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RADON GAS AND INCREASING INTENSITY OF GAMMA RADIATION NEAR GROUND LEVEL INTERFACE ON 2011 IN SÃO JOSÉ DOS CAMPOS, SP, BRAZIL

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ABSTRACT

During the year 2011, the ongoing work of monitoring the intensity of gamma radiation (30 keV to 10 MeV), some of this radiation surges increasing were observed. There were no lightning or electrical dischargesover the instrument of measures in the period time and area. As was observed strong wind arriving from the southeast and after also heavy rains coming. A typical case described in this paper was witnessed by the authors on November 28, 2011 at 17:46 local time, with a sudden and sharp increase in gamma radiation intensity on site. The vertical electric field intensity in the region is monitored and that increase period was observed through rapid variations but small intensities. It is suggested that the source responsible for producing this abrupt increase of gamma radiation at the site is the presence of radon gas (Rn-222), coming up with the intense rain in the region of São Jose dos Campos in State of São Paulo, Brazil.

KEYWORDS: Radon Gas, Gamma Radiation, Monitoring, Rainfalls

INTRODUCTION

The alpha, beta, X and gamma low energy (30 keV to 10 MeV) radiation, present in the local environment, soil-air interface depends mostly on:

- Presence of local radionuclide's from the three series of disintegration and radioactive potassium (^{40}K),
- Secondary cosmic radiation,
- Radon gas in local place,
- Radiation produced by humans.

These radiations are ionizing, has enough energy to strip electrons from the atom (~ 12 eV). The background of this integrated ionizing radiation in a given region is the sum of the four components described above. This land-based radiation of local geology decay is caused by the three series, namely:Uranium-238 (^{238}U), Actinium (^{235}U) and Thorium (^{232}Th), (Bui-van, Martin and Turtelli; 1998). In each decay nuclei emit radiation type alpha, beta, X and or gamma. These sequences give cores radioactive isotopes natural sources belonging to each of the above radioactive series or families (Martin, I.M., 1982). The Uranium-235 has a half-life of 713 million years while the Uranium-238 has a half-life of 4.5 x 10^9 years. This means that there is a lower percentage of Uranium-235 relative to Uranium-238. However and therefore the Uranium-235 is more "consumed" than the Uranium-238. (Master's Thesis A. A. M, Lima, 2007).The other important source of ionizing radiation in the soil-air interface in the region is the presence of radon gas (Rn-222) who is also coming from the disintegration of Uranium - 238 series. Radon gas decays into (^{218}Po, ^{214}Pb and ^{214}Bi) these being measured in the air and local soil. In general radon gas is present always in the rain with winds that arrive before the cold fronts. These rains in general are always intense and living with intense volume of radon gas.

The alpha radiation, beta, and X - gamma rays from the secondary cosmic radiation produced in the lower atmosphere is somewhat variable as a function of time. However its intensities depends on the latitude and altitude with reference to the earth's surface (Martin, I.M; Thèse of Specialité, University of Toulouse, France, 1971). The secondary cosmic radiation produces true "long showers" particles of compounds and energy photons that reach the Earth's surface causing ionization in the environment.

The artificial ionizing radiations are those produced by humans in medical and odontological laboratories, nuclear accelerators. However, these radiations are confined in principle controlled in a given region. In Brazil there is no knowledge, considering nationwide, the percentage measurement of ionizing radiation from soil, radon, cosmic and artificial. In Portugal, for example, these data are well known, that is: Radon 56%; Soil 8.0%; Cosmic 8.0%; artificial 17% and others 11% (Master's thesis Abilio Alberto Machado Lima, University of Coimbra, January 2007, Portugal). The sodium iodide detectors activated with Thallium are very sensitive to X - gamma radiation of low energy mentioned above. Cosmic radiation consists of particles and energy photons that is measured by Geiger counters and solid state detectors sodium iodide and plastic scintillators type NE102A and neutron detectors (Thèse Docteur d`Etat, University of Toulouse, Martin, I.M; Jun of 1974, France).

