CAIRO AIRPORT ANNUAL GASEOUS EMISSION INVENTORY

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ABSTRACT

Civil Aviation is one of the most growing up industries around the world, which consumes large amounts of fossil fuel in its various operations such as takeoff, landing, power generation and each other ground services. This makes determination of emissions inventory from its sources for airports transaction very important to determine the effects of gaseous emissions and airport footprint.

One of those airports is Cairo International Airport which is the major airport in Egypt and is going on to expand its operations and strategic plans aiming to become a large hub airport in the Middle East.

This paper is calculating the emissions from the Airport sources (Aircraft movement, ground services, landside traffic and secondary power generators) by using the mathematical calculation for their emission factor.

It was found that the most affected area is the area near runway end 05C which is near to Nasr city district and there are high traffic movements in comparison to the total passenger movement which is around77624 movement/year, and this number represents 52.8% of the total LTO Cycles in the airport. This makes it the most polluted area; thus, there is a need to redistribute the movements between the runways 05C, 05L and 05R.The traffic movements (245,000 vehicle/day) is very high in comparison to the total passenger movements which is 16 Million passenger/Year (about 43,836 passenger/day), this makes the underground an effective environmental control measure

Key Words: Emission inventory– Cairo Airport Emission– Emission Factor– Vehicle emissions– Aircraft Emissions- Traffic emission– Airport emission inventory

INTRODUCTION

Air pollution is defined as the presence in the outdoor atmosphere of one or more contaminants (pollutants) in quantities and duration that can injure human, plant, or animal life or property. SO_2, NO_x, CO and hydro carbon are some of traditional air pollutants. Also Co_2 is the most famous of Greenhouse Gases.

The possibility that aviation might affect tropospheric O_3 and climate appears to have been first considered during the early stratospheric assessments undertaken in the US, UK and France in the early to mid-1970s (e.g. the CIAP, COMESA and COVOS programs) with the increasing recognition that tropospheric O_3 was a climate warming gas (Ramanathan and Dickinson, 1979; Wang, 1980; Lacis , 1990). The earliest paper that identifies aircraft NO_X increasing tropospheric O_3 is not clear but early literature includes (Hidalgo (1977), Hidalgo and Crutzen (1977)) following earlier recognition of a 'cross-over' from O_3 production from volatile organic compounds (VOCs) and NO_X in presence of sunlight in the troposphere to O_3 destruction in the stratosphere by Johnston and Quitevis (1974).

Since many climate experiments have found an approximately linear relationship between a change in global mean radiative forcing (RF) and a change in global mean surface temperature (ΔTs), when the system has reached a new equilibrium, with some proportionality constant, Aviation affects climate in the following ways: (Lee, 2010)

- Emissions of CO_2 result in a positive RF (warming);
- emissions of NO_x result in the formation of tropospheric O_3 via atmospheric chemistry, with a positive RF (warming);
- emissions of NO_x result in the destruction of ambient methane (CH_4), also via atmospheric chemistry, with a negative RF (cooling), which is accompanied by a parallel, decadal loss of tropospheric O_3 (Wild, 2001);
- emissions of sulphate particles arising from sulphur in the fuel result in a negative (direct) RF (cooling);
- emissions of soot particles result in a (direct) positive RF (warming);
- the formation of persistent linear contrails that may form (depending upon atmospheric conditions) in the wake of an aircraft result in both positive and negative RF effects but overall, cause a positive RF effect (warming);

Definition and Classification of airports: With scheduled services Airports passenger service have several classifications:

- Commercial service airports are those airports receiving passenger service and having 2,500 or more annual enplanements.
- Primary airports are commercial service airports having 10,000 or more enplanements.
- Hub airports are airports that serve as a transfer point for passengers changing flights. Hub service airports are classified as large, medium, or small hub airports or non-hub airports, depending on the percentage of total national enplanements for which they account.

- General aviation airports encompass the bulk of civil aircraft operations. The general aviation system includes 98% of all registered civil aircraft and 95% of all airports.Web1.

Aircraft Emissions: Emissions from aircraft engines are recognized as a major source of pollutants at airports and have been extensively investigated over the past 40 years. (Johnston, 1971)

Emission inventories: An emission inventory is a compilation of all air pollution quantities entering the atmosphere from all sources in a geographical area for a time period.(David , 1999)

Emission factors: An emission factor is the average rate at which a pollutant is released into the atmosphere as a result of an activity, such as combustion or industrial production, divided by the level of that activity. Emission factors relate the types and quantities of pollutants emitted to an indicator such as production capacity, quantity of fuel burned, or miles traveled by an automobile (David, 1999)

