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Temporal variation of soil radon/thoron concentration using twin chamber monitors in San Miguel district, Lima, Peru

César J. Guevara Pillaca[1*], Ricardo Flores Camargo[1], María Elena López Herrera[1], Patrizia Pereyra Anaya[1], Laszlo Sajo-Bohus[2]. Daniel Palacios Fernández[1]

[1]Sección Física, Departamento de Ciencias, Pontificia Universidad Católica del Perú, Lima, Perú

[2]Universidad Simón Bolívar, Caracas, Venezuela

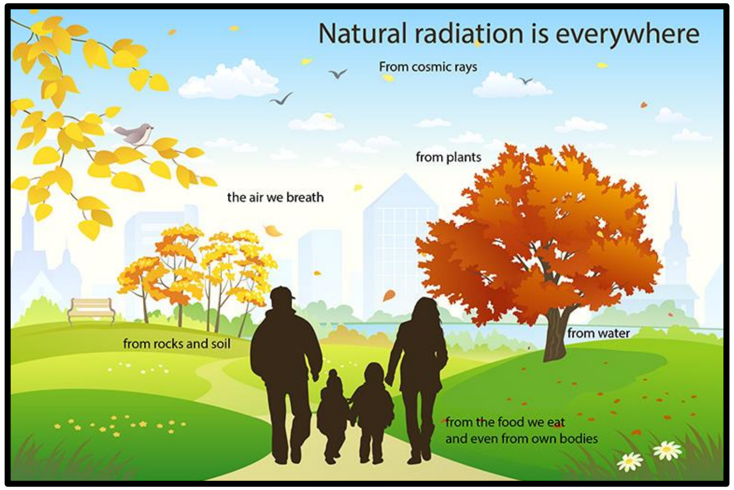
E-mail: cesarj.guevara@pucp.edu.pe

Grupo de Investigación en Técnicas de Huellas Nucleares

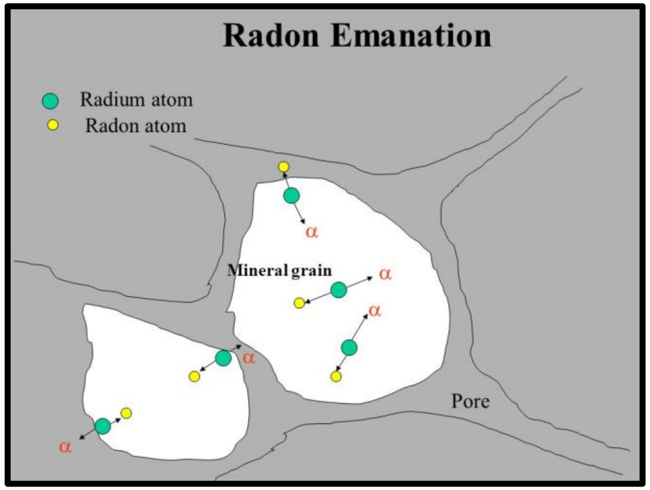
GITHUNU - PUCP

PROBLEM STATEMENT

- Soil is the main source of radon (222Rn) and thoron (220Rn) due to the uranium and thorium content [1].

