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Assessment of radon gas and rainfalls measurements in São Jose dos Campos, SP, Brazil

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ABSTRACT :*The objective of this article was to explain the variation of intensity of the radon gas in the soil / air interface of earth. The physics laboratory and the ACA tower both located at the Technological Institute of Aeronautics (ITA) have been choosed like monitoring site. During the period of 09/14/2018 to 01/02/2019 monitoring was made in the region of São José dos Campos, SP, Brazil. Radon gas is present on every land surface, accounting for approximately half of the ionizing radiation exposed to humans. To monitor the intensity of radon gas the detector was used a RadonEye RD200, where the intensity was obtained in the range of 0 to 2.0 pCi / l every hour. The results obtained from these experimental observations, as well as discussions and suggestions, are presented in this article.*

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I. INTRODUCTION

Radon gas near the surface of the Earth can be measured through its radioactive decay products (alphas particles and gamma photons). It is estimated that about 48% of the ambient ionizing radiation dose at this soil / air interface is from radon gas exhaling from Earth.

Starting from the radioactive current of Earth of the Uranium-238 (238U) disintegrates in the order of 1600 years for Radium-226 (226 Ra) and arrives to Radon-222 (222Rn) in 3.82 days with emission of alphas particles of 5, 49 MeV of energy. Radon is a noble gas, alpha emitter, produced in the natural decay series of uranium and thorium, which occur at varying concentrations in geological materials, especially rocks, soils and water. By diffusion and convection, radon migrates from rocks and soils into the atmosphere through cracks, holes and pipes, entering homes and other constructions.

Thus an easy way to measure radon gas variation at any location is to monitor the presence of alpha particles of that energy in the desired region. This can be done with the RadonEye RD200 portable ionization chamber.

As shown in the decay series, these radionuclides come from series originating from 238U, 235U, 232Th, respectively. Although they are continuously produced in rocks and minerals by the decay α of 226Ra, 224Ra and 223Ra, since they are inert noble gases, these radionuclides do not form chemical compounds and can be detected by their radioactive properties: well defined energy and a sequence of short half-life decay products. In practice, only the isotopes radon (222Rn) and toronium (220Rn) are relevant from the point of view of radiological protection or environmental and geological interest.

Radon (222Rn) has a half-life of 3.82 days, which allows significant mobility to escape from the rock in which it was generated. Radon occurs naturally in soils in the typical range of 4.0 to 40 kBq / m-3 and in the atmosphere not very close to the earth in the typical range of 4.0 to 50 Bqm-3. It is estimated that in Brazil the average annual concentration of 222Rn in air varies from 0.6 to 30 Bq.m-3 (IPEN, 2002 apud Fior, 2008).

According to the authors, for daytime variations, there are high levels of radon in the morning, at which point the atmospheric turbulence is accentuated, maximizingin the seasonal scale, high concentrations of radon tend to occur in the autumn and winter (Eisenbud and Gessel, 1998). However, the radon intensity at the soil-air interface varies with temperature, rainfall, winds and cold fronts from southern Brazil.

II. MATERIAL AND METHOD

To monitor the variation of radon at the soil / atmosphere interface, the detector consisting of a RadonEye RD200 portable ionization chamber was used. Manufactured in South Korea, the RD200 has sensitivity 20 times higher than other radon detectors and has the system in which it releases dual-structure pulses and a highly accurate detection circuit designed by FTLab's own technology. A first reliable 1 hour data view is required, where its sensitivity is 1.35 counts per minute equivalent to 0.5 Becquerel / m3. The measurements were performed in the ACA tower at 25 meters from the ground and at the physics laboratory, both located at the Technological Institute of Aeronautics(ITA). Data acquisition is possible through the available RadonEye application, only on smartphones. Power is supplied via a 12 VDC source connected to the detector where the setting starts automatically. With an Iphone device, the data generated by the RadonEye RD200 detector was transferred through the Itunes software and the Origin 1.5 software was used to graph the measurements of the radon intensity versus time on the surface of the Paraiba and Serra da Mantiqueira Valley regions. The rainfall variation in mm / min was measured by a scraper type rain gauge and a data logger for data acquisition developed in the ITA, in accordance with international recommendations.

Fig.01. ACA tower at 25 m above ground

Fig.02. Data collection of RadonEye RD200 with an Iphone

III. RESULTS AND DISCUSSIONS

During the period from September 09, 2018 to January 1, 2019, the radon gas intensity was monitored at the soil / air interface in the region of São José dos Campos, SP.

