STUDY OF INDOOR RADON/THORON CONCENTRATIONS AND THEIR PROGENY LEVELS IN SOME DWELLINGS BY USING SOLID STATE NUCLEAR TRACK DETECTORS

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RADON is a

COLOURLESS

ODOURLESS

TASTELESS

RADIOACTIVE

Gas

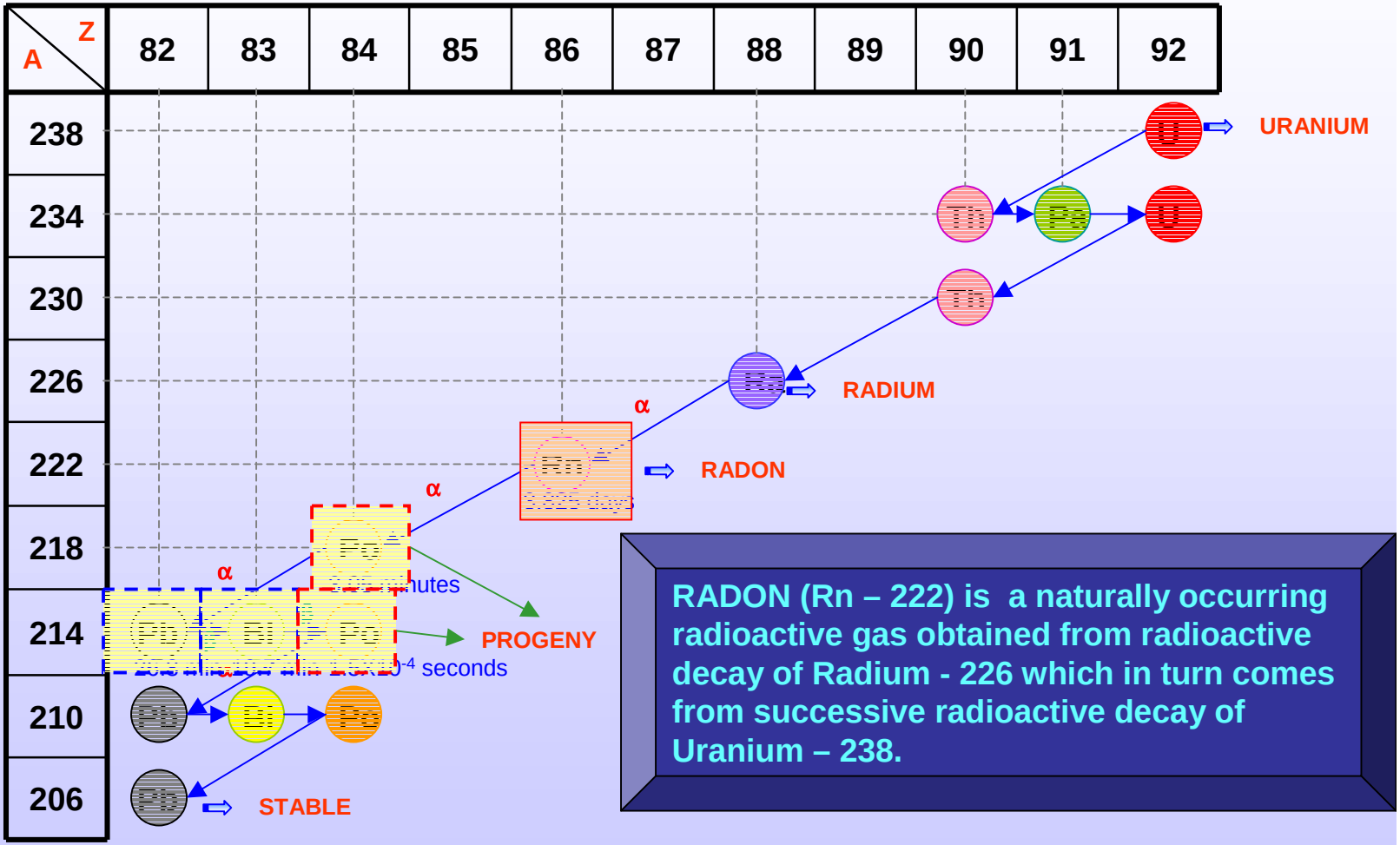
Originating from Natural Radioactive Decay of