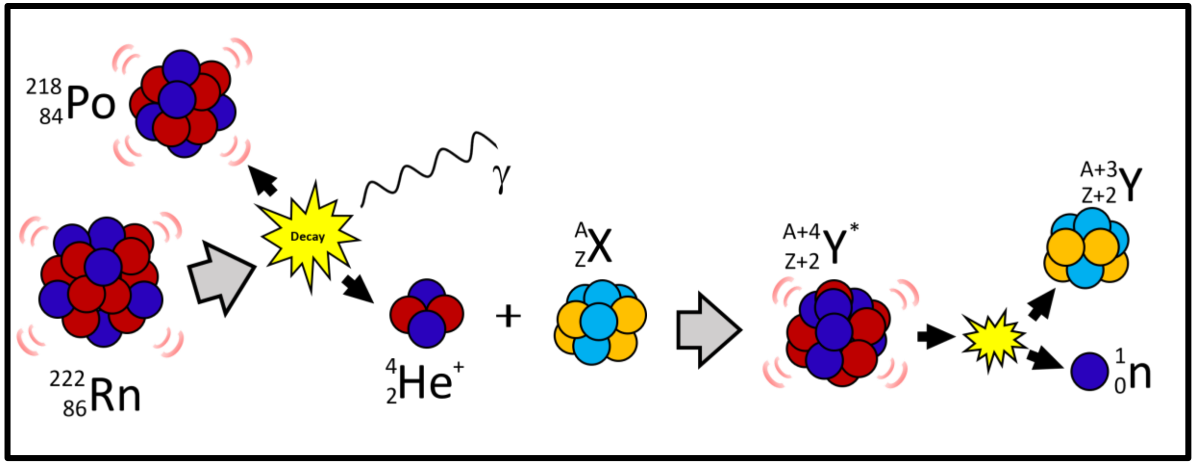


http://nuclearsafety.gc.ca/eng/resources/radiation/introduction-to-radiation/types-and-sources-of-radiation.cfm



https://www.slideserve.com/cedric-grimes/radon-in-groundwater-analysis-of-causes-and-development-of-a-prediction-methodology-powerpoint-ppt-presentation

- Alpha particles emitted in the decay of these natural radioactive elements produce nuclear reactions in the ground, increasing the levels of ionizing radiation.
- Therefore, measure of soil radon and thoron concentrations is important.



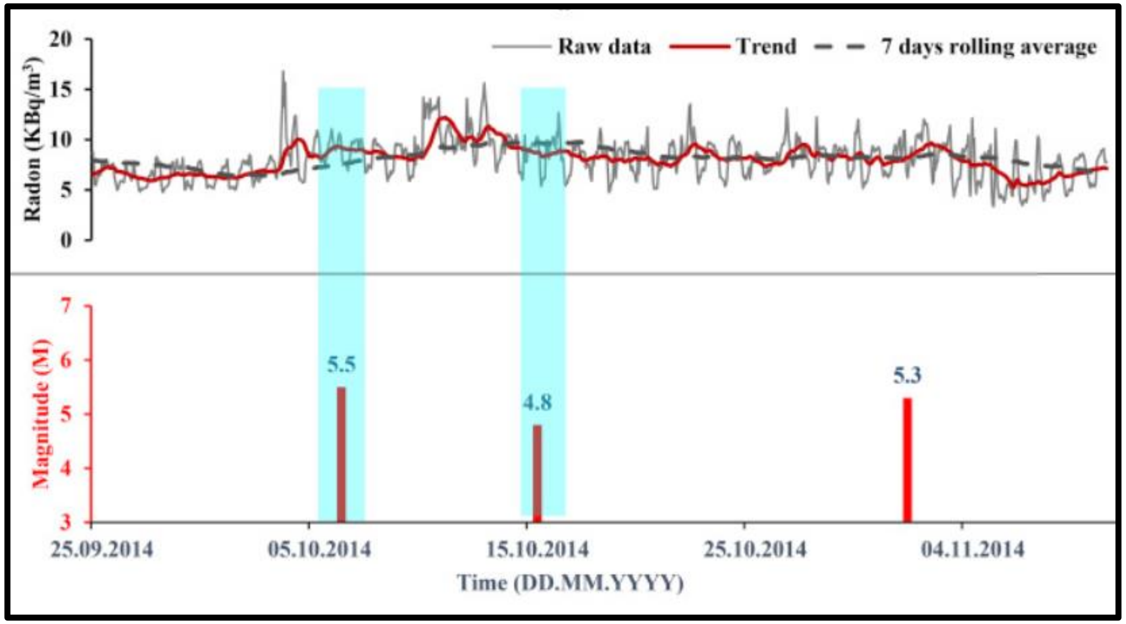
METHODS FOR MEASURING RADON/THORON

- Therefore, measure of soil radon and thoron concentrations is important. Generally, these measurements are made using costly active systems compound of an air extraction pump with 1-m long steel soil probe and a desiccant [2].

