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LOW ENERGY GAMMA RADIATION MONITORING DURING JANUARY TO OCTOBER 2020 IN SÃO JOSÉ DOS CAMPOS, SP, TROPICAL REGION OF BRAZIL

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ABSTRACT

The measurement of environmental gamma radiation every minute during the period from January 27 to October 20, 2020 at the ITA campus in São José dos Campos, Brazil was performed. The dynamics of rainfall throughout this period is well reflected in the measurements of environmental gamma radiation and shows the great influence of the presence of radon gas in the region. During the entire period described above, there are 6 measured gamma radiation peaks corresponding to six heavy rains in the region. Other variations in the intensity of the measured gamma radiation appear when there is light rain and drizzle as well as fog. Between August 21 and October 3, there was only an important peak of gamma radiation measured in the region. From October 3 to October 19, 2020, only 1 major radiation peak was measured, corresponding to intense rainfall in the region. In a qualitative way it can be said that a scintillator of gamma rays between 0.2 to 10.0 MeV observes the dynamics of the rains that precipitated in a tropical region in Brazil.

I. INTRODUCTION

Monitoring gamma radiation close to the ground, essentially consists of measuring the concentrations of the three main natural isotopes that exist here: potassium, uranium and thorium, associated with the first tens of centimeters of the Earth's surface, through gamma radiation measurements [1].

The acquisition of data of this nature can be carried out in two ways: terrestrial or aerial survey (with the aid of aircraft and balloons). However, both are subject to errors and information that are not necessarily related to the geology of the site to be studied. . The main sources of uncertainties are: cosmogenic elements that enter the atmosphere, emanation of radioactive series (mainly radon) and their behavior due to atmospheric factors [2]. This process is accompanied by an emission of particles of energy called nuclear radiation. Nuclides with this characteristic are called radionuclides and the process of nuclear decay or disintegration [3]. Radioactive decay decreases the number of atoms in the radionuclide with time: $N(t) = N(o). e^{-\lambda t}$ (1) where N (t) is the number of atoms present after time t (s); N(o) is the number of atoms present at time t = 0; λ is the radionuclide decay constant (s^{-1}).

The radon in the atmosphere, 222Rn which is produced in the soil by decay of the 226Ra diffuses from the soil into the atmosphere [4]. It and the products of its decay once in the atmosphere can contribute significantly to unwanted measurements of gamma radiation [5]. The exhaled Radon is transported upward by turbulent diffusion processes, and can be taken to considerable altitudes. The sons of radon, 214Pb (T1 / 2 = 26.8 min) and 214Bi (T1 / 2 = 19.8 min), are the two main gamma emitters [6]. These radionuclides bind to dust particles in the atmosphere, and their precipitation is caused by the action of rain. This can lead to an increase of up to 2,000% in uranium concentrations in the soil. Due to this phenomenon, in aerial surveys it is recommended to wait 3 hours after a rain so that the system is in balance [1].

II. MATERIAL & METHOD

To monitor the gamma radiation in energy interval 200 keV to 10.0 MeV, it has been used a portable system detector composed of Sodium Iodide scintillator activated with Thallium NaI(Tl). This crystal (3” x 3”) inches (diameter and

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height) placed in a thin cylinder of aluminum foil and coupled with a PM (photomultiplier) with source power circuit settled in 1500 VDC and with data acquisition system provided by the company (Aware Electronics-Inc., USA) [7]. Detector and associated electronics of gamma ray were previously calibrated in ITA (Technological Institute of Aeronautics) laboratory using radioactive sources (Cs- 137) and (Co-60) in terms of energy from emitted photons 662 keV and 1,17 MeV, 1,33 MeV respectively [8]. The data acquisition in terms of gamma radiation and intensity of rainfall was performed using 1-minute time interval between each measurement. This detail contributes to verify possible correlations between variation of rain intensity, and local ionizing gamma radiation.

The rainfall intensity in (mm) was measured with a pluviometer (bascule/bucket) rain gauge and data logger acquisition developed in ITA according to the international recommendations. The data acquisition in terms of ionizing radiation and intensity of rainfall was performed using 1-minute time interval between each measurement [9].

Using these three tools properly calibrated for the measurements of gamma rays, neutrons and rainfall intensity, he was placed in the tower at 25 meters high for simultaneous monitoring see Figure 1.

Fig. 1 - Aerial and ground view of the tower ACA and his environmental field region in São José dos Campos, SP, Brazil (23° 12'45" S, 45° 52'00" W), (Author).

