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Variation of Thoron with Relative and Absolute Humidity

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Abstract— In order to study of variation of RH and AH with EEC_{Tn} , Temperature and RH were used as variables to calculate AH using 3D MATLAB Program. An equation relating AH, RH and T was obtained. Calculated AH values were plotted vs measured EEC_{Tn}. At all places positive slope has been found between RH and EEC_{Tn} whereas AH vs EEC_{Tn} curves have negative slope, confirming our previous results for EEC_{Rn} . Ratios of EEC_{Tn} to EEC_{Rn} at Bathinda ,Hamirpur and Chakmoh are higher than reported in literature but that of Amritsar is lower.

Keywords— EEC_{Tn}, DSAABC Method, Relative Humidity, absolute humidity, 3D MATLAB equation.

I. INTRODUCTION

^{220}Rn gas and its progenies are present in Indoor and Outdoor dwellings owing to the presence of its parent nuclide (Thorium) in various building materials [1].Radioactive radon and thoron contribute more than 50% of the radiation dose received by individuals from all natural radiation sources[2].Earlier, ^{220}Rn (thoron) was paid little attention in context of radiation protection in homes([3],[4]). The rationale being that its short half-life (55.6 seconds) is insufficient for it to diffuse from soil or rock under the building .The dose distribution from thoron and its progeny is ignored in comparison to radon and its progeny [5]. In the present work results of thoron daughter concentrations are determined from gross beta counts by DSAABC method[6]. EEC_{Tn} is computed from activity concentrations by use of **Bateman differential equations**[7]. Annual effective dose rate of thoron has been calculated from activity concentrations. Measurements are taken from two sites in Punjab (Amritsar, Bathinda) and two sites in Himachal Pradesh (Hamirpur, Chakmoh). Measurements were made three times a day (morning,noon and evening).

The DSAABC method is used in this study was developed by **Papp and Daroczy** [7].This method has several various advantages over old alpha counting and gamma spectrometry.[8].Gamma spectrometry is low efficiency, high background and high cost technique. A low permeability membrane filter and low air flow rate are major requirements of alpha counting methods, to prevent strong self-absorption and energy degradation of alpha particles. In beta counting high air flow rate and glass fibre filter can be used. As beta particles have high penetration power than alpha particles, sensitivity is also higher. Thus, DSAABC method developed by Papp and Daroczy[6] was used to measure the counting efficiency of thoron and its progeny one by one,having errors less than 10%. Values of RH and Temperature have been used to calculate AH using MAT Lab 3D equation[9]. Correlation coefficients were found between EEC_{Tn} vs AH, and EEC_{Tn} vs RH. The average ratio of EEC_{Tn} and EEC_{Rn} has been calculated and compared with literature average[10].

II. METHODOLOGY

It has been estimated that the airborne concentration level of radon progeny depends on the meteorological conditions such as rainfall, snow, wind, humidity and temperature. Out of these parameters temperature, absolute humidity and relative humidity variation has been studied. To measure individual concentrations of radon progeny DSAABC method has been used in four sites of Punjab and Himachal. For each site 40 observations were taken. The measured values of RH and Temperature were taken to calculate corresponding AH values using 3D MATLAB equation[9] with 95% confidence level:

$z = P_{00} + xP_{10} + yP_{01} + x^2 P_{20} + xyP_{11} + y^2 P_{02}$ (1)

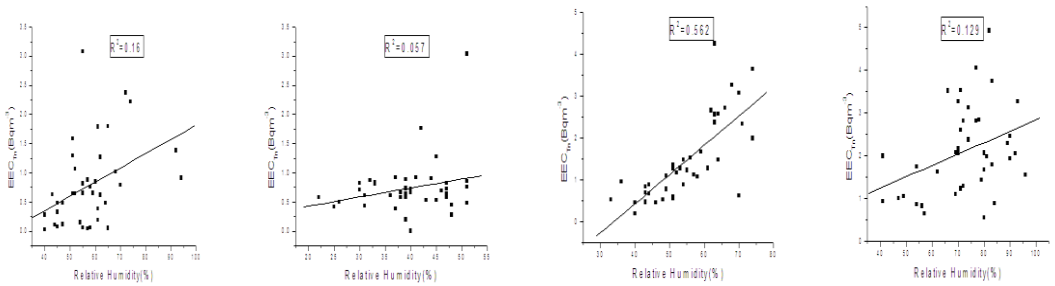
where

$P_{00} = 7.239$
$P_{10} = -0.07071$
$P_{01} = -0.9421$
$P_{20} = 0.0001071$
$P_{11} = 0.01493$
$P_{02} = 0.01868$

Z is mathematical symbol used for A.H., x is for R.H and y is for temperature. AH values calculated from 3D MAT Lab equation has been listed in Table-1 along with corresponding Temperature and RH.The correlation coefficients between EEC_{Tn} and AH, and EEC_{Tn} and RH have been found by plotting graphs in a software Origin.