URANIUM and **THORIUM**

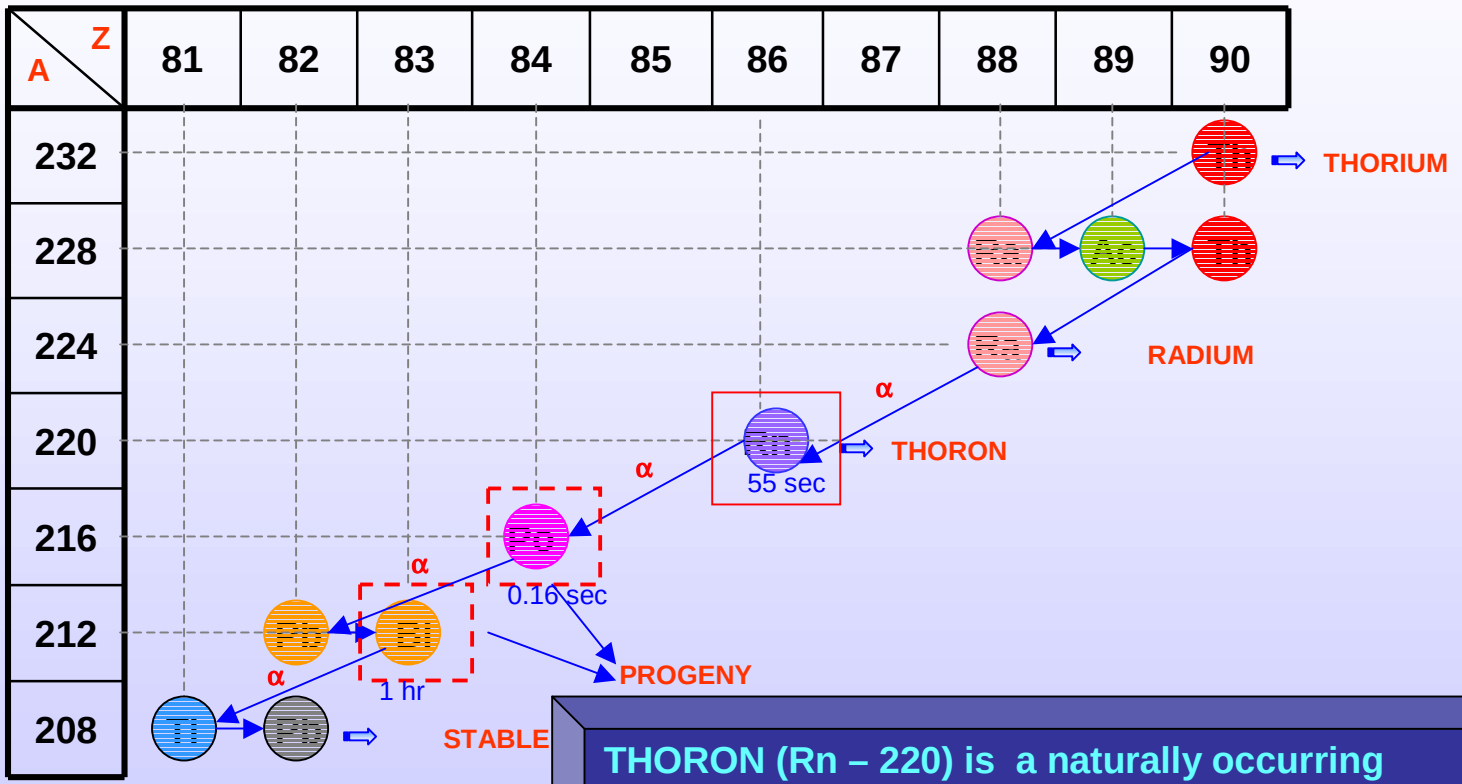
present in

SOIL, ROCKS and **GROUNDWATER.**

U^{238} Radioactive Decay Series

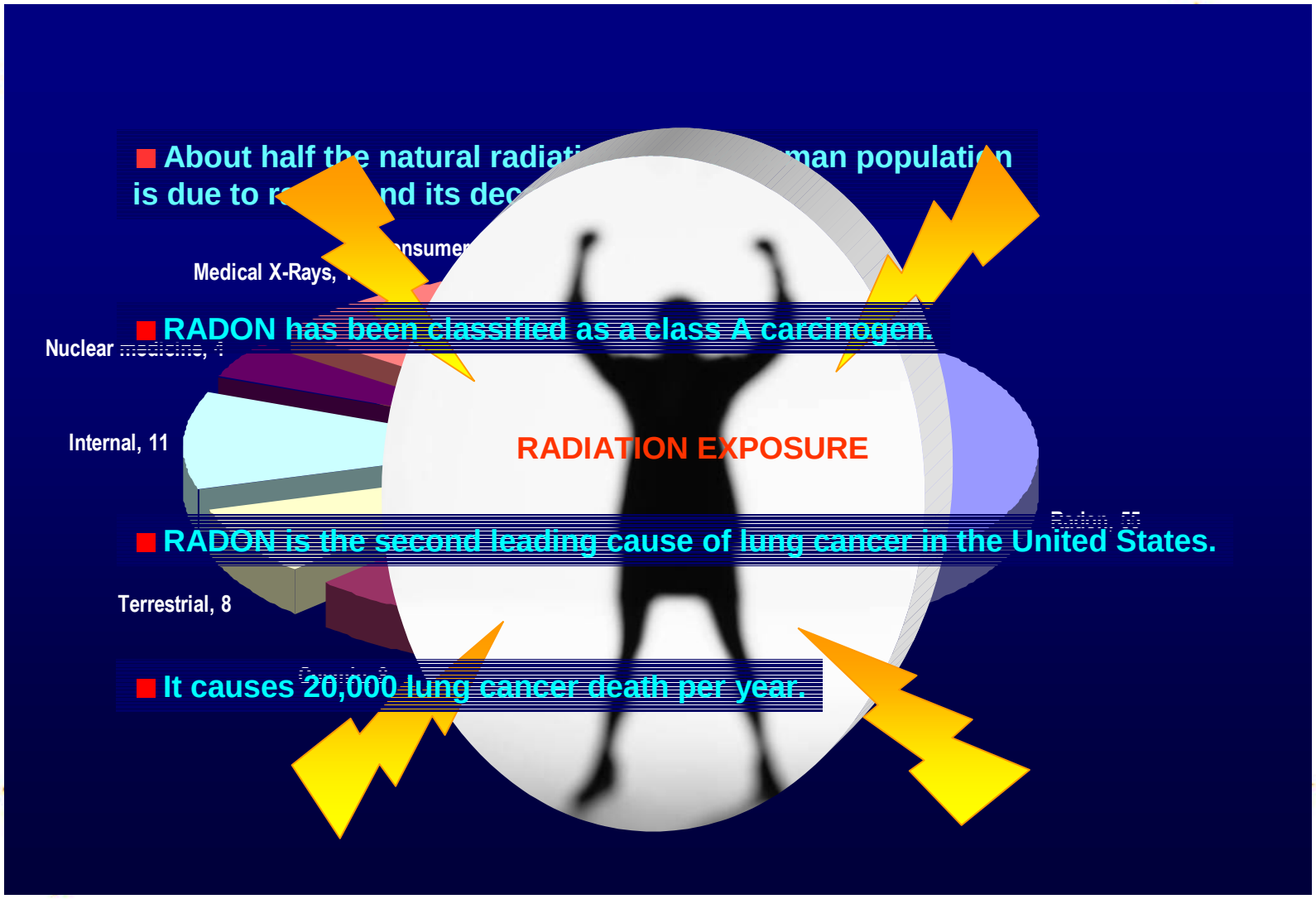


Th^{232} Radioactive Decay Series



THORON (Rn – 220) is a naturally occurring radioactive substance obtained from radioactive decay of Radium - 226 which in turn comes from successive radioactive decay of Thorium – 232.

OBJECTIVE– Why Radon is studied?



WHERE from RADON comes and HOW it enters home?

SOURCES OF RADON

SOIL

- Soil and rock contains trace quantities of radium which intern comes from U^{238} and Th^{232}
- Av. Conc. 25 Bq/Kg (UNSCEAR, 1986)

BUILDING MATERIAL

- Radium content is significant
- Av. Radon Emanation from Concrete = 7.7×10^{-6} $BqKg^{-1}sec^{-1}$
  Gypsum = 6.3×10^{-6} $BqKg^{-1}sec^{-1}$

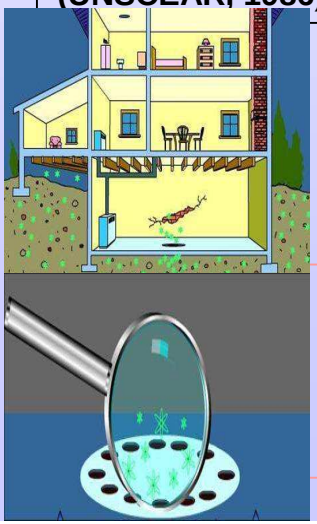
WATER

- Radon get dissolved in groundwater
- Highest conc. In drill well specially in granite area
- Lowest conc. In dug well and surface water

NATURAL GAS

- Rocks present around gas formation site may contain trace quantity of radium.
- Radon emanation from rocks may contaminate natural gas.

GATEWAY OF RADON INSIDE HOME



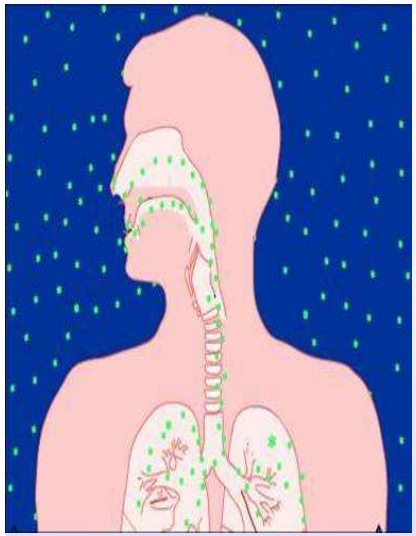
CRACKS

- Cracks in the floor
- Wall slab joint
- Drain
- Openings around plumbing and electrical connections

DIFFERENCE OF AIR PRESSURE

During cold season when windows are closed, heater is on, due to difference of temperature between indoor and outdoor, warm air inside house rises up creating a low pressure region in the lower portion of the building causing ground floor to draw radon gas from the soil into the building.

