An investigation into the impact of airport operations on ambient air quality: the case study of Sphinx International Airport

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Abstract

This investigation focuses on the predicted environmental impact due to emissions and air pollutants resulting from planned airport operations. The analysis relies on the application of the descriptive and analytical approach on a case study developed at the new Sphinx International Airport (ICAO: HESX, IATA: SPX) serving the city of Giza, Egypt. The theoretical part reviews previous studies in the field to draw the most important results. It contains air pollutant monitoring and measuring in the area where the airport is to be established, weather forecast data, calculation of air traffic and plane emissions as well as the implementation of all necessary data for the emission dispersion modelling mapping program. This is instrumental to predict the pollutant concentrations from all activities at the airport. This research has found that the levels of emission concentrations in the airport area are acceptable and below maximum permissible thresholds. However, the emissions from certain specific sources would be considerably lower if mitigation measures will be implemented. Other sources will increase emissions with lower capacity for mitigation. By way of comparison between the results of the actual analyses of the emissions from planes and the energy consumption, different impact was found on the areas adjacent to the airport. To ensure that the outcomes of the analyses for the emissions comply with national and international standards, recommendations are also suggested. This study indicates that the most important measures must be focused on mitigating emissions during the operational phase.

Keywords – air pollutants, emissions, ICAO, pollutant dispersion prediction

1. Introduction

Airports are important sources of pollution as they produce considerable number of emissions. According to the guidelines of the World Health Organization [1], three main pollutants must be considered whose levels in the air determine the level of pollution. These are gases i.e., nitrogen dioxide, carbon monoxide and solid particles less than 10 microns, and their emission affects the environment and its various elements such as air, water, and soil. The environmental spread of these pollutants seriously contributes to climate change, and thus greatly affects the general health of the human beings [2].

Several field studies have been carried out to estimate harmful air pollutants linked with airport operations. An investigation was developed by Tokuslu [3] at Tbilisi International Airport in Georgia and focused on the estimation of air pollutants including nitrogen oxides, carbon monoxide, and hydrocarbons from aircrafts at landing and take-off (LTO) cycles for the year 2018. The estimation model is based on flight data recorded by TAV Airports Holding Corporations in Georgia, including number and type of aircrafts, type of engine, passenger's numbers, and emission factors from the International Civil Aviation Organization (ICAO) Emission Databank for Engine Exhaust [4]. These data were used for calculating the emissions from international flights responsible for 99% of the total LTO emissions from all flights in 2018. Results showed that NOx was mainly emitted during the take-off and climb-out modes, accounting for 27% and 37% of the total emissions, respectively. CO and HC were mostly produced during the taxi mode, accounting for 77% and 70% of the total emissions, respectively. The estimation outlined that a decrease of 2 minutes in taxiing time can result in a decrease of approximately 5% in LTO emissions. To forecast future emissions, it was found that an increase of 50% in LTO cycles might cause a rise of between 55 and 60% in emissions.

Innocentia et al. [5] investigated into the effect of choosing specific methodologies for air quality interpretation. The Marco Polo International Airport at Venice, Italy, was used as the case study. The airport is located in a critical area; due to its proximity to the historical city of Venice and the fragile ecosystem of the Lagoon surrounding the city. Priority was hence to assess the potential impact of the airport on the Venice area. Main objectives of the study were: (I) to understand the impact on air quality of an airport structure in a vulnerable context; (II) to analyse the airport emission trend; and (III) to analyse how the number of flights and aircraft types can affect emissions. Two methodologies for emission estimation (i.e., the EMEP-CORINAIR and the Emissions and Dispersion Modeling System (EDMS)) were tested to identify the best tool for estimation of exhausts' emissions. Results showed a remarkable difference between the two methods, with a general decrease in emission estimation using the EDMS model, except for the NOx and HC cases. Outcomes of this research also show that schedule and number of flights can deeply affect the emission estimation [5].

In Xu et al. [6], aircraft emissions were quantified at Shanghai Pudong International Airport (IATA: PVG, ICAO: ZSPD), China, using ground operational data. This study was motivated by a growth of the air traffic in the airport and the concern for its potential impact on the local air quality and the human health. However, the emission contributions due to aircraft activities, impact on air quality and health effects remained unclear. The ground operational data retrieved from the Aircraft Communication Addressing and Reporting System (ACARS) dataset [6], were newly utilised to obtain PVG-specific emission parameters of 10 distinct aircraft-engine combinations during the taxi (in and out) phases of the LTO cycles. The resulting emission parameters, together with PVG-specific operational conditions, were applied to quantify the annual emissions in 2017 for main engines and auxiliary power units (APUs) at PVG, the emission variations caused by mixing layer height, the sensitivity of black carbon (BC) emissions to the estimation method and the sensitivity of PM2.5 emissions to the fuel sulfur content (FSC). Results show remarkable differences between the corrected fuel flows and nitrogen oxide emissions indicators (EIs) by the method approved by ICAO [4].

