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MEASUREMENTS OF GAMMA RADIATION AND RADON GAS INTENSITY IN TROPICAL REGION OF BRAZIL DURING COVID-19 PANDEMIC PERIOD

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I. INTRODUCTION

A - Radon gas and gamma radiation

At the ground level interface of Earth's surface, ionizing radiation it is composed mainly of gamma ray, soil telluric radiation, primary and secondary cosmic ray radiation [1]. However, it is difficult to separate over time the intensity of the ionizing radiation emanating from each component as the energies overlap. The telluric radiation is given by ^{238}U, ^{235}U, ^{40}K and ^{232}Th disintegration's series that are constant for each region. The gamma ray and neutrons coming from radon gas arriving through the ^{238}U in Earth's crust disintegration to ^{226}Ra and ^{222}Rn reaching the stables isotopes ^{214}Pb, ^{214}Po and ^{214}Bi. Radioactive elements such as Uranium, Thorium and Potassium are found in almost all types of rocks, sands, soils and water [2]. The Radium ^{226}Ra and its decay products are responsible for a major fraction of the dose of internal emissions received by humans. ^{226}Ra has a half-life of 1,600 years, and decays to Radon ^{222}Rn, which has a half-life of 3.82 days. The decay of ^{222}Rn is followed by successive disintegration of short half-life alpha, beta and gamma ray emitters. After decay stages, the radioactive chain ends with stable lead ^{206}Pb. The alpha particles coming from radon gas and in interaction with elements of ground level can produce neutrons. With regard to soils and rocks, the ^{226}Ra is present in virtually all soils and rocks in varying amounts. Areas with high levels of background radiation found in some soils are due to geological conditions and geochemical effects and cause increased terrestrial ionizing radiation. Researches in the world, and specifically in Brazil, show these conditions. Several studies report variations throughout the day of radon concentrations. Maximum concentrations are observed in the first hours of the day and the lowest values are found late near afternoon, when concentrations are about one third of morning values [3]. The same profile is observed with the gamma ray intensity variation in the tropics region. However, it is likely that variations in concentrations in localities of gamma ray intensity are dependent on local meteorological parameters (rain, wind, pressure, temperature and cloudiness) in the gamma ray detector site [4].

Radon is a natural radioactive gas without odour, colour or taste. It cannot be detected without special equipment. Radon is a product of ^{238}U(uranium decay). Uranium is a natural radioactive material found in different amounts of soil and bricks. It occurs everywhere on earth, water and especially in rocky and hilly areas.Radon is an unstable radionuclide that disintegrates through short lived decay, approximately 3,82 days, from ^{226}Ra(Radium) products before eventually reaching the end product of stable lead. The short lived decay products of radon are responsible for most of the hazard by inhalation in humans and animals [5].Radon and its decay products called radon daughters or radon progeny emit highly ionizing alpha-particle and low energy gamma radiation. Decay products are suspended in the air which we breathe. Although the risk is very low when radon is diluted to extremely low concentrations in the open, radon in room air typically contributes up to 50% to the background radiation [6].

B - Health, Lung Cancer and Radon Gas

It is believed that the relationship between radon and risk of lung cancer is linear. In other words, doubling the exposure doubles the risk and halving the exposure halves the risk. Doubling of the risk means much more for a smoker, who is already at high risk of lung cancer, than for a non-smoker with a very small base line risk. Lung cancer risk from residential radon exposure is substantially lower since the exposure in homes is much lower than in mines, although the risk increases with radon concentration level and duration of exposure. For life-time exposure to radon of 20 (Bq/m^3) level at home the risk of lung cancer is estimated to be 0.3% (or 3 deaths in 1000 people). For comparison, risk of accidental death at home is 0.7% (or 7 in 1000). It has been suggested that other effects of radon exposure include increased risk of nonmalignant respiratory diseases but this is much less clearly established than

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the lung cancer risk. It is still not clear whether children are more sensitive to radon exposure. Studies on childhood leukaemia (the most common form of cancer in childhood) have not found clear evidence of risk associated with radon concentrations in homes [7].