RAD 7 System

https://durridge.com/products/soil-gas-probes/

Temporal variation of radon soil

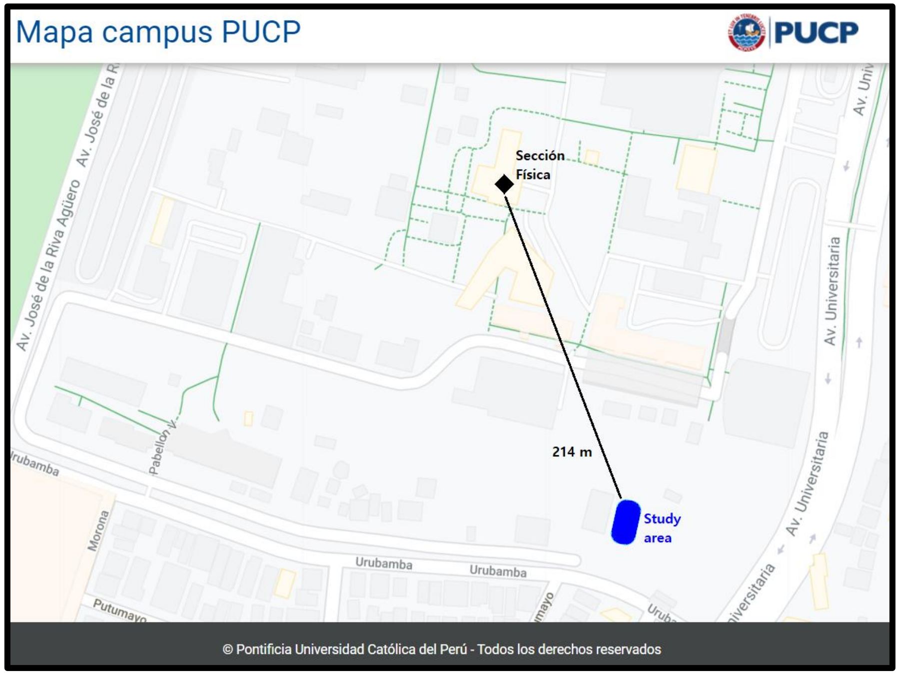


https://www.sciencedirect.com/science/article/abs/pii/S0883292718302336

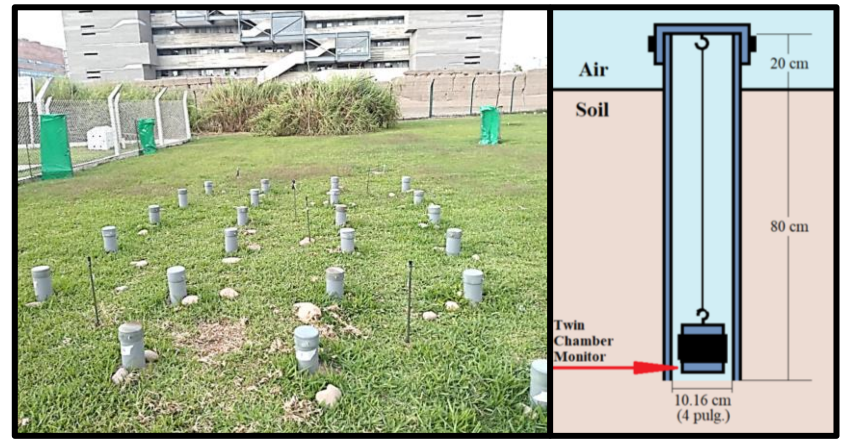
- An alternative is passive monitors that provide integrated measurement, pin-hole monitors have been commonly used for indoor measurement [3].

