# RADON AND THORON LEVELS IN AIR AT SELECTED PLACES IN GEORGIA

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**Abstract**

*Radon ($^{222}$Rn) and thoron ($^{220}$Rn) in air were monitored in a tunnel, and several dwellings, public buildings and spas in Tbilisi, and in the Sataplia and Prometheus caves, using an RTM 1688-2 Radon/Thoron Monitor (SARAD, Germany). While measurement at each point in the cave lasted 20–30 minutes, it did about a day at other places, in order to see the diurnal variations. Highest radon and thoron activity concentrations were found in the Sataplia Cave, being 3094 ± 340 Bq m$^{-3}$ and 347 ± 239 Bq m$^{-3}$, respectively. Lower values were in the Prometheus Cave (1472 ± 236 Bq m$^{-3}$ and 144 ± 88 Bq m$^{-3}$) and at a swimming pool in the Tskaltubo Health Resort (1110 ± 115 Bq m$^{-3}$ and 681 ± 475 Bq m$^{-3}$), and were below 200 Bq m$^{-3}$ elsewhere. Thoron/radon activity ratios ranged from 0.03 to 0.17 in the caves and were in the range of 0.09–0.90 at other places, the highest value found in a monk room in the Vardzia-Cave monastery.*

**Keywords**: radon ($^{222}$Rn), thoron ($^{220}$Rn), air, dwelling, public building, spa, cave

## 1. Introduction

For decades, extensive investigations of radon ($^{222}$Rn, $t_{1/2}$=3.82 days) in various environments worldwide have been performed, while thoron ($^{220}$Rn, $t_{1/2}$=56 s) was mostly ignored, based on an assumption that at usual $^{232}$Th levels in the ground and building material, its activity concentration in indoor air is negligible, because of its short half-life as compared with that of radon. This assumption appeared to be wrong when papers started to report thoron levels, comparable [6] or even higher than those of radon, such as in traditional Japanese houses [3], in Italian buildings made of volcanic material [2], or in cave dwellings in China [9], [11]. It is now well recognised that thoron may contribute significantly to the dose and therefore its inclusion in radon survey is highly recommended [1]; [8]; [10]. Following this recommendation, at several places in Georgia radon and thoron have been simultaneously monitored. In the paper, measurements are described and results presented and commented on.

## 2. Experimental

For this preliminary study, different places have been selected, from dwellings to public buildings and karts caves. While in a building measurement was carried out in one room, in caves it was done at several points along the tourist path. The survey was performed in summer time (from end of June to middle of July).

A portable RTM 1688-2 Radon/Thoron Monitor (SARAD, Germany) was used. Air is pumped continuously through the chamber at a flow rate of 0.3 dm$^3$ min$^{-1}$, the positively charged $^{218}$Po and $^{216}$Po ions, created by $^{222}$Rn and $^{220}$Rn α-transformations, respectively, are deposited on the detector, and based on α-spectrometry, activity concentrations of $^{222}$Rn and $^{220}$Rn are obtained. The analysis frequency was ones in 30 minutes. Measurements at various points in the cave lasted 20–30 minutes, while those at other places from one to several days.

## 3. Results and Discussion

Table 1 shows average values of radon ($C_{Rn}$) and thoron ($C_{Tn}$) activity concentrations and $C_{Tn}/C_{Rn}$ ratios, as obtained with continuous measurements in air at selected places. Although measurements were carried out at ten points in the Sataplia Cave and at fourteen points in the Prometheus Cave, only two results are included. Highest radon and thoron levels were observed in the Sataplia Cave, lower in the Prometheus Cave and in the Tskaltubo Health Resort, and were below 200 Bq $m^{-3}$ elsewhere. Thoron/radon activity ratios ranged from 0.03 to 0.17 in the caves and were in the range of 0.09–0.90 at other places, the highest value found in a monk room in the Vardzia-Cave monastery.

Table 1. Average values of radon ($C_{Rn}$) and thoron ($C_{Tn}$) activity concentrations and $C_{Tn}/C_{Rn}$ ratios, as obtained with continuous measurements in air at selected places (for the Sataplia Cave and Prometheus Cave, only two results are included)