MATERIALS AND METHODS

The measuring of environmental ionizing radiation were performed in the soil-air interface, near the Department of Physics of the Technological Aeronautical Institute (ITA), São Jose dos Campos, SP, Brazil. The measurements were performed during January to December 2011 all in the same location. Were used two detectors scintillators sodium iodide NaI (Tl) (3 "x 3") acquired from Ludlum Measurements Inc., USA (ref. 6,7). A unit after calibration in the laboratory with radioactive sources was placed to measure the integrated count rate of X and gamma radiation between energy(30 keV to 10 MeV). The other unit is coupled to the system an MCA (Multi Channel Analyzer) and a high voltage source (HV) power supply with data acquisition (M PC USB MCA 733 1024 CHANNEL (3 "x 3") from Ludlum Measurements Inc., USA). This set (high voltage and MCA) is powered by a laptop PC via the USB port of the computer. Was monitored throughout the year 2011 the spectrum and the integrated counts rate from (30 keV to 10 MeV). All two detectors have calibration certificates made by the same manufacturer described above. The files (.txt) containing the environmental ionizing radiation measurements versus time was recorded on laptop PC (ref. 8,9 and10).

RESULTS AND DISCUSSIONS

During monitoring of gamma radiation was obtained in different energy spectra and in the integrated counting rate always in the same energy range (30 keV to 10 MeV), as a function of time (minutes) in the same site. Figure 1 shows the integrated score (counts rate/min) obtained during the period from 28 November to 5 December 2011 that best demonstrates this phenomenon (rain precipitation related with X and gamma radiation).

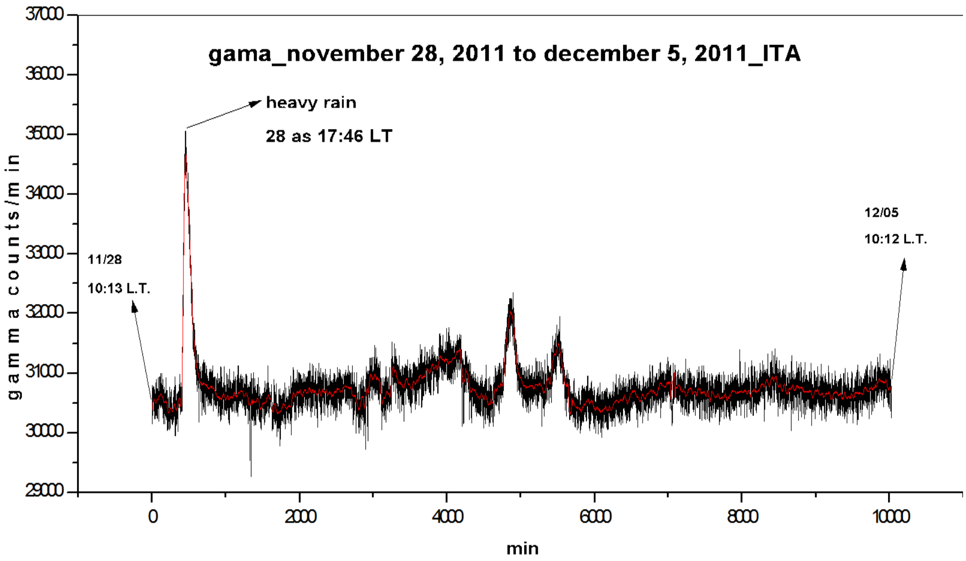

Figure 1: The Monitoring Series of Integrated Intensity of the Counts Rate of X and Gamma Rays, Confirming the Radiation Peak Interval during the Wind and Rain over the Detector Region

A heavy rain reached the detector region causing a sudden increase in gamma radiation at around 14.7% relative to background radiation measured in the region. Figure 2 shows precisely part of a maximum of ionizing radiation time (17:46 local time), the local vertical electric field varied between ± 800(V / m). This figure shows that there is no lightning at that time in the region. Also the electrons accelerated by this potential energy difference are not sufficient for local production of X or gamma rays near the site of detectors.

