# MONITORING THE LEVEL OF POLLUTION IN THE HENRI COANDĂ INTERNATIONAL AIRPORT AREA

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*ABSTRACT: The aviation industry is a large global industry and has a significant impact on the environment. In all phases of air travel, many types of pollutants are released. For this reason, air travel contributes to anthropogenic global climate change. Pollutants emitted by jet engines include both criteria air pollutants, defined as common pollutants considered harmful to public health and the environment, as well as greenhouse gases. Both types of pollutants are known to have serious health effects and a significant impact on the environment.*

*As a research subject, we have chosen the area around Henri Coandă International Airport. The purpose of this research is to understand and estimate the pollution indices in this area, to develop a research algorithm to determine the level of pollution in the airport area, and to develop problem-solving skills. The proposed research project includes both theoretical content and practical content presented in the tables on the following pages.*

*KEYWORDS: airplanes, pollution, airport, carbon dioxide*

## 1. Introduction

The aviation industry is constantly growing, so the impact of these emissions is becoming increasingly concerning. However, new strategies are being developed to reduce the impact of the growing market worldwide. In Romania, approximately 15 million passengers land and take off annually at Henri Coandă International Airport.

The National Airports Company Bucharest recorded, in 2021, at Henri Coandă International Airport and Aurel Vlaicu Băneasa International Airport, an air traffic of 7 million passengers (an increase of 55% compared to 2020) and 93,000 landings and takeoffs, an increase of 37% compared to the previous year. Compared to 2019, the year with the highest traffic, specifically 15 million passengers, the data indicates a decrease of 53%. Otopeni Airport had in 2022 an air traffic of over 12 million passengers, an increase of 82% compared to 2021, but 85% compared to 2019, the reference year before the Covid-19 pandemic. Henri Coandă Bucharest International Airport currently operates 45 airlines, which transport passengers to 128 destinations.

The first part of the study describes the current situation with the definition and objective of the main characteristic parameters: landing time, takeoff time, number of landing airplanes, number of takeoff airplanes. The study model for the current situation is then described, and proposed solutions for improving the air quality in the area are presented. The results were recorded in tables and the data sets were treated with statistical tools.

## 2. Methods used in air pollution assessment in the Otopeni airport area.

For this research, we used the mobile application "Flightradar24", which allows real-time tracking of airplanes in flight. To be able to view an airplane on this application, it needs to have an ADS-B transponder, which works together with GPS and transmits a signal that contains speed, route, weather, wind direction, altitude, angular coordinates, latitude (north and south) and longitude (east and west). In addition to this application, we also used the official website of the airport to see all flights and their landing and takeoff times.

According to sources, an airplane takes about eight minutes to take off, from the moment it leaves the platform until it reaches approximately 9842 feet (3000 meters), and four minutes to land, from the moment the pilot positions on the runway trajectory. From our analysis of flights, airlines operating flights at Henri Coandă Airport use airplanes from manufacturers such as Airbus, Boeing, and ATR. For example, Ryanair only has Boeing 737 in its fleet, Tarom has eight Boeing 737, 13 ATR airplanes, and four Airbus planes, while Wizz Air has a young fleet, consisting of a single type of aircraft, Airbus. In addition to passenger flights, there are also cargo flights at Otopeni Airport, with DHL and Cargoair operating regularly. These companies have Boeing 757F and 737F aircraft in their fleets.

If we analyze from a distance/consumption perspective, the most fuel is consumed until reaching cruising altitude. In these stages, aircraft engines operate at maximum power. For passenger aircraft, fuel burn has been allocated between passenger and cargo transport using the following three equations:

Equation 1:

$$Fuel\ used\ per\ passengers[kg] = \frac{Total\ weight\ of\ passengers[kg]}{Total\ weight[kg]} \times Total\ used\ fuel[kg]$$

Equation 2:

$$Total\ weight\ of\ passengers[kg] = number\ of\ seats \times 50\ kg + number\ of\ passengers \times 100\ kg$$

Equation 3:

$$Total\ weight\ [kg] = Total\ weight\ of\ passengers[kg] + Total\ weight\ of\ the\ plane\ [kg]$$

Therefore, the total fuel/passenger consumption is proportional to the payload mass after taking into account the furniture and service equipment required for passenger operations. Equivalently, once the total fuel consumption is known, it is multiplied by 3.16, which is a constant, and the result represents the number of tons of $CO_2$ produced by burning one ton of aviation fuel (according to the ICAO and IATA Carbon Emissions Calculator Methodology). This provides the total carbon emissions.