| **Place** | **Datein 2012** | **$C_{Rn}$ in air Bq $m^{-3}$** | **$C_{Tn}$ in airBq $m^{-3}$** | **$C_{Tn}$ / $C_{Rn}$** |
|---|---|---|---|---|
| Tbilisi, Guest house (1st floor) | 24.6. 11:26 – 25.6. 20:26 | 12.9 ± 5.4 | 7.2 ± 5.5 | 0.56 |
| Tbilisi, Tunnel | 26.6. 11:42 – 27.6. 11:42 | 115 ± 20 | 28.7 ± 16.5 | 0.25 |
| Tbilisi, Turkish bath (ground floor) | 27.6. 12:55 – 28.6. 16:55 | 10.0 ± 5.5 | 6.6 ± 4.6 | 0.66 |
| Tbilisi, Institute of Geophysics (basement) | 29.6. 14:55 – 2.7. 14:55 | 101 ± 17 | 13.4 ± 10.1 | 0.13 |
| Tbilisi, Private house (basement) | 2.7. 17:53 – 4.7. 10:53 | 190 ± 24 | 17.3 ± 11.8 | 0.09 |
| Vardzia, Cave monastery (monk room) | 7.7. 19:34 – 8.7. 10:34 | 168 ± 25 | 151 ± 36 | 0.90 |
| Vardzia, Cave monastery (cave, at water reservoir) | 8.7. 19:33 – 9.7. 8:33 | 83 ± 24 | 19.3 ± 12.7 | 0.23 |
| Tskaltubo, Hotel Imereti (guest room, 1st floor) | 12.7. 00:01 – 12.7. 9:01 | 34 ± 10 | 6.3 ± 6.0 | 0.19 |
| Tskaltubo Health Resort (room with swimming pool) | 12.7. 11:39 – 12.7. 12:29 | 1110 ± 115 | 681 ± 475 | 0.08 |
| Satalpia Cave (at the end of left branch) | 10.7.2012 15:13 | 1995 ± 279 | 347 ± 239 | 0.17 |
| Satalpia Cave (at Stony Heart) | 10.7.2012 15:43 | 3094 ± 340 | 127 ± 88 | 0.04 |
| Prometheus Cave (Pass) | 11.7.2012 16:40 | 1472 ± 236 | 55 ± 38 | 0.04 |
| Prometheus Cave (at Iberia) | 11.7.2012 17:20 | 1297 ± 220 | 144 ± 88 | 0.11 |

Figure 1 presents diurnal variation of radon and thoron activity concentrations in the basement of the Institute of Geophysics (Figure 1a) and in the basement of a private house (Figure 1b). While at the institute both concentrations were highest overnight and lowest at noon, as expected, this pattern was not observed at other places, including also the tunnel. Because the source and behaviour of radon and

thoron are different, a good correlation between radon and thoron levels can hardly be expected, thus resulting in a wide range of $C_{Tn}/C_{Rn}$. Our range of $C_{Tn}/C_{Rn}$ is narrower than 0.93–2.0 observed in Serbia [12], or 0.05–7 in Hungary [4], [5] or 0.6–6 in Japan [7].

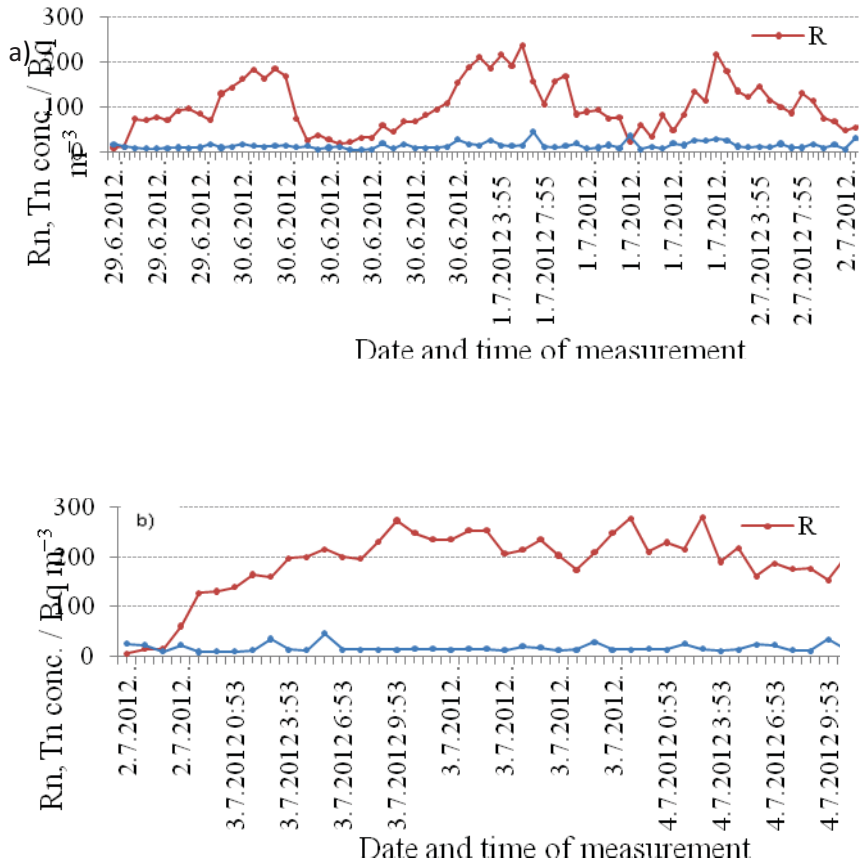


Figure 1. Diurnal variations of radon and thoron activity concentrations in the basement at: a) the Institute of Geophysics and b) in a private house

From average values in Table 1 only, it is not evident that at some places and during some periods of time, thoron level exceeded that of radon. An example is shown in Figure 2 for the monk room in the Vardzia-Cave monastery.

