REVISTA DE GEOCIÊNCIAS DO NORDESTE

Northeast Geosciences Journal

v. 6, nº 2 (2020)

https://doi.org/10.21680/2447-3359.2020v6n2ID20620

ISSN: 2447-3359

CO_2 EMISSIONS AROUND THE INTERNATIONAL AIRPORT OF SÃO PAULO-GUARULHOS

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Abstract

Airports are known to be large emitters of greenhouse gases (GHGs), pollutants and noise. Thus, understanding the emissions from airports can contribute to the development of mitigating actions in the area of global warming by relating anthropogenic emissions to the intensification of global warming, since Carbon Dioxide (CO_2) is seen as the main villain of this increase in temperature on Earth. The main motivation of this study was to verify the CO_2 concentration indexes around the AISP (São Paulo International Airport). For this, CO_2 measurements were performed at different points using portable equipment (CO_2 meter and field GPS). The collected data was analyzed in GIS (Geographic Information System) environment. The results showed that the Carbon Dioxide emissions around the AISP ranged from 436 to 490 ppm/ CO_2. These emissions are well above the maximum rates found by the UN in the first half of 2019, which reached a global average of 409 ppm/ CO_2.

Keywords: CO_2; Airports; Guarulhos; Global Warming.

EMISSÕES DE CO_2 NO ENTORNO DO AEROPORTO INTERNACIONAL DE SÃO PAULO-GUARULHOS

Resumo

Os aeroportos são reconhecidamente grandes emissores de Gases de Efeito Estufa (GEE's), poluentes e ruídos. Assim, compreender as emissões provenientes dos aeroportos pode contribuir para a elaboração de ações mitigadoras na temática do aquecimento global, relacionando as emissões antrópicas à intensificação do aquecimento do planeta já que o Dióxido de Carbono (CO_2) é visto como o principal vilão no aumento da temperatura da Terra. A principal motivação deste estudo foi verificar os índices de concentração de CO_2 no entorno do AISP (Aeroporto Internacional de São Paulo). Para tanto, foram realizadas medições de CO_2 em diferentes pontos com o uso de equipamentos portatéis (medidor de CO_2 e GPS de campo). Os dados coletados foram analisados em ambiente SIG (Sistema de Informação Geográfica). Os resultados demonstraram que as emissões de Dióxido de Carbono no entorno do AISP oscilaram de 436 a 490 ppm/CO_2. Tais emissões estão muito acima dos índices máximos constatados pela ONU no primeiro semestre de 2019, que alcançou uma média global de 409 ppm/CO_2.

Palavras-chave: CO_2; Aeroportos; Guarulhos; Aquecimento Global.

EMISIONES DE CO2 ALREDEDOR DEL AEROPUERTO INTERNACIONAL DE SÃO PAULO

Resumen

Los aeropuertos son reconocidos como los principales emisores de gases de efecto invernadero (GEI), contaminantes y ruido. Así pues, la comprensión de las emisiones de los aeropuertos puede contribuir al desarrollo de medidas de mitigación en la esfera del calentamiento global, vinculando las emisiones antropógenas a intensificación del calentamiento del planeta ya que el Dióxido de Carbono (CO_2) es visto como el principal villano en el aumento de la temperatura de la Tierra. La principal motivación de este estudio fue verificar las tasas de concentración de CO_2 alrededor del AISP (Aeropuerto Internacional de São Paulo). Para ello, se realizaron mediciones de CO_2 en diferentes puntos con el uso de equipo portátil (CO_2 metro y GPS de campo). Los datos recogidos fueron analizados en el (SIG) del Sistema de Información Geográfica. Los resultados mostraron que las emisiones de Dióxido de Carbono alrededor del AISP oscilaban entre 436 y 490 ppm/CO_2. Estas emisiones están muy por encima de las tasas máximas encontradas por las Naciones Unidas en el primer semestre de 2019, que alcanzaron un promedio mundial de 409 ppm/CO_2.

Palabras-clave: CO_2; Aeropuertos; Guarulhos; Calentamiento global.

1. INTRODUCTION

The control of polluting and greenhouse gases has aroused the interests of scholars around the world (HOFER et al. , 2008; HOFER AND EROGLU, 2010; RYERSON AND KIM, 2013; OLIVEIRA, 2014), as these emissions affect people's quality of life and negatively impact the environment, especially in medium and large cities. However, air quality control requires a great deal of effort because the hegemonic pattern of production is based on an energy matrix predominantly powered by fossil fuels, as well as the means of transport.