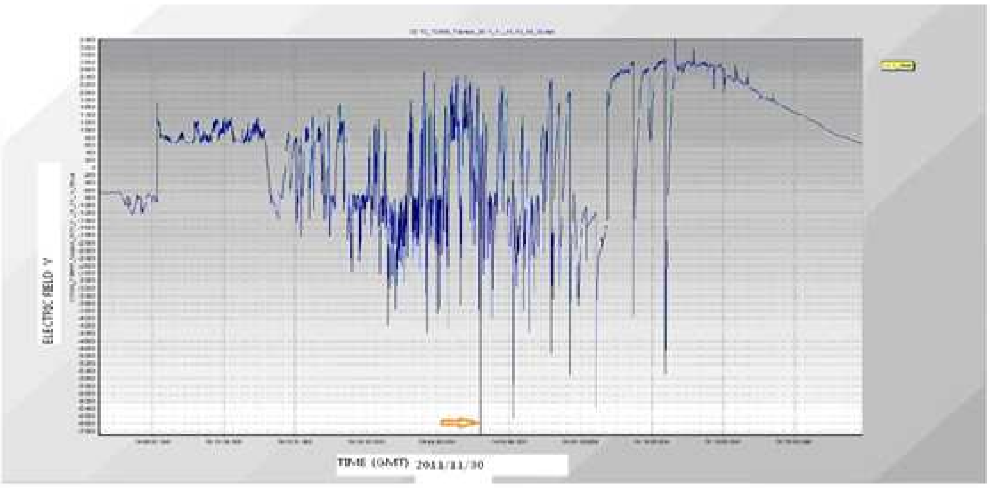

Figure 2: Vertical Electric Field Intensity Measured at the Site (+6000 To -6000) V/M in the Radiation Detector Array Using GMT Time, (See Ref. 11)

In Figure 3 we observe in greater detail as a function of time this increase occurred near ~17:46 local time that is 19:46 GMT, according to Figure 2, coinciding with the maximum electric field variation also measured at the same time and location.

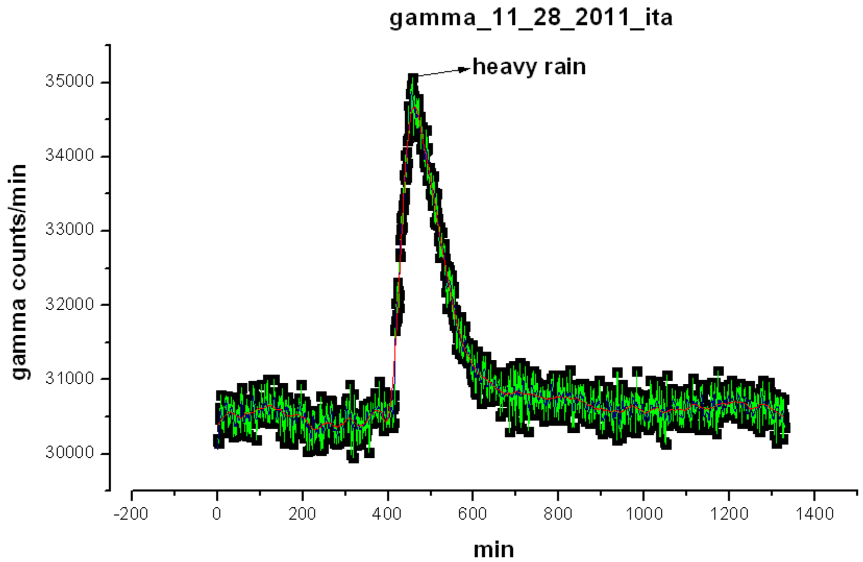

Figure 3 Integrated Counts Rate of Ionizing Radiation Minutes before and after the Event (Black=1 Min., Green=3min., Blue=10min., Red=60min.), Local Time. Note Maximum Radiation at 17:46LT

The abrupt increase in the measured intensity of gamma radiation as shown in Figure 3 indicating that the begin of the cold wind carries water droplets reaching the detector location dropped suddenly and with intense quantity. This phenomena being observed in the day and hour by one of the authors (I. M. Martin), amounting to near 60 minutes of increased radiation, this time duration of heavy rain on site. The intensity that time measured reached 14.7% of normal local value level background. The return to normal intensity level took just over 30 minutes, an amount already noted in the article (see ref. 11), steps here observed in the region. As time average life radon decay is 3.82 days becomes difficult to gauge where does this gas coming.