Figure 3 shows the monitoring of radon gas as a function of time during the analysis period carried out in the ITA physics laboratory. In which it is possible to analyze the radon gas intensity variation on the surface.

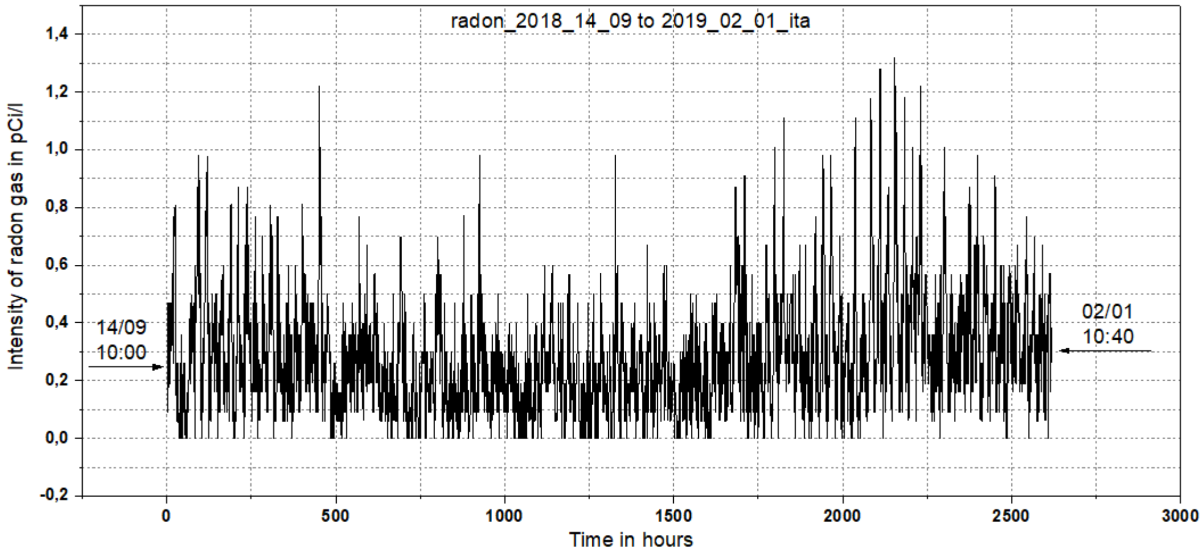

Fig. 03: Correlation of radon gas intensity versus time in hours from 09/14/2018 to 01/02/2019.

In parallel with the monitoring of the intensity of radon gas in the surface, the intensity of rains occurred in the region during the whole month of December 2018, allowing doing the relationship between rain and dry periods, with the radiation exhalation emitted by the radon gas according to Figure 4.

