with arithmetic mean (A.M) value of 33.09±13.18 Bq.kg^{-1} and a geometric mean (G.M) value of 30.65± Bq.kg^{-1}.

The values of indoor radon activity concentration measured from the 21 houses as well as the measured annual radon concentration, annual exposure and estimated life-time fatality risk are given in **table 2.** Our study has been carried out for whole year withfour seasons*viz*. Spring (March to May), Rainy (Juneto August), Autumn (September to November)and Winter(December to February). The average values of the radon concentration for spring (A.M = 52.17±35.9 &G.M= 41.33±2.3 Bq.m^{-3}), rainy (A.M=157.8±119.73 &G.M = 112.13±2.02 Bq.m^{-3}), autumn (A.M=167.5 ±128.3 &G.M=122.09±2.46 Bq.m^{-3}) and winter (A.M=195.05±121.94 &G.M= 162.16±1.86 Bq.m^{-3})seasons. The overall arithmetic mean value of the measured radon activity concentration is found to be 143.13±119.57 Bq.m^{-3} and geometric mean value is found to be 97.87±2.015 Bq.m^{-3}. The annual effective dose (AED)is also calculated and is found to vary from

0.49 to 9.65 mSv.y^{-1}. The life-time fatality risk has been found to range between 0.05 x 10^{-4} (house no.18) and 1.02 x 10^{-4} (house no.21) with an average value of 0.34 x 10^{-4}; this result may be translated as - if 100,000 persons are exposed to the prevailing radon level in their life-time then about 3 persons will probably succumb to lung cancer. **Figure1** shows theannual radon activity concentration (geometric mean value of the radon activity concentration measured for the four seasons) at each site. **Figure2** shows the correlation plot of indoor radon concentration with radium concentrationand**figure3**shows the comparison plot of the four seasons under study with maximum observed in winter and minimum in spring.**Figure4** shows the plot ofaverage radon concentration for different floorings and walls in the room. The average radon concentration for concrete house type is found to be maximum (with143.82±1.76 Bq.m^{-3}) and lesser in semi-concrete (with 93.75±2.06 Bq.m^{-3}) and minimum in wooden house type (with 67.57±1.23 Bq.m^{-3}).

Table 1: Consolidated data of the estimated Radium Content, Radon Exhalation Rates in terms of Mass and Area, and the Alpha Index value in the present study.

Location no.	Radium content (Bq.kg^{-1})	Exhalation rate in terms of		The Alpha index value
		Area (Bq.m^{-2}h^{-1})	Mass(Bq.kg^{-1}h^{-1})	
1	29.3	4.8	0.29	0.2
2	43.7	7.3	0.43	0.2
3	44.1	7.2	0.43	0.2
4	19.5	3.4	0.2	0.1
5	22.5	3.7	0.22	0.1
6	35.9	6.0	0.35	0.2
7	44.5	7.3	0.43	0.2
8	14.1	2.4	0.14	0.1
9	21.3	3.6	0.21	0.1
10	20.1	3.3	0.2	0.1
11	20.2	3.4	0.2	0.1
12	29.8	5.1	0.3	0.2
13	36.8	6.1	0.36	0.2
14	24.0	4.0	0.24	0.1
15	28.0	4.6	0.27	0.1
16	50.6	8.6	0.51	0.3
17	61.8	10.3	0.61	0.3
18	41.5	6.9	0.41	0.2
19	22.6	3.7	0.22	0.1
20	51.5	8.5	0.51	0.3

Table 2: Consolidated data of measured Radon Activity Concentration, Annual Average Radon Concentration, Annual Exposure, Annual Effective Dose and Life-time fatality risk in the present study.

House no.	Flooring and walls	Radon ActivityConc. in $Bq.m^{-3}$ measured in the four seasons			Average# radon conc. in $Bq.m^{-3}$	AED in $mSv.y^{-1}$	Life time fatality risk x 10^{-4}
		MIN	MAX	Average#			
1	Concrete	42.9	157.5	104.5	97.9 ± 2.02	2.8	0.29
2	Wooden	26.6	228.3	136.0		3.6	0.38
3	Concrete	103.3	454.0	291.3		7.7	0.81
4	Wooden	65.4	143.7	95.1		2.5	0.27
5	Semi-concrete*	37.5	123.3	72.5		1.9	0.2
6	Semi-concrete*	101.5	143.1	121.3		3.2	0.34
7	Concrete	36.2	212.2	128.8		3.4	0.36
8	Concrete	72.4	286.9	188.7		5.0	0.53
9	Concrete	57.5	242.1	154.3		4.1	0.43
10	Wooden	20.6	76.3	40.7		1.1	0.11
11	Concrete	21.1	83.2	50.2		1.3	0.14
12	Wooden	13.7	62.5	30.8		0.8	0.09
13	Semi-concrete*	20.8	171.2	93.6		2.5	0.26
14	Concrete	59.6	205.7	135.1		3.6	0.38
15	Concrete	30.6	160.0	92.9		2.5	0.26
16	Wooden	18.7	306.5	43.0		1.1	0.12
17	Wooden	69.0	139.5	108.1		2.9	0.3
18	Wooden	8.6	63.8	18.6		0.5	0.05
19	Wooden	35.4	291.4	139.0		3.7	0.39
20	Wooden	23.4	301.7	150.6		4.0	0.42
21	Concrete	139.2	538.8	365.7		9.7	1.02