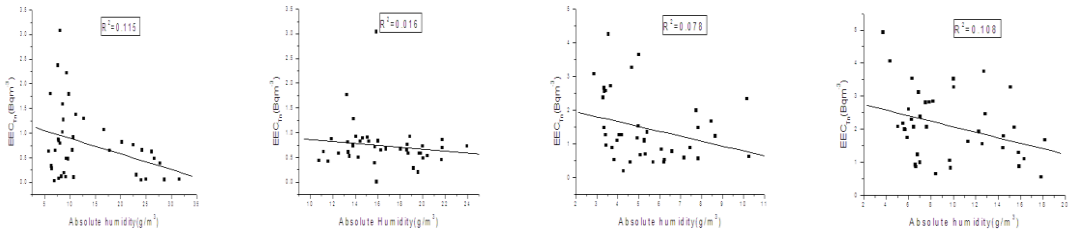
Table 1. $EEC_{Tn,}$ RH and AH at Four sites (two in Punjab and two in Himachal Pradesh)

Amritsar			Bathinda			Hamirpur			Chakmoh		
EEC	**RH**	**AH**	**EEC**	**RH**	**AH**	**EEC**	**RH**	**AH**	**EEC**	**RH**	**AH**
0.91	94	10.60	0.58	22	12.53	2.56	63	3.36	3.12	74	6.88
1.381	92	11.15	0.42	25	11.59	0.69	43	5.32	4.06	77	4.35
0.149	54	23.05	0.5	26	14.26	1.26	51	4.07	2.00	41	5.65
0.062	58	24.97	0.82	30	14.45	2.66	62	3.35	2.18	70	5.52
0.06	55	31.55	0.71	30	15.74	0.67	44	5.07	4.93	82	3.72
0.051	65	28.60	0.43	31	10.77	1.53	56	4.97	0.87	54	6.67
0.047	57	23.99	0.61	31	11.18	2.37	63	3.29	2.08	69	5.05
1.02	68	8.48	0.87	32	11.89	0.46	40	4.59	2.82	77	7.87
0.103	44	10.69	0.81	33	13.32	1.1	49	3.98	0.83	56	9.76
0.331	45	6.25	0.83	33	16.01	2.58	64	3.41	1.23	71	6.81
0.79	70	7.98	0.61	36	13.37	0.78	49	6.58	1.98	81	5.72
0.105	47	9.14	0.92	37	18.85	1.08	58	5.27	0.65	57	8.45
0.478	45	9.60	0.38	37	15.73	2.72	66	3.65	3.53	71	6.32
0.651	55	10.41	0.58	38	18.72	0.45	46	6.20	3.27	93	15.12
2.22	74	9.31	0.67	38	16.72	1.35	51	5.40	1.67	80	18.18
0.192	61	8.75	0.89	39	14.65	3.27	68	4.67	3.75	83	12.74
1.8	65	6.13	0.2	39	19.58	1.67	59	8.45	2.06	92	15.46
0.117	47	8.26	0.73	39	13.82	1.99	74	7.74	1.10	69	16.34
0.634	43	5.78	0.58	39	19.69	3.64	74	5.00	3.28	70	10.04
0.277	40	6.38	0.65	39	18.59	0.84	43	6.09	2.46	90	12.85
0.641	51	7.01	0.67	40	18.02	0.19	40	4.27	0.93	41	6.60
1.271	62	8.64	0.01	40	15.88	0.89	44	3.73	2.60	71	6.01
0.03	40	6.85	0.73	40	19.99	1.27	61	3.42	1.00	47	7.02
0.849	60	7.76	0.92	41	14.06	0.52	48	6.22	1.75	54	5.90
2.373	72	7.59	1.77	42	13.24	1.18	52	4.92	2.07	80	6.47
0.075	45	7.76	0.53	43	13.48	1.48	54	7.84	2.07	70	7.61
0.878	57	7.63	0.9	44	15.08	0.62	70	10.26	2.38	74	7.05
0.816	55	20.25	1.28	45	13.85	0.59	51	7.17	1.06	49	9.67
0.64	52	17.78	0.53	45	20.41	1.23	55	8.66	2.81	72	7.53
1.294	51	12.65	0.69	46	21.72	2.34	71	10.16	2.29	89	6.29
0.654	59	24.18	0.58	47	19.82	0.56	51	7.83	1.63	62	11.31
0.76	58	22.50	0.82	47	15.21	0.89	54	7.45	2.84	78	8.21
1.07	52	16.67	0.64	47	16.27	4.25	63	3.55	3.52	66	10.01
0.38	61	27.74	0.73	47	23.93	0.46	43	5.69	0.88	84	15.87
0.48	64	26.64	0.28	48	19.19	1.13	57	5.26	1.56	96	12.59
0.62	62	26.09	0.45	48	21.67	3.07	70	2.87	0.55	80	17.84
0.48	47	9.21	0.85	51	21.73	0.96	36	3.45	1.79	83	14.50
1.79	61	9.75	3.04	51	15.87	1.27	53	4.20	1.94	90	12.26
1.584	51	8.54	0.76	51	18.61	1.48	64	3.34	1.29	72	15.84
3.082	55	8.00	0.48	51	20.02	0.53	33	3.82	1.44	79	14.44



