RADON MEASUREMENTS IN THE SOILS OF NONGSTOIN AND MAIRANG REGIONS OF WEST KHASI HILLS DISTRICT, MEGHALAYA

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Abstract: This paper reports the measurements on radium in soil samples collected from different location of Nongstoin and Mairang area of West Khasi Hills District, Meghalaya, India, carried out using "Can Technique". The radium content of the soil samples collected from Nongstoin have been estimated to vary from 4.72 to 16.39 Bq.kg^{-1} with an arithmetic mean value of 9.28± 2.99 Bq.kg^{-1} and a geometric mean value of 8.80±1.38 Bq.kg^{-1}. In Mairang, the radium content values was found to vary from 13.51 to 33.42 Bq.kg^{-1} with an arithmetic mean value of 23.64± 5.61 Bq.kg^{-1} and a geometric mean value of 22.98±1.27 Bq.kg^{-1}. The alpha index values (I_α) have also been calculated and the values are found to range between 0.02 and 0.08 for Nongstoin and between 0.07 and 0.17 for Mairang.

Keywords: Radium; Radon exhalation rates; Radon; LR-115; Can technique
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1. Introduction:

Monitoring of any release of radioactivity from all kind of sources to the environment is necessary for environmental protection [1]. One of the most important sources of natural background radioactivity is soil as it contains the precursors to most naturally-occurring radioactive isotopes. Exhalation of alpha-radioactive ^{222}Rn inert gas from soil is associated with the presence of ^{226}Ra atoms in the earth crust [2-8]. Radium is a solid radioactive element under normal temperature and pressure. It decays to radon by emitting alpha particles; it is, therefore, the concentration of radium that basically governs the amount of radon atoms formed [7-11]. Not all the radon atoms formed from the decay of the embedded radium leave the rocks or soil matrix. The fraction of radon atoms that actually emanate from the mineral grain or matter and enter the pore spaces, depends on many factors including proximity of the radium atom to the surface of the grain, the texture and the permeability of the grain, temperature *etc*. The amount of activity released per unit surface area per unit time from material (such as soil) is termed as the exhalation rate. [11-15]. In this paper, we have reported the radium activity concentration measured in the densely populated Nongstoin and Mairang area of West Khasi Hills District of Meghalaya. We suspect that the localization of coal, iron, granite, etc. around the study area and that of uranium deposits in Kylleng-Pyndengsohiong (Mawthabah) areas in nearby district might show unique distribution of radon in soil. The soil samples have been collected from 60 different locations that fall under the study area and brought to the laboratory for the assessment of radium content.

2. Experimental technique:

The 'Can Technique' [16] has been used for the measurement of radium content and radon exhalation rates in 60 soil samples collected from different location of Mairang and Nongstoin area respectively. The dried soil samples from different location were finely powdered and sieved through 90 micron mesh sieve. The finely powdered soil sample (250 gms) from each location was placed and sealed in different bottles for 30 days so as to attain secular equilibrium, after which period, LR-115 type2 plastic track detectors were fixed inside the lid of these glass bottles (acting as emanation chambers) and sealed again and left as such for 90 days. After the exposure period, the films are retrieved from the emanation chamber and etched in 2.5N NaOH solution at 60°C for 90 minutes using a constant temperature water bath. The resulting alpha tracks on the exposed face of the track detector are counted using an optical microscope at magnification of 150x.

The exhalation rates are then determined using the relations,

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

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

where, E_M and E_A are the radon exhalation rate in term 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), λ is the decay constant for radon (h^{-1}), *t* is the exposure time (h), M is 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

$$C_{Ra} = \frac{\rho hA}{KT_e M} \quad (3)$$

where, C_{Ra} is the effective radium content of the soil sample (Bq.kg^{-1}), M is the mass of the soil sample, A is 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, ρ is the background corrected track density (tracks.cm^{-2}) and K is the sensitivity factor (0.0312 tracks.cm^{-2} d^{-1} (Bq.m^{-3})$^{-1}$ [17]).

The Alpha index value is calculated using the relation;

$$I_\alpha = \frac{C_{Ra}}{200 Bq\ kg^{-1}} \quad (4)$$

Table 1: List of the sites with the latitude and longitude values.