$CO_2$ emissions from commercial aviation averaged 150 grams of $CO_2$ per passenger per mile in March 2022.

According to estimates, on average, a Boeing 737 aircraft uses approximately 700 kg/min of fuel during takeoff, with a typical weight of 70,000 kg, of which only the aircraft weighs 42,000 kg, and 300 kg/min during landing. This fuel consumption rate can vary depending on factors such as runway length, aircraft weight, temperature, and air humidity. For example, if the runway is shorter or the aircraft is heavier, more fuel may be needed for takeoff. An Airbus A320 aircraft uses approximately 600 kg/min of fuel during takeoff and 250 kg/min during landing, while an ATR 72 aircraft uses approximately 455 kg/min of fuel during takeoff and 227 kg/min during landing.

## 3. Results and discussion

According to our calculations, the amount of fuel consumed by a Boeing aircraft during the takeoff phase, which lasts about eight minutes, is 5600 kg, and during the landing phase, which lasts four minutes, it is 1200 kg. As for the Airbus aircraft, it consumes approximately 4800 kg of fuel during takeoff and 1000 kg during landing. At the same time, the ATR consumes 3640 kg of fuel during takeoff and 908 kg during landing (see Figure 3).During the takeoff process, the amount of carbon emissions produced by a Boeing aircraft is approximately 17,696 kg, while during landing, it is reduced to approximately 3,792 kg. An Airbus aircraft produces around 15,168 kg of carbon emissions during takeoff and 3,160 kg during landing, while an ATR emits approximately 11,502 kg of carbon emissions during takeoff and 2,869 kg during landing. On average, an aircraft produces 14,789 kg of carbon dioxide during takeoff and 3,274 kg during landing (see Figure 3).

Most flights took place on Thursday, with 197 landings and 196 takeoffs (see Figure 1). On this day, the highest amount of CO2 was recorded throughout the period we monitored the flights, namely 3,555,051 kg (see Figure 5). The graph also shows a sudden increase in takeoffs and landings, as well as in carbon dioxide, during the time intervals of 06:00-07:00; 15:00-16:00 and 20:00-21:00, which are the busiest hours both in the airspace and at the airport (see Graph 1). Taking into account an average of CO2 emissions produced by gasoline and diesel vehicles, we can estimate that 3,555,051 kg of carbon dioxide, produced by airplanes in a single day, mostly during those time intervals, could be emitted by 29,625,425 km traveled by vehicles. The total amount of pollutant emitted on Thursday represents the equivalent of the pollutant amount for the entire car fleet in the capital city, in a day, assuming that a vehicle travels 20 km/day, an average route from home to work and back. Currently, there are 1,500,000 cars in the capital city.

In a week, airplanes produced 22,875,328 kg of CO2, equivalent to 190,628,567 km traveled by vehicles (see Figure 3). Aviation emissions are increasing because the number of flights and passengers is constantly growing.