PROPOSAL SUMMARY

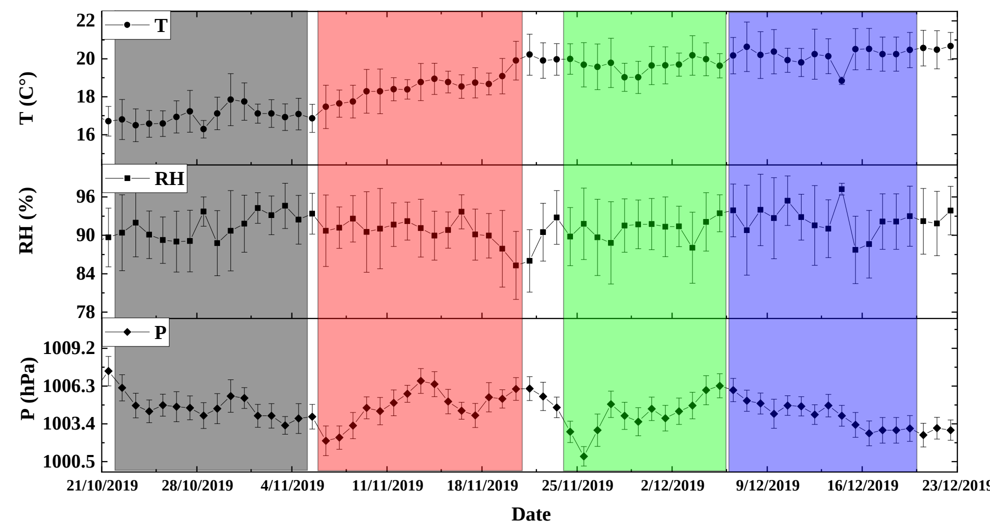
- Radon and thoron concentrations were measured for two months in 24 wells of 80 cm deep with respect to ground level, located within the PUCP university campus in the San Miguel district.



Study area and system of measurement in the soil



Measurement periods and environmental parameters



Due to the influence of the environmental conditions on the exhalation of radon and thoron from the soil, the results obtained were analyzed with environmental parameters [4].

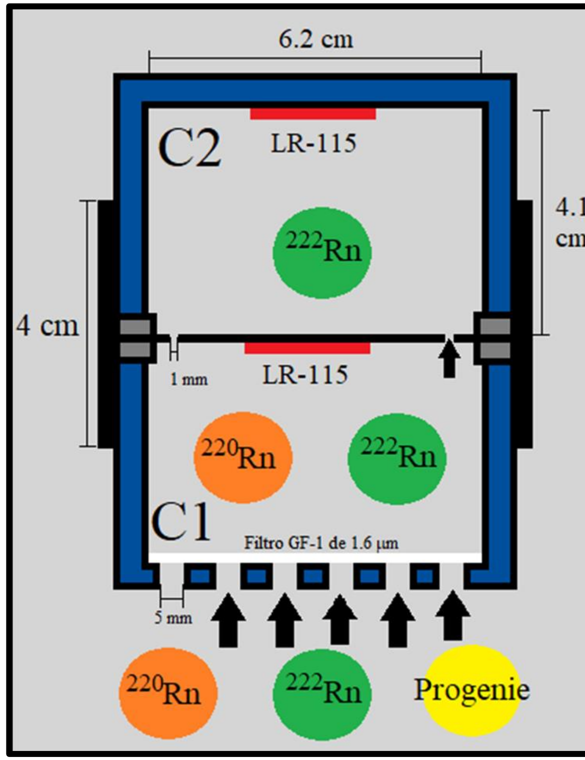
PASSIVE MEASUREMENT

- An alternative is passive monitors that provide integrated measurement, pin-hole monitors have been commonly used for indoor measurement.

