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Intensity variation of gamma radiation on ground level interface in São José dos Campos, SP, Brazil

Inácio Malmonge Martin[1,2], Marcelo Pêgo Gomes[3]*

[1]Department of Mechanical Engineering, University of Taubate (UNITAU), Rua Daniel Danelli, s/n - 12060-440, Taubate-SP, (BRAZIL)

[2]Physics Department of the Technological Institute of Aeronautics (ITA), Rua Marechal Eduardo Gomes, 50, Vila das Acácias, 12228-900, São José dos Campos-SP, (BRAZIL)

[3]Division of Atmospheric Sciences of the Institute of Aeronautics and Space (IAE), Rua Marechal Eduardo Gomes, 50, Vila das Acácias, 12228-904, São José dos Campos-SP, (BRAZIL)

E-mail: gomesmpfis@yahoo.com.br; martin@ita.br

ABSTRACT

In the period June 22 to September 24, 2012 São José dos Campos region experienced dry climate with low relative humidity. The net rain intensity measured in this period was 60 mm and the relative humidity range between 30% to 40% on most days. The intensity of gamma radiation from 0.03 to 10.0 MeV, in the measurement period presents a daily fluctuation well clearly, and some small increases when there is rainfall. These measures were realized at ITA's campus with a scintillator of NaI (Tl), photomultiplier and associated electronics laptop to a Dell 630 PC. A data acquisition interface purchased from (Aware Eletronics, USA) provides a file with measurements versus time, in the range from minute to minute recorded in txt. It was observed that the variation of gamma radiation in the interface soil/air at the region is originating from the local radon gas dynamics and of the presence of wind shear near the ground level.

KEYWORDS

Atmosphere;
Radon gas;
Environmental gamma Radiation;
Rain precipitation;
Gamma-ray portable system.

INTRODUCTION

It is common knowledge that we live in an environment which comprises ionizing radiation (X-rays, gamma rays). These radiations[1], in normal situations, are produced by natural phenomena such as cosmic rays from different sources and the decay of radioactive elements present in the planet's atmosphere and crust. Ionizing radiation can also be produced by human activities such as those related to nuclear power generation and use in medicine. Although ionizing radiations are part of our daily lives, few students or researchers have the opportunity to perform measurements and observations of the background radiation. To overcome this deficiency in education we started a pilot project comprising measures and observations of environmental radiation background with students of the Technological Institute of Aeronautics (ITA, SP) and the University of Taubate (UNITAU, SP) using compact and portable meters to observe gamma radiation.

The geological radiation source is largely the result of the decay of radioactive isotopes of potassium (^{40}K), uranium (^{238}U) and thorium (^{232}Th)[2]. In radioactive decay, nuclei may emit alpha radiation, beta, gamma or X-rays, in addition, besides, are formed the natural radioactive isotopes belonging to each series decay aforementioned. The ^{235}U has a half-life of 713 million years whereas the ^{238}U has a half- life of 4,5 billion year. For this reason there is a much smaller amount of ^{235}U compared to ^{238}U[3].

Radon gas (^{222}Rn) is the other important source of ionizing radiation on interface soil/air which likewise is formed by uranium and thorium decay. In turn, the radioactive decay of radon produces ^{218}Po, ^{214}Pb and ^{214}Bi, These isotopes may be measured in the air[4-7]. A relevant fact related to radon is that during the rainfall its soil concentration may rise due to the transport of that gas through raindrops. The secondary cosmic radiation produced on lower atmosphere has a little variation with time; however, it varies accordingly to latitude and altitude on the earth's surface[8]. Secondary cosmic radiation produces "extensive showers" of energetic particles and photons which arrives to earth's surface[9]. Artificial ionizing radiations are those man-made in several kinds of activities such as medicine, research, and industry. Nevertheless, these radiations source are confined and over control. In Brazil have not yet been made the measures on the territory, of radiation from soil, produced by atmospheric radon, cosmic origin and artificial. But in other countries these values are known, for example in Portugal 56% of ground level radiation is produced by atmospheric radon, 8% produced by soil, 8% is cosmic origin, 17% is artificially produced, and 11% by other sources[10].

MATERIALS AND METHODS

Gamma radiation measurements was realized with a crystal scintillator of NaI (Tl) mounted in an aluminum cell and connected to a photomultiplier tube (Aware Electronics, USA). This detector was coupled to a PC for storing the data series. The scintillator, coupled to the photomultiplier and associated electronics, was previously calibrated with standard radioactive sources in a laboratory.

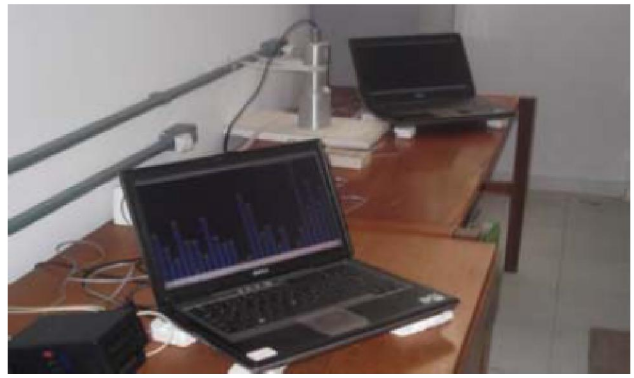

Figure 1 : Portable system for measurements used at this work

RESULTS AND DISCUSSIONS

Measurements of gamma radiation were performed at the Physics Department of the ITA in São José dos Campos, SP, from 22 June 2012 to 24 September 2012 at fixed counting intervals of 1 minute continuously throughout the period. In Figure 2 shows the radiation collected by the detector per minute versus time of measurement. Note that the measurements of X-ray and gamma-ray photons occur omnidirectional, irrespective of direction. During this period the atmosphere near the Earth's surface was extremely dry with low humidity in the afternoons, and around 30% in most parts of the days analyzed. The rains were all weak and of low intensity (mm) distributed among 10/07 and in 07/17, as shown in Figure 2, a total of 54 mm[11]. From