II. MATERIALS & METHODS

A - Gamma ray Detector

A thallium-doped Sodium Iodide crystal scintillator [NaI (Tl)] were used to measure gamma photon counts between 200 keV to10.0 MeV [4]. The scintillator-associated electronics consist of a 1500 VDC continuous 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 terms of energy from emitted photons and particles: 1.17 MeV, 0.90 MeV and 5.4 MeV respectively [6]. 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 ionizing radiation and intensity of rainfall was performed using 1-minute time interval between each measurement [8].

Fig. 1 – Sodium Iodide scintilator and photomultiplier used in this gamma radiation measurements(Aware Electronics, INC, USA) [9].

B - Radon gas RD 200 RADON EYE Detector

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/m³) directly by 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 extension. All instructions are given for that on reference [10].

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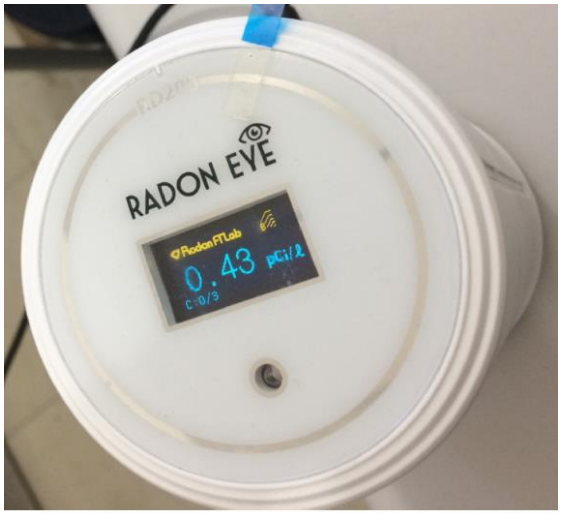

Fig 2 – Top view of RD200 Radon Eye ionization chamber used for monitoring radon gas [10]

In Figure 3 we present series variations that occurred in the measurements in ITA made on January 27 to May 13 of 2020. These measures are shown here giving insight into how easy the RD200 Radon Eye is operated about obtaining, storing and manipulating data. In Figure 2 above is shown the Radon Eye RD200 measuring on a table in open space in ITA. The view count of 0.43 (pCi / l) or 15,9 (Bq/m^3) represents the value at the last hour that the ionization chamber made measurements.

By means of 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. A maximum time of measurements for the Radon Eye RD200 can be considered up to six months in hourly sequence as shown in Figure 3 obtained in ITA via IPhone on May 13, 2020. For periods longer than 6 months, both the acquisition data and download of measures are very slow in time.

The graph measured and viewed by the IPhone on May 13, 2020 is shown in Figure 3 in (Bq / m3) units always at equal intervals of one hour.