Ground Service equipment: GSEs include most of the equipment that an airport offers as a service for flights and passengers and includes a large number of vehicles, such as passenger buses, baggage and food carriers, container loader, refilling trucks, cleaning, lavatory services and de/ anti-icing vehicles, and tugs, which are used to move any equipment or to push the aircraft between gates and taxiways. Only few studies are available on the air traffic-related emissions produced by ground services such as ground service equipment Ground power unit (GPU) ,Air starter unit .(Webb, 2008)

Cairo International Airport: Cairo International Airport (IATA: CAI, ICAO: HECA) is the international airport of Cairo and the busiest in Egypt and serves as the primary hub for EgyptAir and EgyptAir Express as well as several other airlines. The airport is located to the northeast of the city around 15 kilometers from the business area of the city and has an area of approximately 37 square kilometers. The airport has three terminals, the third (and largest) opened on 27 April 2009 and the Seasonal Flights Terminal opened on 20 September 2011. Three parallel runway in 2010. Runway 05L/23R is 3,301 meters (10,830.05 ft.) long, 05C/23C has a length of 4,000 meters (13,123.36 ft.), and the new runway is designated as 05R/23L and is 3,999 meters (13,120.08 ft.). A new cargo Village is also under construction (AIP A.R.E AD 2.HECA-1), web4.

AIMS AND OUTLINE OF THE REVIEW

This paper aims to calculate and summarize the Cairo international airport emissions and attempts to analyze its sources. An overview of current information on airport-related emissions is presented and the key characteristics of the pollution and the impacts on the local and global air quality are studied. The methodologies used for calculations depend on the available data for 2013. Also, determine the environmental footprint to reach suitable recommendations to mitigate civil aviation impact.

METHODS AND CALCULATIONS

Cairo Airport have 3 runways (05L, 23R – 05C, 23C – 05R, 23R) are used for takeoff and landing operations, Taxiways to the 2 working terminal TB1, TB3, with 2 main roads to enter or exit the airport vicinity (routes) EL-Orouba road , Autostrad road (AIP A.R.E AD 2.HECA-1), TB2 EIA,2011

1-Aircraft Emission: The LTO is defined as all activities that take place at altitudes below 3000 feet (915 m).

This cycle consists of four modal phases chosen to represent approach, taxi/idle, take-off and climb and is a much simplified version of the operational flight cycle in table1. ICAO, Doc 9889

Table1: Time mode and trust for LTO Cycle phase

<table>
<tr><th>Operation phase</th><th colspan="2">Time in mode (minutes)</th><th>Thrust setting (% of rated thrust)</th></tr>
<tr><td>Approach</td><td>4.0</td><td></td><td>30</td></tr>
<tr><td rowspan="2">Taxi and ground ideal</td><td rowspan="2">26</td><td>7.0 (in)</td><td rowspan="2">7</td></tr>
<tr><td>19.0(out)</td></tr>
<tr><td>Takeoff</td><td>0.7</td><td></td><td>100</td></tr>
<tr><td>Climb</td><td>2.2</td><td></td><td>85</td></tr>
</table>

Military aircraft: Despite the relatively high potential impact of military aircraft emissions under particular circumstances, the task of studying military emissions is very difficult. Unlike civil aviation, military operations generally do not work to set flight profiles and do not follow fixed plans (Wahner, 1995) In addition, national and military authorities are reluctant to disclose sensitive information either about operations or in-use technologies. The lack of comprehensive data about military operations makes realistic assessments of the contribution of military aircraft in terms of fuel consumption extremely difficult. In addition, some aircraft may have a dual function, such as the C-130 Hercules, which can be engaged in both military and civilian operations. (Henderson, 1999)

2-Ground Service (GS) Emissions calculation: Using the aircraft-based approach, emissions can be calculated using the number of aircraft arrivals, departures, or both, and default emission factors, emissions are calculated by multiplying the number of movements for Narrow-body aircraft (single-aisle fixed-wing jet and Wide-body aircraft (double-aisle fixed-wing jet) by the emission factor

(ICAO, Doc 9889).

Table 2: Emission factor for GSE

Pollutant (kg/cycle)	**Narrow-body**	**Wide-body**
NO_X	0.400	0.900
HC	0.040	0.070
CO	0.150	0.300
PM_{10}	0.025	0.055
CO_2	18	58

3-Secondary Power plant fuel consumption:

Emission estimate requires the following for each source category and fuel:

- Data on the amount of fuel combusted in the source category
- A default emission factor

Emission factors come from the default values provided together with associated uncertainty range

Default emission factors for stationary combustion in the energy industries

(Kg of greenhouse gas per TJ on a Net Calorific Basis)

Table 3: Emission factor for **Secondary Power plant**

Fuel	CO_2	CH_4	N_2O
Gas/Diesel Oil	74,100	3	0.6

Emissions $_{GHG, fuel}$ **= Fuel Consumption** $_{fuel}$ **• Emission Factor** $_{GHG, fuel}$