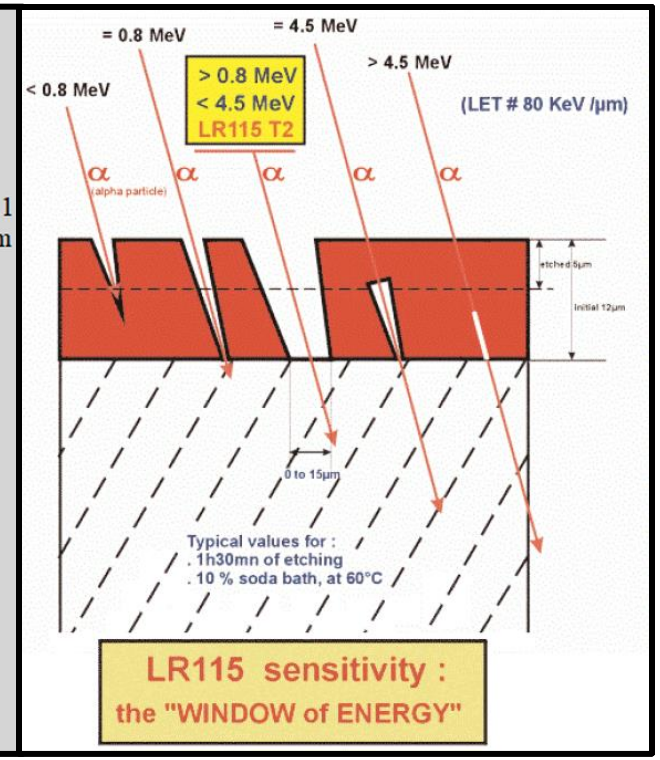
Monitor Features

- Radon and thoron concentrations are measured in chamber 1 (C1)
- Radon concentration are measured in chamber 2 (C2)
- Uses a glass fiber filter paper (inside C1)
- Four pin-holes of 2 mm length and 1 mm diameter.
- Each chamber has a length of 4.1 cm and radius of 3.1 cm
- Two LR-115 type II detectors of size 2 cm x 2 cm were fixed at end of the two chambers