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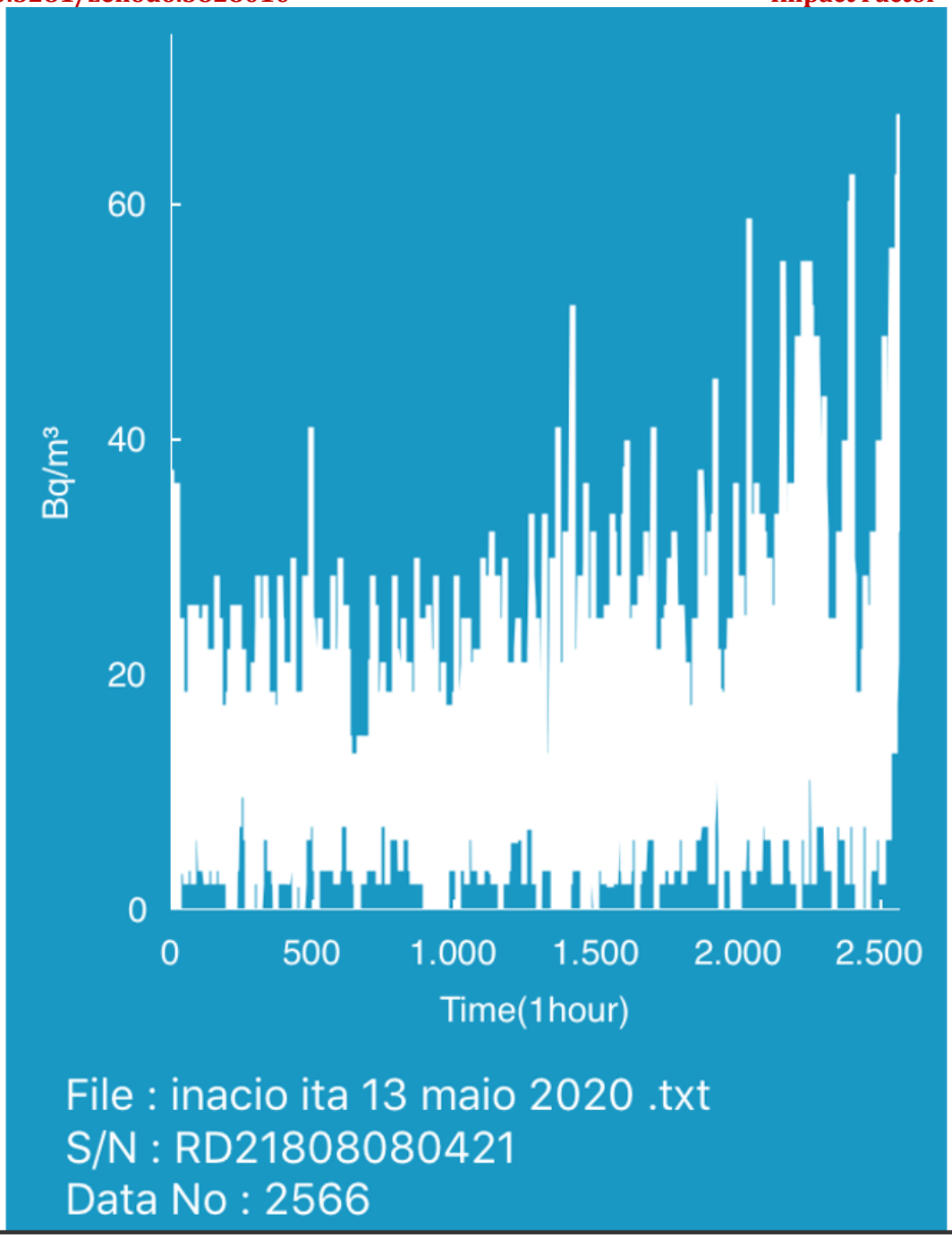

Fig. 3 – Spectrum of intensity of radon gas versus time with 1 hour of step from 27 January to 13 May 2020 in ITA campus

III. RESULTS AND DISCUSSION

Preliminary measurements of the radiation spectra were made in a region without any human and / or electromagnetic interference as shown in Figure 4.

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Fig. 4 - Aerial and ground view of the tower in ITA campus and his environmental field region in São José dos Campos, SP, Brazil (23° 12'45" S, 45° 52'00" W).