Conversely, the application of the maximum height of the mixing layer contributes to emission increases as high as 16.9% (NOx). An alternative estimation of BC emissions leads to an increase of 50% compared with first-order approximation 3 (FOA3), whereas a reduction in PM2.5 emissions can be predicted by minimising the FSC.

2. Aims and objectives

A main aim of this research is to highlight the importance of determining the environmental impact of civil airport operations with special reference to emissions and air pollutants. To this purpose, a case study is presented at the Sphinx International Airport in the City of Giza Governorate, Egypt. The site was monitored in 6th October City to identify potential effects of the operations on the air quality in the vicinity of the airport area before the scheduled start-up date.

Another major aim of this study is to identify potential measures for mitigation of emissions and pollutions and compare them with the limits established by domestic and international legislation. Mitigation measures for potential impact of operating airports related to the Sphinx International Airport are therefore assessed for compliance with the international legislative requirements by ICAO, with a focus on reducing emissions and air pollutants.

To achieve the above aims, field measurements of ambient air quality at a specific location in the airport area were carried out over a full week for 24 hours a day, to set a benchmark on the existing scenario on site before starting the future airport operations.

3. Air quality monitoring equipment and methodology

The potential environmental impact of airport operations on the surrounding environment was first analysed. Subsequently, the impact of airport operations on air quality in the airfield area and the areas adjacent to the airport have been assessed. To determine the air quality in the current situation and to monitor the air quality background, field measurements of air quality were carried out in the region using the Ambient Air Pollution Monitoring System, over a full week for 24 hours a day. A Mobile Air Quality Monitoring Station (MAQMS) Model THERMO was used in the airport area for the investigation and its photos from outside and inside. As shown in Figure 1, the MAQMS can continuously sample, analyse and log the concentrations of pollutant gases and particulates in the vicinity of the investigated site. The equipment can record hourly values, maximum, minimum, and average concentrations during the 24 hours for NO_2, CO and PM-10 concentrations. Results of the measurements were compared with the threshold limits established by the Egyptian Environmental Law [7] and guided by the procedures of the ICAO [8]. Air traffic volumes expected to be operated by the airport in future years were provided by the Egyptian Airports Company (EAC). Parallel to this, the number of emissions expected from airport air traffic in the same time horizon were calculated using the ICAO database [4]. Besides, the volume of emissions and air traffic were used in addition to geographical, weather and climate information. Emission dispersal modelling was therefore implemented at the airport and its adjacent area, and the outcomes of the modelling were analysed.

Fig. 1 - The Mobile Air Quality Monitoring Station (MAQMS) used in the airport area for the investigation. The Station (a) and the data logger unit (b)

4. The Sphinx International Airport: background information and surrounding environment

The Egyptian Ministry of Civil Aviation represented by the EAC aimed to establish, operate and develop the Sphinx International Airport to mitigate the air traffic pressure on Cairo International Airport and vehicles traffic congestion within the municipality of Cairo.

The area around the airport is mostly uninhabited so establishing the Sphinx International Airport would increase investment and contribute to the growth of population in this area, as shown by the satellite images in Figure 2 and Figure 3.

This airport serves the Al-Sheikh Zayed city, 6th. of October city and several other governorates as it is located on the Cairo-Alexandria desert road at km 45 in Giza Governorate, west of the capital, Egypt [2]. The nearest residential area to the airport is in the southeast at about 10 km, as shown in Figure 4.

To the north, is a desert area in addition to private farms, and two primary treatment plants for agricultural wastewater.

From the south, an uninhabited desert area is present as well as the Cairo-Alexandria Desert Road and some private farms. The West Cairo Military Air Base is located from east, whilst several private farms and the Sonbol Development City (Sonbol Theatre) are from the west. The Sphinx International Airport technical description and main components layout [9] are showed in Table 1 and Figure 5, respectively.

4.1. Measurement of pollutants at the Sphinx Airport

Measurements of the maximum concentration of pollutants were collected for a 24-hour period from the collecting station at the Sphinx International Airport.

Measurement results include i) Carbon monoxide concentration (CO) in the airfield, ii) Nitrogen dioxide (NO_2) concentrations for an average hour over a 24-hour period, iii) suspended-substances less than 10-micron concentrations for an average of an hour over a 24-hour period

Fig. 2 - Satellite image of the investigated area before construction of the Sphinx International Airport

, and iv) concentration measurements of suspended substances (PM-10) in the airfield.