Name of the site	Latitude	Longitude
Mawlein	25.53103	91.2594167
Mawkhmahwir	25.53664	91.2618333
Pyndengrei. Vil	25.54097	91.2649722
Mawkhmahwir	25.54392	91.2695278
New Nongstoin	25.52167	91.2614722
Nanbah(Nong)	25.52319	91.2728611
Circuit House	25.52778	91.28275
Upper New Nong	25.51856	91.2665833
Upper Nong (Block-1)	25.52397	91.2757778
Por Sohsat	25.52883	91.2888611
Dewsaw	25.55368	91.65408
Dongate	25.56534	91.63472
Langstiehrim	25.54872	91.65484
Lummarlong	25.55987	91.64555
Mairangbah	25.56337	91.63457
Mawlum	25.5647	91.63217
Mansawa	25.56459	91.69736
Mission	25.56118	91.64253
Sanshnong	25.55958	91.6494
Umsohkhlur	25.55476	91.64101

3. Results and discussions:

The values of radium content from 20 locations under the study area are given in Table 2. The Radon exhalation rate in terms of mass and area and the alpha index have been calculated and also presented in Table 2. The values of radium content in soil samples from Nongstoin were found to vary from 4.72 to 16.39 $Bq.kg^{-1}$ with an arithmetic mean value of 9.28± 2.99 $Bq.kg^{-1}$ and a geometric mean value of 8.80±1.38 $Bq.kg^{-1}$. In Mairang, the radium content values were found to vary from 13.51 to 33.42 $Bq.kg^{-1}$ with an arithmetic mean value of 23.64± 5.61 $Bq.kg^{-1}$ and a geometric mean value of 22.98±1.27 $Bq.kg^{-1}$. The alpha index values (I_α) is found to range between 0.02 and 0.08 for Nongstoin and between 0.07 and 0.17 for Mairang.

The measured average radium activity concentration values for Nongstoin is 9.28± 2.99 $Bq.kg^{-1}$ and for Mairang is 23.64±5.61 $Bq.kg^{-1}$ and is well within the estimates given by UNSCEAR for India *i.e.* 7 and 81 $Bq.kg^{-1}$[18].

Table 2: List of the sites and locations (from where the soil samples were collected) with the calculated radium content, Average radon exhalation rates in terms of area and mass and the Alpha index value.

Name of the sites	Name of location	Radium Content (Bq.kg-1)						Average radon Exhalation Rate				Alpha index
		Max.	Min	AM	SD	GM	GSD	Area ($Bq.kg^{-1}.h^{-1}$)		Mass ($Bq.m^{-2}.h^{-1}$)		
								AM	SD	AM	SD	
Nongstoin	Pyndengrei 1	14.3	8.0	10.4	2.8	10.2	1.2	3.4	0.9	0.10	0.03	0.05
	Pyndengrei 2	11.8	5.4	9.8	3.0	9.4	1.4	3.3	1.0	0.10	0.03	0.05
	Pyndengrei 3	16.4	5.0	10.5	6.3	9.0	1.8	3.5	2.1	0.11	0.06	0.05
	Pyndengrei 4	15.0	9.4	11.7	2.4	11.5	1.2	3.9	0.8	0.12	0.02	0.06
	Wahriat	12.4	9.7	10.6	1.3	10.5	1.1	3.5	0.4	0.10	0.01	0.05
	BDO office	12.5	8.3	10.0	1.7	9.9	1.2	3.3	0.5	0.10	0.02	0.05
	Circuit house	9.4	5.5	7.3	2.1	7.1	1.3	2.5	0.7	0.07	0.02	0.04
	New Nongstoin market	10.8	7.7	9.0	1.3	9.0	1.1	3.0	0.4	0.09	0.01	0.05
	Ladweitang	7.2	5.2	6.5	0.9	6.4	1.1	2.2	0.3	0.06	0.01	0.03
	Porsohsat	9.6	4.7	6.9	2.2	6.6	1.3	2.3	0.7	0.07	0.02	0.03
Mairang	Dewsaw	31.3	28.1	29.7	2.2	29.7	1.1	0.3	0.0	4.74	0.35	0.15
	Dongate	20.2	18.2	19.2	1.4	19.2	1.1	0.2	0.0	3.03	0.22	0.10
	Langstiehrim	21.7	18.0	19.7	2.6	19.7	1.1	0.2	0.0	3.21	0.35	0.10
	Lummarlong	33.4	29.3	31.3	2.9	31.3	1.1	0.3	0.0	4.85	0.45	0.16
	Mairangbah	31.3	28.2	29.7	2.2	29.7	1.1	0.3	0.0	4.60	0.33	0.15
	Mawlum	18.4	13.5	15.8	3.5	15.8	1.2	0.2	0.0	2.63	0.57	0.08
	Mawsawa	27.0	25.3	26.1	1.2	26.1	1.0	0.3	0.0	4.31	0.20	0.13
	Mission	22.7	21.9	22.3	0.6	22.3	1.0	0.2	0.0	3.54	0.03	0.11
	Sanshnong	19.5	15.8	17.6	2.6	17.6	1.1	0.2	0.0	2.80	0.50	0.09
	Umsohkhlur	26.6	22.5	24.4	2.9	24.4	1.1	0.2	0.0	3.89	0.43	0.12

*AM=arithmetic mean; SD = standard deviation; GM = geometric mean; GSD = geometric standard deviation; WLM = working level month; AED = annual effective dose.

