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DYNAMICS OF GAMMA RAY COUNTS RATE AND RADON GAS MEASUREMENTS IN TROPICAL REGION OF BRAZIL

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ABSTRACT

In this experimental work, measurements of low energy gamma radiation are shown every minute and radon gas every hour during an uninterrupted period of six months. These measurements close to the ground were carried out in the city of São José dos Campos, ITA and IAE ground area in a tropical region of Brazil. Both measures show a correlation with day / night and dry and wet weather. It is observed from the measurements that most of the low energy gamma radiation originates from the exhalation in the region of radon gas and it vertical movement. During the period from January 27 to August 3, 2020, there were only six rainy intervals, the rest being very dry. These intervals are well revealed in the measurements of the local gamma radiation in energy range up to 10.0 MeV.

I. INTRODUCTION

To monitor environmental gamma radiation from anywhere on the ground / air interface, proportional counters (Geiger) and / or thallium activated NaI or CsI scintillating crystals can be used. In the case of Geiger they depend on the sensitive type tubes that are manufactured. They depend on the gas inside, the internal pressure of this gas and the high operating voltage of this pipe. The best and cheapest Geiger tubes are made in Russia and China. Nowadays Geiger-associated electronics are found in international trade market at reasonable prices. The Arduino electronic system can be used for this task of feeding and acquisition data measurements. Geiger can only show the count per unit time of the environmental gamma radiation from the site to a previously chosen energy range. Sodium iodide or Cesium iodide crystal with thallium activated allow to measure local environmental gamma radiation by the scintillation process. This process with a more elaborate electronics allows determining the radiation energy being measured. Environmental gamma radiation consists of photons that vary depending on local geology, surface high relative to sea level, and primary - secondary cosmic radiation. It is also function of atmospheric pressure and relative humidity, drought and local rainfall regime. This environmental gamma radiation strongly depends on the presence of radon gas intensity at the measurement site [1,2]. Uranium-238's nuclear decay series and cosmic radiation from outside of planet Earth are responsible for producing gamma radiation on the Earth's surface [3].

II. MATERIALS & METHODS

A Thallium-doped Sodium Iodide crystal scintillator [NaI (Tl)] was used to measure gamma photon counts between 200 keV to10.0 MeV [4]. The scintillator-associated electronics consist of a 1500 VDC continuous voltage source and a minute data acquisition system. All of this electronics and crystal scintillator were designed and calibrated in energy and intensity by Aware Electronics Inc, USA [5]. Figure 1 shows the photomultiplier-coupled scintillator that were used in this work. Both radiation measurements (counts / minute) and rainfall intensity measurements (mm / minute) were recorded during this work in (.txt) files and saved to PC computer. Detector and associated electronics were previously calibrated in ITA (Technological Institute of Aeronautics) laboratory using radioactive sources Cs-137, Sr-90 and Po-210 in 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 gamma radiation and intensity of rainfall was performed using 1-minute time interval between each measurement [6].

Fig. 1 – Sodium Iodide scintilator (3x3 inches) and photomultiplier used in this gamma radiation measurement, (Aware Electronics, INC, USA).

Radon gas measurements

The radon gas detector is a portable ionization chamber as shown in Figure 2. It is powered with 110 or 220 V. It can measure hourly counts between 0.00 and 10000.00. These counts can be transformed into (pCi/l) or by (Bq/m^3) directly from the FTLab application software coming jointly with the detector to acquire the data in Android Smart appliances. This application can generate files on each download and can be saved in .txt. All instructions are given on reference [7].

Fig 2 – Top view of Radon Eye RD200 ionization chamber used for monitoring radon gas [7]

The view count of 0.43 (pCi / l) represents the value at the last hour that the ionization chamber made measurements. By means of an ITunes software installed on an IPhone, you get the data that is already plotted on the screen of the IPhone as indicated by Figures 3 below.