The maximum value of the (NO_2) concentrations was 10.3 μg/m^3, where the maximum concentration of an hour according to law is 300 μg/m^3, 150 μg/m^3, and 125 μg/m^3 (IFC Standards) [10].

Fig. 3 - Satellite image of the investigated area after construction and layout of the Sphinx International Airport

Fig. 4 - The residential area near the Sphinx International Airport

Tab. 1 – The Sphinx International Airport Technical Description

Airport Technical Description		
Item	**Quantity**	**Describtion**
An integrrated civilian, Including an airfield	1	
Main Ruway	1	(16R /34L) 3650M long
Taxiway	3	TWY(F), TWY(E) &TWY(D)
Apron	1	Eight Stands Code (C) Aircraft, Dimention (650m x 210m)
Initial Terminal Building	1	Area 3416 m² for 300 Passengers/Hour and it contains of: 1-Domistic(Departure,Arrival). 2- International (Departure, Arrival). 3- Transit. 4- Waiting Area. 5- Baggage Recall etc.
Parking Area	1	Capacity of 500 Cars / 15 Buses.

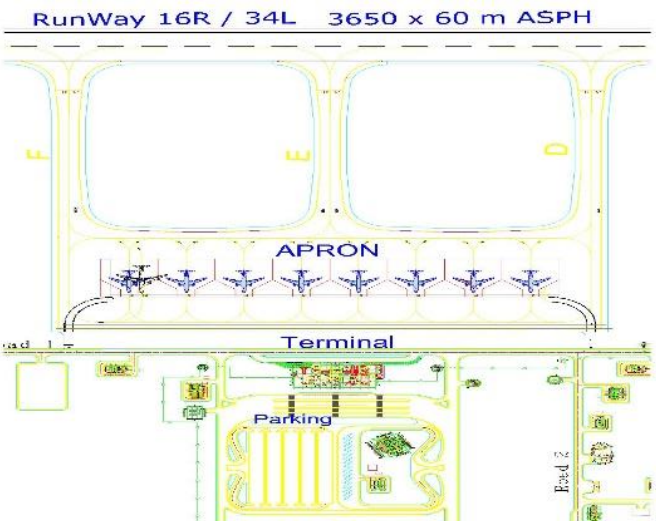

Fig. 5 – The Sphinx International Airport main components layout

The concentration average value suspended-substances less than 10-micron concentrations for an average of an hour was 68 µg/m^3, with 150 µg/m^3 being the maximum concentration of 24 hours according to the law, International Standards and IFC Standards [10].

4.2. Weather forecasting data in previous years

Weather data are necessary inputs for the generation of airport dispersion modelling maps, as well as to provide an overall understanding of the weather conditions and their variability in the airport area, and the quality of field measurements.

4.3. Wind rose

Wind rose shows the prevailing wind direction at the level of the year or season that is being worked on at the Sphinx Airport, as shown in Figure 6.

One of the most important inputs for modelling the dispersal of emissions is the speed and direction of the prevailing winds for the site throughout the year. It is therefore important to use the wind rose as part of the supporting data for the modelling of emission dispersal as well as in the initial report of the weather**.**

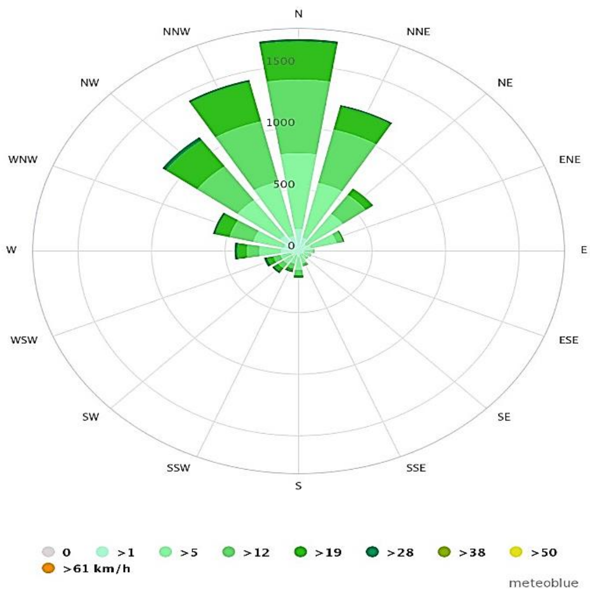

Fig. 6 - The wind rose of the Sphinx International Airport

4.4. Monthly temperature average

The monthly temperature average is another major input for modelling the dispersal of emissions, as shown in Figure 7. The graph shows the levels of temperature (high and minimum) in the two directions (right and left of the graph) the maximum temperatures on the right, the minimum temperatures on the left. The black line shows the average temperature for each of the last 12 months.