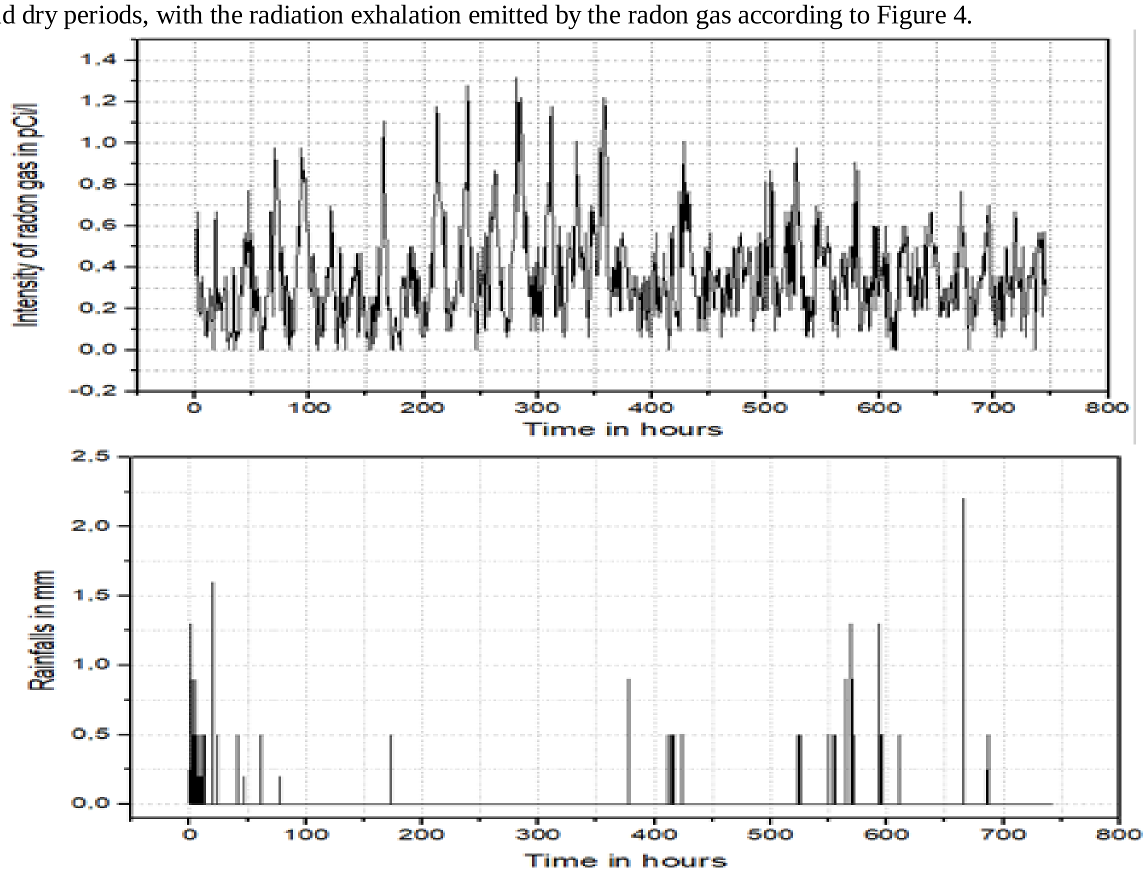

Fig.4. Correlation of the radon intensity in pCi /l per hour with the amount of rain in mm per hour of the month of December 2018.

The measurements carried out inside the ACA tower located at 25m height are shown in Figure 5, with the radon gas intensity monitored during the period from 10/25/2018 to 02/01/2019.

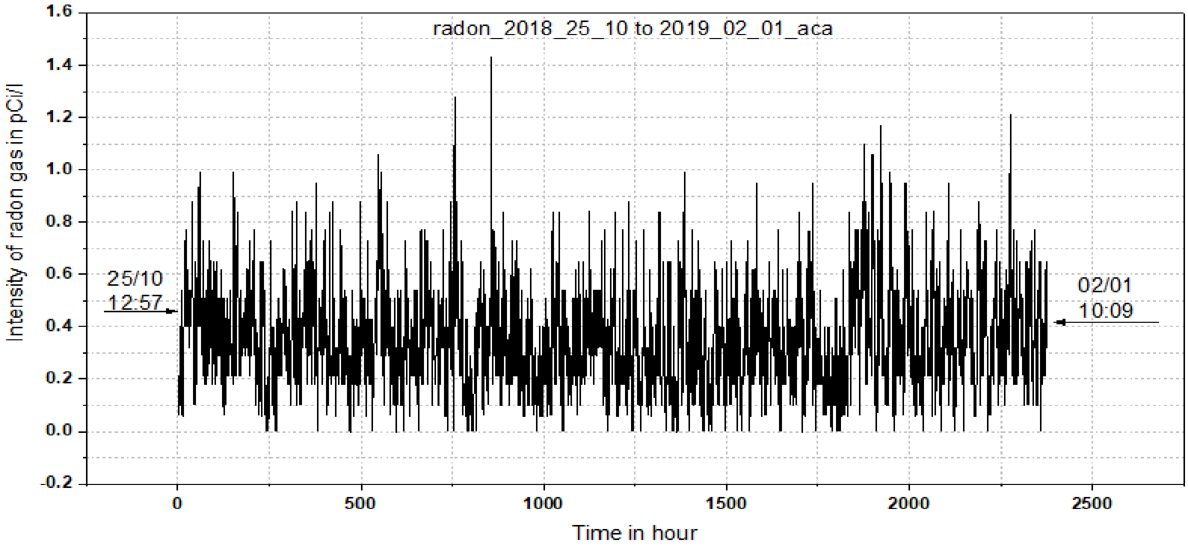

Fig.5. Measurements of radon gas intensity in the period from 10/25/2018 to 01/02/2019, carried out in the ACA tower, 25 m above ground level

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Then the same relation was made with the intensity of rains and the intensity of Radon gas present in the region, but now using as reference the data obtained through the measurements made in the ACA tower. It is possible to analyze this correlation in Figure 6.