Average# is the geometric mean value

*Semi-concrete refers to type of houses which are constructed with concrete walls and wooden floors or vice-versa.

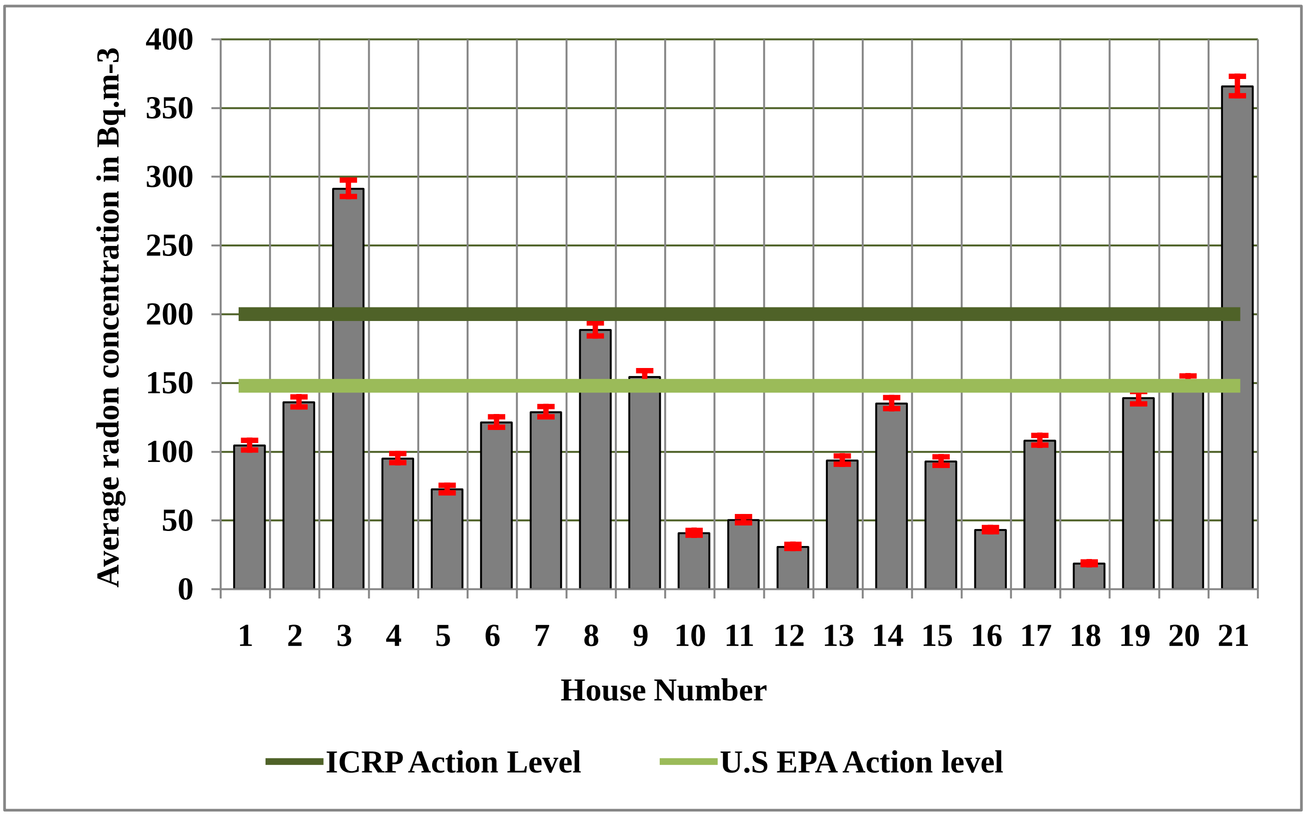

Figure 1: Average# radon concentration measured for each household.