The thick red line shows the average temperature calculated during the past thirty years per month (climate). This line refers to the exact average temperature although it does not reveal temperature fluctuations from year to year. The orange area around the red line denotes the variations between the past thirty years even clearer. It shows how far temperatures have been distributed over the past thirty years, including maximum and minimum monthly average [11].

Fig. 7 - Current season compared to the average climate of the chosen location

4.5. Predicted pollutants and emissions

The year 2021 was selected as the base year and year 2030 as the target year for the forecast, owing to the possibility of operating the airport at full capacity in 2030 after completion of development and upgrading work. This is according to the feasibility study carried out by the owner of the project (Egyptian Airports Company). Table 2 shows data of predicted emissions per aircraft corporation within the forecast time frame [9].

In terms of predicted air traffic volume at the Sphinx International Airport, Figure 8 shows a prediction of 26,448 planes until 2030 according to the expected annual increase rate from the Egyptian Airports Company (EAC), based on the statistics on the operation of its airports.

4.6. Sources of emissions and pollutants inside the airport

Many sources of emission and pollutants exist inside an airport that must be considered for emission calculation. These include planes, equipment of ground services, backup generators, parking lots, service vehicles working in the airport, traffic from and to the airport, consumption of energy and fossil fuel.

4.7. Results for emissions expected from air traffic

Air traffic volume referred to as take-off and landing operations will result in different and large quantities of pollutants and emissions during these manoeuvres. Thus, forecasting scenarios for the levels of pollutants and emissions from the amount of air traffic expected at the airport until 2030 were to be drawn up through the ICAO database [4].

Tab. 2 – Predicted emissions from 2021 to 2030 per aircraft corporation

Total Forecasting Quantities of Aircraft Families Types 2021-2030									
Type	Year 2021	Year 2023	Year 2024	Year 2025	Year 2026	Year 2027	Year 2028	Year 2029	Year 2030
Airbus Family	516	733	1350	1818	2812	5008	7814	8200	9400
Boing Family	322	504	633	712	866	920	1100	1150	1226
Embraer Family	203	511	766	944	1201	1216	1575	1988	2004
Others	1100	2550	3100	5420	7888	9112	10790	12890	13818
Total	2141	4298	5849	8894	12767	16256	21279	24228	26448

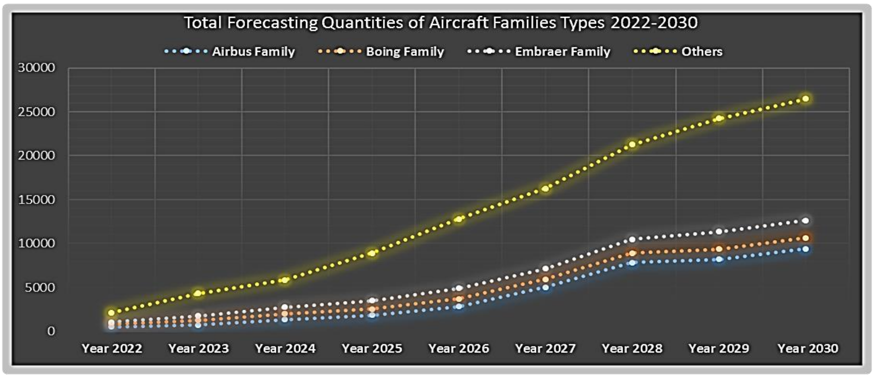

Fig. 8 - Predicted air traffic volume at the Sphinx International Airport per aircraft corporation (2022-2030)

It defines the expected emission levels for each plane model and it maps the emission levels for each plane at the rate of number of operations (take-off and landing) at the airport until 2030 as well as in case of the worst operational conditions.

This volume of emissions from different sources may affect the areas around the Sphinx Airport, due to the saturation of the airport area with most of the emissions, except for plane emissions in the take-off and landing cycles. These emissions spread in the ambient air and may negatively affect the area around the airport.

4.8. Air traffic and plane emissions until year 2030

Planes and air traffic at the airport result in undefined-in-scope emissions; the areas affected by the emissions are not defined in total (inside and outside the airport) and in the atmosphere in general. Since there is no effective way to measure air traffic and plane emissions directly from their sources at the airport, the emission calculation factor for the take-off and landing cycles of planes will be used based on the ICAO databank as a method of calculation [4]. Then the concentrations of pollutants in this area will be monitored and recorded. A map modelling emission dispersion in the air is therefore produced from these records using the ICAO databank [4].

Table 3 shows the volume of emissions from the take-off and landing cycles for all the plane models at the airport according to forecasting of the Egyptian Airports Company (EAC) as per the total number of different aircraft families, as shown in Table 2.