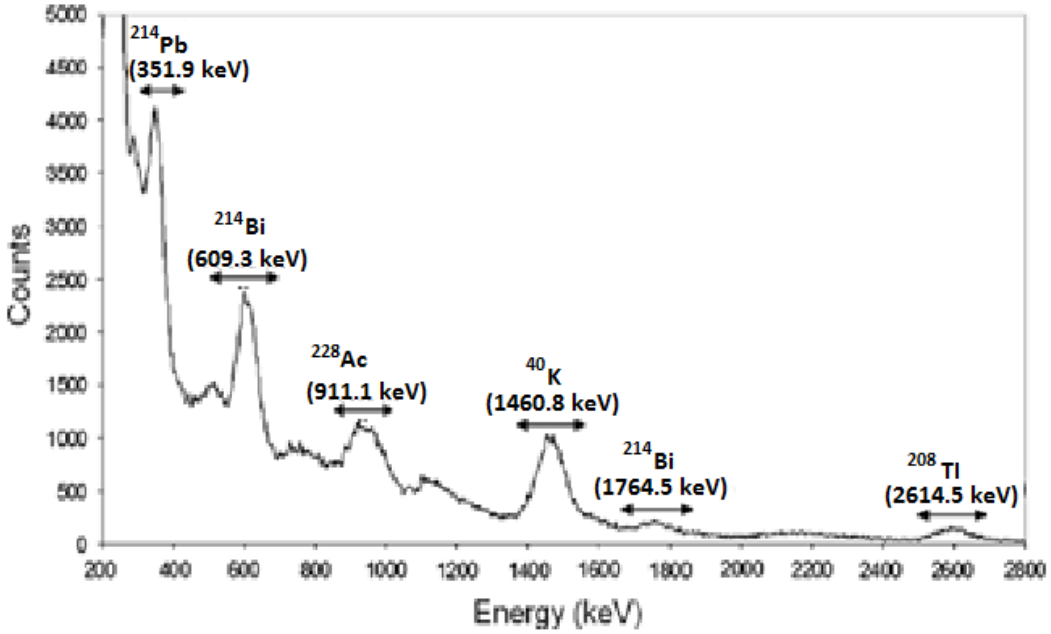

Fig. 5 –Environmental spectrum of gamma rays in the site shown in Figure above, took on 23 April 2020 with net time of one half hour of measurements.

The series of monitoring of gamma radiation carried out next to the trailer in the lower part of the Tower between 27th of January to 13th of May 2020 is shown in Figure 6.

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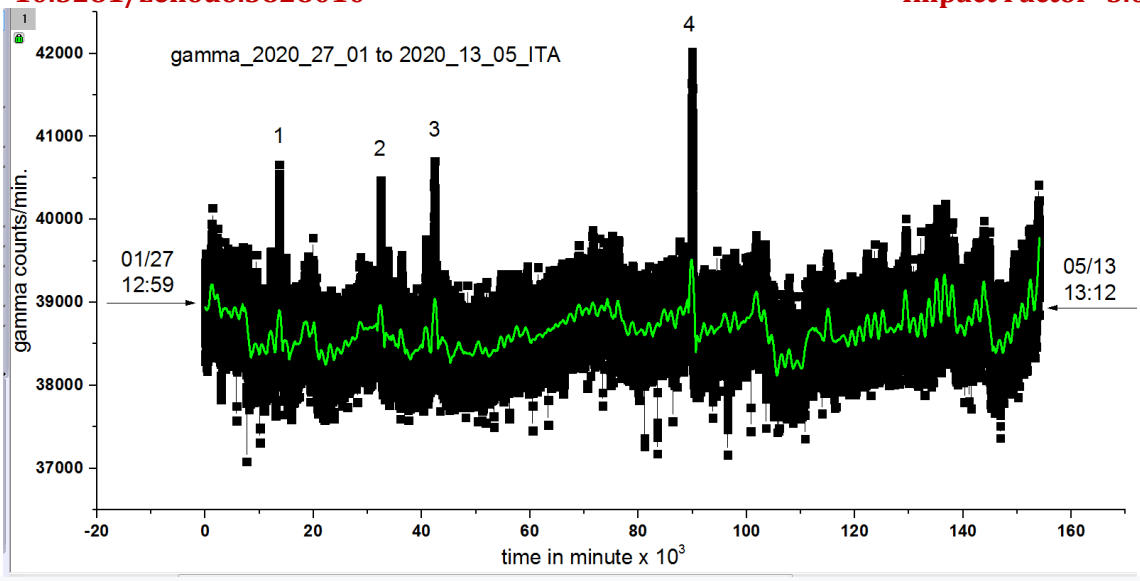

Fig. 6 – Monitoring of gamma radiation in 200 keV – 10.0 MeV energy interval in counts per minute. The green line is smoothed for one day.

These gamma radiation measurements were performed at the same location where the radon gas detector was installed. The series of monitoring of this gas carried out in the same time interval with a 1 hour step is shown in Figure 7.