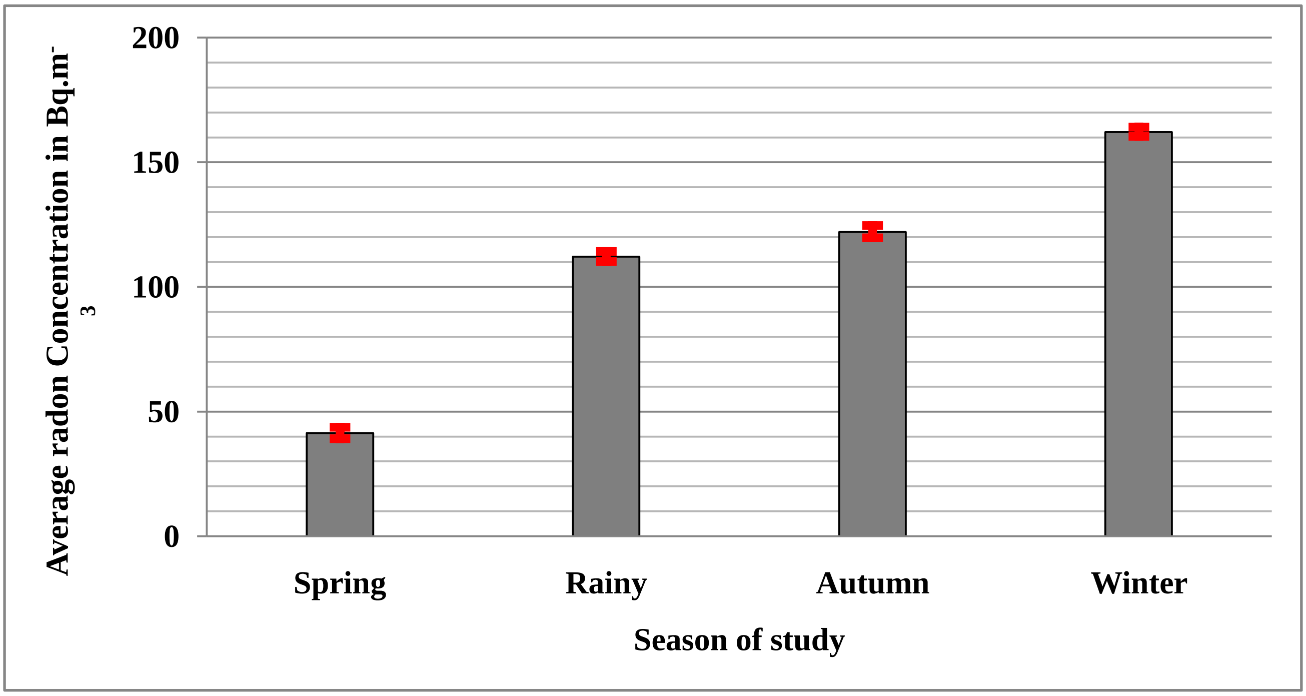

Figure2: Comparison of average# radon concentration value for the four period of study