Figure 9 shows that the total expected emission volume of carbon dioxide equivalent (CO_2e), including greenhouse or warming gases, from all the plane models using the airport for take-off and landing cycles, is about 396000 t of CO_2e. This equals 84% of the total expected emissions from all the airport operations.

Tab. 3 – Air traffic and plane emissions until year 2030

Total Aircrafts Family Emissions 2021-2030 (LTO) Cycle (Metric ton)									
Aircraft Type	**Quantity**	CO2 (Kg)	NOx (Kg)	Sox (Kg)	H2o (Kg)	CO (Kg)	HC (Kg)	CH4	N2O
Total Others	13818	147,990,780	206.994	18.033	26,510,968	193.771	2.689	18.982	4.745
Total Embraer	885	1,342,465	3.929	354	524.203	3.637	35	177	89
Total Boeing	1225	3,203,064	12.836	851	1,250,177	9.714	1.038	567	123
Total Airbus	8912	22,809,257	97.982	6.148	8,936,555	47.292	14.620	356	893

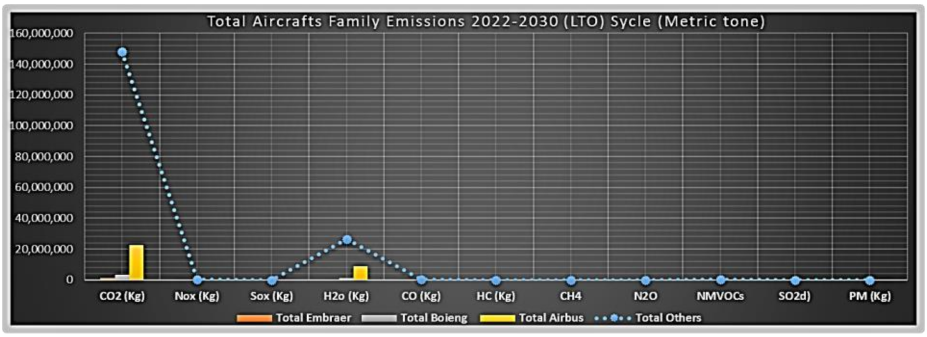

Fig. 9 - Total predicted emission volume of carbon dioxide equivalent (CO_{2e}) from all the plane models expected to utilise the airport (take-off and landing cycles)

4.9. Predicted emissions from electricity consumption

The same equivalent gas produced by plane electricity generation equipment (ground generation equipment) has been calculated by using an arithmetic factor to estimate the emission volume from burning this type of fuel [12]. Figure 10 shows the power consumption to year 2030 calculated through the above-mentioned arithmetic factor. The total expected equivalent emissions from the airport's electricity consumption are estimated at 16.700 t.

4.10. Modelling the dispersion of predicted emissions through the case study of the Sphinx International Airport

Results are estimated using the Aviation Environment Design Tool (AEDT) [2, 9] developed by the Federal Aviation Administration (FAA) and used for pollutants concentration calculation. Inputs required to model the dispersion of expected emissions are as follows:

a. Emissions from planes,
b. Emissions from power consumption,
c. Emissions from ground equipment,
d. Meteorological data,
e. Geographic data and site coordinates.

- Emission sources and concentration of pollutants

Inventory of emissions are created from fixed sources; vehicle and plane emissions; nitrogen dioxide-focused modelling (NO2); carbon oxide (CO) concentrations from these sources.

Pollutant concentration distributions are presented similar to NOx and CO_2, as well as concentrations representing seasonal average and peak ceilings in the Sphinx Airport area.

- Change in atmospheric elements during the study period

It will be discussed below the change in the monthly averages of the atmospheric pressure, temperature, relative humidity, wind rose, as well as the state of air stability during study years (2021 to 2030) at the Sphinx International Airport and the surrounding area. This is based on the results of the regional climate model depending on the climate change scenario RCP 4.5, which has been used as an input to the diffusion and dispersion model of emissions [11].

- Atmospheric pressure at sea level

Results show that in 2021, the atmospheric pressure monthly average values at sea level may range between 1013 millibars in July and 1027 millibars in January.