(a) (b) (c) (d)

Figure 1:Correlation between EEC_{Tn} andRelative humidity (a) Amritsar (b) Bathinda (c) Hamirpur (d) Chakmoh



(a) (b) (c) (d)

Figure 2: Graph between EEC_{Tn} and Absolute humidity (a)Amritsar (b)Bathinda (c)Hamirpur (d)Chakmoh

III. RESULTS AND DISCUSSIONS

Values of AH calculated using 3D equation have been listed in Table1. Graphs have been shown for EEC_{Tn} vs RH and EEC_{Tn} vs AH for (a) Amritsar,(b) Bathinda, (c) Hamirpur, (d) Chakmoh in Figure 1 and Figure 2 respectively. Correlationcoefficients have been found from curves using software named Origin. The values of slope R for EEC_{Tn} vs RH are 0.40±0.66, 0.24±0.46, 0.75±0.65, 0.36±0.97. Correlation coefficients for EEC_{Tn} vs AH are (a) Amritsar,(b) Bathinda, (c) Hamirpur, (d) Chakmoh and have been found and shown also in Table 2.The values of slope R for EEC_{Tn} vs AH are-0.34±0.67,-0.13±0.47, -0.28±0.95 and -0.33±0.98 respectively in Table-2. The plots(a),(b),(c),(d)in Figure1 show positive slope between EEC_{Tn} vs RH.The graph (a)(b)(c)(d) in figure-2 have negative slope between EEC_{Tn} and AH. To calculate the ratio of Thoron and Radon, Radon values were taken from our previouspaper[11].The average values have been calculated and listed in Table-3 for all the four places in Punjab and Himachal Pradesh and compared with Literature average.

Table 2.Correlation coefficients of EEC_{Tn} vs RH and AH at four sites

	Amritsar	**Bathinda**	**Hamirpur**	**Chakmoh**
RH	R=0.40±0.66	R=0.24±0.46	R=0.75±0.65	R=0.36±0.97
AH	R=-0.34±0.67	R=-0.13±0.47	R=-0.28±0.95	R=-0.33±0.98

Table 3.Average values of ratio of Thoron and Radon (EEC_{Tn}/EEC_{Rn}) in four place

AMRITSAR	**BATHINDA**	**HAMIRPUR**	**CHAKMOH**	**REFERENCE 11**
0.11	0.68	0.18	0.87	0.15

IV. CONCLUSIONS

It has been concluded that EEC_{Tn} vs RH shows positive correlations for all the four sites but EEC_{Tn} vs AH shows negative correlations for the same sites . This supports the results of [8] in which RH vs EEC_{Rn} and AH vs EEC_{Tn} are respectively having positive and negative slopes[12] in which both have positive slope. Our ratio of Thoron to Radon at Amritsar is lower than that reported in literature [10] but at other places it is higher.

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