INDOOR RADON PROBLEM – a flow chart analysis



Primary Sources of Radon

Building Material | Soil | Water | Natural gas

RADON/THORON

Half – life of
RADON = 3.8 DAYS
Progeny ~ few seconds

HOUSE

Ventilation
Outdoor
Ventilation

Indoor

Decay

Progeny

Inhalation

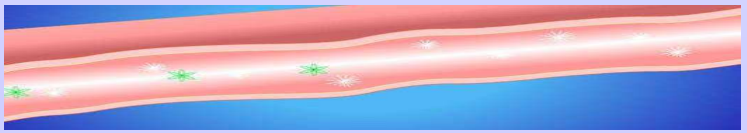
Decay takes place

Decay does not take place

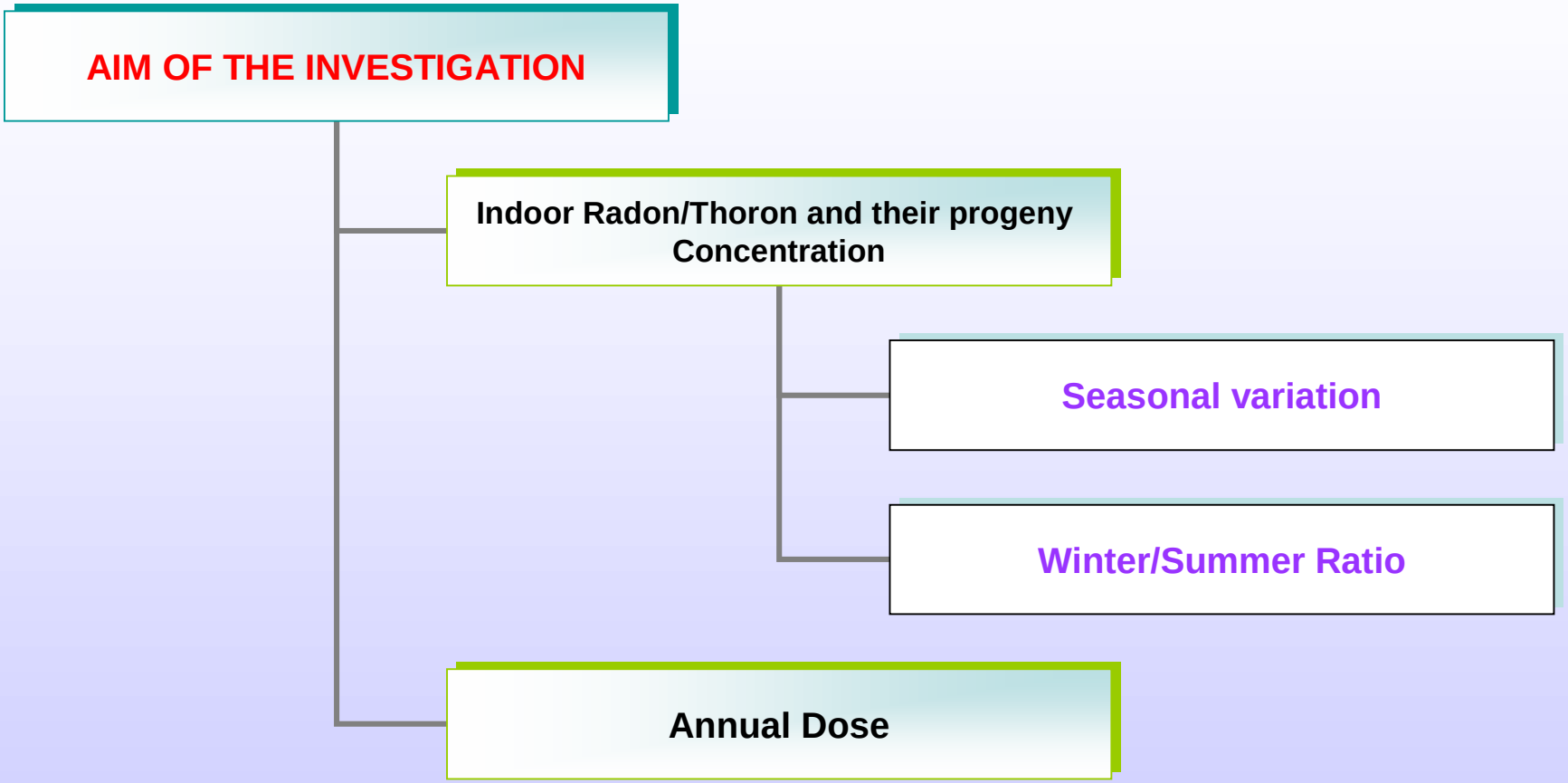
Dangerous

Safe

Why ?



Decay is associated with emission of alpha particles which irradiates the cell tissue of lung

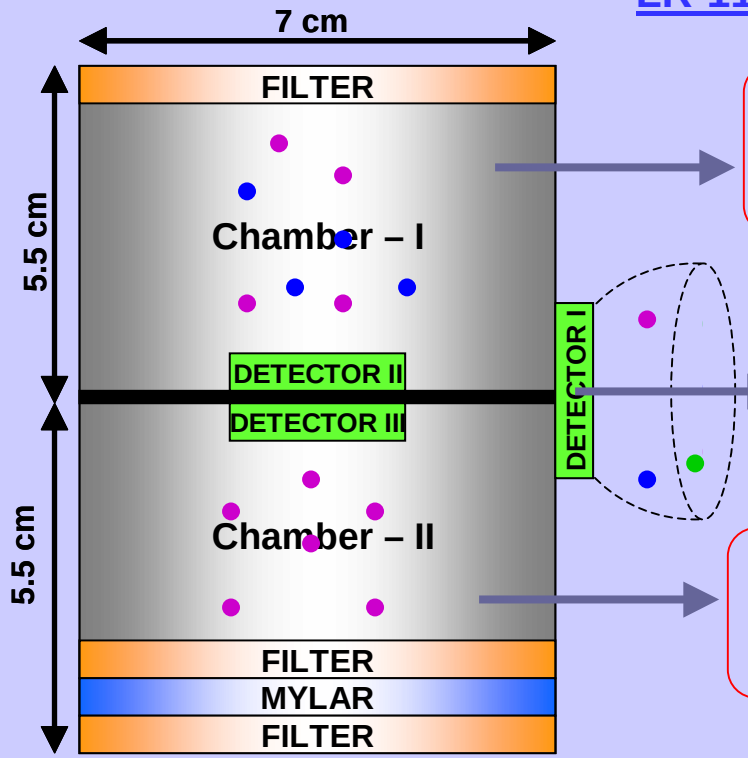

AIM OF THE INVESTIGATION
Indoor Radon/Thoron and their progeny Concentration
Seasonal variation
Winter/Summer Ratio
Annual Dose

AREA OF INVESTIGATION

- Noonmati Area of Gauhati Refinary
- Geographic Location
  - Latitude: $26^{0}13^{/}$ N
  - Longitude: $91^{0}52^{/}$ E
- 64 m above the mean sea level.
- RCC type of house

EXPERIMENTAL TECHNIQUE

LR-115 (type II), exposed in three different modes:



Cup with FILTER Paper: Detector (II) can detect only RADON and THORON. Its solid progenies can not pass through filter.

Bare Mode: Detector (I) can detect RADON, THORON and PROGENIES, within a hemisphere of radius 10 cm.

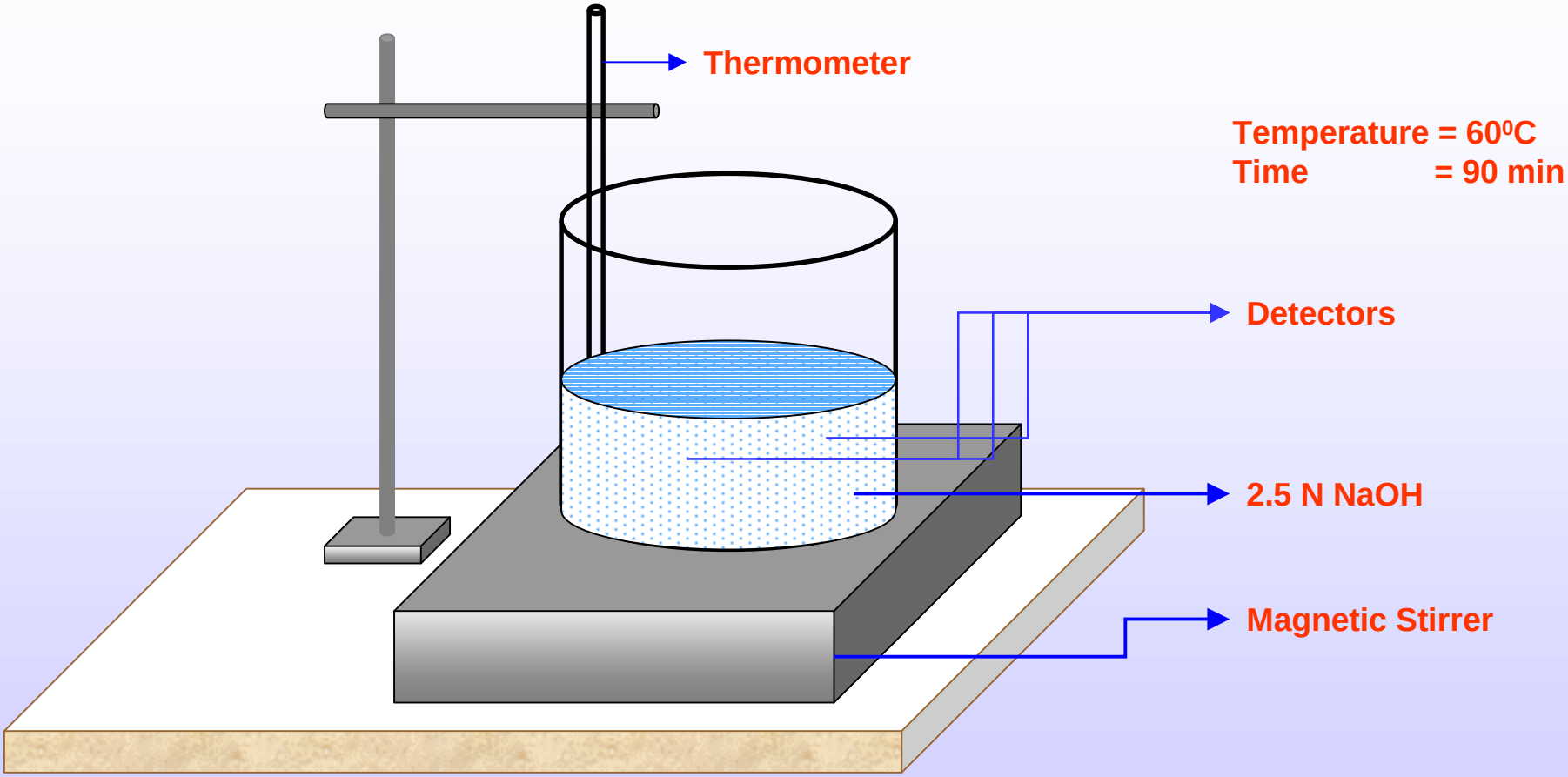
Cup with FILTER Paper and MYLAR: Detector (III) can detect only RADON. Short lived THORON also fail to pass through.