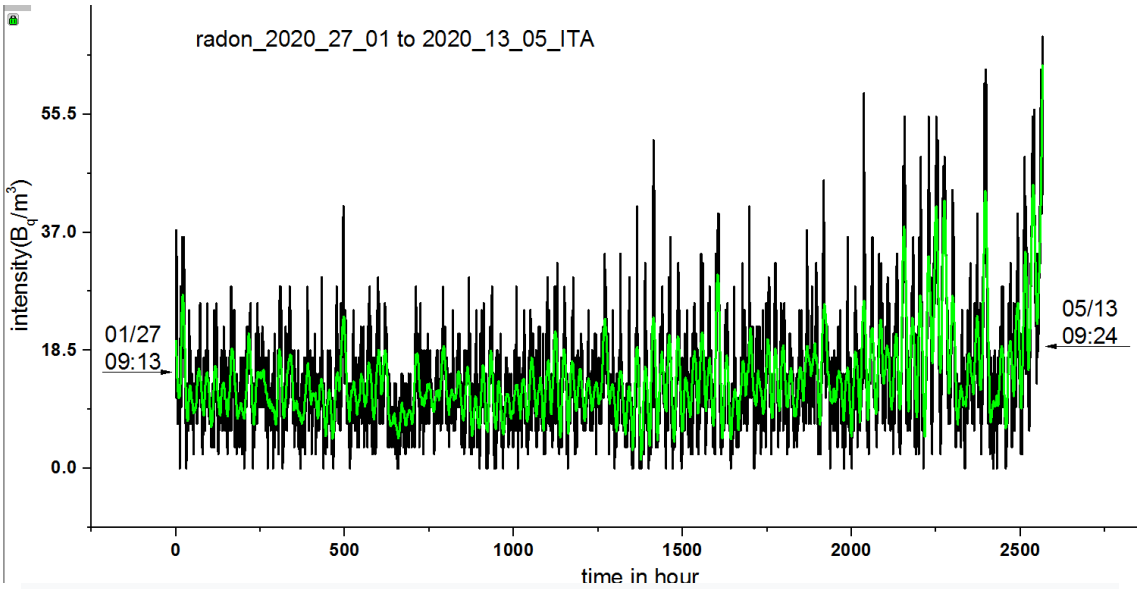

Fig. 7 – Measurements of radon gás at each hour dark line and smoothed by each day in green line.

In Figure 8, the number of people infected with the Covid-19 virus is plotted for the period and for the region of São José dos Campos, the number of those cured and the total deaths that occurred as a result of the virus.

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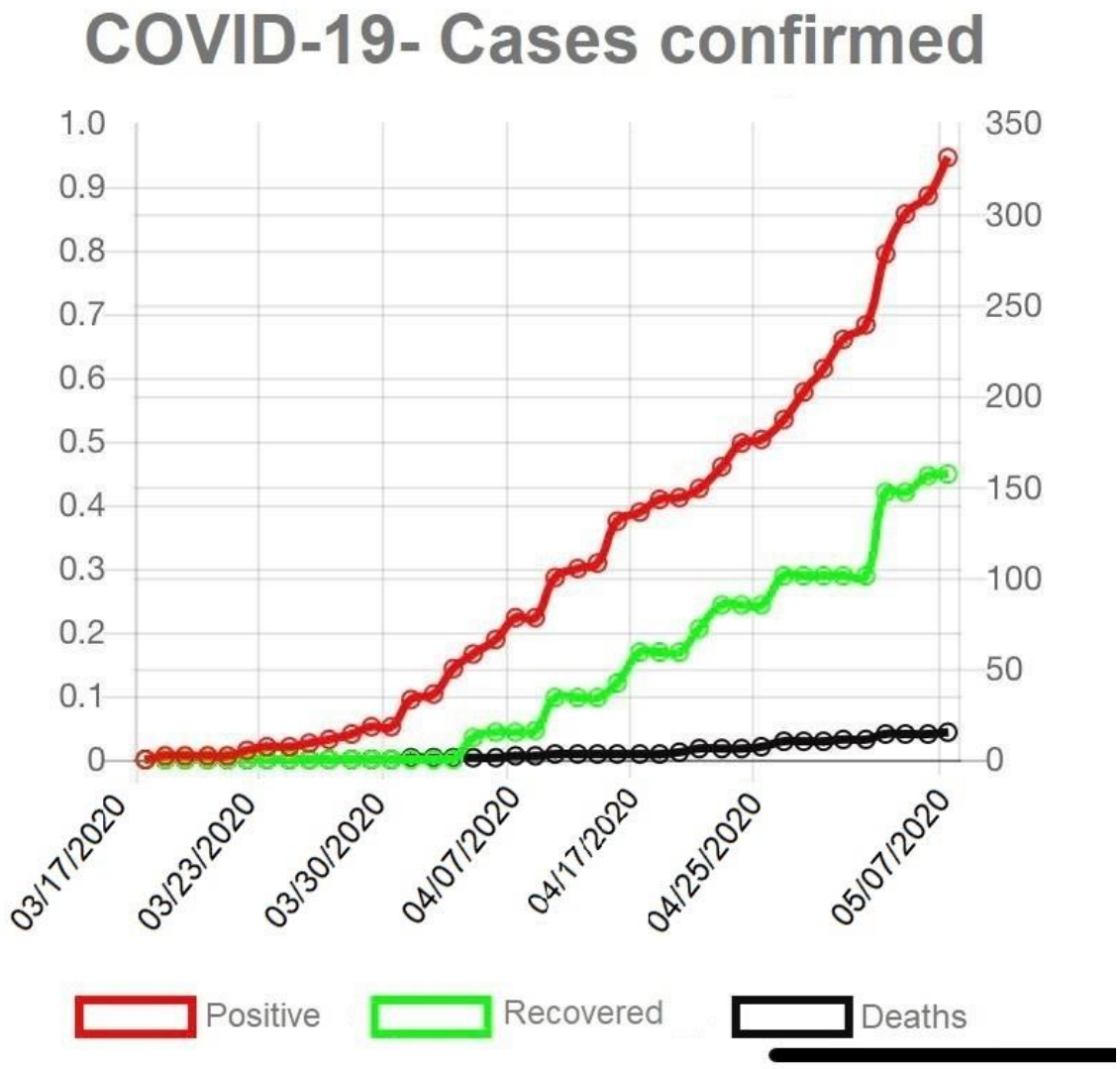

