Radon and Thoron Concentrations in Selected Historic Buildings (Brisbane)

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ABSTRACT

Radon-222 (radon) and Radon-220 (thoron) are noble gas decay products of uranium-238 (U-238) and thorium-232 (Th-232) respectively. Radon and it's decay progeny is the second most important cause of lung cancer[1] and many studies have undertaken. In this work both radon and thoron are measured using Sarad Thoron Scouts in historic buildings constructed of stone and masonry. Activity concentration of Uranium (U), Thorium (Th), and Potassium (K) were measured using a GF Instrument 2" BGO detector and derived air kerma rate (dAKR)[2] is calculated.

INTRODUCTION

Radioactive radon gas and decay progeny inhalation is the second most important cause of lung cancer. There is no known threshold below which radon exposure carries no risk. Radon is a natural radioactive material that is present in the outside environment, houses, buildings, underground mines and tunnels. It may also present in groundwater. Radon progeny inhalation is the highest dose delivery vector, and inhalation is related to radon concentration in air. Thoron is short lived compared to radon and therefore often ignored. In this study we have measured both radon and thoron.

The Australian Radiation Protection and Nuclear Safety Agency 'Guide for Radiation Protection in Existing Exposure Situations' (RPS G-2)[3] recommends a monitoring program for radon be implemented for public buildings and infrastructure, to establish if mitigation practices are required.

Generally, stone and masonry buildings with poor ventilation have a higher probability of having elevated radon and thoron concentrations, and for this reason public buildings of this construction method have been selected for this scoping study.

METHOD

A total of six historic buildings used for various purpose in Brisbane, Queensland were studied. These buildings were chosen for their construction material and accessibility. Two locations were chosen in each building, the first being chosen as a general occupied space with typical office ventilation, and the second chosen was either in a basement or storeroom type location with passive or poor ventilation.

Measurements were taken over a 7-day period with consecutive 120 minute sampling periods, using SARAD Thoron Scout instruments (sn:00026 and 00030). The activity concentration of radon and thoron, air temperature, relative humidity and barometric pressure were measured for each location.

Radon and thoron concentration in air was determined by measurement of the short-lived progeny products generated by the radon and thoron decay inside the instrument measurement chamber. Radon is measured via immediate daughter polonium-218 (Po-218, 3.05 min half-life) and it takes >15 min (i.e. 5 half-life) to reach equilibrium. Thoron is measured via Po-216 (< 1 sec half-life) and due to such short half-life Po-216 is in equilibrium immediately[4].

Elemental U, Th and K activity concentrations measured using GF Instrument Model: VB6 Vario sn:18010013.

Figure 1 illustrate the experimental set-up.

Figure 1: Experimental set-up in a historic buildings

RESULT

Table 1 illustrate the radon and thoron concentration along with elemental U, Th and K concentrations and derived air kerma rate (dAKR) in nGy/h. Results for Building 1 and 4 were > 200 Bq/m³ for radon and thoron and therefore suggest more investigation although the levels are just above the recommended action levels[5] of 200 Bq/m³.

Figure 2 illustrate the graphical representation of radon and thoron concentration in six buildings.