Below is a spectrum of environmental gamma radiation from this location between 0.2 and 10.0 MeV, that is, for a measurement interval of 1 hour. The presence of the absorption peaks of Thorium, Potassium and Uranium, already well known on planet Earth, is verified and shows good functioning of the detector.

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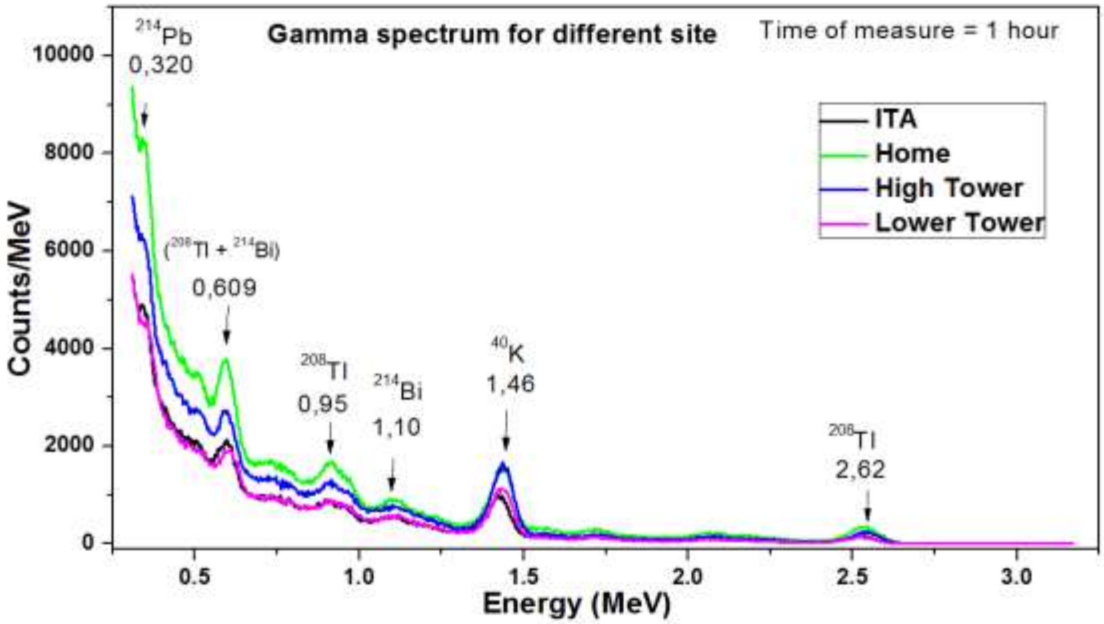

Fig. 2 – Measurement of spectrum between 0.2 to 10.0 MeV in four different places realized in October 30, 2019, (Author).

Figure 2 was placed here because it was not the result of this article, but an important tool that shows the very good functioning of the gamma ray detector in the energy range between (0.2-10.0) MeV employed here.

III. RESULTS AND DISCUSSIONS

During the period from 01/27/2020 to 10/20/2020, 11 major peaks of gamma radiation are observed, as shown in Figure 3,4and 5. However, in Figure 6, the measurements of rainfall intensity show 4 major peaks indicating heavy rains. Therefore, it is admitted that not only heavy rains cause an increase in the observed gamma radiation. The intensity during each day varies regarding related to weather dynamic in the place of monitoring mmeasurement site.