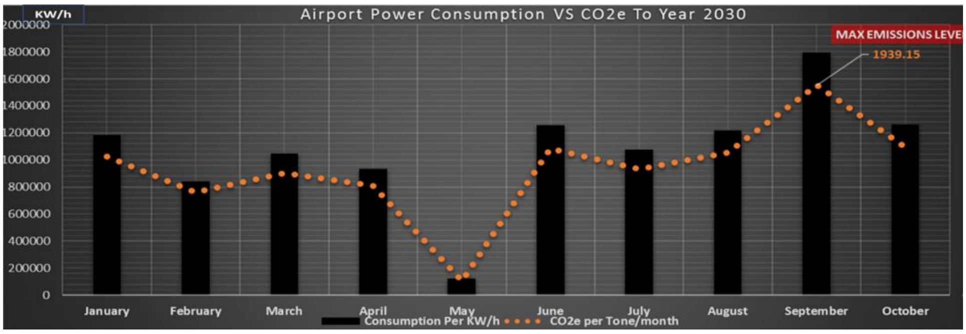

Fig. 10 - Power consumption predicted to year 2030

It is also predicted that the pressure will increase in 2025 compared to the 2021 values in months March, April, July and November. The pressure values in 2030 in October and December increase significantly over the rest of the years, whereas in 2030 the average pressure in April and November increases over the rest of the years [11].

- Temperatures at (2) meters altitude

The study shows that in 2021, the average temperatures may range from 10°C in January to 26°C in June, July and August. Temperature predictions increase in 2025 during August and December by 1°C [11].

Temperatures significantly rise again in 2030 during majority of months in the year. More specifically, in 2030 temperatures rise in January and December to unexpectedly exceed 10°C.

- Relative humidity at (2) meters altitude

It has been noted from the results of the study that humidity in winter reached over 80% in 2021, with lower values in summer up to more than 55%. Values in the rest of the years are vary from increase to decrease, with no overall trend of increase in the rest of the years [11].

- Atmospheric stability state

Figure 11 shows the percentages of atmospheric stability states ranging between extreme stability (accompanying most severe pollution states) and extreme atmospheric instability.
The study shows that all states range from very stable at a very low rate, to unstable at about 5-7% of the study states, and that more than 60% of the states are moderate in all years [11].

5. Results and discussion

5.1. Carbon monoxide (CO)

Highest daily average in a year of carbon monoxide (CO) of air (μg/m³)

Figure 12 shows carbon monoxide dispersion and diffusion in the area around the airport. The concentration increases during the study period from 2021 to 2030. The highest concentration will be on the civil take-off and landing runway. The farther away from the runway, the less gradually the concentration. The highest daily average of this pollutant around the runway is expected to be 21.6 μg/m^3 in 2021.

The concentration decreases by getting away from it to about 0.1 μg/m^3. Pollution concentrations continue to increase gradually around the runway and its surrounding area by increasing the number of planes to reach the highest daily average of 141 μg/m^3 in about 2030, with the lowest concentration in this period being about 1 μg/m^3.

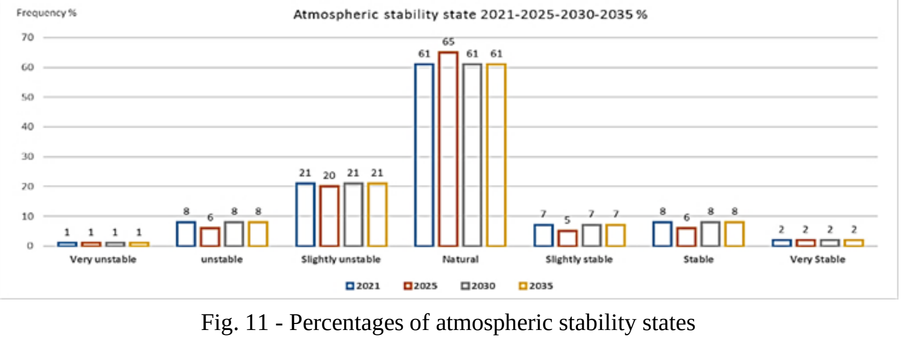

Fig. 11 - Percentages of atmospheric stability states

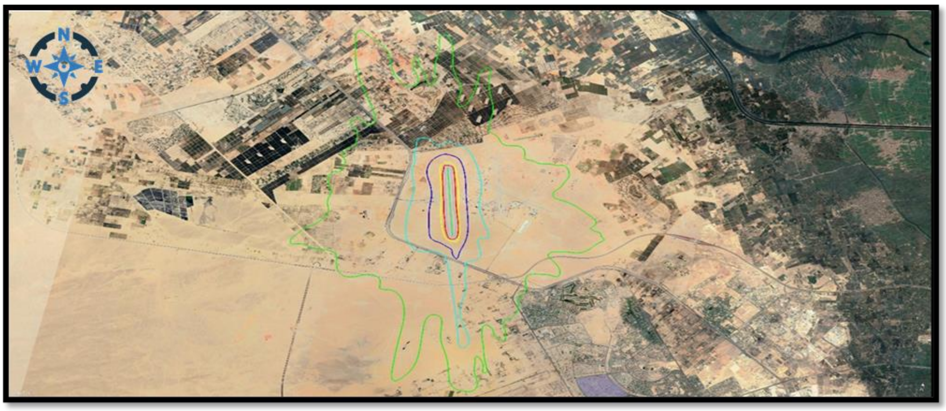

Fig. 12 - Carbon monoxide (CO) dispersion and diffusion in the area around the airport

5.2. Nitrogen dioxide (NO_2)

Highest daily average in a year of nitrogen dioxide (NO_2) of air (µg/m³).