Emissions $_{GHG, fuel}$ = emissions of a given GHG by type of fuel (kg GHG)

Fuel Consumption fuel = amount of fuel combusted (Tera-Joule (TJ))

Emission Factor GHG, fuel = default emission factor of a given GHG by type of fuel (kg gas/TJ). (IPCC, 2006)

1 ton of oil equivalent = 0.0419 TJ Web1, Web2:

4-Land Side vehicle Emission (Traffic): On-road landside vehicles include taxis, vans, buses and privately-owned cars; light- and heavy-duty vehicles; and motorbikes and scooters travelling on the airport's internal roadway network and within the airport are parking facilities. Its emission can be calculated using the Following general equation:

$$E = RL \times NV \times EF$$

Where:

E = emissions (e.g. grams);

RL = road length (e.g. kilometers);

NV = number of vehicles on the road by class, age and speed;

EF = emission factor considering vehicle class, age and speed (e.g. grams/vehicle-kilometer travelled).

Egyptian Vehicle Emission Factor shown in the following table:

Table 4 :emission factor for Land Side vehicle

Total HC	Exhaust HC	Evaporated HC	CO	NOx
11.8	6.0	5.8	61.7	5.0

(Eugene, 1996)

RESULTS AND DISCUSSIONS

Table5: Runway Used in Aircraft operation

Runway	Annual Movement	Percentage (%)
05C	77624	52.8
05L	26228	17.8
23C	20773	14.1
Runway	**Annual Movement**	**Percentage (%)**
23R	9293	6.3
05R	6972	4.7
(blank)*	4191	2.8
23L	1982	1.3

*Due to mistakes in flight data registration(from the source) or security issues some Runway Sid isn't registered in the raw data

Here we found the most used runway is runway Sid 05C with 52.8% followed by 05L while o5R which built as mitigation measure to remove the operations and emissions from Nasr city and Sheraton district used 4.7% due to air traffic controller officer wasn't familiar with this new runway and also there was power failure in its light support

Table 6: Annual Aircraft type movement

More Than 1,000 LTO Cycle Movement \ year					
AC type	**Count**	**AC type**	**Count**	**AC type**	**Count**
A320	14854	**A321**	5006	**B772**	2425
B738	13896	**A332**	3679	**B777**	2115
E170	11333	**A333**	3190	**E190**	1037
More Than 100 LTO Cycle Movement \ year					
A306	615	**T204**	346	**B734**	180
B737	582	**A310**	264	**BE**	166
B744	579	**B733**	256	**A300**	146
A319	477	**B763**	235	**B735**	137
A343	434	**MD83**	231	**A342**	125
MD11	427	**B773**	215	**Total**	**62950**

Airbus A320 and Boing B738 the most used aircraft as the largest operator in Cairo airport is EgyptAir depend on it in both international and domestic flights.

Table7: Cairo Airport working Ground Service Gasoline Vehicles

Vehicle Type	Count	Vehicle Type	Count
pickup	28	**staff car**	8
Van	16	**limousine**	2
Microbus	11	**Basket elevator**	1
Grand Total		66	

Table8: Cairo Airport working Ground Service Diesel Vehicles

GSE vehicle	Count	GSE vehicle	Count	GSE vehicle	Count
baggage tractor	226	**pushback**	34	**Water tank**	11
pickup	150	**fuel tank**	33	**Air Handling**	8
stairs	126	**Air Handling Units**	32	**basket elevator**	7
baggage belt	97	**Microbus**	28	**scavenging**	6
Passenger bus	72			**Transporter**	5
Ground Power Unit	70	**Minibus**	22	**staff bus**	4
aircraft cargo loader	68	**accessibility vehicle**	19	**garbage**	1
Catering	49	**Toilet**	17	**Rubber Scavenger**	2
Van	48	**Crew microbus**	14	**Grand total**	975
forklift	39	**Air Handling Units**	13		

Traffic Emission: CAI Average Daily Traffic on the Orouba Road and Autostrade Road (ring road) is 140000 and 105000 vehicles/day, respectively.

