[Martin, 8(5): May 2021]
DOI: https://doi.org/10.29121/gjesr.v8.i05.2021.1

ISSN 2348 – 8034
Impact Factor- 5.070

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

GAMMA RAYS, RAINFALL AND RADON GAS INTENSITY OBSERVED IN THE SÃO JOSE DOS CAMPOS REGION FROM APRIL TO OCTOBER 2021

Inacio Malmonge Martin
Instituto Tecnológico de Aeronáutica – ITA – São José dos Campos, SP, Brasil

ABSTRACT

The period from April to October 2021 was extremely dry in the region of São José dos Campos, SP, Brazil. In general, it is observed in the region that the intensity of local rainfall varies the flux and intensity of gamma radiation measured as a function of time. This fact occurs due to greater or lesser emission of radon gas as a function of time, close to the earth's surface, at the location of measurements. It is observed that hot days and dry land surfaces the emission of radon gas increases. This causes greater emission of gamma radiation in the period. With an NaI(Tl) gamma radiation detector of 3" x 3" inches in diameter and a coupled PM photomultiplier, it was possible to distinguish the flux of this radiation measured at 1 minute of time. It is also observed at the site that when heavy rains arrive, there is a great local increase in the flow of gamma rays. This is due to the wash of rain of radon gas existing in suspension in the lower atmosphere air. The objective of this work is to show this correlation between rainfall and gamma radiation measurements of (0.2 – 10.0) MeV in the region.

Keywords: *gamma rays, radon gas and rainfalls.*

I. INTRODUCTION

At the (soil/air) interface of the Earth's surface, ionizing radiation is mainly composed of radon gas, ground telluric radiation, primary and secondary cosmic ray radiation. However, it is difficult to separate over time the intensity of ionizing radiation emanating from each component as the energies overlap. Telluric radiation is given by ^{238}**U,** ^{235}**U,** ^{40}**K** and ^{232}**Th** that is constant for each region [1]. Radon gas from the disintegration of ^{238}**U** on the earth's crust to ^{226}**Ra** and ^{222}**Rn** arrives in the ^{214}**Pb**, ^{214}**Po** and ^{214}**Bi** isotopes, generating alpha and gamma radiation [2]. Primary cosmic radiation consists mainly of galactic and extragalactic protons, with very high energy and those from the Sun that interacts with the Earth's atmosphere producing Extensive Air Showers (EAS) [3]. The efficiency of this interaction is maximum when it occurs at altitudes between 13 and 17 km in the tropics, which form secondary cosmic rays with muonic, mesonic and neutronic components that reach the Earth's surface in the region [4]. These radiations can cause health problems for civil aviation crew and passengers and are present at the beginning of the stratosphere called by Pfotzer maximum. However, this component contributes less to the concentration of radiation on the earth's surface. Another possible source of ionizing radiation in the Earth's lower atmosphere is produced by lightning strikes between earth-clouds, clouds-earth and clouds-clouds. X-rays, gamma rays, neutrons and beta particles are formed by the lightning cone [5]. Other sources of ionizing radiation are those produced in medical, dental and hospital clinics, but these are mainly controlled in small areas. The objective of this work was to monitor low energy gamma rays and rainfall every minute in São Jose dos Campos, São Paulo, Brazil.

II. METHODOLOGY

The gamma ray detector prepared for 200 keV to 10.0 MeV energy range, consists of a 3-inch high by 3-inch diameter thallium doped scintillator crystal. This crystal is directly coupled to a photomultiplier (PM) that records the pulses shape's coming from the amplified scintillator and a digital analog converter with signals recorded by a computer [6]. This experimental set (Figure 1) is located in the inner room of a tower 25 m high relative to the ground (**ACA** Tower). The scintillator attached to the photomultiplier is wrapped in a thin layer of aluminum to make it portable. The set (scintillator + associated electronics + data acquisition) relies only on a laptop with a charged battery to measure radiation for up to 8 continuous hours. However, for long measurement series, electricity or photovoltaic power is used. The scintillator and associated electronics were calibrated for energy and intensity counts per minute in the ITA

[Martin, 8(5): May 2021] ISSN 2348 – 8034
DOI: https://doi.org/10.29121/gjesr.v8.i05.2021.1 Impact Factor- 5.070

teaching experimental physics laboratory using radioactive sources and a (0.2 – 10) MeV spectral analyzer [7] and [8].