| Ora/Zi | Sambata | | | | Duminica | | | | Luni | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Aterizari | Decolari | A+D | CO2 | Aterizari | Decolari | A+D | CO2 | Aterizari | Decolari | A+D | CO2 |
| 00:00 - 01:00 | 11 | 1 | 12 | 165.951 | 11 | 3 | 14 | 172.498 | 8 | 4 | 12 | 131.405 |
| 01:00 - 02:00 | 11 | 0 | 11 | 162.677 | 12 | 0 | 12 | 177.466 | 9 | 0 | 9 | 133.099 |
| 02:00 - 03:00 | 4 | 1 | 5 | 62.429 | 1 | 0 | 1 | 14.789 | 3 | 0 | 3 | 44.366 |
| 03:00 - 04:00 | 2 | 0 | 2 | 29.578 | 1 | 1 | 2 | 18.063 | 3 | 0 | 3 | 44.366 |
| 04:00 - 05:00 | 1 | 0 | 1 | 14.789 | 0 | 0 | 0 | 0 | 1 | 2 | 3 | 21.336 |
| 05:00 - 06:00 | 0 | 5 | 5 | 16.369 | 0 | 4 | 4 | 13.095 | 1 | 3 | 4 | 24.610 |
| 06:00 - 07:00 | 16 | 17 | 33 | 292.275 | 13 | 16 | 29 | 244.635 | 16 | 15 | 31 | 285.727 |
| 07:00 - 08:00 | 1 | 11 | 12 | 50.800 | 1 | 8 | 9 | 40.979 | 3 | 18 | 21 | 103.294 |
| 08:00 - 09:00 | 2 | 12 | 14 | 68.863 | 2 | 13 | 15 | 72.136 | 3 | 15 | 18 | 93.473 |
| 09:00 - 10:00 | 2 | 3 | 5 | 39.399 | 2 | 3 | 5 | 39.399 | 10 | 6 | 16 | 167.531 |
| 10:00 - 11:00 | 2 | 2 | 4 | 36.125 | 3 | 7 | 10 | 67.283 | 10 | 6 | 16 | 167.531 |
| 11:00 - 12:00 | 7 | 5 | 12 | 119.890 | 12 | 4 | 16 | 190.561 | 14 | 7 | 21 | 229.960 |
| 12:00 - 13:00 | 8 | 10 | 18 | 151.048 | 8 | 10 | 18 | 151.048 | 9 | 7 | 16 | 156.016 |
| 13:00 - 14:00 | 7 | 8 | 15 | 129.712 | 11 | 11 | 22 | 198.688 | 12 | 13 | 25 | 220.024 |
| 14:00 - 15:00 | 10 | 6 | 16 | 167.531 | 10 | 10 | 20 | 180.626 | 12 | 9 | 21 | 206.929 |
| 15:00 - 16:00 | 22 | 9 | 31 | 354.817 | 21 | 11 | 32 | 346.576 | 16 | 12 | 28 | 275.906 |
| 16:00 - 17:00 | 1 | 9 | 10 | 44.253 | 5 | 11 | 16 | 109.955 | 10 | 10 | 20 | 180.626 |
| 17:00 - 18:00 | 10 | 9 | 19 | 177.352 | 7 | 16 | 23 | 155.902 | 11 | 13 | 24 | 205.236 |
| 18:00 - 19:00 | 2 | 16 | 18 | 81.958 | 6 | 16 | 22 | 141.113 | 3 | 22 | 25 | 116.389 |
| 19:00 - 20:00 | 5 | 3 | 8 | 83.765 | 10 | 5 | 15 | 164.257 | 11 | 6 | 17 | 182.319 |
| 20:00 - 21:00 | 14 | 5 | 19 | 223.412 | 14 | 11 | 25 | 243.055 | 13 | 9 | 22 | 221.718 |
| 21:00 - 22:00 | 3 | 10 | 13 | 77.104 | 8 | 7 | 15 | 141.227 | 6 | 8 | 14 | 114.923 |
| 22:00 - 23:00 | 4 | 8 | 12 | 85.345 | 4 | 14 | 18 | 104.988 | 6 | 7 | 13 | 111.649 |
| 23:00 - 00:00 | 9 | 1 | 10 | 136.373 | 10 | 0 | 10 | 147.888 | 5 | 0 | 5 | 73.944 |
| Total/Zi | 154 | 151 | 305 | 2.771.813 | 172 | 181 | 353 | 3.136.224 | 195 | 192 | 387 | 3.512.378 |