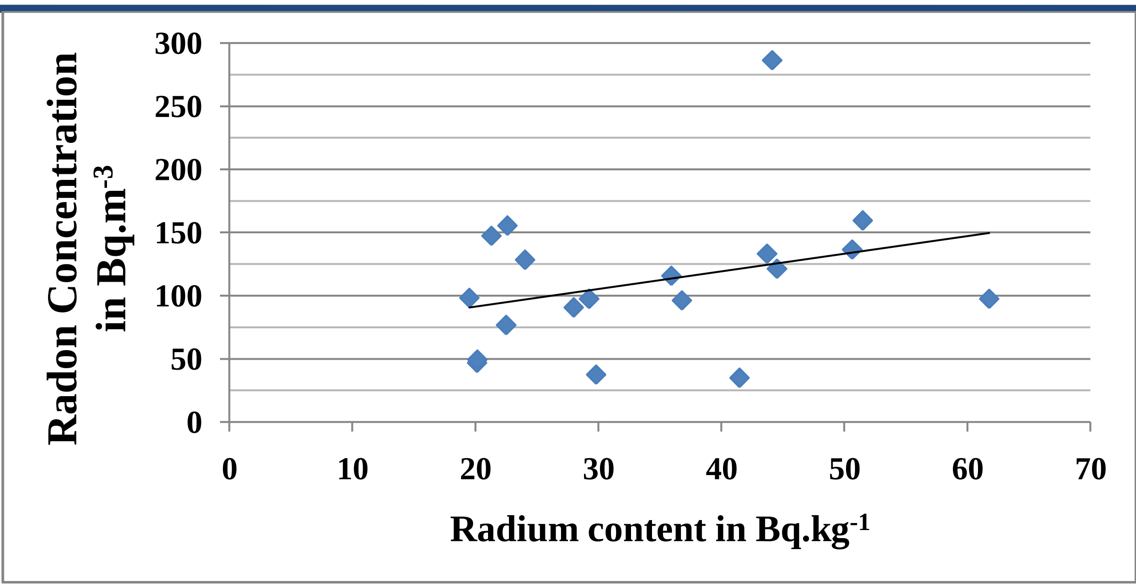

Figure 3: Correlation plot of radium concentration and radon concentration.

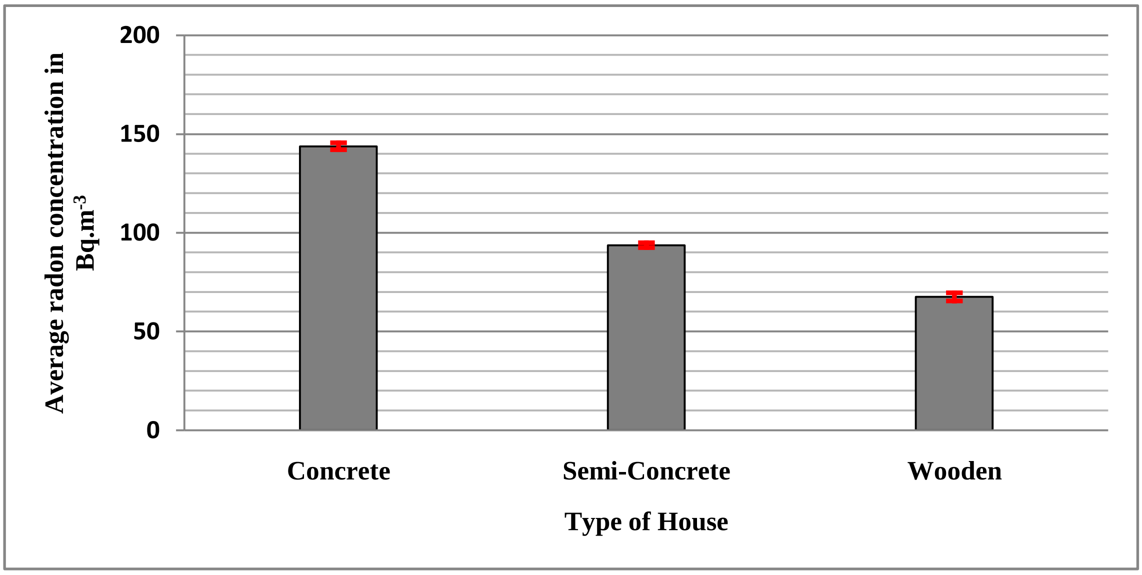

Figure 4: Average# radon concentration for different type of house.

DISCUSSION

The measured average radium activity concentration values are well within the average estimates given by UNSCEAR for India *i.e.* 7 and 81 $Bq.kg^{-1}$**[9]**. The range of alpha index also is below the recommended level of 1**[11]**. The value of average radon concentration and annual effective dose are also within the action level recommended by ICRP of 300-600 $Bq.m^{-3}$ and WHO recommended level of 10 $mSv.y^{-1}$**[3]**respectively. Maximum value of radon concentration has been observed during winter season this may be because of the poor ventilation during this period as most of the doors and windows of the dwellings remain closed during winter and there is an increased temperature and pressure difference between the indoor and outdoor environment [**9**] further augmented with the used of heating system such as a heater, charcoal etc., which creates a condition that allows the gas from the soil-air environment to seep into the indoor environment. Minimum value of indoor radon concentration is observed in spring season, caused possibly by higher moisture content in soil causing lower amount of radon exhaled as the mean distance that radon can travel is minimum in saturated porous soil.Higher average radon concentration for concrete houses might result from lower ventilation levels of such structures and higher exhalation of radon from the concrete walls,which are known to contribute to indoor radon concentration [**12].**

CONCLUSION

From the alpha index valueobtained it can be concluded that the radium activity of soil samplesalone is unlikely to produce radon concentration exceeding 200 $Bq.m^{-3}$ inside dwelling and may be considered safe for use in habitable building construction**[13]**. From the correlation study, it is found that there exists a very weak correlation (~ r=0.3) between radium content and indoor radon concentration values which may be becauseindoor radon concentrationmay not only be sourced from radium in the soil but from other sources such as building material, water and natural gas.

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