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

The scintillator coupled to photomultiplier is wrapped in a thin layer of aluminum to make it portable. The set (scintillator + associated electronics + data acquisition) only depends on a laptop using a charged battery to measure the radiation for up to 8 continuous hours. However, for series of long measurements it uses electrical network or photovoltaic energy. The scintillator and associated electronics were calibrated in terms of energy and counting intensity per minute at the experimental teaching physics laboratory of ITA using several radioactive sources and a spectral analyzer of counts versus energy in the range of (0.2 to 10) MeV [9-11].

III. RESULTS AND DISCUSSION

During the year 2021, measurements of gamma radiation counts were performed in the energy range described above, always during an interval of one minute. As shown in Figure 1, these measurements were carried out in a room at the ITA located in an isolated tower with an altitude of 25 meters. Figure 2 below shows these measurements over the period from 12/03 to 21/05, 2021 continuously. See that there were 2 intense peaks of radiation corresponding to two intense rains at the site. More 3 small peaks of radiation were identified in the period corresponding to the presence of 3 light rains. In the rest of the period analyzed, the radiation presents small variations in intensity due to the presence of cold fronts arriving in Brazil. It also presents variations in radiation intensity corresponding to the day/night period. The average intensity over the period is ~32000 counts per minute. In figure 2a, the gamma radiation measurements were zoomed exactly at the time 10500 to 11000 minutes, which coincides with the arrival of the first rain in the region. At first there is disarrangement in the local atmosphere, then there is a sudden increase in the intensity of radiation corresponding to the onset of rain. Then the gamma radiation drops to its previous normal level. This same scheme is shown in Figure 2b, with the radiation peak being smaller due to the rainfall intensity which was also lower. Figure 3 shows in the same place the set of measurements carried out in the period from 22/09 to 11/10, with the beginning of the rains in this region of Brazil. On this period, the measurements of gamma radiation show 2 intense peaks and 8 moderate to small peaks of radiation. These peaks correspond to the rains that occurred in the place in the period in question. Figure 3a shows a magnification in gamma radiation measured in time equivalent to a major radiation peak between times 17700 to 17900 minutes. The peak was very fast ascending and its fall very slow. It can be observed that the measurements made during wettest period (Figure 3) that the data obtained are fluctuating around 32000 counts per minute, which represents the background noise of gamma radiation. The green line in both figures represents the smoothed curve in one day.

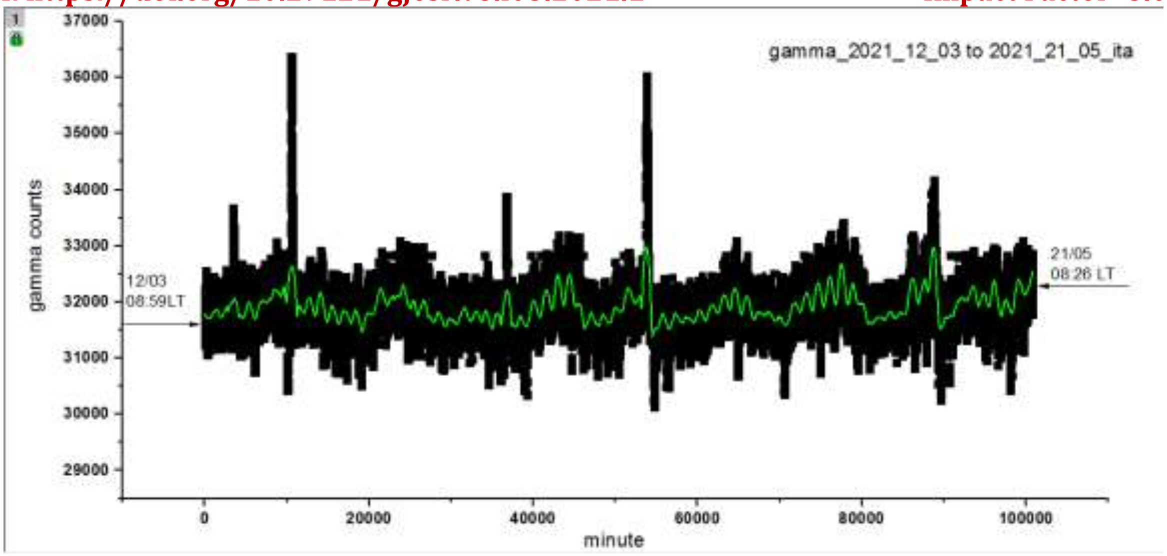

Fig. 2 – Gamma radiation measurements from 03/12 to 05/21 of 2021 with rainfalls influences (author).

