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Measuring Radon and Thoron Levels in Sri Lanka

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Abstract. For the first time in Sri Lanka, an attempt was made to measure the outdoor radon levels using CR 39 type passive radon detectors. Preliminary results indicate that in Sri Lanka, ^{220}Rn isotope is more abundance than ^{222}Rn isotope. These results were also confirmed by in-situ measurements. Sri Lanka has one of the highest ^{220}Rn values in the region. It was also noted that environmental conditions and other physical factors have a significant effect on the outdoor radon measurements using passive discriminative detectors.

Introduction

Radon is decay product radium, which is a decay product of uranium. In the Earth's crust, uranium is generally concentrated in ore-bearing rocks scattered around the world. Although currently 36 isotopes of radon have been characterized, none of them is stable. Generally, "*radon*" refers to ^{222}Rn, which is the most stable radon isotope. Radioactive decay of most stable thorium isotope (^{232}Th) produces ^{220}Rn, which is generally called "*thoron*". Every 2.6 km^2 of surface soil, to a depth of 15 cm, contains approximately 1 gram of radium, which releases radon in small amounts to the atmosphere [1]. Radon concentration varies wildly from place to place. In the open air, it ranges from 1 to 100 Bq/m^3.

In some countries, it is a requirement to monitor the radon levels and take mitigating actions if the levels are high enough to pose a health risk [2]. Usually radon levels are varied seasonally throughout the year as well as within the day [3]. Scientists monitor the seasonal variations of the indoor radon levels using passive radon detectors, which usually show accumulated counts during the exposure period. During last few decades several types of passive radon detectors were developed [4-5]. One of the most common types is the CR39 based passive radon monitors that can discriminate between radon and thoron. Chung and Tokonami [5] successfully used CR39 type passive detectors to conduct a preliminary radon survey in Korea.

While indoor radon levels are important in assessing health risks, outdoor radiation levels are also important to monitor for many reasons. Oikawa et al [6] conducted a nationwide outdoor radon survey on radon concentration in Japan. During recent years, some scientists have suggested that radon could be used as an indicator to predict the earthquakes as relatively larger quantities of radon may be released due to the opening of the faults prior to earthquakes [7]. In addition, there is a possibility that radon concentration be higher at the faults and fractures in the earth's crust. High concentrations of radon can be also found in some spring waters and hot springs.

Because of radon's rapid loss to air and comparatively rapid decay, radon is used in hydrologic research that studies the interaction between ground water and streams. Any significant concentration of radon in a stream is a good indicator that there are local inputs of ground water. Radon concentrations are generally higher over the faults [8-9]. Similarly, it has found some limited use in prospecting for geothermal gradients. Measurement of environmental radioactivity is conducted around the country to establish the natural baseline for the country as well as to monitor any locations with unusual radiation levels. Some of the preliminary results are presented in this paper.

Methodology

Radon-Thoron discriminative passive detectors with CR39 chips were used in this study for long-term outdoor monitoring. NIRS, Japan, provided the first batch of detectors. These detectors were installed at predetermined locations around the country. These locations were selected to represent a fair spatial distribution while considering the geological features such as faults and fractures. Further, detectors were established near the known thermal springs in the country. The passive radon detectors were placed in custom built housing to protect them from elements, as well as from possible damage by animals when installed outdoors. The location was accurately marked on a map using GPS reading. In-situ radiation measurements were also taken at the same locations for comparison.

After 3-6 months of exposure, these detectors were removed, placed in radon-proof bags and sent back to NIRS for data extraction and analysis.

Results and Discussion

Preliminary results indicate that thoron (^{220}Rn) levels are unusually higher compared to radon (^{222}Rn) levels in Sri Lanka (Fig. 1). Same trend is confirmed by in-situ natural radiation measurements conducted by the Atomic Energy Authority of Sri Lanka earlier (Table 1.). Radon (^{222}Rn) is a product of radium decay, while ^{222}Rn (thoron) is a decay product of the most stable thorium isotope (^{232}Th). This is an indication that in average, Sri Lanka has a higher thorium concentration in its soil.

Table 1. Naturally occurring radioactivity levels in some of the countries in the region. Note that highest value for ^{232}Th is from Sri Lanka, while ^{40}K and ^{226}Ra values are average.