Many studies point to anthropic GHG emissions as the major responsible for climate change and the largest global warming of the Earth, with CO_2 being the main gas of this change in the global temperature pattern (CHAPIN et al., 2002;; XAVIER AND KERR, 2008; OLIVEIRA, 2014) . Data from NOAA (2019) show an average annual growth of emissions between 2% and 3% in the last decade and an average concentration for the month of August 2019 that reached 409.95 ppm/CO_2 against 406.99 ppm/CO_2 for the same month of 2018.

According to the Intergovernmental Panel on Climate Change (IPCC) in its 2018 report, it signaled that human activities have caused approximately 1°C of global warming above pre-industrial levels, with a likely range of 0.8°C to 1.2°C and is expected to reach 1.5°C between 2030 and 2052, if the current ghg emissions pattern continues. Furthermore, for the IPCC, anthropogenic CO_2 emissionsare the great villain of the global rise in the Earth's temperature.

The UN (United Nations) has presented 17 Sustainable Development Goals (SDGs), including numbers 11 (sustainable cities and communities) and 13 (action against global climate change) that prioritize urgent measures to combat climate change and its impacts. Thus, there is a global call for countries to mobilize through public/private actions in combating climate change.

According to a report by the National Civil Aviation Agency (ANAC, 2017), AISP is the largest emitter of CO_2 in Brazil. Therefore, it is important to consider the need to monitor air quality around large airports in the country, as is the case of the object of study analyzed here..

The municipality of Guarulhos (SP) has the second largest population in the State of SãoPaulo, with approximately 1,365,000 inhabitants and a vehicle fleet of 636,000 (IBGE, 2020). It also houses the largest international airport in Latin America: São Paulo International Airport (AISP), que which moves about 37 million passengers annually (GruAirport, 2018).

For Santos and Balassiano (2014) and Santos (2014), climate change can affect transport systems (rail, waterway,road and air) in all countries, potentially preventing urban mobility and affecting the quality of life of populations. Such warnings can already be perceived with reports of studies in some cities around the world, such as Chicago and Durban, which point to climate change as responsible for the increase in transportnetwork infrastructure costs (HAYHOE et al., 2010; REVI et al., 2014).

The International Civil Aviation Organization (ICAO), in its 37th Edition of the Assemblyéis general, endorsed the International Program for Action on Aviation and Climate Change to develop a comprehensive framework for operational, technological and market-based measures, as well as the use of fuels to combat international aviation emissions (ICAO, 2013).

According to the National Yearbook (2017), of the National Civil Aviation Agency (ANAC), in Brazil urban mobility is excessively based on the use of private vehicles. Also,according to the author cited above, in 2017 passenger transport in the country grew 2.7%, representing a total of 112.5 million passengers paid in the country, 90.6 million domestic flights and 21.8 million international flights. As a result, the air transport system served 49 million more passengers than in 2008. In this way, the transport sector has a huge contribution to GHG emissions and pollutants.

The air transport sector has serious technological limitations in reducing its GHG emissions,, and it is a barrier to creating bottleneck for the diversification of its energy matrix, which is concentrated in fossil fuels (IATA, 2015).) Thus, a special effort is needed for research that may present alternatives to this energy matrix, because we are facing a scenario of uncertainties about its future, since these fuels are finite.

Carbon dioxide is the most important anthropogenic GHG in the atmosphere, contributing approximately 66% of the radiative force and accounting for about 82% of the radiation increase (WMO, 2019).

The pre-industrial level represented a balance of flows between the atmosphere, oceans and terrestrial biosphere of 278 ppm/CO_2. The molar fraction of COin 2018 globally stood at an average of 407.8 ppm/CO_2. The increase in the annual average from 2017 to 2018, 2.3 ppm/CO_2, is almost the same as for 2016 to 2017 and almost equal to the average growth rate of the last decade (WMO, 2019).

The main motivation of this study was to verify the rates of CO_2 - concentrations around the AISP. Thus, it was possible to understand the concentration of CO_2 - at the local level of mediations of a large airport.