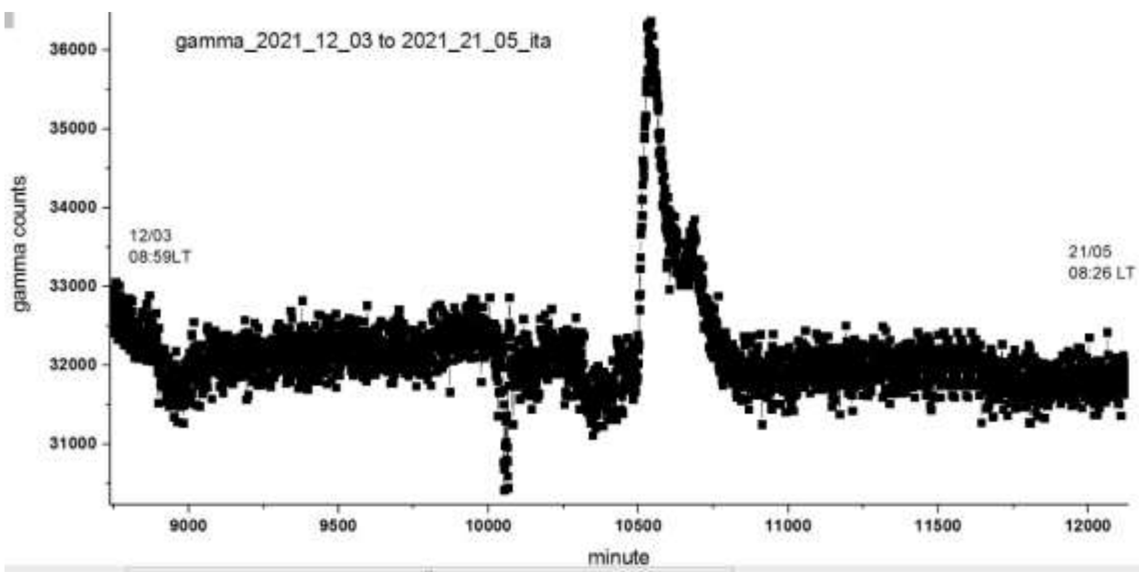

Fig. 2a – Zoom view of the gamma radiation peak between 10500 to 11000 minutes of measurements with rainfall influence (author).

RESEARCHERID
THOMSON REUTERS
[Martin, 8(5): May 2021] ISSN 2348 – 8034
DOI: https://doi.org/10.29121/gjesr.v8.i05.2021.1 Impact Factor- 5.070

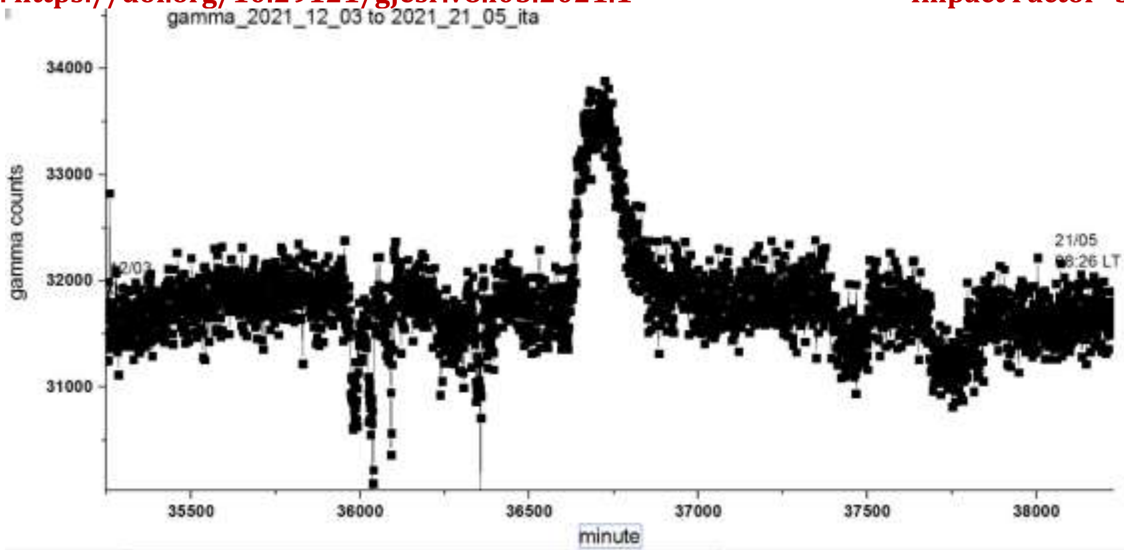

Fig. 2b – Zoom view of gamma radiation peak in time between 36500 to 37000 of measurements with rainfall influence (author).