RADON THORON PROGENIES

- The detectors are exposed for 90 – 95 days inside a room.
- After that detectors are retrieved from dosimeter cup and kept in a specially designed container.
- These are then chemically etched within 24 hours after retrieval.

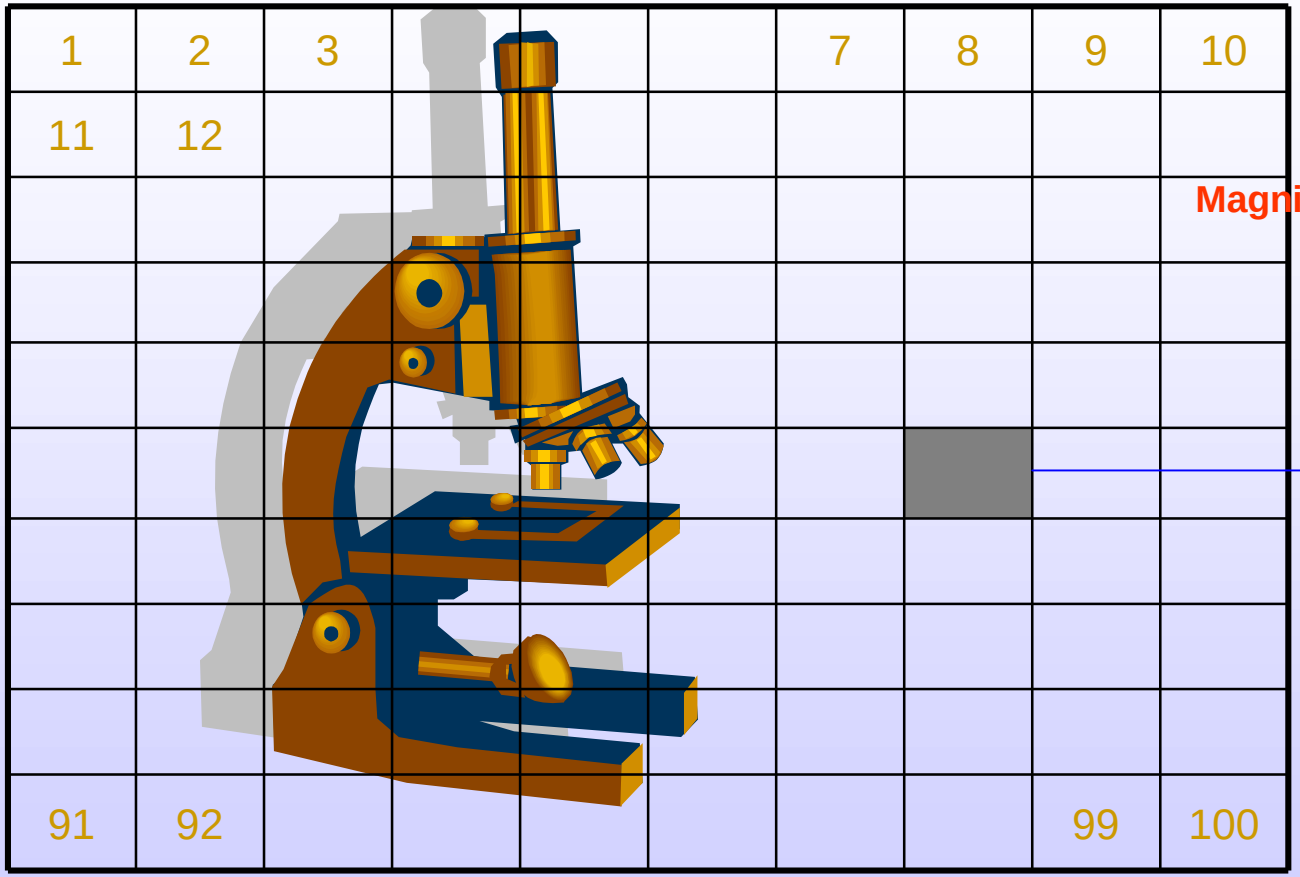

Bare film (Duaghter products)
Film with Filter Paper
(Radon & Thoron)
Film with Filter Paper, Mylar
& Filter Paper
(Radon)

CHEMICAL ETCHING



Latent tracks are enlarged to microscopically visible size by chemical etching.

TRACK COUNTING



ESSENTIAL FORMULAE

CONCENTRATION for

Radon

$$C_R = \frac{T_1}{dK_R}$$

Thoron

$$C_T = \frac{(T_2 - T_1)}{dK_T}$$

K_R and K_T are Sensitivity Factors for Radon and Thoron gas,
d is the number of exposure days,
T_1 and T_2 are track densities in membrane and filter mode of exposure.

Progeny working levels for

RADON

$$WL_R = \frac{C_R F_R}{3.7}$$

$$F_R = \left(0.104F_{R-A} + 0.518F_{R-B} + 0.37F_{R-C}\right)$$

THORON

$$WL_T = \frac{C_T F_T}{275}$$

$$F_T = \left(0.908F_{T-B} + 0.092F_{T-C}\right)$$

F_R and F_T are equilibrium factors for Radon and Thoron progeny respectively, calculated with regard to the estimated extract ventilation rate.

$$F_{R-A} = \frac{D_{R-A}}{\left\{D_{R-A} + \left(UF_{R-A} \times WLF\right) + \left(1 - UF_{R-A}\right) \times WLC + V\right\}}$$

$$F_{R-C} = \frac{F_{R-B} \times D_{R-C}}{\left\{D_{R-C} + \left(UF_{R-C} \times WLF\right) + \left(1 - UF_{R-C}\right) \times WLC + V\right\}}$$

$$F_{R-B} = \frac{F_{R-A} \times D_{R-B}}{\left\{D_{R-B} + \left(UF_{R-B} \times WLF\right) + \left(1 - UF_{R-B}\right) \times WLC + V\right\}}$$

$D_{R\text{-}A}$ is the decay constant of RaA(^{218}Po) (=3.79×10^{-3}s^{-1}) and
$UF_{R\text{-}A}$ is the unattached fraction for RaA (=0.2),
WLF is the wall loss rate for the fine fraction (=10h) and
WLC is the wall loss rate for the coarse fraction (=0.1h^{-1})
$D_{R\text{-}B}$ is the decay constant of RaB(^{214}Pb) (=4.3×10^{-4}h^{-1}) and
$UF_{R\text{-}B}$ is the unattached fraction for RaB (=0.025),
WLF is the wall loss rate for the fine fraction (=10h) and
WLC is the wall loss rate for the coarse fraction (=0.1h^{-1}) and
V is the estimated ventilation rate.

$$F_{T-A} = \frac{D_{T-A}}{D_{T-A} + WLC + V}$$

$$F_{T-C} = \frac{F_{T-A} \times D_{T-C}}{D_{T-C} + WLC + V}$$

$$C_{T-A} = C_T \times F_{T-A}$$

$$C_{T-C} = C_T \times F_{T-C}$$

$D_{R\text{-}C}$ is the decay constant of RaC(^{214}Bi) (=5.78×10^{-4}s^{-1}) and
$UF_{R\text{-}C}$ is the unattached fraction for RaC (=0.001).
$D_{T\text{-}A}$ is the decay constant of ThA(^{216}Po) (=1.82×10^{-5}h^{-1}).
$D_{T\text{-}C}$ is the decay constant of ThC(^{212}Bi) (=1.91×10^{-1}s^{-1}).