| Ora/Zi | Marti | | | | Miercuri | | | | Joi | | | | Vineri | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Aterizari | Decolari | A+D | CO2 | Aterizari | Decolari | A+D | CO2 | Aterizari | Decolari | A+D | CO2 | Aterizari | Decolari | A+D | CO2 |
| 00:00 - 01:00 | 11 | 1 | 12 | 165.951 | 12 | 5 | 17 | 193.834 | 12 | 1 | 13 | 180.739 | 10 | 5 | 15 | 164.257 |
| 01:00 - 02:00 | 8 | 0 | 8 | 118.310 | 9 | 1 | 10 | 136.373 | 9 | 1 | 10 | 136.373 | 10 | 0 | 10 | 147.888 |
| 02:00 - 03:00 | 2 | 0 | 2 | 29.578 | 2 | 0 | 2 | 29.578 | 3 | 2 | 5 | 50.914 | 1 | 0 | 1 | 14.789 |
| 03:00 - 04:00 | 2 | 0 | 2 | 29.578 | 1 | 0 | 1 | 14.789 | 3 | 0 | 3 | 44.366 | 5 | 0 | 5 | 73.944 |
| 04:00 - 05:00 | 1 | 2 | 3 | 21.336 | 2 | 0 | 2 | 29.578 | 1 | 0 | 1 | 14.789 | 1 | 0 | 1 | 14.789 |
| 05:00 - 06:00 | 0 | 3 | 3 | 9.821 | 0 | 0 | 0 | 0 | 0 | 5 | 5 | 16.369 | 0 | 4 | 4 | 13.095 |
| 06:00 - 07:00 | 10 | 13 | 23 | 190.447 | 14 | 4 | 18 | 220.138 | 14 | 16 | 30 | 259.423 | 17 | 17 | 34 | 307.064 |
| 07:00 - 08:00 | 2 | 17 | 19 | 85.232 | 5 | 16 | 21 | 126.324 | 2 | 15 | 17 | 78.684 | 4 | 18 | 22 | 118.083 |
| 08:00 - 09:00 | 4 | 15 | 19 | 108.262 | 4 | 15 | 19 | 108.262 | 4 | 17 | 21 | 114.809 | 4 | 15 | 19 | 108.262 |
| 09:00 - 10:00 | 6 | 4 | 10 | 101.828 | 8 | 18 | 26 | 177.238 | 13 | 5 | 18 | 208.623 | 10 | 6 | 16 | 167.531 |
| 10:00 - 11:00 | 11 | 4 | 15 | 175.772 | 12 | 5 | 17 | 193.834 | 7 | 6 | 13 | 123.164 | 8 | 5 | 13 | 134.679 |
| 11:00 - 12:00 | 11 | 3 | 14 | 172.498 | 14 | 8 | 22 | 233.233 | 14 | 6 | 20 | 226.686 | 7 | 9 | 16 | 132.985 |
| 12:00 - 13:00 | 12 | 12 | 24 | 216.751 | 11 | 6 | 17 | 182.319 | 13 | 9 | 22 | 221.718 | 14 | 9 | 23 | 236.507 |
| 13:00 - 14:00 | 7 | 12 | 19 | 142.807 | 9 | 9 | 18 | 162.563 | 5 | 9 | 14 | 103.408 | 10 | 15 | 25 | 196.994 |
| 14:00 - 15:00 | 9 | 4 | 13 | 146.194 | 10 | 8 | 18 | 174.078 | 11 | 8 | 19 | 188.867 | 11 | 5 | 16 | 179.046 |
| 15:00 - 16:00 | 20 | 8 | 28 | 321.966 | 15 | 9 | 24 | 251.296 | 18 | 8 | 26 | 292.388 | 18 | 10 | 28 | 298.936 |
| 16:00 - 17:00 | 5 | 9 | 14 | 103.408 | 9 | 9 | 18 | 162.563 | 9 | 11 | 20 | 169.111 | 8 | 8 | 16 | 144.500 |
| 17:00 - 18:00 | 9 | 15 | 24 | 182.206 | 10 | 8 | 18 | 174.078 | 4 | 13 | 17 | 101.714 | 7 | 12 | 19 | 142.807 |
| 18:00 - 19:00 | 4 | 20 | 24 | 124.630 | 6 | 13 | 19 | 131.292 | 8 | 16 | 24 | 170.691 | 6 | 22 | 28 | 160.756 |
| 19:00 - 20:00 | 6 | 5 | 11 | 105.102 | 8 | 23 | 31 | 193.607 | 9 | 14 | 23 | 178.932 | 7 | 7 | 14 | 126.438 |
| 20:00 - 21:00 | 11 | 4 | 15 | 175.772 | 8 | 7 | 15 | 141.227 | 18 | 7 | 25 | 289.115 | 14 | 7 | 21 | 229.960 |
| 21:00 - 22:00 | 6 | 5 | 11 | 105.102 | 10 | 6 | 16 | 167.531 | 5 | 11 | 16 | 109.955 | 8 | 9 | 17 | 147.774 |
| 22:00 - 23:00 | 3 | 12 | 15 | 83.652 | 3 | 8 | 11 | 70.556 | 6 | 16 | 22 | 141.113 | 4 | 12 | 16 | 98.440 |
| 23:00 - 00:00 | 6 | 0 | 6 | 88.733 | 8 | 12 | 20 | 157.596 | 9 | 0 | 9 | 133.099 | 7 | 0 | 7 | 103.522 |
| Total/Zi | 166 | 168 | 334 | 3.004.932 | 190 | 190 | 380 | 3.431.886 | 197 | 196 | 393 | 3.555.051 | 191 | 195 | 386 | 3.463.044 |