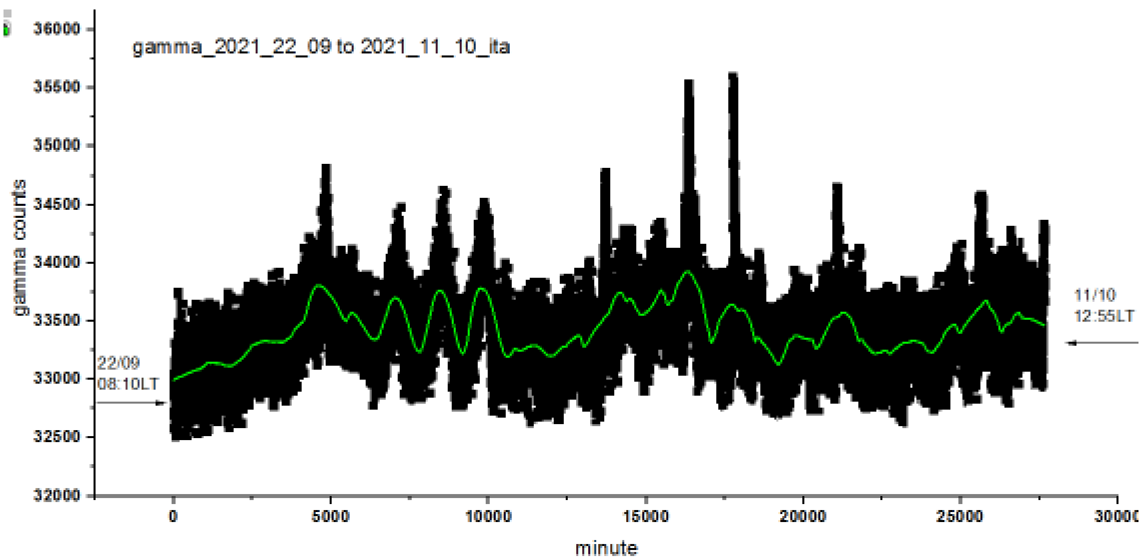

Fig. 3 – Gamma radiation measurements from 09/22 to 10/11 of 2021 with rainfalls influences (author).

ISSN 2348 – 8034
Impact Factor- 5.070

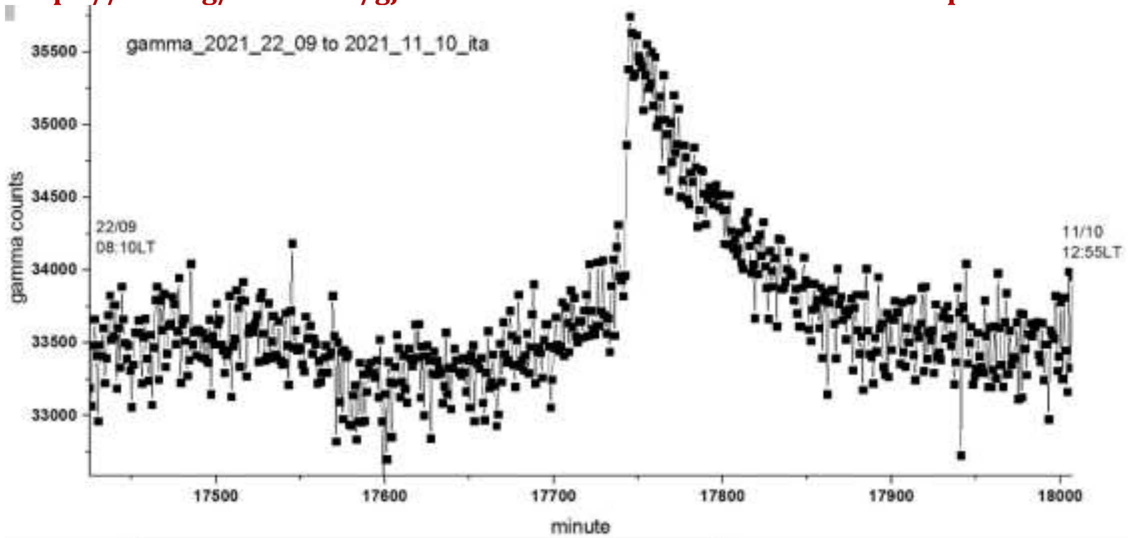

Fig. 3a – Zoom view of the gamma radiation peak measured between the times 17700 to 17900 minutes with fast rainfall influence (author).