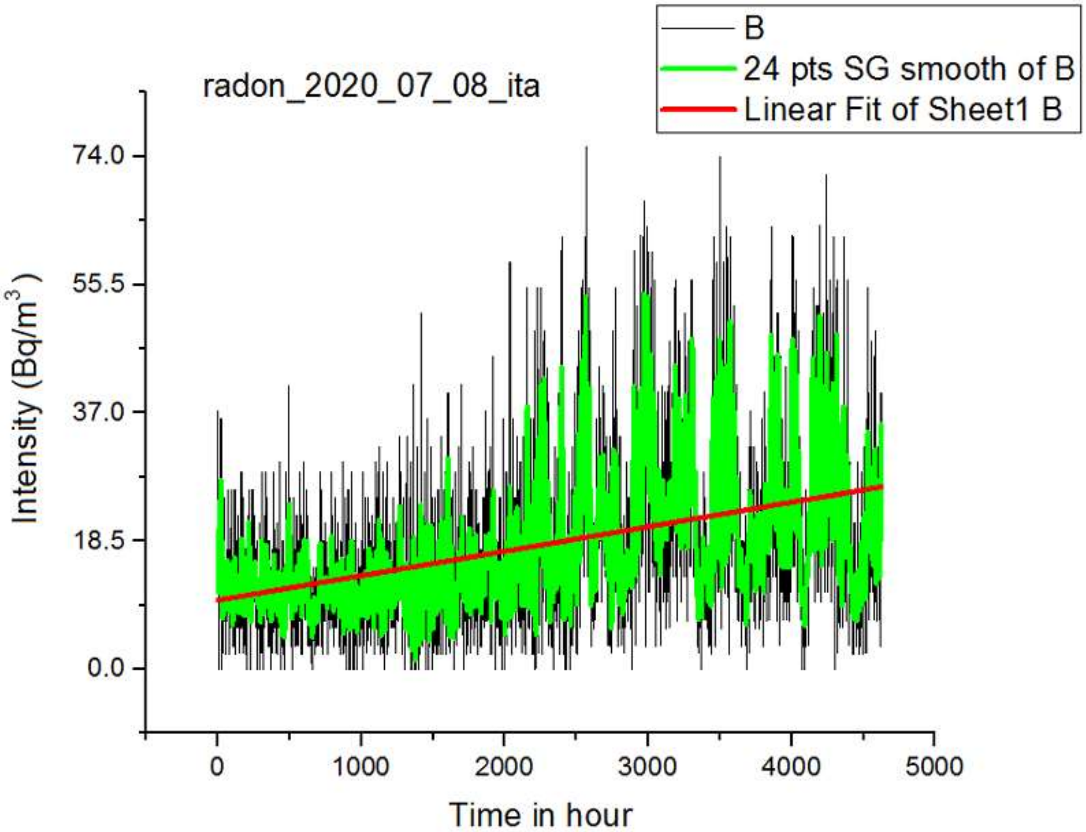

Fig. 3 – Measurements of 4625 hours of radon gas with one day variation in green color and linear fit during the net period in red color. Begin in January 27 to August 03 2020 [8].

III. RESULTS AND DISCUSSIONS

Based on the graph of measurements every minute of gamma radiation between 01/27/2020 and 03/08/2020, see figure 4. The presence of six peaks clearly above 40000 counts / minute is noted. Each peak shown in this Figure is related to the presence of rain in that location. This rain is usually intense or moderate. When the rain is light or fog it is difficult to perceive directly in the graph of the gamma radiation measured at the location. Is necessary to zoom in the vicinity of the time of the rain. The graph in Figure 5 shows the fact It corresponds to a zoom done in the time interval from 0 to approximately 50000 minutes of measurements. This chart highlights three different intervals of gamma radiation peaks showing the dynamics of rainfall intensity with different intensities. This phenomenon relating the presence of increased gamma radiation in the rainy season, mainly in the tropical and equatorial regions, is explained by the greater and lesser exhalation of radon gas in the region In a very dry region that suddenly has an intense rain for a very short time, the intensity of the gamma radiation increases a lot, a phenomenon known as washing of the radon gas in the lower atmosphere.