Figure 13 shows the nitrogen dioxide dispersion and diffusion in the area around the airport. The highest concentration will be on the civil take-off and landing runway. The farther away from the runway, the less gradually the concentration.

The highest daily average of this pollutant around the runway is expected to be 16.8 µg/m^3 in 2021. The concentration decreases by getting away from it to about 0.07 µg/m^3. Pollution concentrations continue to increase gradually around the runway and its surrounding area by increasing the number of planes to reach the highest daily average of 100 µg/m^3 in about 2030, with the lowest concentration in this period being about 0.5 µg/m^3.

5.3. Air suspended substances (PM10)

Highest daily average in a year of air suspended substances (PM10) of air (µg/m³).

Figure 14 shows air suspended substances dispersion and diffusion in the area around the airport. The concentration increases during the study period from 2021 to 2030. The highest concentration will be on the civil take-off and landing runway. The farther away from the runway, the less gradually the concentration.

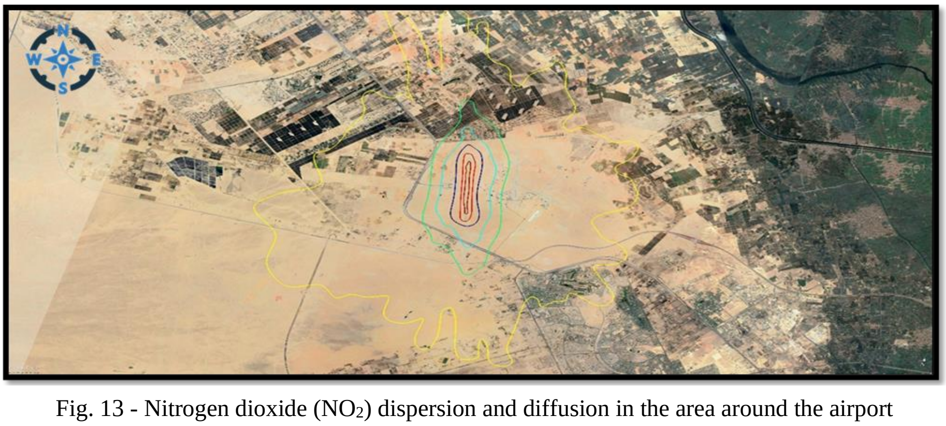

Fig. 13 - Nitrogen dioxide (NO_2) dispersion and diffusion in the area around the airport

Fig. 14 - Air suspended substances (PM10) dispersion and diffusion in the area around the airport

The highest daily average of this pollutant around the runway is expected to be 0.3 μg/m^3 in 2021. The concentration decreases by getting away from it to about 0.01 μg/m^3. Pollution concentrations continue to increase gradually around the runway and its surrounding area by increasing the number of planes to reach the highest daily average of 6.45 μg/m^3 in about 2030, with the lowest concentration in this period being about 0.03 μg/m^3.

Table 4 and Figure 15 show the maximum pollution concentration at 2021 and 2030 of carbon monoxide (CO), nitrogen dioxide (NO_2) and air suspended substances (PM10) around the Sphinx Airport.

Table 5 shows the maximum pollution concentration of carbon monoxide (CO), nitrogen dioxide (NO_2), and air suspended substances (PM10) within 24 hours in the year 2030 and the threshold maximum limits established by the local legislation [7].

Tab. 4 – Air traffic and plane emissions until year 2030

Levels of Pollutants Concentrations on Runway and Apron Area (μg/m^3)		
Parameter	**MAX Year 2021**	**MAX Year 2030**
CO	21.6	141
NO2	16.8	100
PM10	0.32	1.5

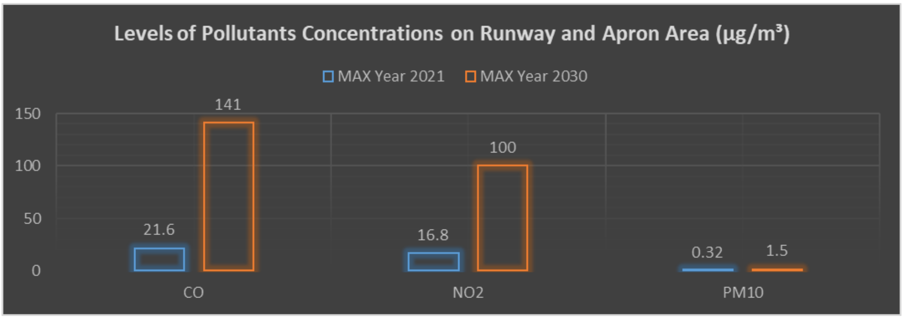

Fig. 15 - Maximum pollution concentration of CO, NO_2 and PM10

Tab. 5 – Maximum concentration of pollutants and limits of local and international standards