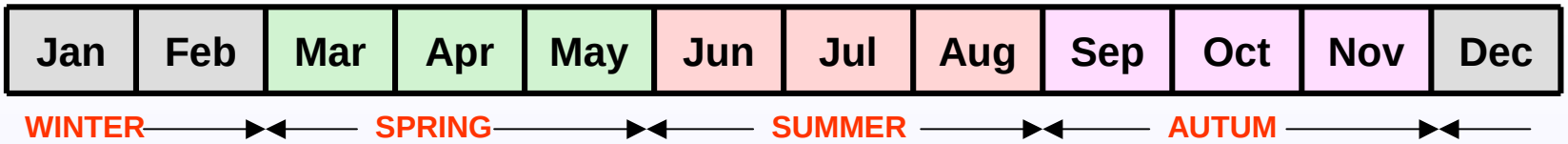
Annual Dose received by population

$$D = \{(0.17 + 9F_R)C_R + (0.11 + 32F_T)C_T\}/1000$$

F_R and F_T are equilibrium factors for Radon and Thoron resectively.

Ref: Deka PC, Sarkar S, Sarma B K, Goswami T D, Ramachandran T V, Nambi K S V, Indoor plus Built Environment, 12, (2003), 343.
Sarma H.K, Deka P.C, Sarkar S, Goswami T.D, Sarma B.K. International Journal of Pure & Applied Physics, Vol. 6, No.2 (2010)pp. 157-164.

CLIMATE OF THE INVESTIGATED AREA



WINTER

- Month: Dec – Jan – Feb
- Temp ~ 10^0C
- Characteristics: Cold and Foggy

SPRING

- Month: Mar – Apr– May
- Temp ~ Moderate
- Characteristics: Pleasant

SUMMER

- Month: Jun – Jul– Aug
- Temp. ~ 38^0C
- Characteristics: Hot and Humid

AUTUM

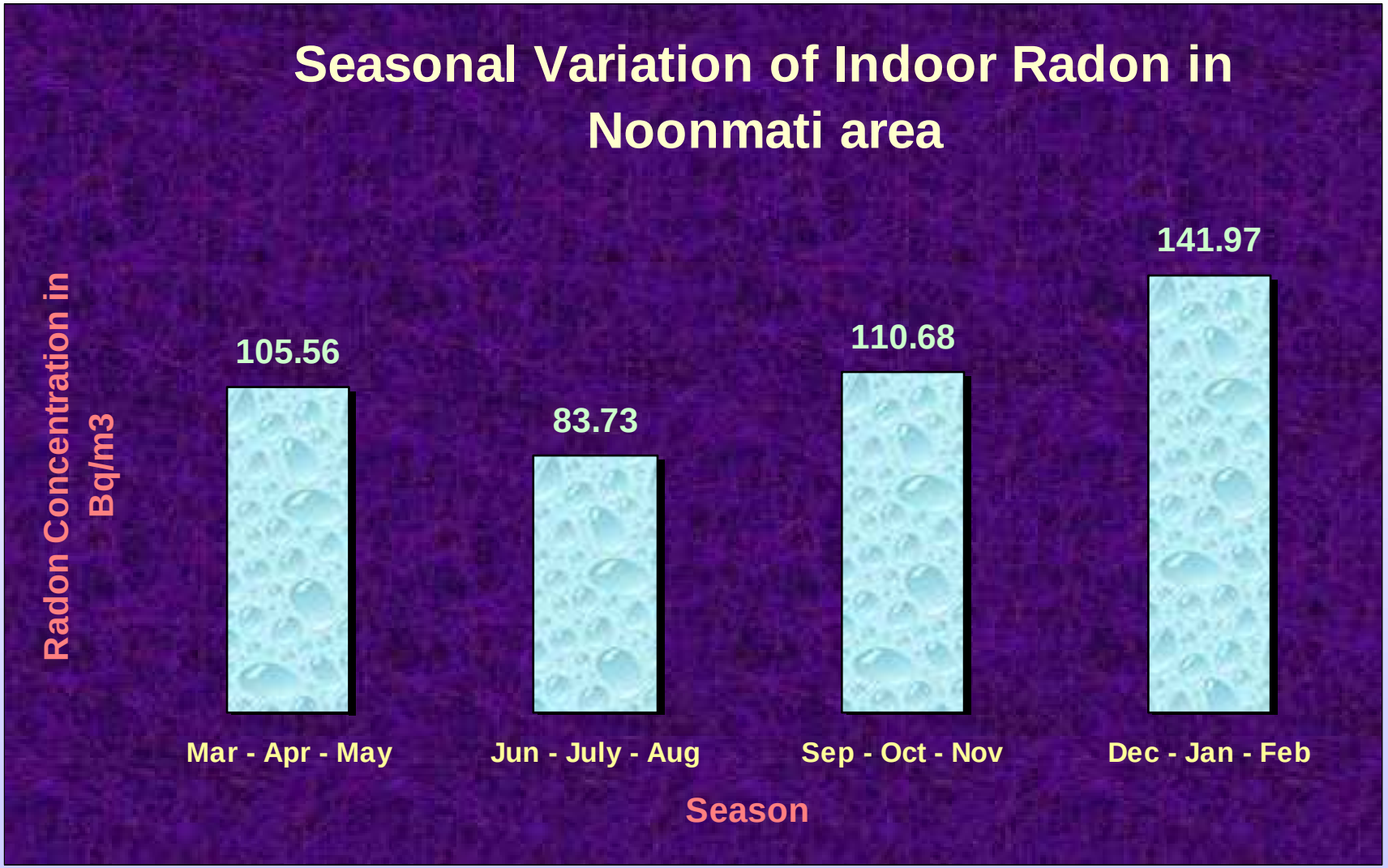
- Month: Sep – Oct – Nov
- Temp ~ Moderate
- Characteristics: Pleasant