Country	**^{40}K**		**^{238}U**		**^{226}Ra**		**^{232}Th**	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Bangladesh	350	130-610			34	21-43		
China	440	9-1800	33	2-690	32	2-440	41	1-360
Hongkong	530	80-1100	84	25-130	59	20-110	95	16-200
India	400	38-760	29	7-81	29	7-81	64	14-160
Japan	310	15-990	29	2-59	33	6-98	28	2-88
Kazakhstan	300	100-1200	37	12-120	35	12-120	60	10-220
Korea (Rep. of)	670	17-1500						
Malaysia	310	170-430	66	49-86	67	38-94	82	63-110
Thailand	230	7-712	114	3-370	48	11-78	51	7-120
Sri Lanka	**308**	**19-1378**			**49**	**5-761**	**138**	**9-1166**

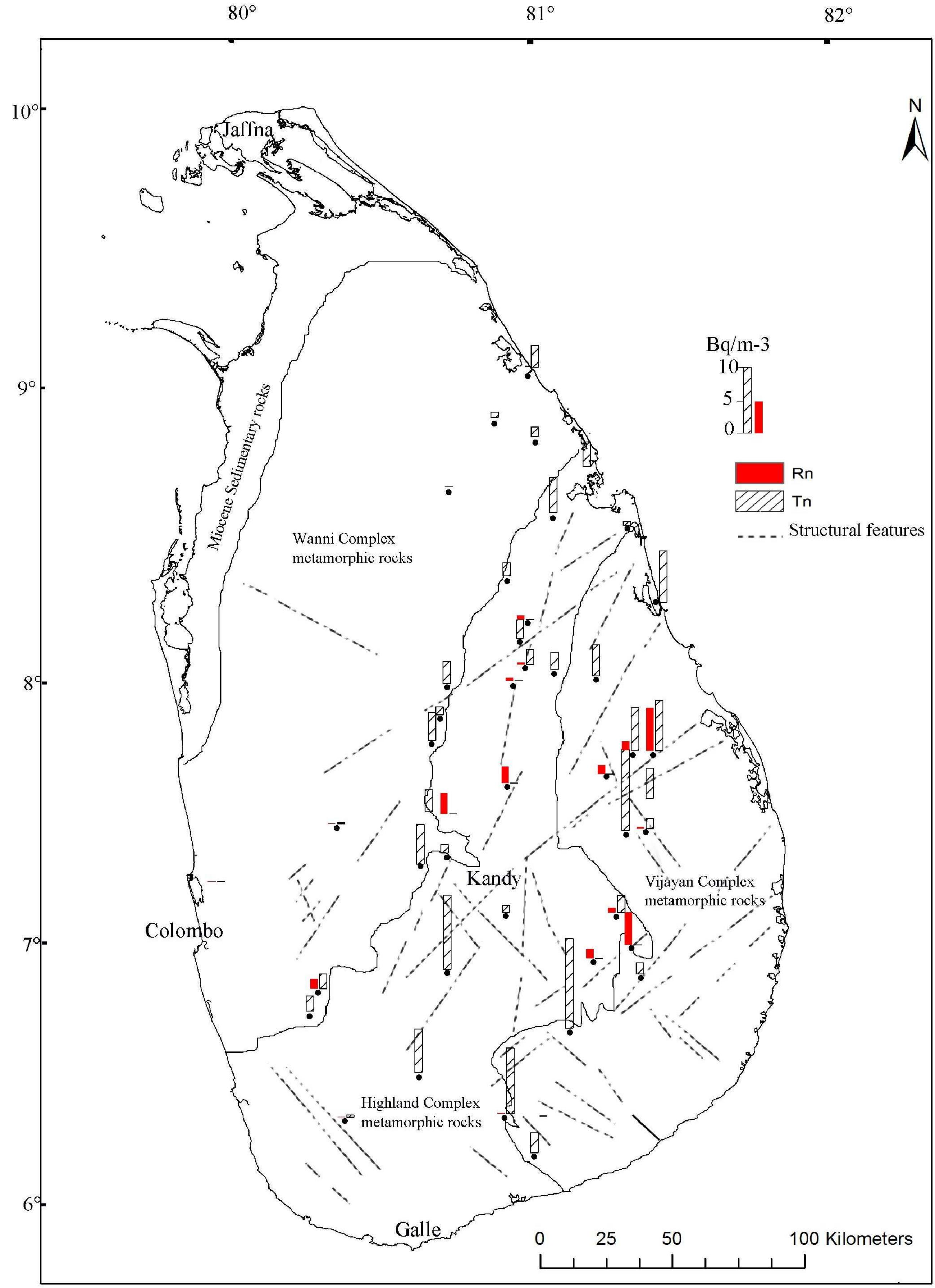

Fig. 1. Radon (^{222}Rn) and thoron (^{220}Rn) distribution in the study locations in Sri Lanka.

In this preliminary radon survey, it was noted that many of the passive radon detectors recorded radon levels below the detection limit. Possible reasons include: insufficient detection time, strong wind and rain, obstruction of free air passage due to the additional housing that was used for the protection of the detectors and, placing the detector too far from the ground. Effect of the environmental factors on passive discriminative radon-thoron detectors were discussed in detail by Sorimachi et al [10].

However, where measurements are successful and the reliable data is obtained, data confirm the general trend expected and support the results of the in-situ measurements.

Conclusions

First ever radon level measuring campaign was initiated with intention to establish background radiation levels and observe any anomalies. Results indicate that Sri Lanka has higher average thorium content compared to the other countries in the region. This study also indicated that passive radon detectors can be utilized for outdoor radon measurements, and that the accuracy of the measurements highly depend on the designing of the housing and the way of installing the detectors.

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