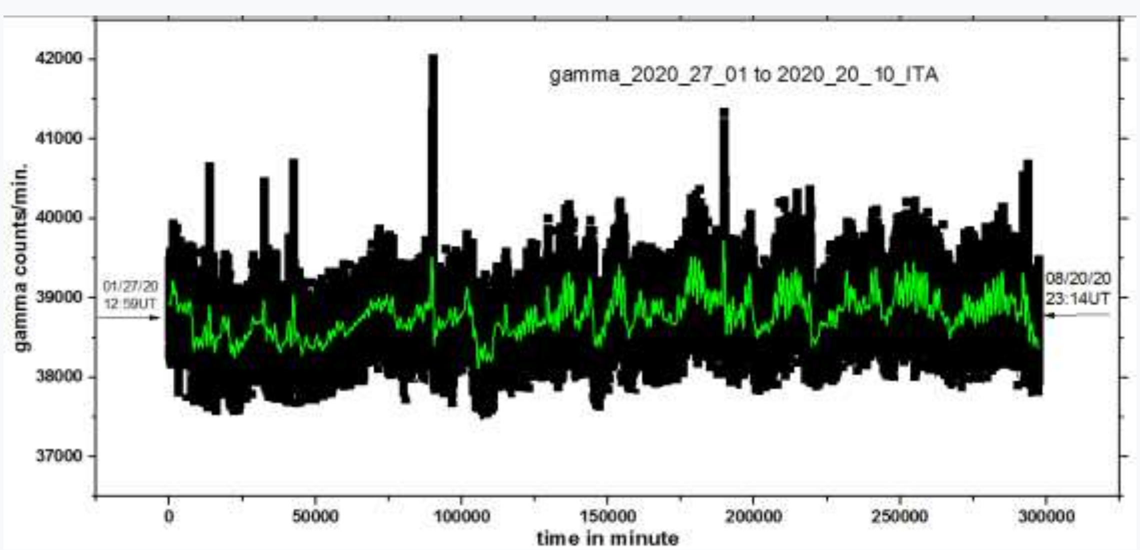

Fig. 3 – Gamma radiation measurements between 2020-27-01 and 2020-20-10 with 6 peaks indicating intense rains. Green line shows counts integrated during one day,(Author).

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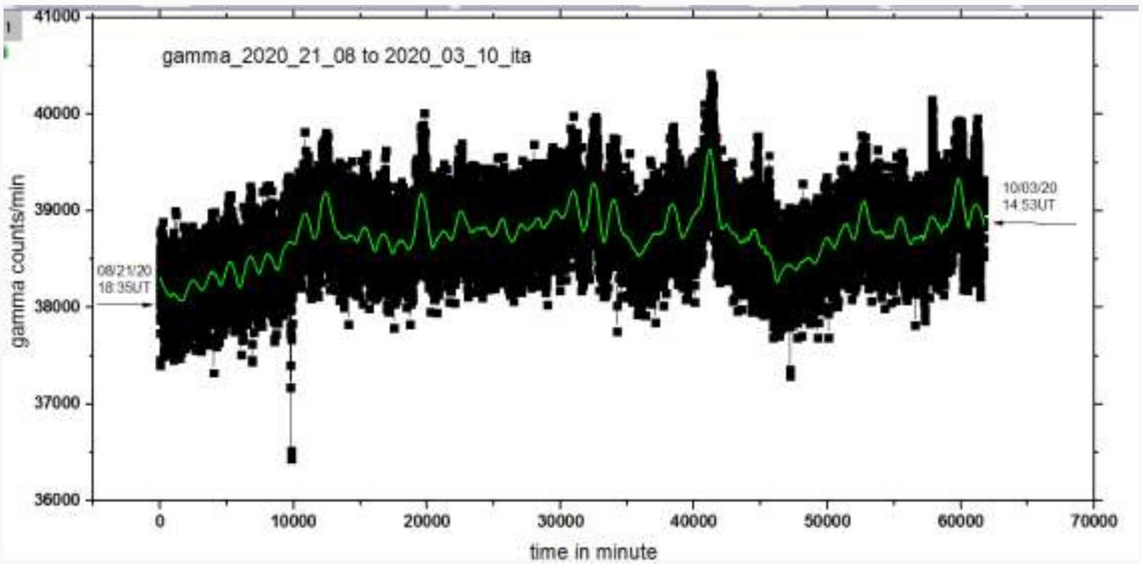

Fig. 4 – Gamma radiation measurements in the interval from 2020-21-08 to 2020-03-10 showing 4 peaks on that interval. The green line is smoothed for one-day complete measurements. (Author).