Maximum concentration (24H) around airport year 2030 (μg/m³)						
Parameter	EUS	EPA	WHO	IFC	LOCAL	Year 2030
1-CO						1
2- NO2					150	0.2
4- PM10	50	150	20	50	150	0.01

From the study of the base year-2021, it was found that the levels of dispersal of emissions and concentrations in the airport area are very reasonable. These levels are within the limits and levels established by the Egyptian Environment Law No. 4 of 1994, as amended by Law No. 9 of 2009 [7], as well as within the limits set by the World Bank [13] and the World Health Organization [1]. Some sources of emissions would be much lower than before as a result of mitigation measures.

Other sources would increase emissions, such as those from the Cairo-Alexandria desert road, due to the complete shift of traffic to this alternative road. From the above, a comparison between the results of the analyses of emissions from planes and energy consumption shows different impacts on the community and areas adjacent to the airport.

6. Conclusion

This research is focused on monitoring emissions prior to the start-up date of the Sphinx International airport and predicting future emissions from the airport at full operational capacity through three main stages.

The first stage includes planning, selecting the measurement systems, determining the measurement site and how to use the output from the measurement station, and linking air traffic to pollutant sources.

The second stage is related to conducting field measurements on site.

The third stage is focused on the collection of the necessary information to enter the pollutant spread prediction program, producing the emission dispersal modelling maps, and determining the results of the impact of these pollutants on the surrounding area .

It is concluded that the volume of pollutants resulting from the operation of the airport falls under the threshold limits established by the Egyptian Environmental Law. Additionally, it is observed that the volume of emissions resulting from the operation movement is within the safe limits, according to the modelling of the dispersal and spread of the emissions.

7. Recommendations

To ensure that results are consistent with the laws, the following recommendations are advised:

a. Monitoring the actual air traffic rates and comparing them with the rates expected in this study to ensure that the concentration of pollutants does not exceed the identified acceptable values.
b. In case of volume changes in emissions, supplementary studies must be put in place and adhere to the following general operational mitigation measures:
    - supply and installation of a permanent ambient air pollution control system.
    - Supply and installation of a permanent emission control system. This could be an integrated and mobile system to facilitate its setting in different areas inside and outside the airport. This is to conduct field measurements for collection of readings of emissions from the airport operations.

- ➢ Ground service equipment depend on developed and modern technologies that reduce fuel consumption, and consequently reduce emission volumes. Use of advanced technologies in the world of plane engine production must be accelerated and continue to produce new, less fuel-consuming and less emission-producing engines.
- ➢ Airports must be also encouraged to serve planes from airlines powered by new biofuels. This can offer several advantages, including to contribute to mitigating emissions from planes.
- ➢ The international regulations regarding the reduction of plane emissions in the airport area and nearby areas may be summarised as follows:

  When the plane is on the ground:
  - Avoid ordering a plane to execute a sudden stop. Alternatively, reduce the speed with appropriate pace, as any stop followed by movement is to use more power and, hence, to cause more pollution.
  - The plane movement should be continuous as much as possible. For example, if a plane is waiting for a flight clearance, it is appropriate to give it a permission to move instead of ordering access to the runway and stopping afterwards.
  - In case there is a vehicle intercepting the plane, priority must be for the plane; the vehicle is supposed to wait for the plane to finish its manoeuvre.
  - If pilots request to head to the runway for take-off, it is appropriate to run one engine instead of two engines or two engines instead of four.
  - In case the waiting is too long for another plane to exit the apron, it is appropriate to notify the waiting plane turning off one of the engines.
  - The pilot should be notified if the take-off is delayed due to air traffic overcrowding and given the take-off order instead of waiting near the runway to limit early engine operations and long standing in the waiting queue.

  In case of establishing a new international airport:
  - An appropriate area should be selected through carrying out environmental and social impact assessment studies and the contour study of expected emissions.
  - The process should be coordinated with the executive agencies (governorates) near the airport to consider when developing the future strategic plan of the city. This includes consideration of the airport operation navigation area (from 6 to 8 miles) and not establishing or licensing sensitive activities such as compound residential communities, hospitals, hotels, tourist resorts, and similar.
  - Providing annual installation and operation of permanent pollutant measurement systems and modification of dispersion modelling maps.
  - Receiving and implementing constructive customer complaints concerning the airport operations.

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