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Ionizing radiation measurements (0.2 to 10.0) MeV near ground level in São José dos Campos, SP, Brasil

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Abstract
In the period from August 1 to October 30, 2024, the region of São José dos Campos, SP, Brazil, experienced significant variations in the intensity and quality of air near the Earth's surface. This phenomenon occurred due to severe drought and high temperatures with intense wildfires in Brazil and also in this region of the Paraíba Valley. Continuous measurements were conducted every minute in this region. This experimental work presents the counts per minute of gamma radiation one meter above the ground. Several spectra were also recorded at the same height and location during this period to identify radiation from various smoke clouds present at the site. The analysis and discussions of the measured results are provided in this work.

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I. Introduction

Gamma radiation near the Earth's surface in the energy range of (0.2 – 10) MeV originates from three possible sources: secondary cosmic rays, primordial Earth radiation, and lightning at the measurement site [1-3]. Secondary cosmic radiation is produced in the Earth's atmosphere at altitudes of 14-17 km above the measurement site, known as the Pfotzer maximum [4], by primary cosmic rays. The Earth also, during its formation, produced various radionuclides that emit gamma radiation within this energy range. Lightning also produces this radiation in the measurement region [5]. A gamma radiation spectrum analyzer within a selected energy range displays the number of gamma photons at each photon energy. This allows the determination of which energy peaks are present in the measurement region [6]. Using a gamma-ray scintillator, it is possible, with specific electronics and radioactive sources of various energies, to determine the integrated photon count within a given energy range. Thus, the gamma radiation dose in that energy range at the measurement site can be evaluated. This dose varies across different regions of the Earth's surface [7].

II. Material and Methods

To measure gamma radiation between 0.2 and 10 MeV (million electron volts), a gamma-ray scintillator (3x3 inches) made of sodium iodide activated with thallium and shielded with a 1 mm thick aluminum casing was used. This scintillator, combined with specific electronics, detected the number of pulses in the scintillator every minute. A computer recorded and stored this parameter over time [8]. Figure 1 shows the detector comprising the scintillator, associated electronics, and computer, along with a graph of a specific measurement period with one-minute intervals between readings.

Fig. 1: View of gamma scintillator with associated electronics and computer. (Author)

The computer screen displays the pulse intensity measured as a function of the time interval selected for each measurement. The black box above the photomultiplier contains all the necessary electronics to process the measurement data; for more information, consult [9]. By using radioactive sources within the (.2 to 10) MeV range and the circuits in the black box, the lower and upper energy thresholds of the measured photons can be calibrated. Additionally, the photon measurement voltage can be set between 500 to 1500 volts.

Fig. 2: NaI(Tl) scintillator, associated electronics, and PC. (Author)

Figure 2 provides a clearer view of the electronic system, photomultiplier, and NaI(Tl) scintillator, now with the electronics box in white. This integrated gamma radiation detection system will operate continuously for at least one month at the Atmosrad laboratory of ITA.

III. Results and Discussions

The gamma radiation measurements were conducted at the Institute of Aeronautical Technology (ITA) in the Atmosrad laboratory during the specified period from 06/06/2024 to 09/12/2024. Figure 3 shows the overall graph of these measurements, correlating the gamma photon counts per minute (vertical axis) with time (horizontal axis) in one-minute intervals.

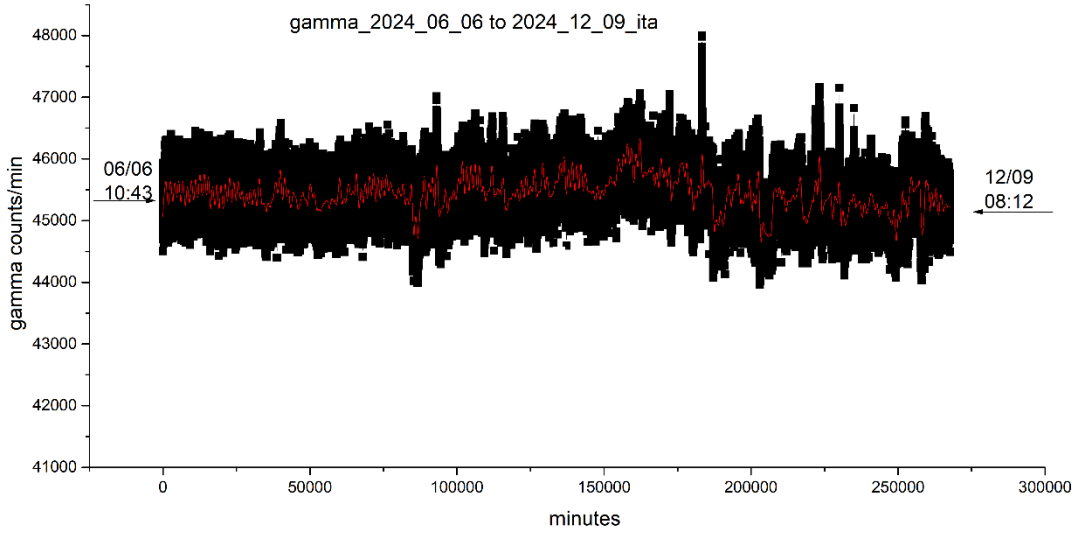

Fig. 3: Gamma radiation intensity measurements from 06/06 to 12/09, 2024. (Author)

This continuous monitoring of gamma radiation under the same conditions and location reveals two distinct periods. From 06/06/2024 to 150,000 minutes, the influence of dry weather and wildfire smoke, shown in figure 4, is observed in the municipality of São José dos Campos, SP.

Fig. 4: View of wildfire smoke intensity in São José dos Campos, SP. (Author)

Between 150,000 minutes and 270,000 minutes, there are more variations in radiation intensity due to the influence of clouds and rain in the region. The main result of this work is to show the variations in gamma radiation intensity in the region under very dry conditions, wildfire smoke, and cloudy and rainy weather. The year 2024 was notably different in terms of drought and wildfires in the Paraíba Valley region, as well as rainfall in October, November, and December 2024.

IV. Conclusion

From June to December 2024, the region of São José dos Campos, SP, experienced a dry period with wildfires that released a large amount of smoke into the lower atmosphere, as well as cloudy and rainy weather above normal levels. This observed atmospheric behavior in the region's lower atmosphere was also reflected in the variation profile of gamma radiation intensity in the (0.2 – 10) MeV range monitored during the same period and location. Thus, it is experimentally proven that dry, cloudy, and rainy weather alter the gamma radiation profile near the Earth's surface.

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