2. METHODOLOGY

2.1. Area of Study: An Overview

The municipality of Guarulhos is an integral part of the Metropolitan Region of São Paulo - RMSP (Figure 1). Its territory has an extension of about 318,675 km² and a strategic geographical location for the movement of people and goods, with important logistics equipment: *a)* the largest international airport in Latin America; *(b)* approximately 80 km from the Port of Santos; *(c)* 110 km from Viracopos airport (Campinas); *(d)* 17 km from the city center of São Paulo (which also has another important domestic airport: Congonhas) and is cut off by the two most important federal highways in Brazil – BRs-116 and 381.

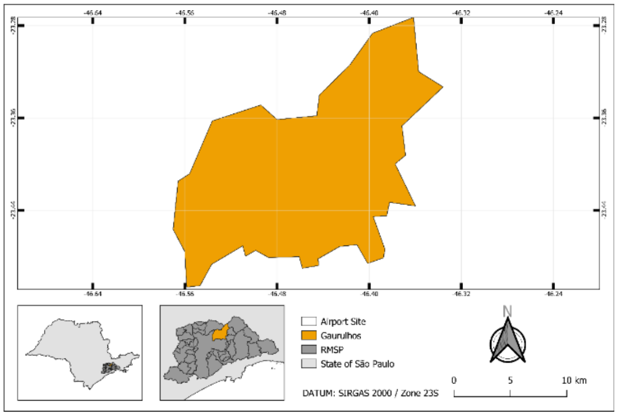


Figure 1 - Location of the Study Area. Source: Authors (2020).

2.1.1. São Paulo International Airport (AISP)

The AISP was inaugurated in 1985, and occupies an area of 14 km² and is the largest international airport in Latin America in passenger movement, reaching approximately 37 million people per year, with 266,000 landings and take-offs (GruAirport, 2018). In 2012 the airport complex was granted to the private sector, and was managed by the consortium between Invepar and Airports Company South Africa for a period of 20 years.

The AISP has three terminals for shipments and disembarkations, which are attended predominantly by the road modal (Figure 2).

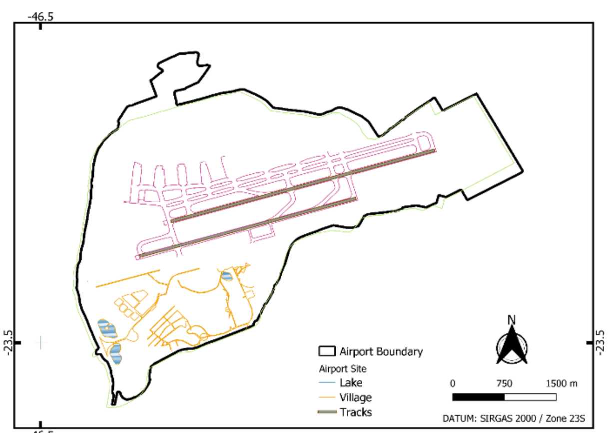


Figure 2 - Airport site. Source: Authors (2020).

From 2018 a railway extension was inaugurated that accesses the airport, the Airport-Guarulhos station is part of line 13-Jade of São Paulo Metropolitan Train Company (CPTM). Line 13-Jade connects the airport to Engenheiro Goulart station, this route is about 12 km long, from where you have access to Line 12-Safira, which goes to tatuapé, Brás and Luz stations (express airport).

In the AISP surroundings, land occupation is predominantly horizontal with residential, industrial and many warehouses with logistic distribution centers, where a consolidated and low quality urbanization is characterized in the provision of basic services for the population, such as sewage collection, solid waste management, in addition to poor education and health.

2.2. Techniques

The monitoring of air quality is undoubtedly an easy task, since it depends on a set of environmental factors,technical andadministrative-bureaucratic, the latter being what makes the work more difficult, because the absence of a network of monitoring of gases and unavailability of these has become a complicator. However, some cities have been developing open data policies that greatly contribute to studies and understanding. The present research study collected data on CO_2 emissions in 29 points around the AISP.

The samples were collected in situ in the morning period between 7:00 a.m. and 1:00 p.m. on March 19, 2018, with a temperature between 21°C and 33°C, with low cloud cover and relative humidity ranging from 41 to 61%. Furthermore, altimetry, relative humidity, temperatureand and CO_2 of the points were collected. The measurements were through mobile medidor equipment (CO_2 meter and GPS), the CO meter was also used to collect temperatura and relative humidity of the air, while GPS (Global Positioning System) collected altimetry data and geographic coordinates of the sampled points. The distribution of the points was such that they were evenly distributed at the head runways around the airport site. For that, 4 areas were determined to perform the measurements that contemplated the landing and take-off points and the surroundings (Figure 3).