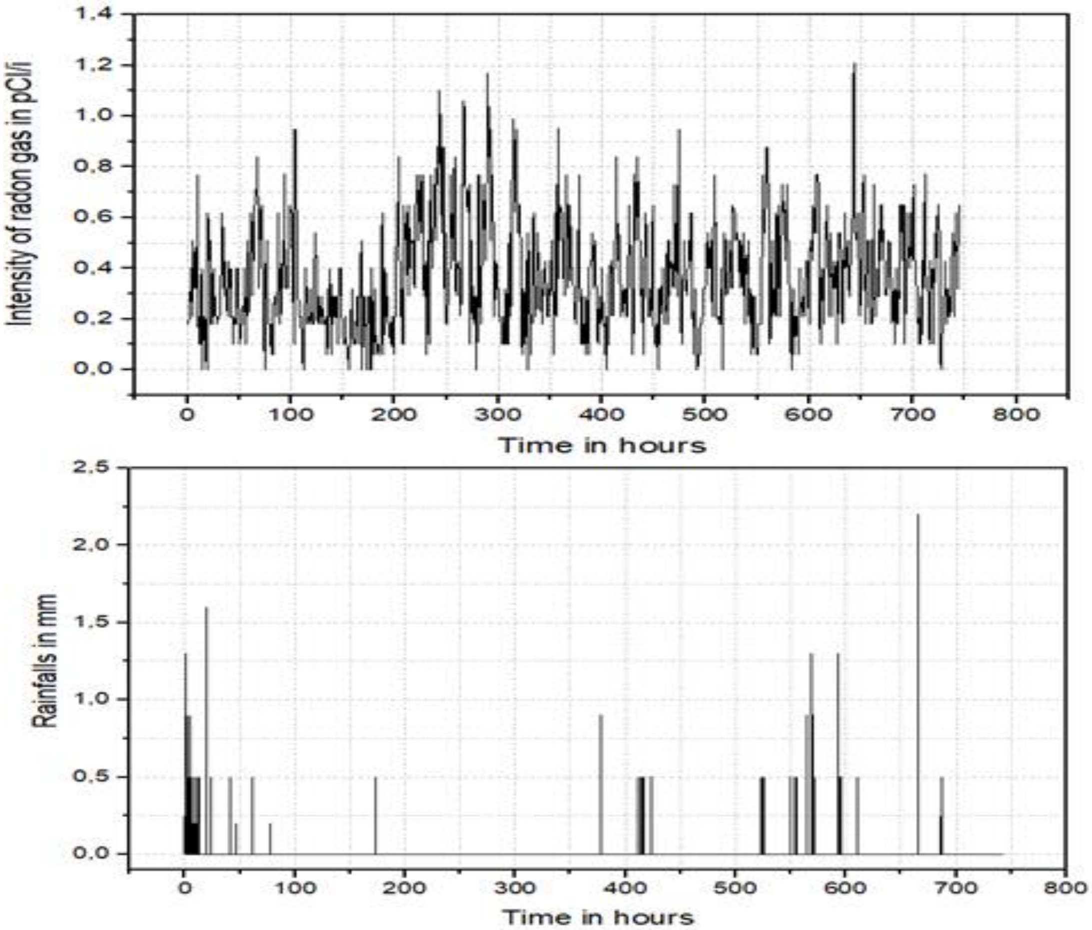

Fig.6. Correlation of the radon intensity in pCi / l hour with the amount of rainfall in December 2018

IV. CONCLUSION

This paper presents the analysis of the radiation from the Radon gas that exists on the surface of the earth. Having as origin from the soil, through the decay of the radioactive elements Uranium and Thorium. For this was used a fully portable equipment the RadonEye RD200, in which it allows to monitor the intensity of radon gas where it can be connected to a smartphone to monitor and collect the data. And together, a rain sensor, of the tip type, to collect data of rains in the region. Through this measurement system, it is possible to present the relationship between the intensity of Radon gas and the intensity of rainfall in the region of the ITA campus in São José dos Campos, Brazil.

By analyzing Figure 3, it can be stated that the intensity of radon gas at the earth's surface is higher in times of drought. By means of the high temperature in which the soil is, the exhalation of the radon gas becomes greater. In the night period, with the absence of the sun, the molecules of the radon gas in the atmosphere are no longer expanded, so they descend to near the ground. With this the gas is in greater contact with the detector where the radiation intensity is higher.

Figure 5 shows the same rainfall relationship, analyzing results obtained at 25 meters high in which the ACA tower is located. According to the monitoring carried out under these conditions, it is possible to identify some points in which, at the exact moment when the first rainfall occurred, a peak in the radiation spectrum from the radon is highlighted. This phenomenon is caused by air washing. Where the molecules of radon gas is carried by rain concentrate in greater quantity at the height, next to the detector.

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