We investigated others periods during the 2011 year where this phenomenon occurred. In Figure 4 it is showing the monitoring of intensity of gamma radiation from 29 March to 29 April 2011. Only five occasions there was increased radiation during that month however the biggest one were only 6.3% above the normal level of the background measuring. The intensity of rainfall that month was also relatively small.

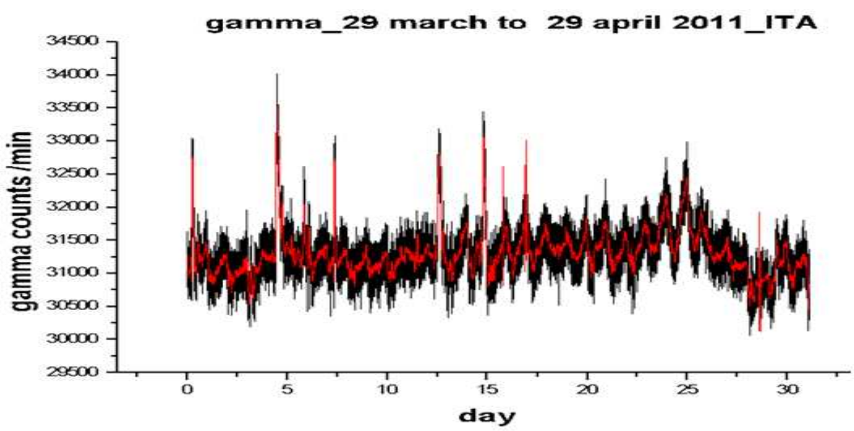

Figure 4: Correlation between Arrival of Rainfalls and Increasing Intensity of X and Gamma Rays

In the period from April to August 2011 there was no rain in the region and the air was very drier with relative humidity below 30% coming. In Figure 5, as a typical example, it is shown how the dynamics of varied environmental measurement radiation intensity with time during this period presenting clearly day and night cycles provoked by release of local radon gas.

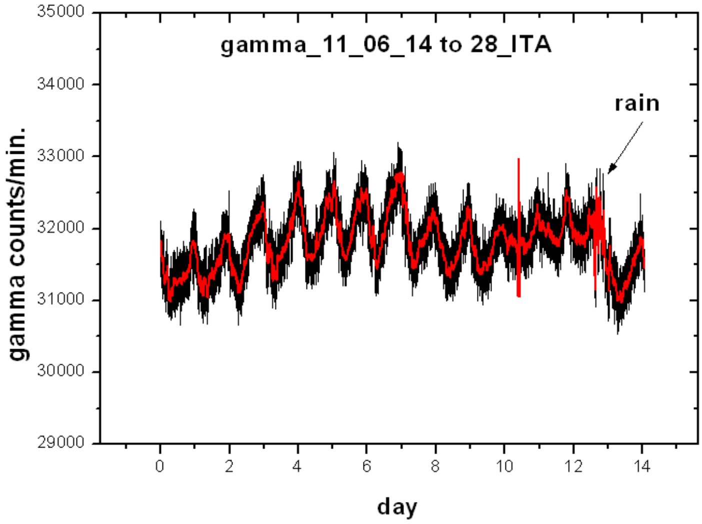

Figure 5: Variation of Environmental Radiation in the Dry Season in the Region. Note Perfectly Periodicity of 1 Day Due to Local Presence of Radon Gas (Black = 1min and Red = 60 Min)

Between 14 to 28 May is observed clearly diurnal variation (cycle 1 day) phenomenon produced by the accommodation of the local atmosphere (night – dayeffect) due to large temperature difference. There is no rapid increase in radiation as in periods of rain. However besides the variation of diurnal cycle, a longer time variation appears. In August it was found that the first rain after a long period of soil and dry air, an increase of 9.5% was measured. During this month the rains were scarce and the humidity was very low also reaching 30%. The two rains of the month were reported in this monitoring and the increased environmental radiation was observed as shown in Figure 6.