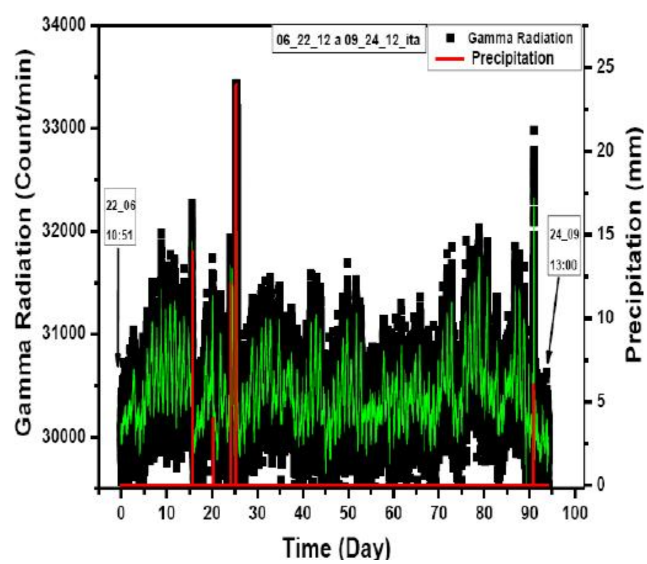

Figure 2 : Measurements of gamma radiation and precipitation[11] in São José dos Campos the period

the day 07/17 until day 09/21, the local atmosphere was very dry. On 09/22 the first rain arrived with very low intensity, near 6 mm. Even with low intensity of precipitation in those days it was noted a correlation with the intensity of gamma radiation observed.

Figure 3 shows the variation between the above-mentioned measure of relative humidity experienced in the region. For each day the average value was determined in that moisture. The data used to calculate the average value of relative humidity were obtained through a datalogger system[12].

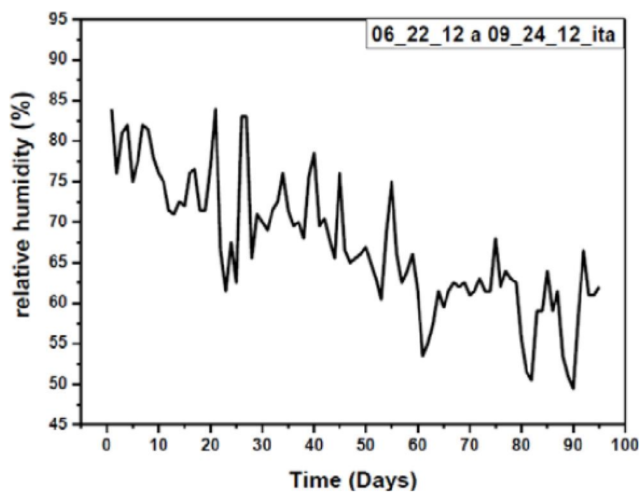

Figure 3 : Relative humidity % average per each day[12]

In every period measures the radiation varies with a cycle of 24 hours perfectly shown in the graph of Figure 4 (power spectra FFT). This cycle is quite evident in measurements with dry weather interference where rain is almost null. The radiation in this period without rain always increases between dawn until the sun 11-12 hours local, this is due to greater presence of

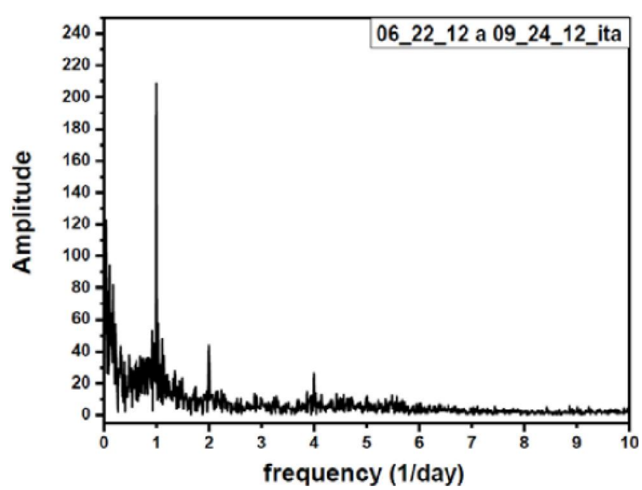

Figure 4 : The power spectra (FFT) obtained for the period

radon gas (^{222}Rn) which decays after 3.8 days in ^{214}Pb and ^{214}Bi, emitting gamma photons belonging to the energy range of the scintillator measuring. At the time of rain radon gas also increases due to the phenomenon of washing the lower atmosphere where the radon gas is diluted in suspended water droplets.

CONCLUSION

The measurements of gamma radiation from 0.03 to 10.0 MeV were performed continuously from 06/22 to 09/24, 2012, per each minute on the campus of the Physics Department of the ITA in São José dos Campos, SP, Brazil in ground level interface. Atmospheric pressure, relative humidity and temperature were also measured at the same time and location with the same time interval of minutes. The analysis of these measurements clearly shows how the radon gas provokes influence of the dry period, causing a well-defined cycle of 1 day. The average relative humidity during all days clearly shows its decline from the month of June to September 2012 where occurred the first small rainfall of this period.

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