Twin chamber monitor



LR115 sensitivity

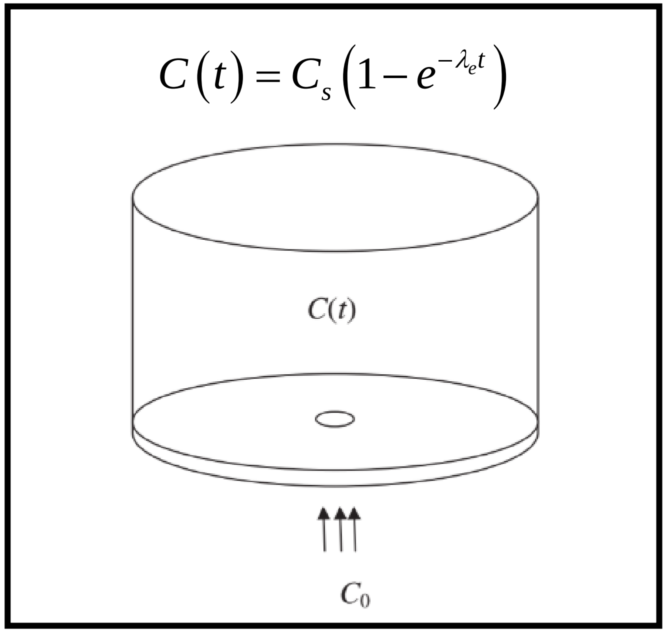


http://www.gt-analytic.at/downloads_en/Kod_tech_det.pdf

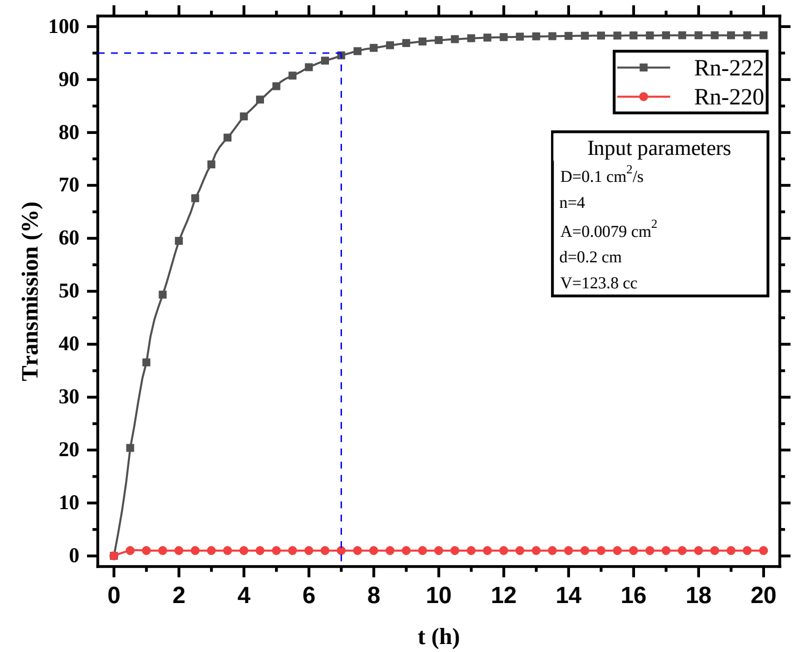
MECHANISM FOR THE DISCRIMINATION OF RADON AND THORON

- *C(t)* is the average 222Rn/220Rn gas concentration in the chamber volume at time t. At large times, steady state concentration (Cs) in the pin-hole chamber is reached [3].

Schematic of a pin-hole chamber system



C2 chamber response



Transmission time (T_{95})

$$T_{95} = \frac{3Vd}{\lambda Vd + AD}$$

Transmission factor (F)

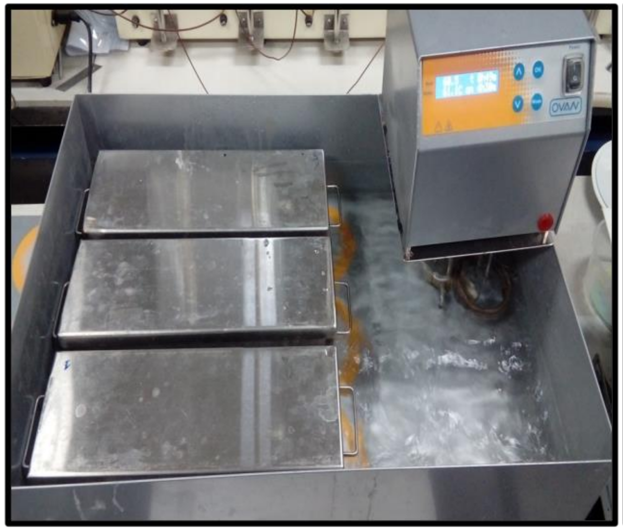
$$F = \frac{AD}{AD + \lambda Vd}$$

	Transmission time (T_{95})	*Transmission factor (F)*
^{222}Rn	6.46 h	0.98
^{220}Rn	2.97 min	0.01