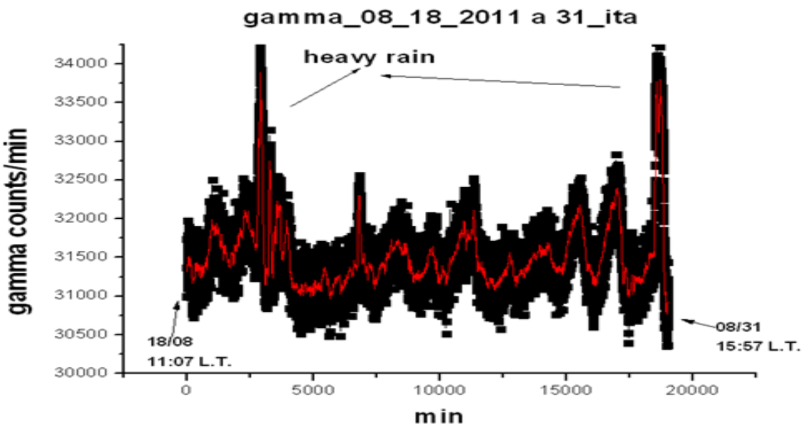

Figure 6: Variation of Environmental Radiation for the Month of August 2011, with Onset of the Rains. Only Two Intensive Rains Appeared in this Month

In October after the 13th day the rains were frequent and where observed an increase 13% above the normal background level. Figure 7 shows the variation of environmental radiation measured during this period.

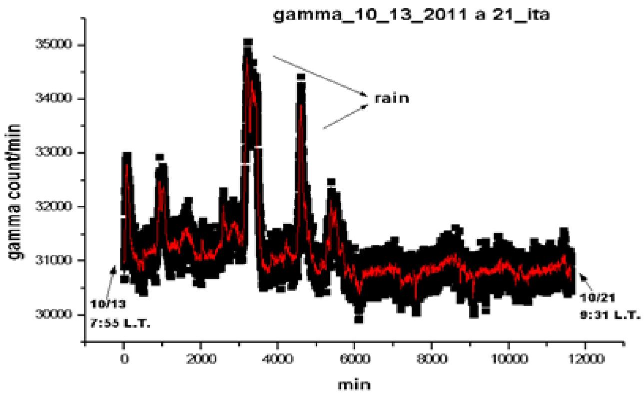

Figure 7: Variation of Environmental X and Gamma Radiation for October 2011 (Black= 1 Min. And Red = 12min)

During November 2011, there wasno rain in the region. Between 17 and 25 days, there was only a heavy rain shown in Figure 8. The increase regarding the background radiation level has reached near 8% for this month.

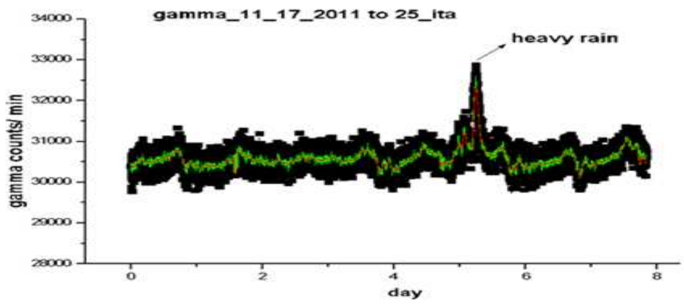

Figure 8: Variation of Environmental Radiation for Period from 17 to 25 November 2011 (Black = 1 Min., Green = 12 Min. and Red = 60 Min.)

As this period was no intensive local rain, there is also the phenomenon of one day cycle. Note that the intensity spent ~ 8%, from an average of 30000 to 31000 counts per minute to a value greater than 32750 counts per minute of sudden growing in intensity. After several minutes the average returns in its normal value for the region.

In Figure 9, we observe the existent environmental radiation between 5 and 15 December 2011. In this period only one heavy rain was measured and the increase of 8.3% of X and gamma radiation relatively to normal level with possibly radon gas that was observed (ref.11 and 12).

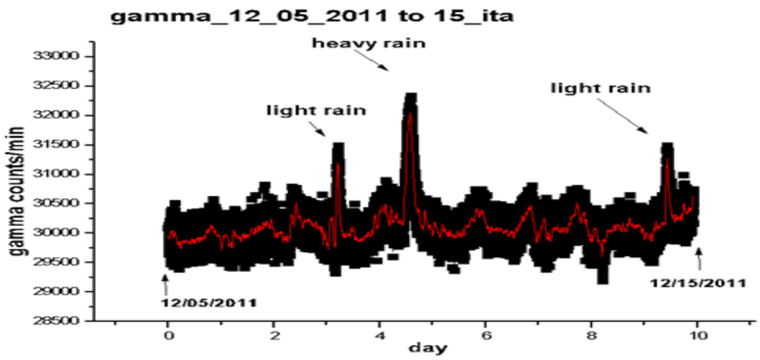

Figure 9: Variation of Environmental Radiation between 05 to 15 December 2011 (Black = 1 Min and Red = 60 Min.)