Fig. 1 Landings, Takeoffs and CO2 Total / Every hour

| | Combustibil consumat la decolare [kg] | Combustibil consumat la aterizare [kg] | CO2 produs la decolare [kg] | CO2 produs la aterizare [kg] |
|---|---|---|---|---|
| Boeing | 5600 | 1200 | 17.696 | 3.792 |
| Airbus | 4800 | 1000 | 15.168 | 3.160 |
| ATR | 3640 | 908 | 11.502 | 2.869 |
| Medie Consum | 4680 | 1036 | 14.789 | 3.274 |

Fig. 2 Fuel Used

| Ora/Zi | Total/Interval Orar | | | | Medie CO2/Interval orar [Kg] |
|---|---|---|---|---|---|
| | Aterizari | Decolari | A+D | CO2 | |
| 00:00 - 01:00 | 75 | 20 | 95 | 1.174.635 | 167.805 |
| 01:00 - 02:00 | 68 | 2 | 70 | 1.012.186 | 144.598 |
| 02:00 - 03:00 | 16 | 3 | 19 | 246.442 | 35.206 |
| 03:00 - 04:00 | 17 | 1 | 18 | 254.683 | 36.383 |
| 04:00 - 05:00 | 7 | 4 | 11 | 116.617 | 16.660 |
| 05:00 - 06:00 | 1 | 24 | 25 | 93.359 | 13.337 |
| 06:00 - 07:00 | 100 | 98 | 198 | 1.799.708 | 257.101 |
| 07:00 - 08:00 | 18 | 103 | 121 | 603.396 | 86.199 |
| 08:00 - 09:00 | 23 | 102 | 125 | 674.066 | 96.295 |
| 09:00 - 10:00 | 51 | 45 | 96 | 901.548 | 128.793 |
| 10:00 - 11:00 | 53 | 35 | 88 | 898.388 | 128.341 |
| 11:00 - 12:00 | 79 | 42 | 121 | 1.305.813 | 186.545 |
| 12:00 - 13:00 | 75 | 63 | 138 | 1.315.407 | 187.915 |
| 13:00 - 14:00 | 61 | 77 | 138 | 1.154.196 | 164.885 |
| 14:00 - 15:00 | 73 | 50 | 123 | 1.243.270 | 177.610 |
| 15:00 - 16:00 | 130 | 67 | 197 | 2.141.886 | 305.984 |
| 16:00 - 17:00 | 47 | 67 | 114 | 914.416 | 130.631 |
| 17:00 - 18:00 | 58 | 86 | 144 | 1.139.294 | 162.756 |
| 18:00 - 19:00 | 35 | 125 | 160 | 926.828 | 132.404 |
| 19:00 - 20:00 | 56 | 63 | 119 | 1.034.420 | 147.774 |
| 20:00 - 21:00 | 92 | 50 | 142 | 1.524.258 | 217.751 |
| 21:00 - 22:00 | 46 | 56 | 102 | 863.615 | 123.374 |
| 22:00 - 23:00 | 30 | 77 | 107 | 695.744 | 99.392 |
| 23:00 - 00:00 | 54 | 13 | 67 | 841.154 | 120.165 |
| Total/Zi | 22.875.328 | | | | |