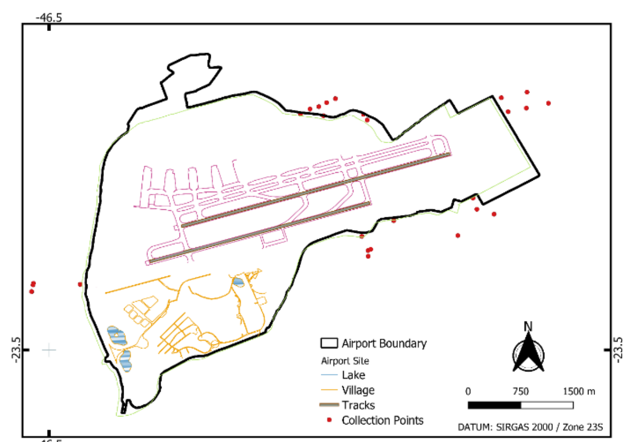


Figure 3 - Airport Site: Collection Points: CO_2/ppm. Source: Authors (2020).

The data collected in the field were treated and geospatialized through geoprocessing techniques in GIS (Geographic Information System) environment, using the geoprocessing software QGis, version 3.10.6. Through the Data) Interpolation *plugin* Inverse distance weighting method (IDW) it was possible to create isovalues for the CO_2 data. IDW is the most frequently used method by GIS specialists (LONGLEY et al. , 2005). According to Pietrobelli; Vargas (2019), "to predict a value for any unsampled location, IDW uses the values measured around the forecast location. These measured values closer to the forecast location will have greater influence on the predicted value than those more distant. "

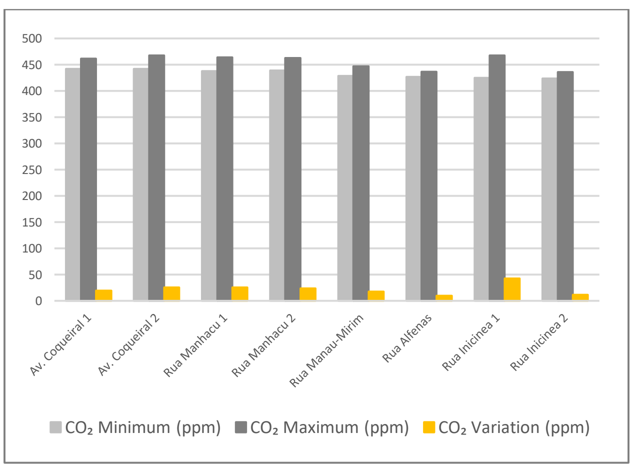
For analysis of CO_2 concentration,the data were grouped into (N-north; NNE-north-northeast; NE-northeast; ENE- east-northeast; E-east; ESSE-east-southeast; SE-southeast; SSE-south-southeast, S-south; SSW-south-southwest; SW-Southwest; WSW-West-Southwest; W-west; WNW-West-Northwest; NW-Northwest and NNW-northnorthwest).

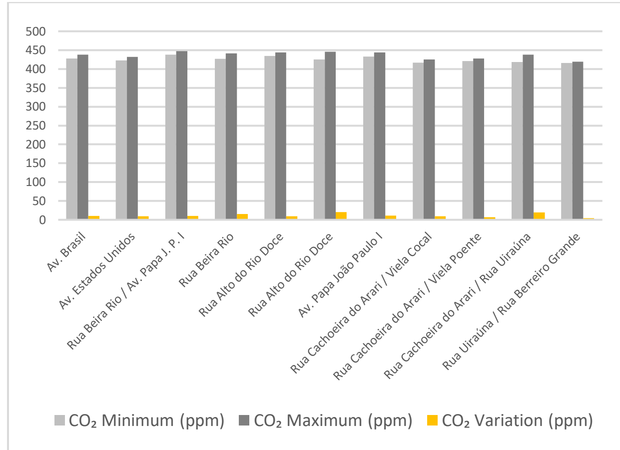
For a better understanding of the gas concentration, colletions of the altimetric quotas, temperature and relative humidity of the air along the points were made. Thus, with the application of the dispersion diagram, correlation and linear regression it was possible to compare the maximum concentration of CO_2 with the different parameters mentioned above. Finally, a statistical modeling was done identify the variation in CO_2 concentration over the sampled points. For this, the minimum and maximum values were consided.