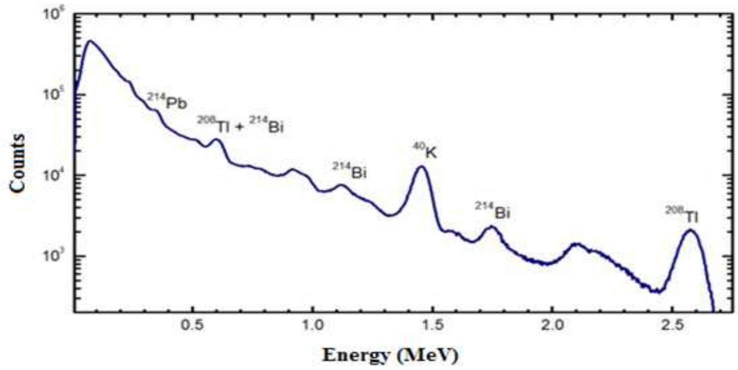

Figure 10: The Energy Spectrum for One Day in July 2011 without Rain on Local, See (Potassium 1, 46 Mev and Thorium 2, 62 Mev) Most Abundances Radionuclides in Region

Figure 10 plots the spectrum up to 3.0 MeV regarding energy function in the same location of measurements representative of the region (primordial radiation) using the same sodium iodide detector coupled to MCA(Mult-Channel-Analyser). Note that this spectrum shows for the region the radionuclides emitting gamma radiation in the energy range considered. The peak of ^{40}K (1,46MeV), is what most influences the spectrum followed by Thorium (^{232}Th) in energy 2.62 MeV and ^{214}Pb and ^{214}Bi) in the energies of 0.609 and 1.2 MeV. During the course of the entire year of 2011, it was measured energy spectrum with local environmental radiation, each week over a 1-hour integration time. Figure 10 shows the averaged values in intensities of radiation and in energy from 30 keV to 3,0 MeV. Note in Figure 10 that peaks of ^{40}K and ^{208} Tl is representative of abundances in the region.

CONCLUSIONS

It was measured in the region of São José dos Campos, SP, Brazil, on November 28, 2011, a significant increase in radiation levels range between 30 keV and 3.0 MeV, using integrated counting rate per minute. We also measured in the same day and hour the electrical field showing the maximum change in the place of vertical component of electric field, with increased from ± 800 V / m was observed. A cold front coming from the south pole to São José dos Campos with strong to moderate winds causing heavy rain on the region above gamma radiation detector. It was measured an increase of **about 14.7% more than the background noise level of this radiation** in the region, the most intense observed throughout 2011, should be attributed to the presence of radon gas in the rain (water droplets). This fact is also confirmed by the absence of lightning that day in the region of measures and in the same time. The increasing observation at that time and the fall of the radiation intensity to the local level were well determined and compared with other measurements. On the day and time the heavy rain preceded by a strong wind arrived at the place of the detector there was no lightning in the region, a phenomenon that would cause the presence of gamma radiation of low energy. The variation of atmospheric vertical electric field was also small (± 800 V / m), indicating no presence of lightning or electrical discharges in the area. The presence of radon gas in the cold front edge from the south pole cause a sudden increase in the radiation intensity in the order of 14.7% compared to the normal background noise (see Figure 3). Such as radon gas through their decays also emits gamma radiation in the range of 0.60 to 1.240 MeV, it will add the land-based component being evident in integrated counting as is shown in Figure 3. Other occurrence of increased intensity of gamma radiation was analyzed throughout 2011, but with lower relative percentage of increase that the November 28, 2011 discussed here with more detail. So it is confirmed by this measurements a dynamic of gas radon, X and gamma radiation and rainfalls in the region of São José dos Campos, SP, Brazil during year 2011.

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