- Orouba-Salah Salem road (Route 1). With Length 3.6 Km
- El-Nasr / Autostrade /Ring Road (Route 2). 6.5 Km

Table9: Annual Land Side traffic emissions in Kg

Route	Total HC	CO	NO_x
Orouba	2,170,728.0	11,350,332.0	919,800.0
Autostrade	2,939,527.5	15,370,241.3	1,245,562.5
Total (E_T)	5,110,255.5	26,720,573.3	2,165,362.5

Table10: Aircraft Annual LTO Cycle emissions (Ton \ Year)

AC type	Total LTO Cycle	CO2	HC	NOx	CO	SO2	Fuel
Total	**63,405**	**208,082.16**	**70.62**	**1,105.43**	**565.29**	**67.94**	**70,224.12**

Table 11: Emergency Power Generator Annual emissions (Kg)

Station name	Oil used (Ton)	Oil used (TJ)	CO_2	CH_4	N_2O
05R/23L	1.80	0.08	5,588.62	0.23	0.05
S.S	1.80	0.08	5,588.62	0.23	0.05
TDC3	35.82	1.50	111,213.58	4.50	0.90
hall 3	1.08	0.05	3,353.17	0.14	0.03
hall 4	1.08	0.05	3,353.17	0.14	0.03
fire Hall4	0.09	0.001	279.43	0.01	0.00
Hall 4 hangar	1.80	0.08	5,588.62	0.23	0.05
Hall 4 fire hangar	0.09	0.001	279.43	0.01	0.00
Grand Total (E_P)	43.56	1.83	135,244.65	5.48	1.10

Finally CAI annual emissions can be calculated as follow:

$$E = E_T + E_F + E_{GS} + E_P$$

Where:

E= the annual total emitted emissions

E_T **=** annual emission from landside traffic

E_F **=** annual emission from flight Operation

E_{GS} **=** annual emission from ground service

E_P= annual emission from Emergency Power Generator

Pollutant	**CO_2**	**HC**	**CO**	**NO_X**	**N_2O**	**SO_2**
Total/Ton	208,217.40	5,180.88	27,285.86	3,270.80	0.001	67.94

CONCLUSION

- Most of Airport pollution comes from aircraft operation as it use massive amount of Fuel in take-off and landing.
- The most affected Area from the Airport landing- takeoff cycle is this one at the end of runway 05C which corresponding to the Airway over Nasr City area followed by 05L which is over Heliopolis district while
- Regular Using Military Aircraft in civilian Airports makes it so difficult to determine or control Airport Pollutants
- The high traffic movements is very high regard to the total passenger movement 16 Million\Year about 43,836 passenger\day while there are 245,000 vehicle/day

RECOMMENDATION

- Some of Narrow bodies Aircrafts Such like Embraer- E190, Tupolev Tu-204 and like Embraer- E170 should be replaced by more environmental friend Aircrafts or apply environmental charge on it
- Runway Sid 05R and 05L should be used to reduce the load on 05C
- Using terminal tube service can reduce movement of about 407 vehicles running in Airside area (stairs, air handling, APU, Crew microbus ,Passenger bus)
- Using Cairo Metro Will help reducing the land side traffic emissions

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حصر سنوي للانبعاثات الغازية الصادرة من مطار القاهرة

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المستخلص

تعتبر صناعة الطيران المدني واحدة من اكثر الصناعات نموا في العالم والتي تستهلك كميات كبيرة جدا من الوقود الاحفوري في مختلف عملياتها مثل اقلاع وهبوط الطائرات وتوليد الطاقة وكذا الخدمات الارضية للطائرات ونقل الركاب مما يجعل حصر الانبعاثات من مصادرها المختلفة في المطارات هام للغاية لتحديد تأثير الملوثات الغازية المنبعثه وكذلك تحديد البصمة البيئية للمطارات

من احد هذه المطارت مطار القارة الدولي وهو المطار المحوري والرئيسي لجمهورية مصر العربية والذي يقوم بتوسعات مختلفة ساعيا كي يصبح مطارا محوريا في منطقة الشرق الاوسط

ونحن بصدد دراسة الانبعاثات الغازية الصادرة من حركة الطائرات ومعدات الخدمات الارضية وكذا مولدات الطاقة الاحتياطية والانبعاثات الغازية الصادرة عن حركة المركبات المارة في الطرق الرئيسية من والي المطار.

وبحسابها رياضيا تلاحظ ان المنطقة الاكثر تعرضا لتلوث الهواء هي المنطقة القريبة من طرف ممر الاقلاع والهبوط المرمز ب 05C والذي يعتبر شديد القرب من منطقة مدينة نصر وامتدادها حيث شهدد ٧٧٦٢ دورة اقلاع وهبوط خلال عام وهي ما يمثل ٥٢,٨% من اجمالي الحركة في مطار القاهرة مما يستدعي ان يتم توزيع هذه الحركة علي باقي اطراف الممرات 05L,05R لخفض التأثيرات البيئية كما تلاحظ ان حركة ٢٤٥٠٠٠ سيارة ومركبة في الطرقات يوميا وهو عدد كبيرا مقارنة بعدد الركاب اليومي للمطار (٤٣٨٣٦ في اليوم من اصل ١٦ مليون راكب في العام) مما يجعل انه في حالة استخدام مترو الانفاق سيساعد كثيرا في تحسين نوعية الهواء بمطار القاهرة ويكون بذلك معالجة بيئية جيدة