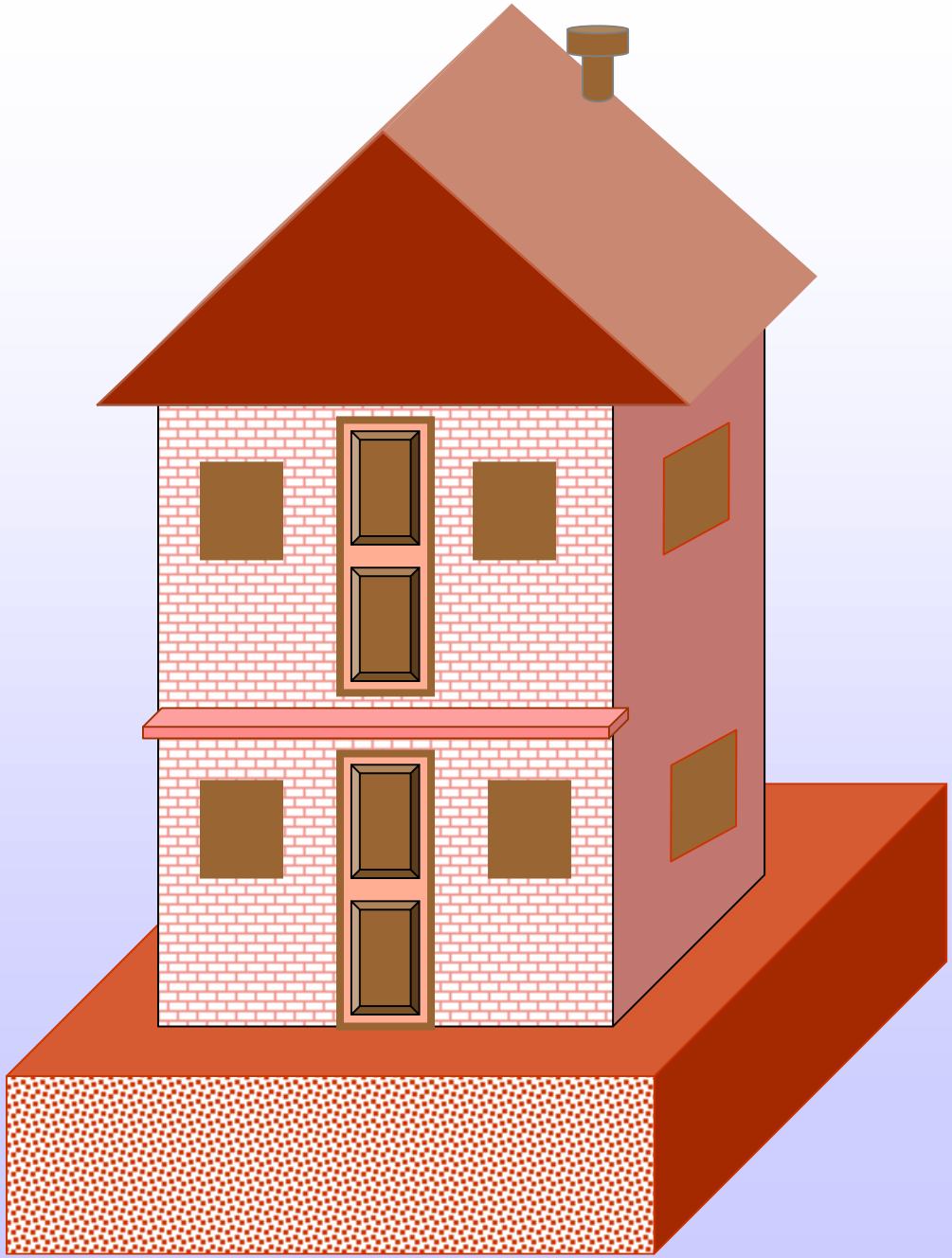
Measured Indoor Radon Levels of RCC Houses of Noonmati Area

Locations	House No.	Radon Levels in Bq/m3				Mean
		Mar - Apr - May	Jun - July - Aug	Sep - Oct - Nov	Dec - Jan - Feb	
Sankardev Nagar	1	100.585	98.246	135.673	159.064	120.84
	2	126.316	88.889	105.263	128.655	111.05
	3	98.246	77.193	88.889	168.421	103.22
	4	119.298	70.175	119.298	145.029	109.70
	5	86.55	74.854	100.585	112.281	92.49
	6	123.977	105.263	119.298	135.673	120.56
	7	95.906	98.246	109.942	133.333	108.41
Bishnurava Nagar	1	126.316	121.637	109.942	196.491	134.98
	2	138.012	98.246	133.333	159.064	130.22
	3	109.942	79.532	102.924	138.012	105.57
	4	126.316	74.854	81.871	114.62	97.05
	5	116.959	86.55	77.193	145.029	103.18
	6	100.585	98.246	86.55	123.977	101.48
	7	91.228	79.532	102.924	109.942	95.19
Salbari	1	109.942	74.854	107.602	149.708	107.30
	2	100.585	77.193	114.62	128.655	103.44
	3	91.228	84.211	123.977	149.708	109.27
	4	77.193	72.515	133.333	166.082	105.52
	5	81.871	70.175	138.012	156.725	105.58
	6	95.906	67.836	112.281	128.655	98.46
	7	86.55	72.515	119.298	123.977	98.16

Measured Indoor Radon Levels of RCC Houses of Noonmati Area

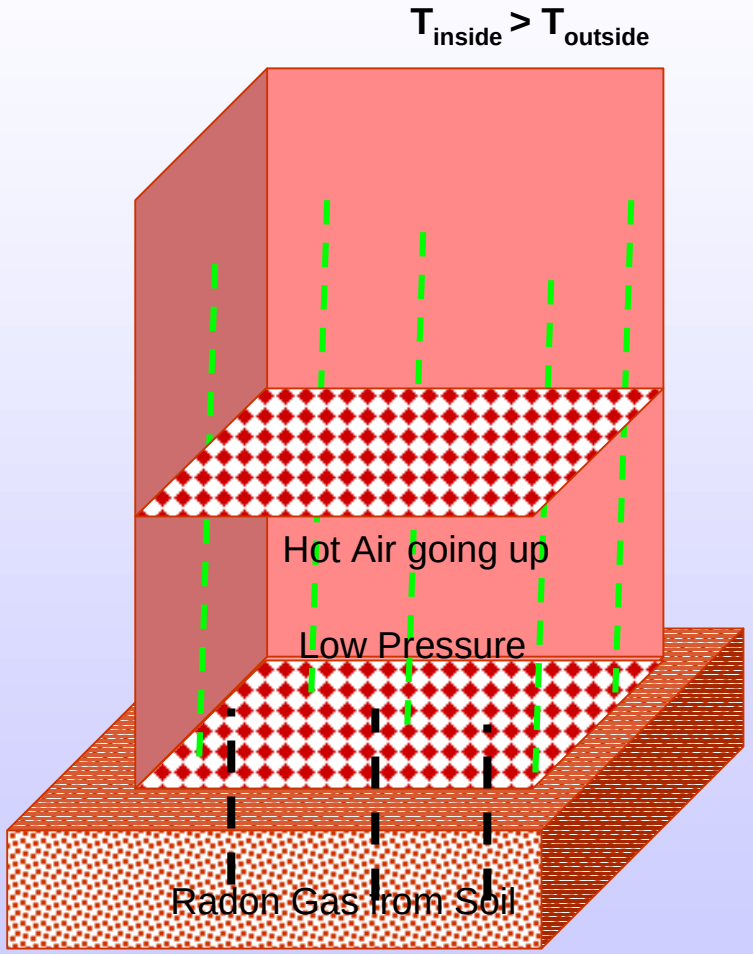
Locations	Mean Radon Levels in Bq/m3				Winter/ Summer Ratio
	Mar - Apr - May	Jun - July - Aug	Sep - Oct - Nov	Dec - Jan - Feb	
Sankardev Nagar	109.16	85.77	111.50	141.52	1.65
Bishnurava Nagar	115.62	91.23	99.25	141.02	1.55
Salbari	91.90	74.19	121.30	143.36	1.93
Mean of Noonmati =>	105.56	83.73	110.68	141.97	1.71


Seasonal Variation of Indoor Radon in Noonmati area
Radon Concentration in Bq/m3
105.56
83.73
110.68
141.97
Mar - Apr - May
Jun - July - Aug
Sep - Oct - Nov
Dec - Jan - Feb
Season



CAUSE:

- **Poor Ventilation**
- **Thermal Stack Effect**

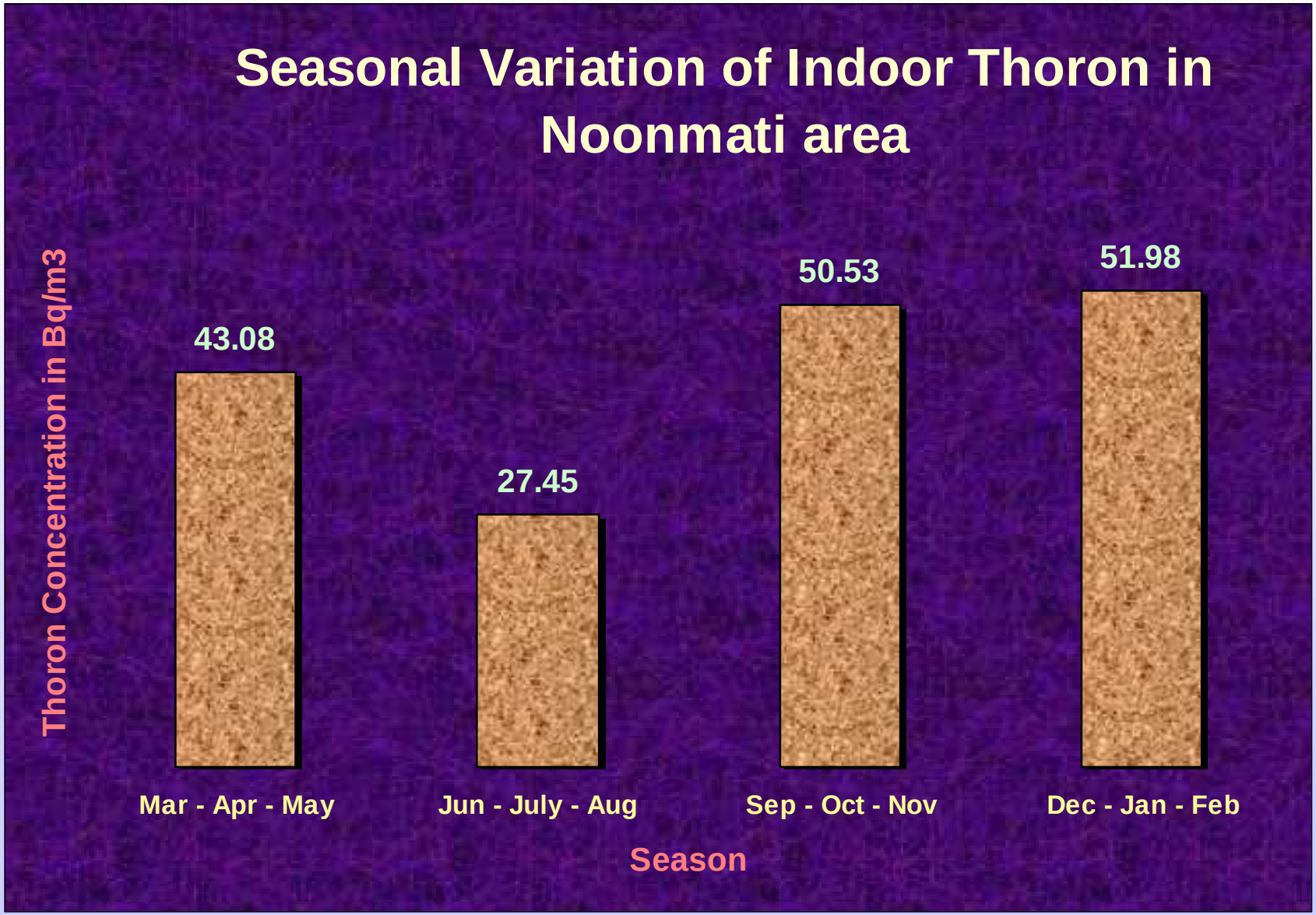


Measured Indoor Thoron Levels of RCC Houses of Noonmati Area

Locations	House No.	Thoron Levels in Bq/m3				Mean
		Mar - Apr - May	Jun - July - Aug	Sep - Oct - Nov	Dec - Jan - Feb	
Sankardev Nagar	1	33.33	25.00	58.33	47.22	38.92
	2	52.78	25.00	41.67	63.89	43.29
	3	75.00	19.44	80.56	55.56	50.54
	4	63.89	25.00	58.33	41.67	44.39
	5	16.67	25.00	30.56	38.89	26.53
	6	69.44	38.89	30.56	69.44	48.93
	7	61.11	25.00	30.56	38.89	36.71
Bishnurava Nagar	1	55.56	30.56	83.33	72.22	56.54
	2	50.00	41.67	50.00	44.44	46.39
	3	47.22	25.00	55.56	55.56	43.69
	4	47.22	19.44	63.89	55.56	42.49
	5	50.00	16.67	50.00	36.11	35.02
	6	41.67	25.00	33.33	38.89	34.09
	7	30.56	36.11	63.89	88.89	50.03
Salbari	1	33.33	41.67	38.89	63.89	43.10
	2	22.22	25.00	50.00	50.00	34.33
	3	11.11	30.56	36.11	41.67	26.73
	4	50.00	30.56	55.56	36.11	41.84
	5	38.89	27.78	27.78	30.56	30.94
	6	33.33	27.78	44.44	38.89	35.57
	7	30.56	13.89	58.33	69.44	36.21

Measured Indoor Thoron Levels of RCC Houses of Noonmati Area

Locations	Mean Thoron Levels in Bq/m3				Winter/ Summer Ratio
	Mar - Apr - May	Jun - July - Aug	Sep - Oct - Nov	Dec - Jan - Feb	
Sankardev Nagar	53.17	26.19	47.22	50.79	1.94
Bishnurava Nagar	46.03	27.78	57.14	55.95	2.01
Salbari	31.35	28.17	44.44	47.22	1.68
Mean of Noonmati =>	43.52	27.38	49.60	51.32	1.88


Seasonal Variation of Indoor Thoron in Noonmati area
Thoron Concentration in Bq/m3
43.08
27.45
50.53
51.98
Mar - Apr - May
Jun - July - Aug
Sep - Oct - Nov
Dec - Jan - Feb
Season

Locations	House No.	Radon Progeny Concentration				Mean
		Mar. - April. - May.	June - July - Aug.	Sept. - Oct. - Nov.	Dec. - Jan. - Feb.	
Sankardevnagar	1	0.383	0.353	0.487	0.571	0.449
	2	0.453	0.345	0.750	0.462	0.503
	3	0.353	0.931	0.319	1.241	0.711
	4	0.428	0.418	0.428	0.521	0.449
	5	1.611	0.269	0.575	0.403	0.715
	6	0.445	0.378	1.336	0.487	0.662
	7	0.344	0.353	0.537	0.479	0.428
	Mean	0.574	0.435	0.633	0.595	
Bishnuravanagar	1	0.453	0.437	0.395	0.705	0.498
	2	0.495	0.353	0.479	0.571	0.475
	3	0.395	0.285	0.369	0.495	0.386
	4	0.453	0.269	0.294	0.411	0.357
	5	0.420	0.311	0.277	0.521	0.382
	6	0.361	0.353	0.362	0.445	0.380
	7	0.327	0.285	0.369	0.395	0.344
	Mean	0.415	0.328	0.364	0.506	
Salbari	1	0.395	0.269	0.411	0.537	0.403
	2	1.078	0.277	0.411	0.462	0.557
	3	2.348	0.302	0.445	0.537	0.908
	4	0.277	0.260	0.479	0.596	0.403
	5	0.294	0.252	0.495	0.563	0.401
	6	0.344	0.243	0.403	0.462	0.363
	7	0.311	0.260	0.428	0.445	0.361
	Mean	0.721	0.266	0.439	0.515	

Locations	House No.	Thoron Progeny Concentration				Mean
		Mar. - April. - May.	June - July - Aug.	Sept. - Oct. - Nov.	Dec. - Jan. - Feb.	
Sankardevnagar	1	0.078	0.055	0.127	0.103	0.091
	2	0.115	0.059	0.193	0.14	0.127
	3	0.164	0.166	0.176	0.268	0.194
	4	0.14	0.095	0.127	0.091	0.113
	5	0.24	0.055	0.111	0.085	0.123
	6	0.152	0.085	0.238	0.152	0.157
	7	0.133	0.055	0.093	0.085	0.092
	Mean	0.146	0.081	0.152	0.132	
Bishnuravanagar	1	0.121	0.067	0.182	0.158	0.132
	2	0.109	0.091	0.109	0.097	0.102
	3	0.103	0.055	0.121	0.121	0.100
	4	0.103	0.042	0.14	0.121	0.102
	5	0.109	0.036	0.109	0.079	0.083
	6	0.091	0.055	0.086	0.085	0.079
	7	0.067	0.079	0.14	0.194	0.120
	Mean	0.100	0.061	0.127	0.122	
Salbari	1	0.073	0.091	0.091	0.14	0.099
	2	0.165	0.055	0.109	0.109	0.110
	3	0.24	0.067	0.079	0.091	0.119
	4	0.109	0.067	0.121	0.079	0.094
	5	0.085	0.061	0.061	0.067	0.069
	6	0.073	0.061	0.097	0.085	0.079
	7	0.067	0.03	0.127	0.152	0.094
	Mean	0.116	0.062	0.098	0.103	