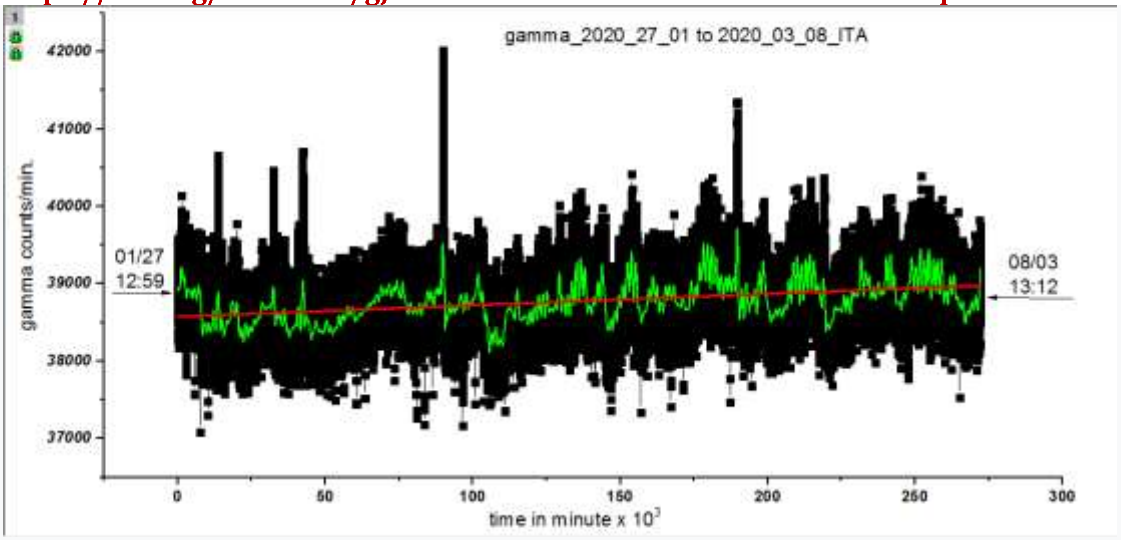

Fig. 4 – Gamma radiation counts per minute with the six largest peaks observed in this measurement period. Green line is data smoothed for one day. Red line correspond to linear fiting of net period.

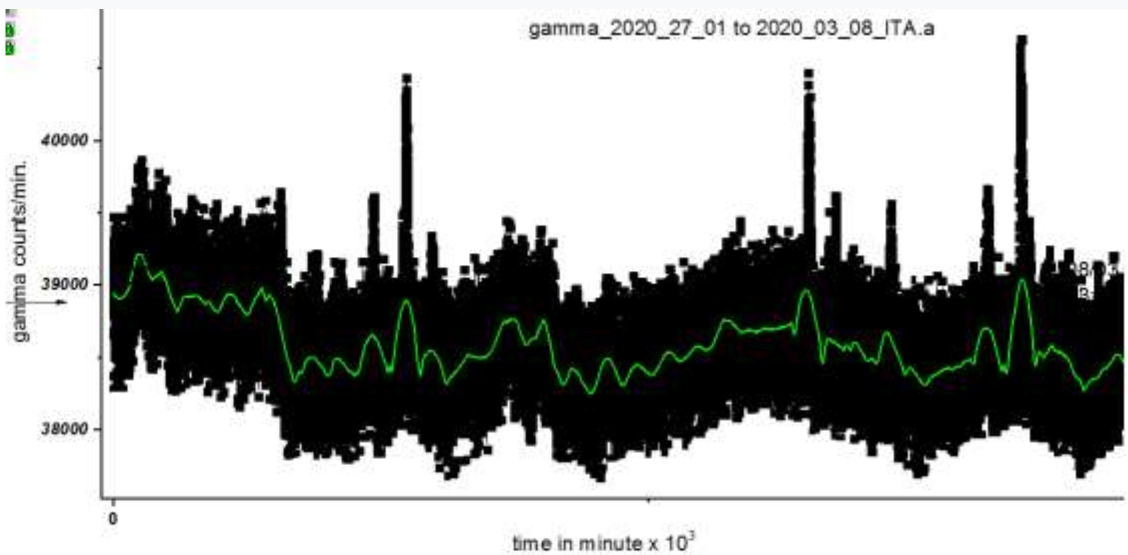

Fig. 5 – Smoothed view of three major radiation peaks showing heavy rain and five minor peaks indicating light rain. Green line is data smoothed for one day.