Fig. 3 Total of every Landing, Takeoff and CO2 per hour

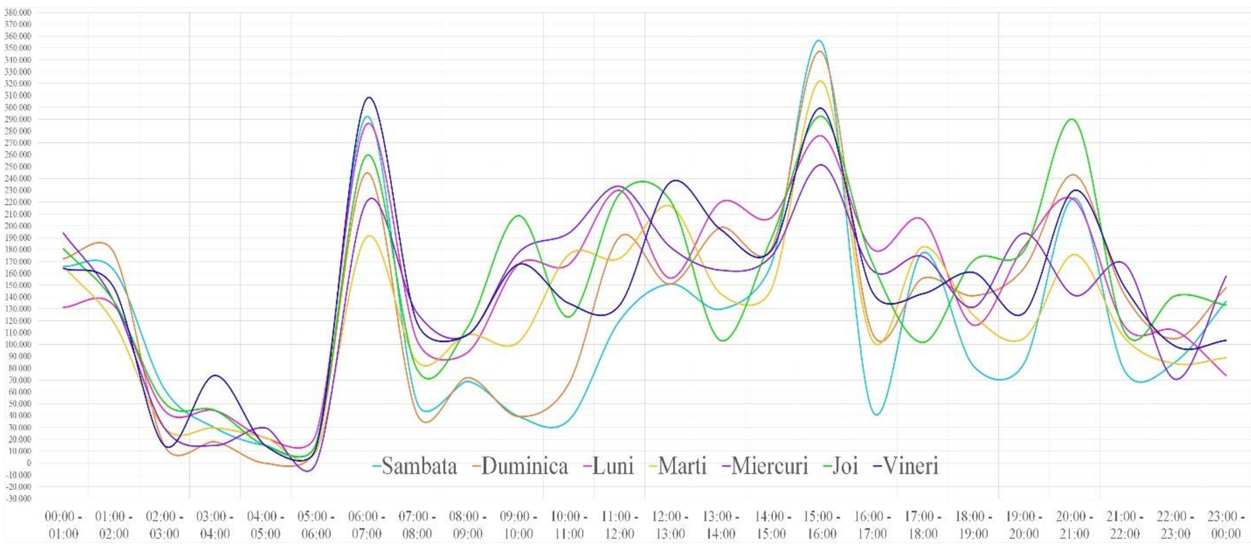


Fig. 4 The amount of carbon dioxide, by hourly intervals, for one week

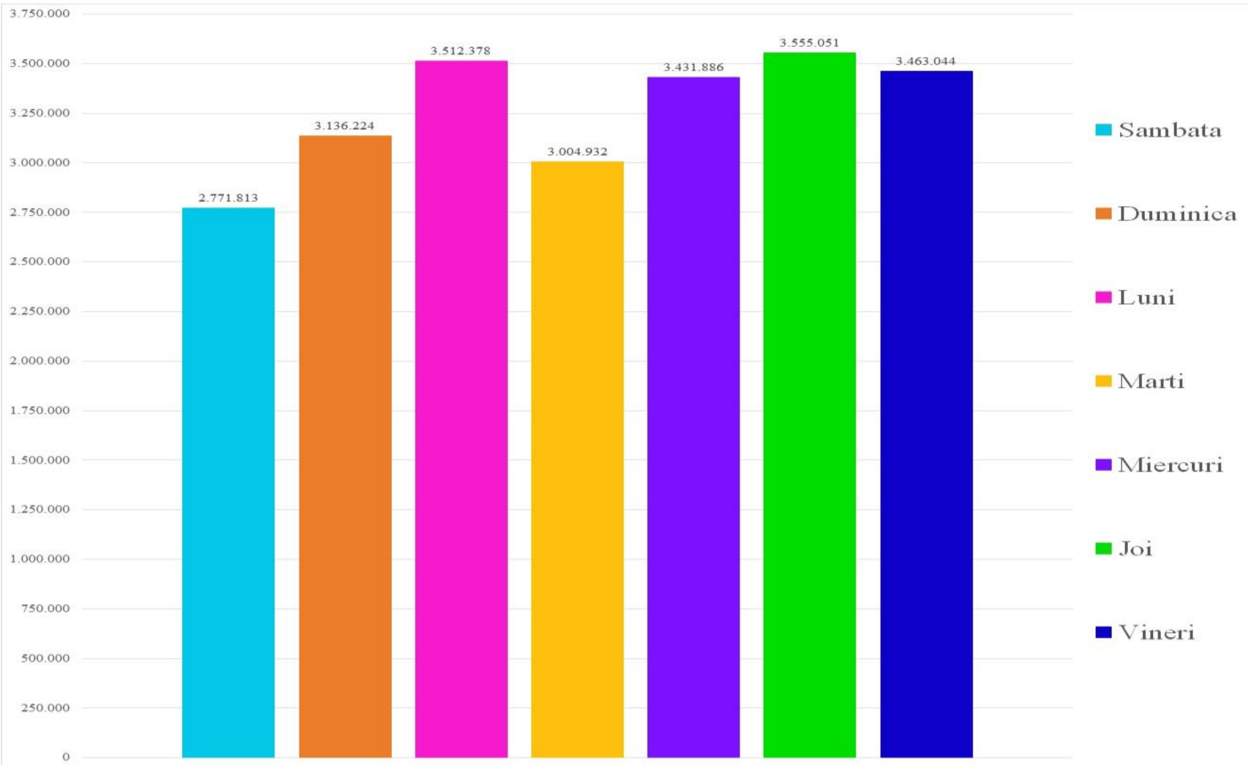


Fig. 5 CO2 Total / Day

## 4. Conclusion

Pollution around the "Henri Coanda" airport is a significant problem for the environment and the health of people living in those areas. Airplanes produce a wide range of atmospheric pollutants, including fine particles, nitrogen oxides, hydrocarbons, and excessive noise. These pollutants can have negative effects on air quality and contribute to the development of respiratory and cardiovascular diseases. Also, pollution can affect the fauna and flora in the surrounding areas. A study conducted in 2009 by the MIT, a research institute specializing in climate research, concluded that airport areas have much higher pollution levels (covering an area of approximately 20 km, exactly the size of Bucharest) and the emissions from altitude destroy the ozone layer and enhance the greenhouse effect. An airplane taking off produces as many toxic emissions as a car traveling 40,000 km.

There are several technologies and modifications to airplanes that can be implemented to reduce the pollution impact on the environment:

1) Using more fuel-efficient aircraft: Aircraft manufacturers are developing new engines and aircraft models that consume less fuel and emit fewer greenhouse gases. Airlines should upgrade their fleets with these newer and more efficient aircraft to reduce global emissions.

2) Using sustainable aviation fuels (SAF): SAF is a category of biofuels that are produced from renewable sources, such as plants, used oils, or algae. When used in airplanes, SAF can significantly reduce $CO_2$ emissions compared to traditional aviation fuel. Some airlines are testing and using SAF (Alaska Airlines, Delta Air Lines, KLM, Lufthansa) to reduce their carbon footprint.