3. RESULTS AND DISCUSSION

3.1. Variation in CO_2 Concentration

The CO_2 concentration data presented a minimum value of 416 ppm and reaching a maximum of 517 ppm, which represents a difference of 101 ppm, and the variation oscillated between 4 ppm and 78 ppm (Figure 4). The high indexs occurred near the head of the runway facing the north face in the region of influence of Natalia Zarif Avenue, which concentrates most of the landing and take-off operations, besides being an area with important avenues that access the airport site.





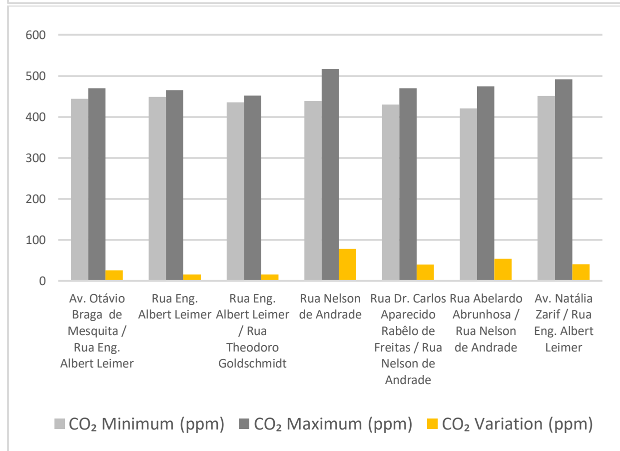


Figure 4 - CO_2 Variation graph from CO_2. Source: Authors (2020).

3.2. Relationship Between CO_2 Concentration with: Temperature - Altimetry - Relative Humidity

The highest concentration of gas occurred in the lowest temperatures, that is to say., in the first hours of the measurements with the thermometers marking between 20° and 22° C, as the hours aprogressed there was a reduction in the concentration. It is also worth noting that the greatest movement of aircraft (landings and takeoffs) occurs early in the morning, the so-called Peak 1. The results for the altitude and relative humidity of the air also did not show relation in the concentration of CO_2 (Figure 5). However, a factor that can hinder its dispersion is the land use and occupation, which in the surroundings of the aeroportuári site occurs predominantly in a horizontal way, even because the Master Plan doesn't allow constructions with more than three floors.