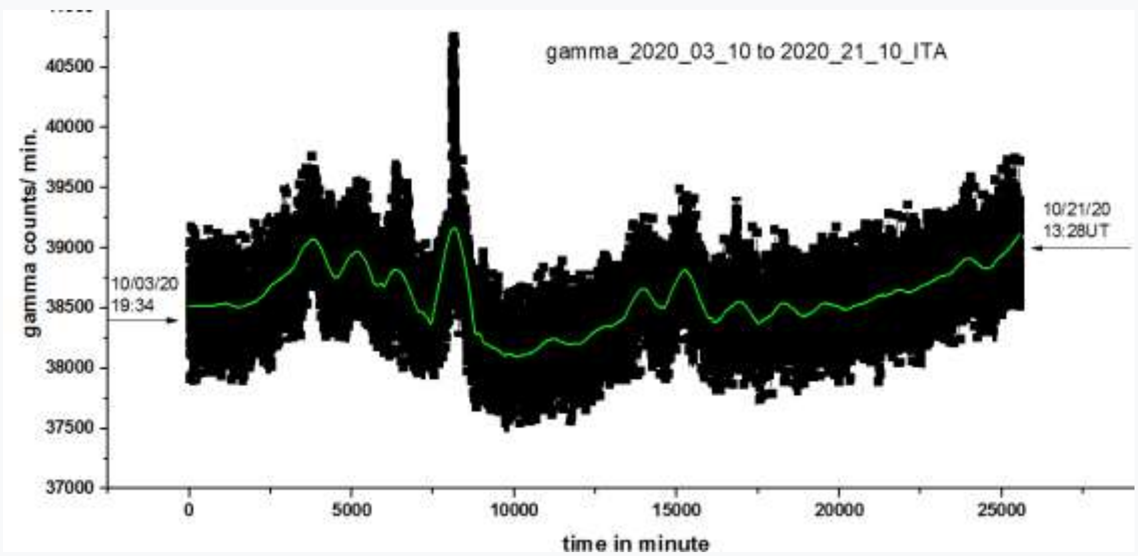

Fig. 5 – Monitoring of gamma ray radiation on the period of 2020-03-10 to 2020-21-10 where only one big rain appeared with promptly increasing during the rainfall, (Author).

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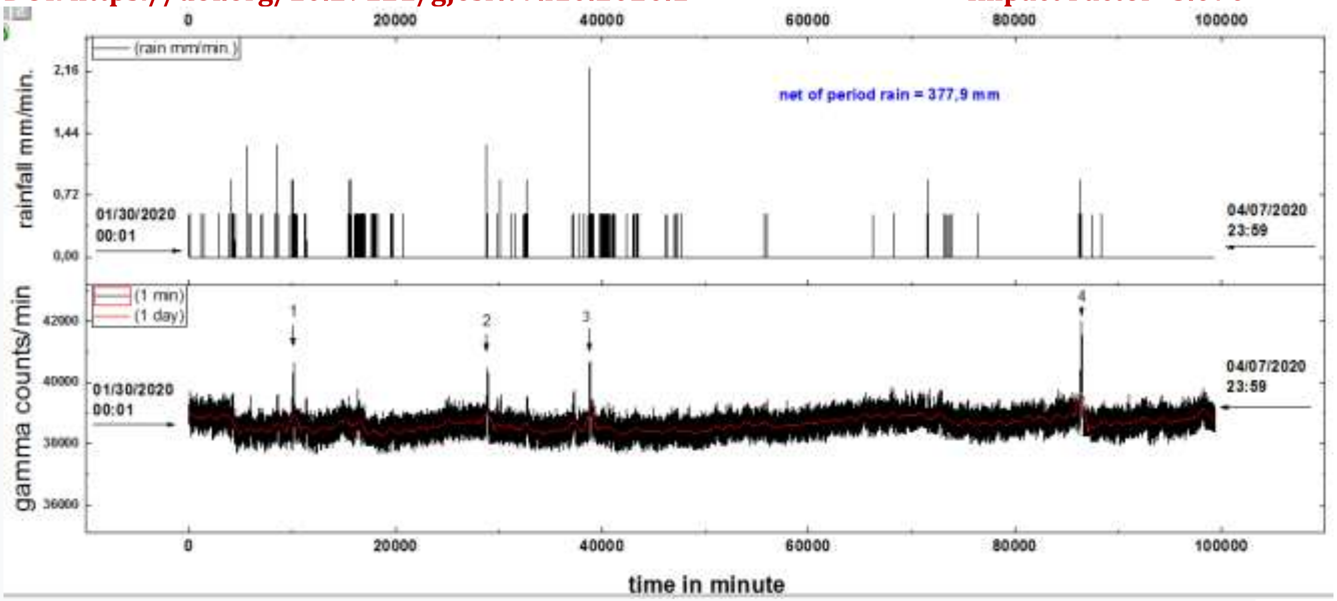

Fig. 6 – Typical example of measurements of rainfall intensity (mm / min.) and radiation intensity (counts / min.) in the time interval described in the figure, (Author).