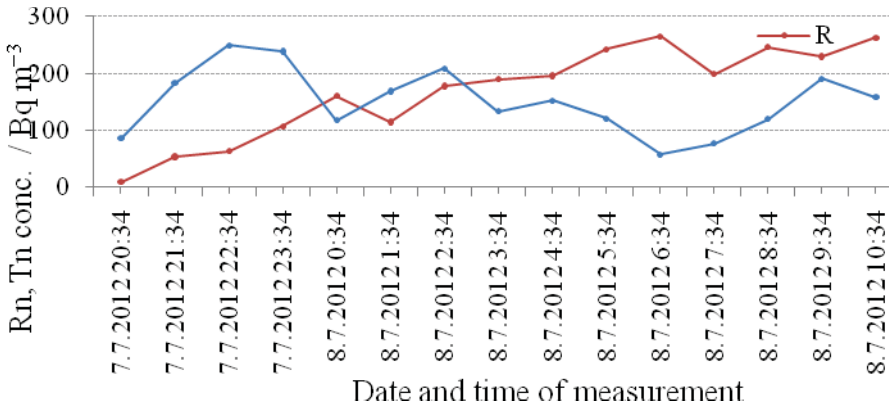

Figure 2. Diurnal variations of radon and thoron activity concentrations in a monk room in Cave monastery

In both caves, radon levels are higher than at other places surveyed, as expected for the caves [9], and are also considerably higher than those of thoron. The tunnel, though underground, is obviously well ventilated and consequently radon levels low (Table 1).

## 4. Conclusion

According to these preliminary results, Georgia may be considered as a country with moderate thoron levels. Therefore, thoron will not be ignored in our future radon investigations and its contribution to the dose will be considered.

## References:


[1] Akiba S, Tokonami S, Bochicchio F, McLaughlin J, Tommasino L, Harley N. Thoron: its metrology, health effects and implications for radon epidemiology: a summary of roundtable discussions. Radiat Prot Dosim 141, 477–481 (2010).

[2] Bochicchio F, Campos Venuti G, Nuccetelli C, Risica S, Tancredi F. Indoor measurements of $^{220}$Rn and $^{222}$Rn and their decay products in a Mediterranean climate area. Environ Int 22 (Suppl. 1), S633–S639 (1996).

[3] Doi M, Kobayashi S. Characterization of Japanese wooden house with enhanced radon and thoron concentrations. Health Phys 66, 274–282 (1994).

[4] Kávási N, Németh Cs, Kovács T, Tokonami S, Jobbágy V, Várhegyi A, Gorjánácz Z, Vígh T, Somlai J. Radon and thoron parallel measurements in Hungary. Radiat Prot Dosim 123, 250–253 (2007).

[5] Kovács T. Thoron measurements in Hungary. Radiat Prot Dosim 141, 328–334 (2010).

[6] Steinhäussler F, Hofmann W, Lettner H. Thoron exposure of man: a negligible issue? Radiat Prot Dosim 56, 127–131 (1994).

[7] Sugino M, Tokonami S, Zhuo W. Radon and thoron concentrations in offices and dwellings of the Gunma prefecture, Japan. J Radioanal Nucl Chem 266, 205–209 (2005).

[8] Tokonami S, Sun Q, Akiba S, Zhuo W, Furukawa M, Ishikawa T, Hou C, Zhang S, Narazaki Y, Ohji B, Yonehara H, Yamada Y. Radon and thoron exposure for cave residents in Sahnxi and Shaanxi Province. Radiat Res 162, 390–396 (2004).

[9] Tokonami S. Why is $^{220}$Rn (thoron) measurement important? Radiat Prot Dosim 141, 335–339 (2010).

Vaupotič J. Radon levels in Karst caves in Slovenia. Acta Carsol 39, 503–512 (2010).

[10] Vaupotič J, Streil T, Žunić Z S, Tokonami S. Diurnal variations of radon and thoron activity concentrations and effective doses in dwellings in Niška Banja, Serbia. Radiat Prot Dosim 157, 375–382 (2013).

[11] Zhang B, Chen B, Gao Y, Wang Y, Cui H, Li Z. Thoron levels in traditional Chinese residential dwellings. Radiat Environ Biophys 44, 193–199 (2005).

[12] Žunić Z S, Čeliković I, Tokonami S, Ishikawa T, Ujić P, Onischenko A,