4. Conclusions:

The average radium content estimated in the present study is found to be more in Mairang by a factor of 2.5 compared to the value for Nongstoin, although both the values are lower than the world average value of 32 $Bq.kg^{-1}$[19, 20]. The measured values of alpha index value (I_α) ranges between 0.02 and 0.08 for Nongstoin and between 0.07 and 0.17 for Mairang, which are well below the recommended value of 1. Hence, it can be concluded that the radium activity of soil samples from these two study-sites are unlikely to produce radon concentration exceeding 200 $Bq.m^{-3}$ inside dwelling and may be considered safe for use in habitable building construction.

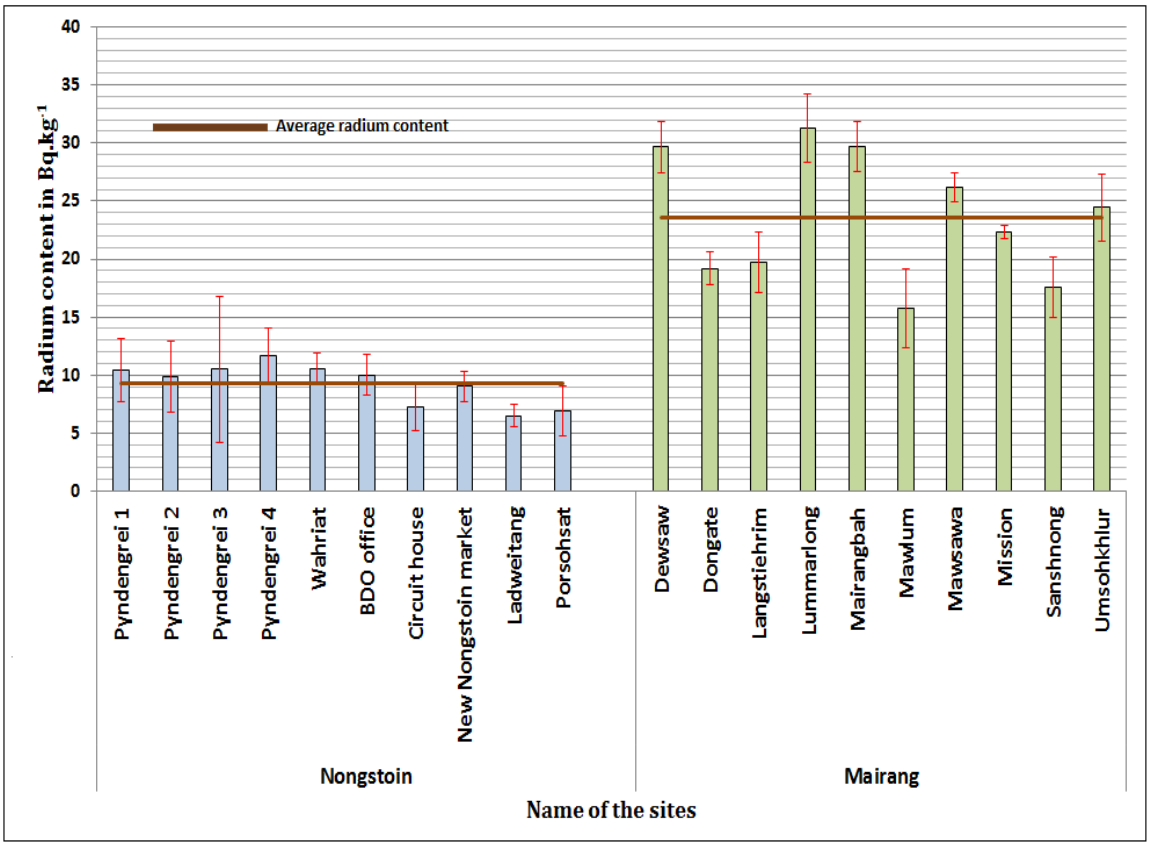

Figure 1: Average Radium content value measured from the Nongstoin and Mairang study sites and error bars representing the counting errors.

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