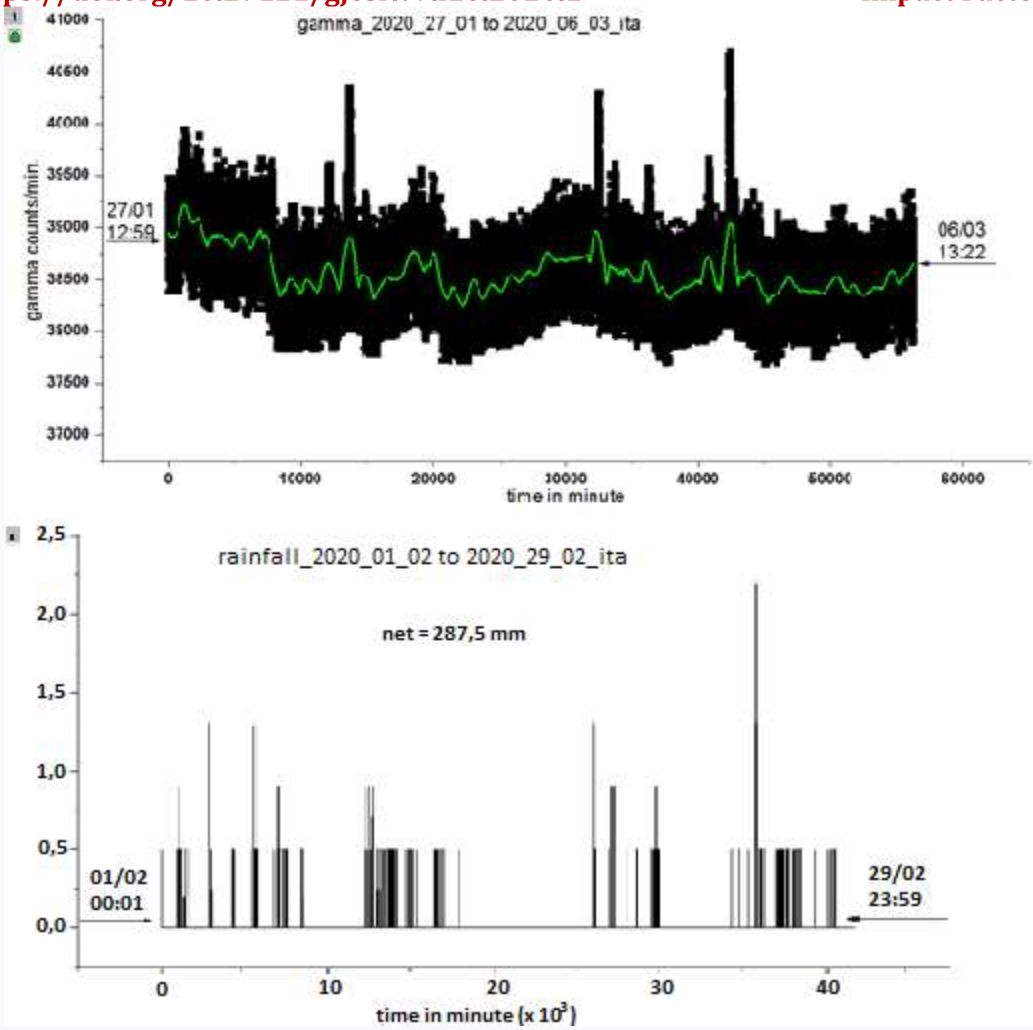

Fig.7 - Intensity of gamma radiation and rainfall intensity during 2020-01-02 to 2020-29-02 (Author).

This Figure 7 shows the 3 rainy regions that caused an increase in the intensity of gamma radiation in the same measurement site and time. In general, it is seen that intense and rapid rains cause more intense peaks of gamma radiation in this measured energy range. The increase in gamma radiation during heavy rain is caused by the washing of radon gas in low layers of the atmosphere. This same phenomenon is seen with intense fog, but it causes small increases in gamma radiation without forming peaks in intensity.

The year 2020 was quite irregular in terms of rainfall in this tropical region of Brazil. There was a lot of intense rain between January and the end of April 2020. Very little intense rain between May and the beginning of October 2020. This dynamics of rain can be seen in the measurements of gamma radiation in that same period in figures 3.4 and 5. The year was typical of vegetation burning due to the great lack of rain in the region.

IV. CONCLUSION

In the period from 01/27 to 10/20, 2020, the intensity of gamma radiation from 0.2 to 10.0 MeV and intensity of rains under the same conditions and location were monitored every minute. In general, large peaks of measured radiation correspond to intense rainfall in the region. Dry and very sunny weather causes visible variations in gamma radiation during night / day. All this variation in gamma radiation is caused by the exhalation of the Earth's surface of the radon

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gas originated by the decay of Uranium-238 in Radium-226 and Radon-222. During intense rain it flushes the radon gas impregnated in water molecules from the lower atmosphere air to the Earth's surface. This phenomenon then causes an increase in gamma radiation during the rainwater fall on the ground.In order to better understand this phenomenon, research continues with measurements in the tropical region of Brazil of gamma radiation and the intensity of rains every minute.

V. ACKNOWLEDGEMENTS

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