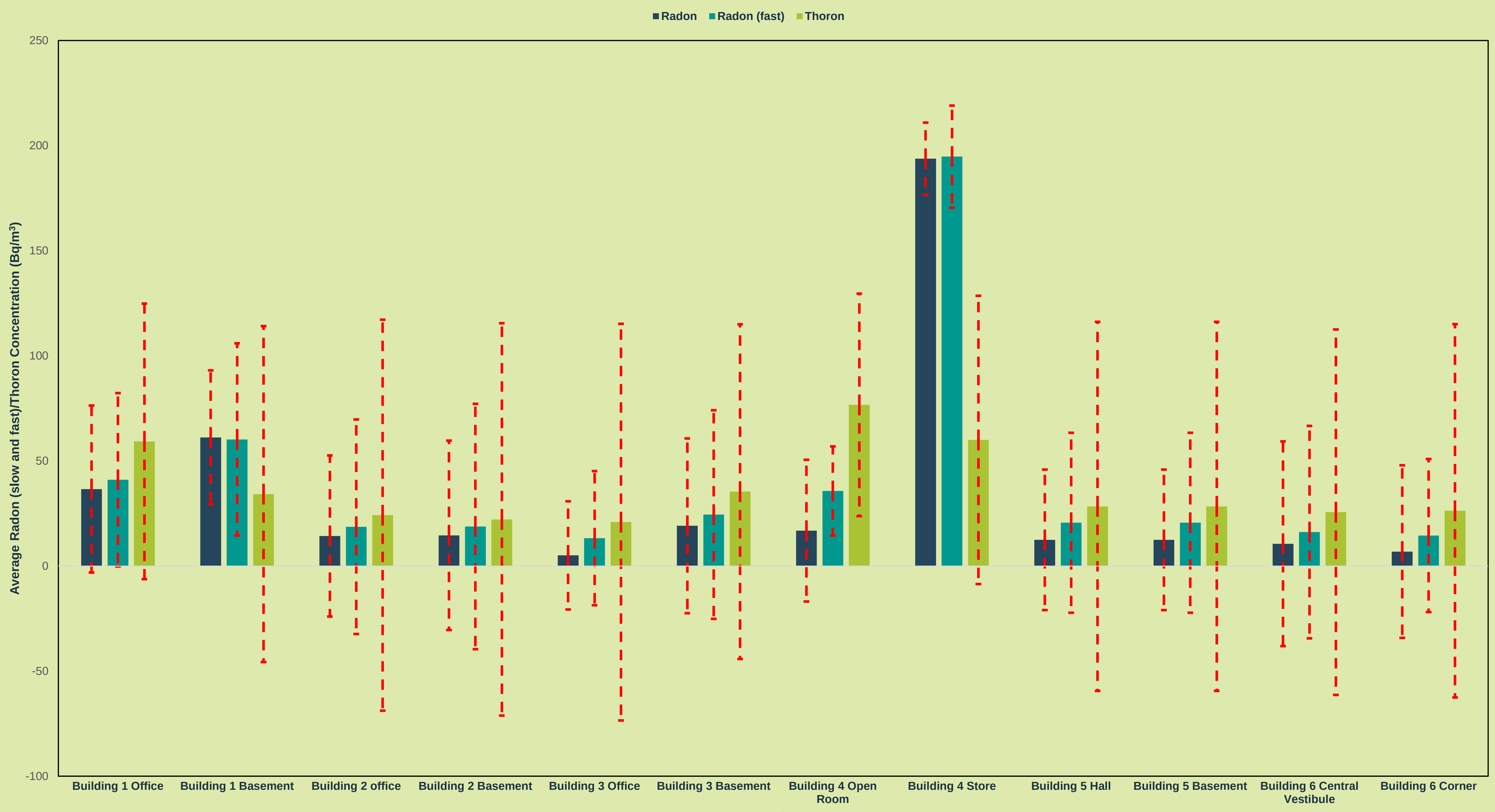

Figure 2: Average Radon and Thoron concentration in various buildings

Location		Radon	Error	Thoron	Error	Average K	Average eU	Average eTh	Average dAKR
		(Bq/m³)	(%)	(Bq/m³)	(%)	(Bq/kg)	(Bq/kg)	(Bq/kg)	(nGy/h)
Building 1	Upper Floor	37 (4 -103)	40 (-1 - 97)	59 (29 - 307)	66 (24 - 85)	252	30	23	38
	Basement	61 (0 - 292)	32 (-1 - 72)	34 (19 - 50)	80 (66 - 101)	479	32	29	52
Building 2	Front room	14 (0 - 48)	38 (-1 - 100)	24 (18 - 36)	93 (74 - 103)	496	50	49	73
	Basement	15 (0 - 54)	45 (-1 - 100)	22 (17 - 34)	93 (74 - 103)	341	42	40	58
Building 3	Meeting Room	5 (0 - 28)	26 (-1 - 100)	21 (17 - 35)	94 (71 -101)	94	20	21	26
	Under the Hall	19 (0 - 67)	42 (-1 - 100)	35 (18 - 76)	80 (50 -102)	754	43	48	81
Building 4	Front room	17 (0 - 60)	34 (-1 -99)	77 (31 - 208)	53 (29 - 81)	601	36	49	72
	Store room	194 (3 -362)	17 (-1 - 58)	60 (19 - 121)	69 (42 - 100)	958	47	62	99
Building 5	Hall	12 (0 - 39)	33 (-1 - 100)	28 (17 - 53)	88 (58 - 101)	255	35	35	48
	Basement	12 (0 - 67)	33 (-1 - 100)	28 (19 - 57)	88 (58 - 101)	552	49	55	79
Building 6	Central Vestibule	11 (0 - 32)	49 (-1 - 99)	26 (18 - 36)	87 (71 - 99)	-	-	-	-
	Corner	7 (0 - 34)	41 (-1 - 99)	26 (19 - 39)	89 (70 - 99)	-	-	-	-

Measurements in parentheses are range of radon and thoron concentrations.

Table 1 : Average Concentration radon and thoron (Bq/m³), U, Th, and K (Bq/kg) along with dAKR (nGy/h)

CONCLUSION

This investigation indicating that, of the buildings tested, office areas with air-conditioning good ventilation/air mixing have relatively low radon and thoron concentrations.

The basement and confined areas with low occupancy, had higher mean concentrations of 360 and 310 Bq/m³ for radon and thoron respectively. This work was undertaken over a 7-day sampling period. Longer term monitoring is required to capture the seasonal impact on radon and thoron concentration.

Although, the most of levels are below the recommendation workplace action level of 1000 Bq/m³, one of the important concepts in radiation protection is the ALARA principle and having well measured data of radon/thoron concentration can help in timely intervention to upheld the ALARA principle.

Historical buildings of similar construction materials in smaller towns may or may not have proper ventilation/modification as compared to bigger cities due to economical factor and therefore can have elevated radon/thoron concentration compared to this work and knowing it will help in designing/improving the ventilation to reduce unnecessary exposure to the users.

Also, to get better understanding of attached/unattached fraction of radon/thoron progeny and it's variation due to seasonal effect long term measurements of at least 12 months is required.

If economical viable then bringing levels below the recommended investigation level i.e. 200 Bq/m³.

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