Fig. 8 – Variation of Covid-19 of positive, recovered and deaths from the region of São José dos Campos, Brazil[11].

It was observed in Figure 6 in the measurements of gamma radiation 4 peaks above the background noise of the radiation at that location. This was due to the intense rains that had occurred at that time and place. The rain washes away and brings the radon gas suspended in the air close to the Earth's surface. The more radon gas the more gamma radiation in that energy interval will appear.

The monitoring of the gas radon seen in Figure 7 shows a small increase after 1250 hours in relation to the beginning of the measurements. This is due to the cold, sunny and dry weather in the region around the winter season. Under these conditions, there will always be a greater emission of radon gas from the Earth's surface.

The variation of infected cases of Covid-19 in relation to those that were cured and the deaths originated in the region of São José dos Campos, in Brazil, in this period there was also an appreciable increase. Could this increase

be related to the local climatic variation and to the increase of radon gas at the site? This answer is very difficult for us to come up with today.

IV. CONCLUSION

From January 27 to May 13, 2020, monitoring of gamma radiation, radon gas intensity and variation in the incidence of Covid-19 virus was carried out on the ITA campus in tropical region of Brazil. Analysis of this monitoring indicated an increase in these three measured parameters in relation to their starting date of the measurements on January 27, 2020. In all this measurement period, there were only 4 occasions of intense rains that caused sudden increases in the presence of gamma radiation in the place. This increase was caused by the washing of the radon gas suspended in the air close to the Earth's surface. This was possible to observe in this monitoring of gamma radiation due to the precision in time of these measurements of one minute. In the case of radon gas as the precision of the measurements is hourly, this specific measure of the increases was not possible. The variation in the increase in the incidence of Covid-19 in the region certainly has to do with the climatic variation but it is necessary to verify the greater or lesser mobility of people in the region with important effects the variation in the incidence of Covid-19 in the region at that time.

V. ACKNOWLEDGEMENTS

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VI. SUMMARY

Between the periods from January 27 to May 13, 2020, the emission of radon gas was monitored every hour and the intensity of gamma radiation every minute close to the ground where measured. During this entire period only 4 intervals of heavy rain were recorded and the maximum intensity of exhaled radon gas was in the order of 70 (Bq / m^3). It is thus shown that in the region of São Jose dos Campos, Brazil, the measured radon intensity is about half the amount harmful to human health, which is of 150 (Bq / m^3). During the Covid -19 advance time period in the region there was a great daily increase in January 2020 of 1 infected and one death arriving to 1603 infected and 63 deaths in 13 May 2020.

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