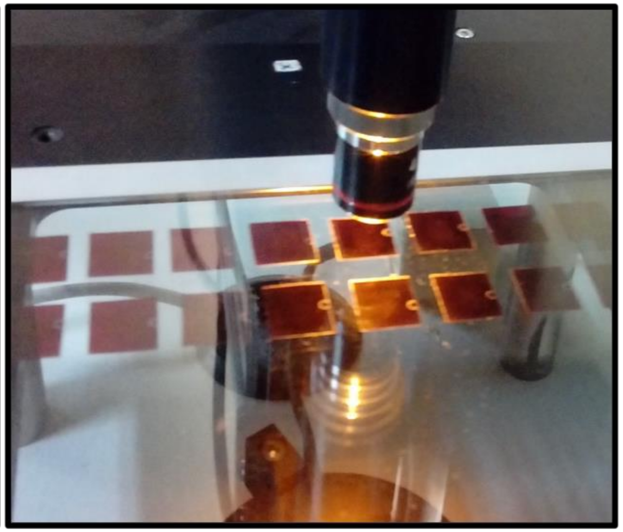
METHODOLOGY

Etching process

2.5 N NaOH solution at 60°C for 90 min



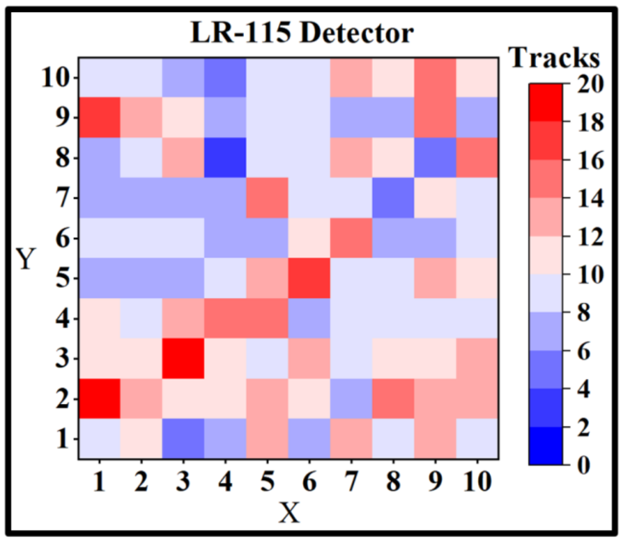
Scanning process



Track counting

$$\sum_{i=1}^{n} Tr_i = Tr_1 + Tr_2 + Tr_3 + \ldots\ldots + Tr_n$$

Tr : tracks on a field



Concentrations determination

Track density on LR-115 detector

$$T \pm u(T) = \frac{1}{n \cdot A_0} \sum_{i=1}^{n} Tr_i \pm \frac{1}{A_0} \sqrt{\frac{1}{n(n-1)} \sum_{i=1}^{n} (Tr_i - \overline{Tr})^2}$$

Radon concentration (inside C2 chamber)

$$C_R \left(Bq / m^3 \right) = \frac{T_2 - B_2}{K_R \cdot d}$$

Thoron concentration (inside C1 chamber)

$$C_T \left(Bq / m^3 \right) = \frac{(T_1 - B_1) - \left(d \cdot C_R \times K_R' \right)}{K_T \cdot d}$$

n : number of scanned fields

A_0 : area of a field (cm^2)

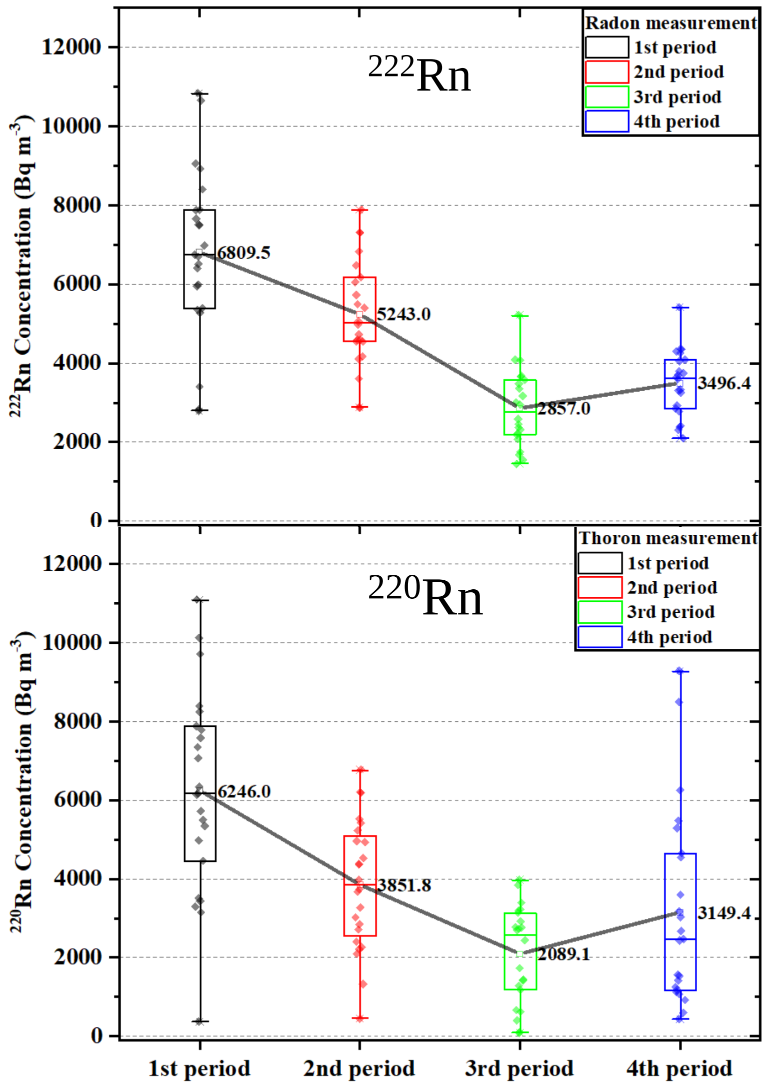
T : track density ($Tr\ cm^{-2}$)