Figure 6 shows exactly the situation when after a long time without rain an intense rain arrives in near 90000 minutes. On that occasion for an hour it rained around 38 mm. Note that this dynamic of rain in this measurement period is clearly observed in the presence of the gamma radiation detected in the region.

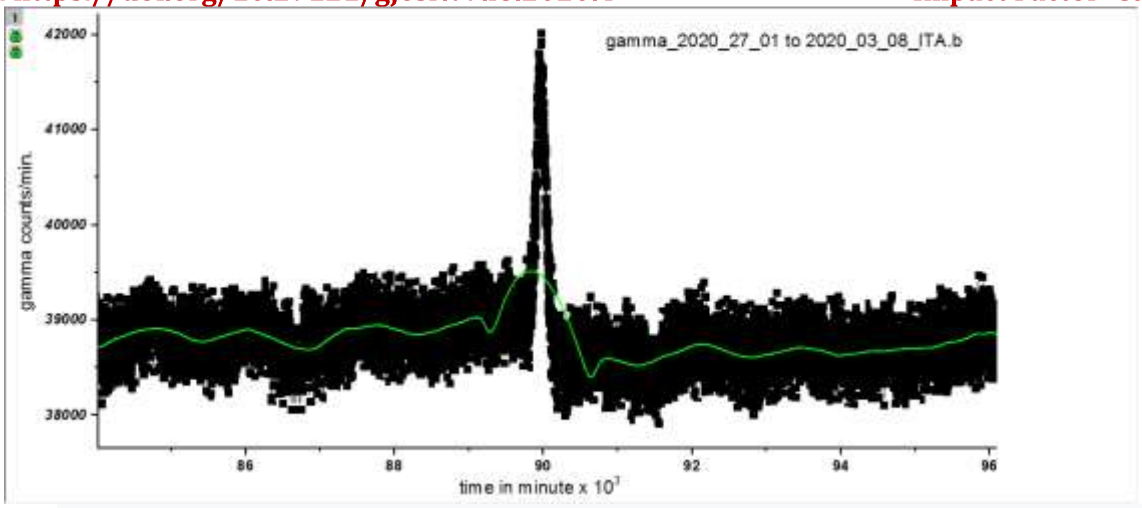

Fig. 6 – Intense rain after a long period of drought with washing of the radon gas from the low atmosphere shown in the increase of gamma radiation near 90000 minute.