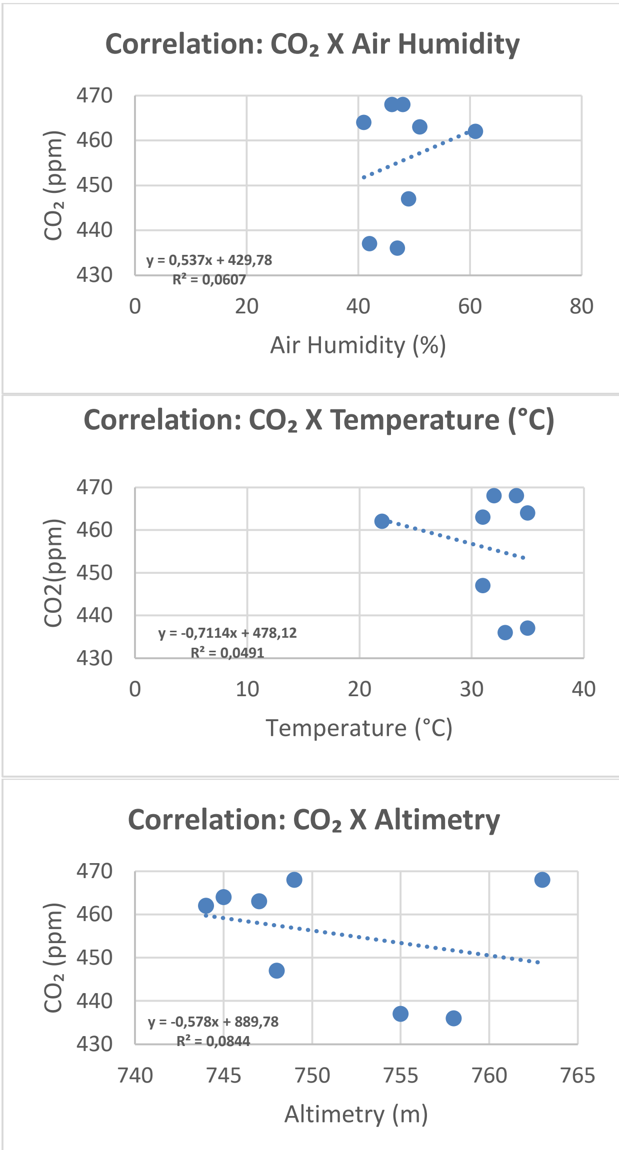


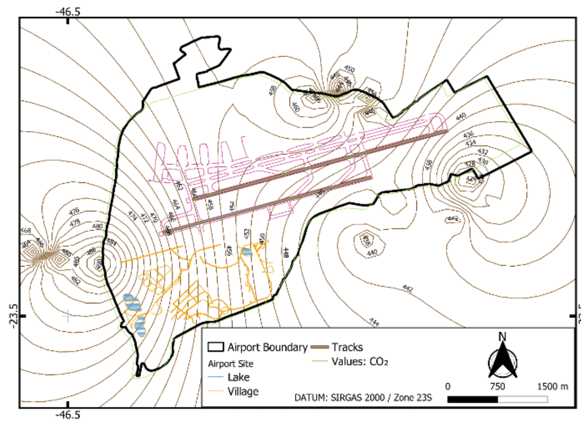
Figure 5 - Correlation Graph between CO_2 and: Relative Humidity, Altimetry, Temperature. Source: Authors (2020).

3.3 Geographical Distribution Of The Plume Of CO_2

The CO_2 emissions on the vicinity of the AISP present a pattern of higher concentration in the landings and takeoffs areas (head of airport runways) with an emphasis on the north side , indicating a contribution of the air modal in the total emissions around the airport site.

The values observed in the headlands of the tracks varied between 432 to 490 ppm/CO_2 while in the surroundings of the site there was an oscillation between 436 and 454 ppm/CO_2 with a variation of 54 ppm. However, it is necessary to register the fact that the concentration values of CO_2 in the surroundings are close to head runway is due to the intense presence of heavy vehicular traffic, therefore, with the analysis of the data, it is possible to affirm that Face N (one of the head runways) of the airport is the largest contributor to CO_2 emissions in the region, both because it is directly exposed to landings and take-offs as for the interference of SP-019, the only road that accesses the airport site. Furthermore,it is possible to observe the strong concentration of CO_2 to WNW, NW and NNW (Figure 6).

A)



B)

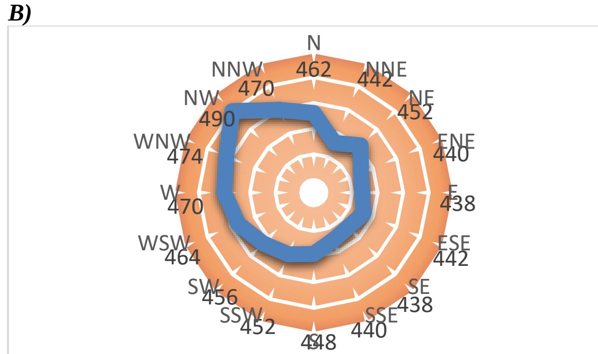


Figure 6 - A) Isovalues: CO_2 Plume Geographical Concentration; B) Concentration and Dispersion Graph CO_2 of ppm. Source: Authors (2020).

4. FINAL CONSIDERATIONS

This study sought to present the CO_2 concentration indexes around the largest airport in Latin America, especially the emissions from aircraft-related operations.

The emissions of CO_2 in the airport region showed higher levels in head runways (particularly on Face N - Norte), not by chance, since they are directly related to the higher average annual operations of aircraft landings and take-offs, in addition of the aircrafit, besides the fact of the proximity of SP-019, which is the highway that accesses the airport. Thus, it is possible to affirm that AISP airport complex contributes significantly to the increase emissionsin of CO_2 the region where is located.

The urgency of reducing GHG emissions to reduce the effects of global warming alerts the airline sector to a need to review its policies regarding its emissions, including the AISP. As well as regulators and supervisors who should demand best practices from the sector. Furthermore, the international community may include civil aviation in international climate policy regimes with emissions control.

Finally, free of any haughting, this study can instigate so that other researches to elucidate facts that have were not presented here or stimulate different understandings, such as the effects of air pollution on the health of the people who live there, especially children, the elderly and those who generally suffer from chronic respiratory problems.

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Received in: 30/04/2020
Accepted for publication in: 23/11/2020