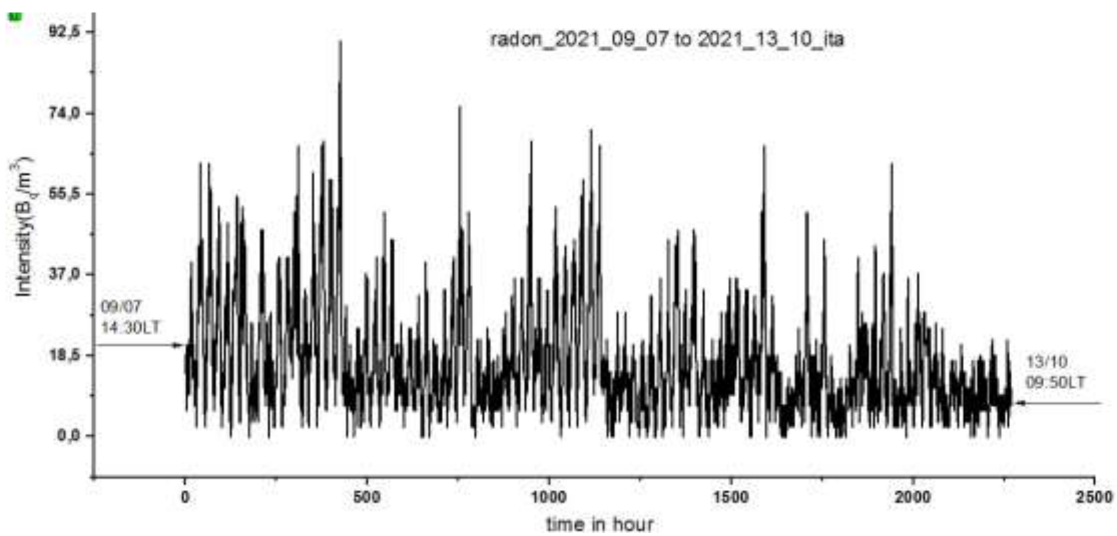

Fig. 4 – Same-site variation of gamma radiation measurements every hour of radon gas intensity (author).

October 2021, the gamma radiation intensity at 25 meters above the ground was measured every minute at the ITA campus in São José dos Campos, SP, Brazil. The radon gas flow in Becquerel (Bq)/m3 every hour and the rainfall intensity in mm/min were also observed in the same place, every minute . These measurements show correlations between variations in gamma radiation intensities, rainfall intensities and radon gas intensities in the region.

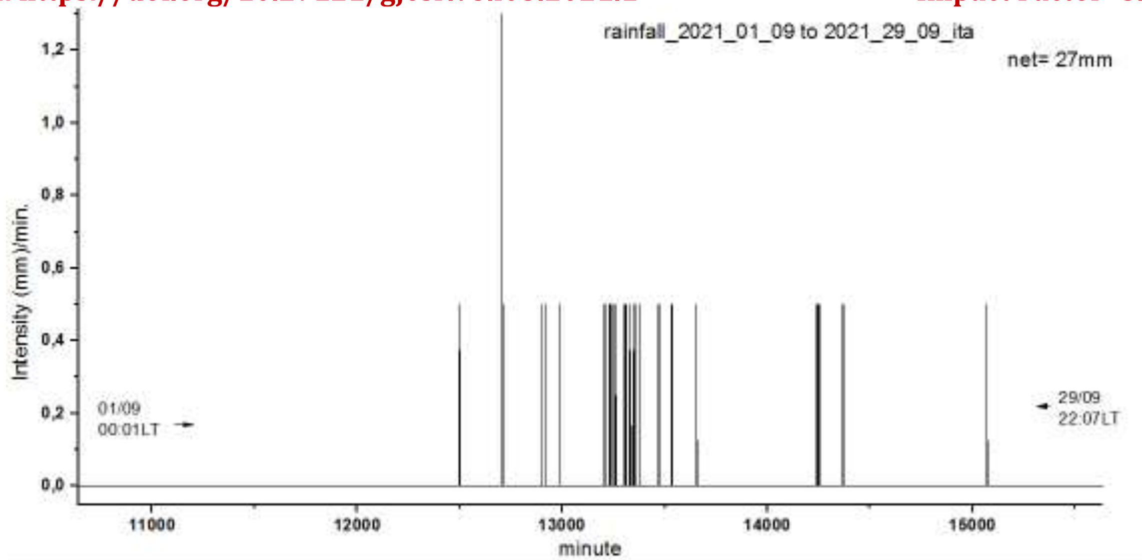

Fig. 5 – Typical sample of rainfall variation in (mm/min.) also at the same site of gamma radiation measurements (author).