B : background track density ($Tr\ cm^{-2}$)

K : calibration factors ($Tr\ cm^{-2}\ d^{-1}/\ kBq\ m^{-3}$) of [3]

d : exposure time (days)

RESULTS



A high inverse correlation (-0.95) between radon concentration and temperature was found during the investigation period.

The maximum radon and thoron concentration values were presented in the first period, were found to be 6809.5 Bq m^{-3} and 6246 Bq m^{-3}, respectively.

The minimum radon and thoron concentration values were presented in the third period, were found to be 2857 Bq m^{-3} and 2089.1 Bq m^{-3}, respectively.

The average concentrations of radon and thoron were observed to be 4601.5 ± 1784.3 Bq m^{-3} and 3834.1 ± 1763.7 Bq m^{-3}, respectively.

Measurement Period	Radon (^{222}Rn)	Thoron (^{220}Rn)	Temperature (T)	Relative Humidity (RH)	Atmospheric pressure (P)
	Bq m^{-3}	Bq m^{-3}	C°	%	hPa
1st	6809.5 ± 835.5	6246.0 ± 1590.6	17.0 ± 0.4	91.1 ± 2.0	1004.9 ± 1.1
2nd	5243.0 ± 652.6	3851.8 ± 1258.5	18.5 ± 0.6	90.6 ± 2.0	1004.7 ± 1.4
3rd	2857.0 ± 369.4	2089.1 ± 717.4	19.7 ± 0.3	91.0 ± 1.5	1004.1 ± 1.5
4th	3496.4 ± 444.8	3149.4 ± 884.3	20.2 ± 0.4	92.4 ± 2.5	1004.1 ± 1.0

CONCLUSIONS

- The first time series measured with passive monitors for two months demonstrated the high levels of radon and thoron in the soil gas of the study area.
- Measure radon and thoron concentration in soil with passive monitors in a only place can give an non-representative value of the study area was demonstrated.
- Analysis of radon and thoron concentrations in the soil suggests that the influence of meteorological parameters on radon exhalation at 80 cm deep with respect to ground level cannot be neglected.
- The data constitute preliminary results, give us insight it is needed to measure to major depth to reduce the effects of these environmental parameters on soil gas radon/thoron concentration.

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- [2] Kaur, Manpreet, et al. "Study of radon/thoron exhalation rate, soil-gas radon concentration, and assessment of indoor radon/thoron concentration in Siwalik Himalayas of Jammu & Kashmir." Human and Ecological Risk Assessment: An International Journal 24.8 (2018): 2275-2287.
- [3] Sahoo, B. K., et al. "A new pin-hole discriminated 222Rn/220Rn passive measurement device with single entry face." Radiation Measurements 58 (2013): 52-60.
- [4] Conde-Mendoza, Luis, et al. "Puesta en marcha de un laboratorio para la caracterización de tecnologías fotovoltaicas a sol real bajo las condiciones climáticas de Lima." Tecnia 30.1 (2020): 80-89.