Progeny Concentration of RCC Houses of Noonmati Area

Locations	Radon Progeny Concentration			
	Mar. - April. - May	June - July - Aug	Sept. - Oct. - Nov	Dec. - Jan. - Feb
Sankardevnagar	0.574	0.435	0.633	0.595
Bishnuravanagar	0.415	0.328	0.364	0.506
Salbari	0.721	0.266	0.439	0.515

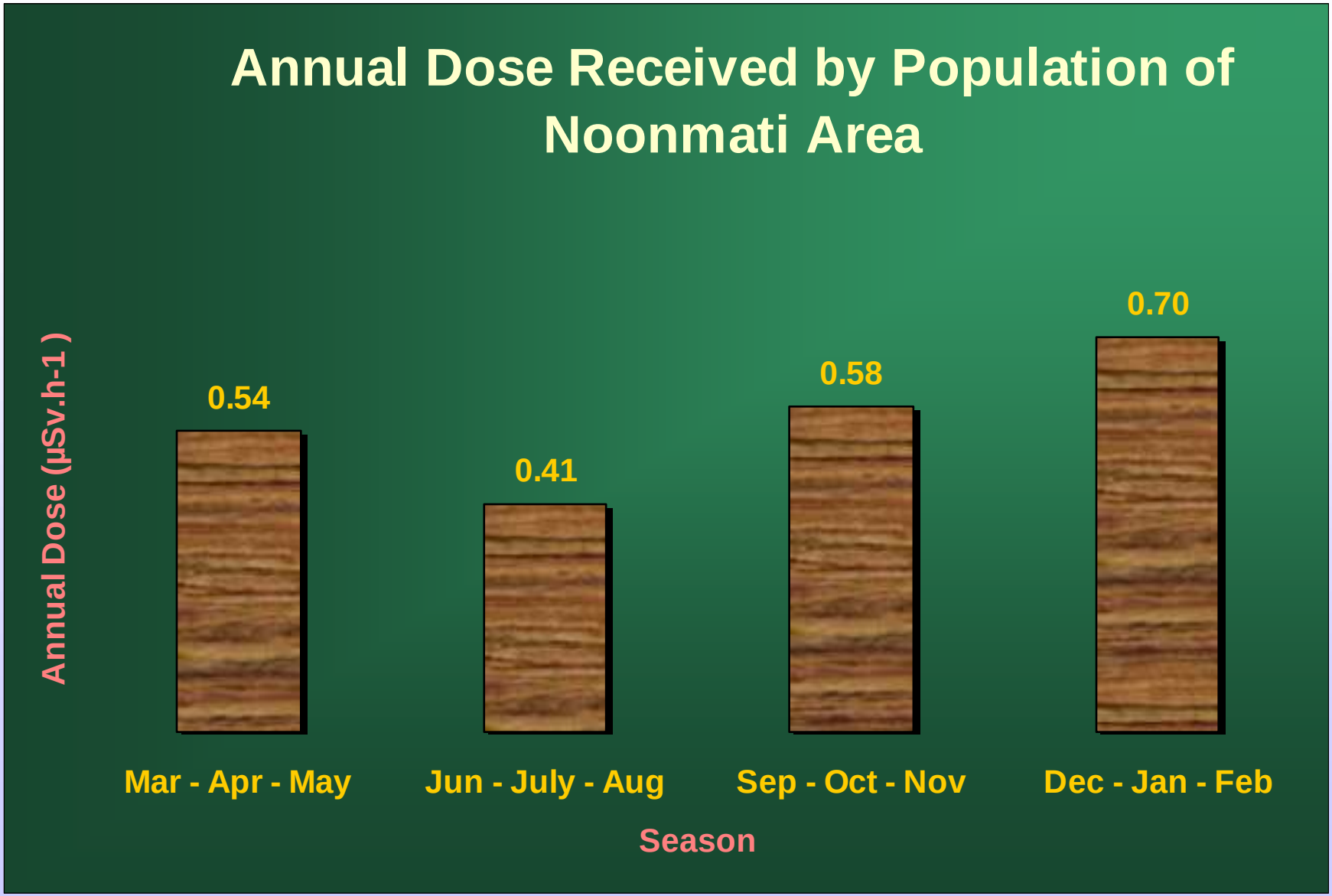
Locations	Thoron Progeny Concentration			
	Mar. - April. - May	June - July - Aug	Sept. - Oct. - Nov	Dec. - Jan. - Feb
Sankardevnagar	0.146	0.081	0.152	0.132
Bishnuravanagar	0.100	0.061	0.127	0.122
Salbari	0.116	0.062	0.098	0.103

Annual Dose Received by Population of Noonmati Area

Locations	House No.	Annual Dose				Mean
		Mar - Apr - May	Jun - July - Aug	Sep - Oct - Nov	Dec - Jan - Feb	
Sankardev Nagar	1	0.49	0.453	0.705	0.756	0.59
	2	0.651	0.418	0.535	0.697	0.56
	3	0.619	0.355	0.602	0.819	0.57
	4	0.661	0.347	0.643	0.685	0.56
	5	0.381	0.365	0.48	0.552	0.44
	6	0.697	0.526	0.551	0.741	0.62
	7	0.564	0.453	0.516	0.631	0.54
Bishnurava Nagar	1	0.66	0.56	0.69	0.98	0.71
	2	0.686	0.508	0.668	0.747	0.65
	3	0.571	0.383	0.572	0.704	0.54
	4	0.633	0.347	0.52	0.616	0.52
	5	0.606	0.381	0.457	0.666	0.51
	6	0.517	0.453	0.437	0.596	0.50
	7	0.445	0.419	0.599	0.709	0.53
Salbari	1	0.525	0.42	0.534	0.776	0.55
	2	0.453	0.374	0.598	0.651	0.51
	3	0.381	0.419	0.587	0.702	0.51
	4	0.457	0.375	0.687	0.746	0.54
	5	0.437	0.357	0.612	0.692	0.51
	6	0.472	0.348	0.57	0.614	0.49
	7	0.427	0.319	0.643	0.697	0.50

Annual Dose Received by Population of Noonmati Area

Locations	Annual Dose ($\mu Sv.h^{-1}$) Received by Population of Noonmati Area			
	Mar - Apr - May	Jun - July - Aug	Sep - Oct - Nov	Dec - Jan - Feb
Sankardev Nagar	0.58	0.42	0.58	0.70
Bishnurava Nagar	0.59	0.44	0.56	0.72
Salbari	0.45	0.37	0.60	0.70
Mean of Noonmati =>	0.54	0.41	0.58	0.70


Annual Dose Received by Population of Noonmati Area
Annual Dose (µSv.h-1)
0.54
0.41
0.58
0.70
Mar - Apr - May
Jun - July - Aug
Sep - Oct - Nov
Dec - Jan - Feb
Season

SUMMARY OF RESULT

	Maximum	Minimum	Mean	Recommended Action Level Value, ICRP 1993
Indoor RADON Concentration (Bq/m^3)	134.97	92.48	113.7	200 – 600
Indoor THORON Concentration (Bq/m^3)	56.5	26.5	41.5	
Winter/Summer Ratio for RADON	2.2	1.2		
Winter/Summer Ratio for THORON	2.8	1.1		
Indoor RADON Progeny Concentration (mWL)	0.908	0.344	0.482	
Indoor THORON Progeny Concentration (mWL)	0.194	0.069	0.108	
Annual Dose ($\mu Sv.h^{-1}$)	0.7	0.41	0.56	0 – 10

CONCLUSION

- Average Radon Concentration is much lower than the recommended action taken values.
- Annual dose received by the population is not so significant.
- Through investigation of indoor radon/thoron concentration, their dependence on building material, geology of the area can be understood.

Thank You.....