3) Improving operational efficiency: Airlines are implementing operational improvements that can help reduce fuel consumption and emissions, such as optimizing flight routes, reducing aircraft weight by using a higher percentage of composite materials, and improving ground operations.

4) Generally, buying airline tickets during less busy periods can contribute to reducing the environmental impact. Reducing baggage weight can contribute to reducing fuel consumption and greenhouse gas emissions during the flight. If each passenger reduces the weight of their luggage by a few kilograms, fuel consumption and greenhouse gas emissions could be significantly reduced. For this reason, airlines charge high prices for luggage requests that are much heavier than what is provided in the ticket.

Finally, as the manager of Henri Coanda airport, I would like to disperse the amount of pollutants by trying to eliminate pollution peaks, increasing the hourly time interval of flights. As observed in the chart, the time intervals of 06:00-07:00; 15:00-16:00; 20:00-21:00 are the busiest, and I propose to be moved to time intervals close to those where pollution is very low. For example, some flights that are in the first hourly interval can be moved between 04:00-06:00, where the records are minimal. Some flights from the next hourly interval could be moved between 14:00-15:00, or between 16:00-17:00. In the last interval, flights can be interspersed between 19:00-20:00 and 21:00-00:00.

I would try to suggest, at the time of ticket purchase by the consumer, days or hourly intervals when pollution is lower, by displaying a banner on the website where ticket reservations are made.

These measures can be taken together or separately, depending on the specific needs of each airport and the communities in the surrounding area.

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ations/
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## 6. Notes

The following symbols are used in the paper:
ADS-B=Automatic Dependent Surveillance Broadcast
ICAO= International Civil Aviation Organisation
IATA=International Air Transport Association
MIT= Massachusetts Institute of Technology
SAF=Sustainable Aviation Fuel