IV. CONCLUSION

At the beginning of the rains, from a very dry period onwards, it produces a sharp increase in gamma radiation at the site. This can be explained by the rapid washing that the rain makes of the radon gas fixed in the chemical elements present in the air of the lower atmosphere. However, this rain persisting for more than half an hour, it plugs the Earth's pores from where the radon gas exhales. Therefore, the radon gas flow becomes very constant and low during these rains. The same happens then with the gamma radiation measured at the location, as it is mostly coming from the local radon gas. Hence the presence of a radiation peak when there is heavy rain in the area.

V. ACKNOWLEDGEMENTS

Thanks to CNPq (National Counsel of Technological and Scientific Development) Proposal 306095/2013-0, 480407/2011-8 and 305145/ 2009-6 and CAPES (Coordination for the Improvement of Higher Education Personnel) by the fellowships grants support to the group's researchers. To the INCT-FNA-ITA for providing instruments. The Division of Fundamental Sciences, Department of Physics - ITA -Technological Institute of Aeronautics and IAE Institute, for the support of infrastructure.

REFERENCES

1. *N. A. Bui Van, I. M. Martin and A. Turtelli Jr. – Measurements of natural radioactivity at different atmospheric depths. Revista Geofísica, IPGH, numero 28, enero-junio 1988, México.*
2. *Fujinami, N. 2009. "Study of Radon Progeny Distribution and Radiation Dose Rate in the Atmosphere." Japan Journal Health Physics 44 (1): 88-94, Japan.*
3. *Grieder, P.K.F. 2010. Extensive Air Showers, Book Springer: Verlag Berlin Heidelberg, Germany.*
4. *Malyshevsky,V.S. and Fomin, G. V.; Electromagnetic Radiation in the Atmosphere Generated by Excess Negative Charge in a Nuclear Electromagnetic Cascade, NASA Astrophysics Data System (ADS), 2017, https://www.science.gov/topicpages/e/electromagnetic+cascade+shower.html accessed in 06/07/2017.*
5. *Jayanthi U B, Gusev A A, Neri J A C F, Villela T, Júnior O P, Pugacheva G I, Talavera K C, Martin I M (2005). Ground Gamma Radiation Associated with Lightning and Rain Precipitation, In 29th I, Cosmic Ray Conference (1): 177-810.*
6. *Ravisankar, R., Vanasundari, K., Chandrasekaran, A., Rajalakshmi, A., Suganya, M. Vijayagopal, P.&Meenakshisundaram, V. (2012). Measurement of natural radioactivity in building materials of*

Namakkal, Tamil Nadu, India using gamma-ray spectrometry. Applied Radiation and Isotopes, 70 (4): 699-704.

7. *Boardman B J (2015). Aware Electronic Corp. Accessed in 2017, www.aw-el.com.*
8. *Matheus Carlos Silva, Douglas Carlos Vilela, Victor G. Migoto, Marcelo P. Gomes, Inácio M. Martin and Silvério J. Germano. In Ionizing radiation measurements using low cost instruments for teaching in college or high-school in Brazil published to Physics Education, may 2017 see http://iopscience.iop.org/journal/0031-9120.*
9. *Inacio Malmonge Martin- Environmental low energy gamma ray spectrum in São José dos Campos, Brazil region, Global Journal of Engineering Science and Researches, Vol.7, serie 1, pag. 30-37, January 2020, DOI-10.5281/zenodo.3611220.*
10. *Federico, C.A., O. L. Gonçalez, E.S. Fonseca, I.M. Martin, L.V.E. Caldas; Neutron spectra measurements in the south Atlantic anomaly region; Radiation Measurements, vol. 45, pg. 1526-1528, 2010.*
11. *Inacio Malmonge Martin, Marcelo Pego Gomes & Anatoli A. Gusev, Low Energy Gamma Rays Measurements During January to February 2017 in São José dos Campos, SP, Brazil Region. International Journal of Research in Engineering & Technology, ISSN(E)2321-8843, vol. 5, Issue 3, March 2017, pag 21-26.*