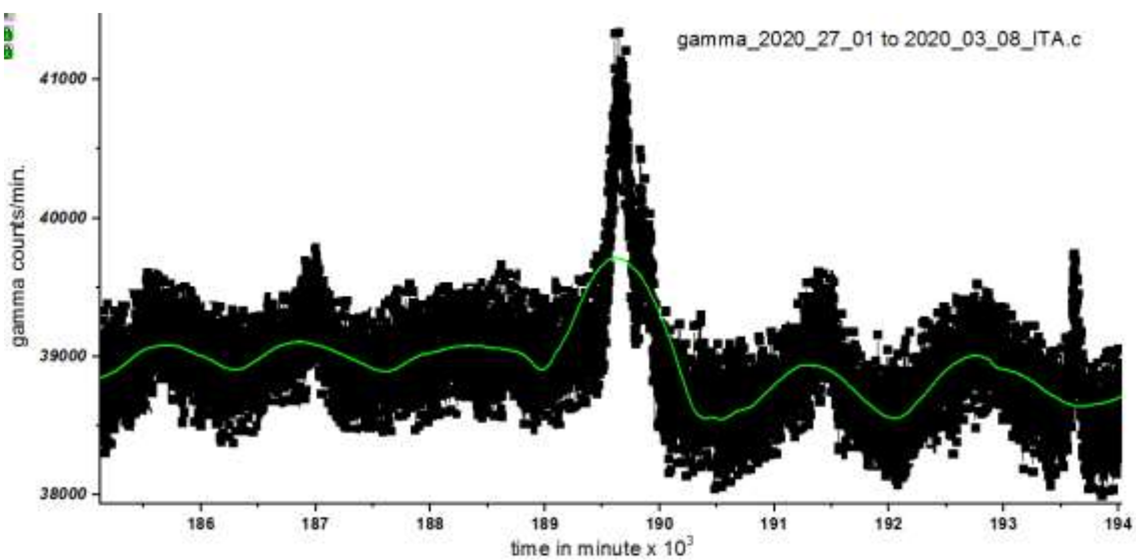

Fig. 7 - The third radiation peak shows moderate rain close to 190000 minutes of measurements with less intensity in counts/min. than previous one of figure 6.

The net intensity of this moderate rain reached 13 mm, which was very well observed by measuring the gamma radiation in the place.

The last rain shown through the gamma radiation measurements in this work was around 219000 minutes of measurements. It was very weak in the order of 5 mm total shown in figure 8. Although the gamma radiation graphs in figures 6, 7 and 8 seen similar, a more specific study of each shows the different meteorological dynamics for them. Soon using a good sodium iodide scintillator or similar it becomes possible to report the meteorological parameters that occurred in a place close to the ground during a period in tropical regions.

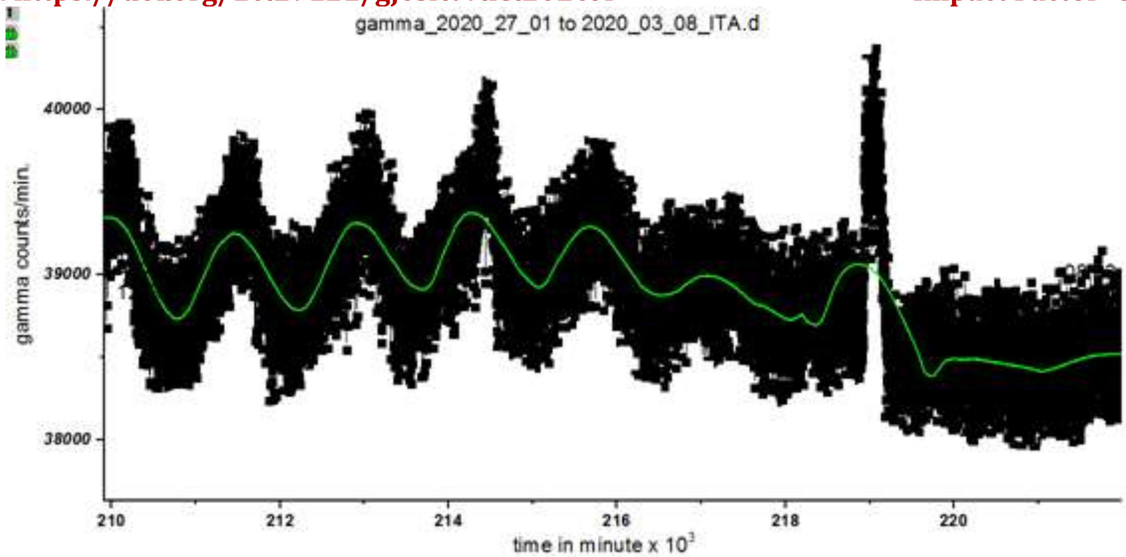

Fig. 8 – Gamma radiation graph showing the effect of light rain after a period of sunshine. The green curve represents a day's smoothed in minute measurements.

IV. CONCLUSION

Based on six months of measurements every minute, from low energy gamma radiation (0.2 to 10.0) MeV, with a Sodium Iodide scintillator [NaI (Tl)] close to the ground, variations in intensity of this (day / night) radiation, dry weather, wet weather, light rain, heavy and moderate rain and even fog were observed. The variation of gamma radiation in this energy interval is closely linked to the exhalation intensity of radon gas ^{222}Rn originating from radium ^{226}R from uranium ^{228}U in this region. During intense rains originating shortly after a very long and dry time, the radon gas is washed from the low atmosphere sky close to the ground, causing an increase in gamma radiation at that time and place.

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