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Air Pollution Impact Assessment for Sharm El-Sheikh Airport

Bjarne Sivertsen

Ministry of State for
Environmental Affairs

Norwegian Institute
for Air Research

Preface

This report is prepared as input to the report on environmental impact assessments prepared by The Engineering Consultants Group (ECG). The input is prepared to be directly inserted in the complete report given by the Table of Contents presented by ECG during a meeting in Cairo on 8 October 2003.

The work has been undertaken during a very short period of time, and can not be considered as a final and complete assessment of all aspects of air pollution

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Summary

The total air pollution impact from the future Sharm El-Sheikh airport will not result in any adverse health impacts. The concentrations are normally well below the air quality limit values given in Law no. 4 of Egypt and by the World Health Organisation guideline values. Short term concentrations of NO_2 and SO_2 in the unloading zone near the Terminal building may represent the most "critical" case.

The Norwegian Institute for Air Research (NILU) together with the Egyptian Environmental Affairs Agency (EEAA) has been requested to undertake an Environmental Impact Assessment (EIA) related to air pollution emitted from the different sources at the Sharm El-Sheikh International Airport.

The Air Pollution Impact Assessment has been based on measurements and modelling of ground level concentrations due to emissions from road traffic and aircraft operations. The main air pollution problem in the background atmosphere is suspended particles originating mainly from natural wind blown dust.

The total air pollution impact from the future Sharm El-Sheikh airport will not result in any adverse health impacts. The concentrations are normally much below the air quality limit values given in Law no. 4 of Egypt and by the World Health Organisation guideline values.

The most "critical" case is the maximum one-hour average NO_2 concentration in the unloading and parking zone at the Terminal building. The maximum concentration may reach 75 % of the air quality limit for Egypt, and is higher than the WHO guideline value.

Based on the outcome of the concentration estimates presented for Sharm El-Sheikh airport there will probably not be an urgent need to start evaluation an optimal abatement plan for the airport activities at this point in time. However, there are reasons to look at the impact from the road traffic bringing passengers to and from the airport.

The NOx exposure predicted at the Terminal area may be reduced considerably by implementing three-way catalytic converters in all cars. The change from using diesel in all mini buses and buses may also reduce some of the impact. The SO_2 impact will disappear almost completely in this case and CO and VOC emissions will also be reduced.

Air Pollution Impact Assessment for Sharm El-Sheikh Airport

1 Introduction

The Norwegian Institute for Air Research (NILU) together with the Egyptian Environmental Affairs Agency (EEAA) has been requested to undertake an Environmental Impact Assessment (EIA) related to air pollution emitted from the different sources at the Sharm El-Sheikh International Airport.

As a first task NILU was requested to briefly outline the work necessary to present the EIA. A very limited amount of finance has been made available. No detailed air pollution modelling has thus been possible. Some background air quality data has been collected, and further information about the general air quality on the Sinai peninsula will have to be collected from the EIMP programme. (Ras Mohamed station)

2 Input to Ch. 4, description of the environment

General information about background air quality in the areas of Sharm El-Sheikh will be collected from the EEAA/EIMP air quality monitoring station at Ras Mohamed. Measurements at the airport have also been started in September 2003.

2.1 Meteorology and climate

The meteorological conditions in the area surrounding the Sharm El-Sheikh airport is dominated by the Bay of Aqaba as well as the mountains of Sinai. A very predominant northerly wind is prevailing in the area.

During the summer season the weather is dry and hot with prevailing winds from north and north-northeast. During winter the wind is frequently also blowing from southerly directions. In the Spring strong dusty winds may occur bringing high concentrations of dust. During Autumn season it may occasionally rain heavily.

We have tried to obtain a relevant wind direction frequency distribution (Wind rose) for Sharm El-Sheikh, but this has been completely impossible during the development of this report.

2.2 Air Quality Baseline studies

Within the short deadline of the project it has been very limited possibilities to collect background information at the airport and in areas of the new terminal. However, a mobile (moveable) station as provided by EEAA Suez Regional Branch Office has been located near the existing terminal building and near the airport terminal. Some short tem measurements have also been carried out at hotels, which have been assumed to be impacted by emissions from airport activities.

We have proposed to use as few sampling points as possible and rather find one or two representative sites, where the maximum impact could be identified. Meteorological data that should have been used together with air quality data to explain the sources of impact did not work properly during the campaign..

The mobile laboratory has instruments for measuring the most relevant indicators and compounds such as:

- Nitrogen oxide (NO_2, NO_x) (1 hour resolution)
- Sulphur dioxide (SO_2) (1 hour resolution)
- Carbon monoxide (CO) (1 hour resolution)
- Hydrocarbon (NMHC) (1hour resolution)

Particles < 10 um (PM_{10}) was not measured during the campaign, but data are available from the EIMP/EEAA network. These are used to define the background level of suspended dust.
A map of the locations of monitors and samplers is presented in Figure 1.

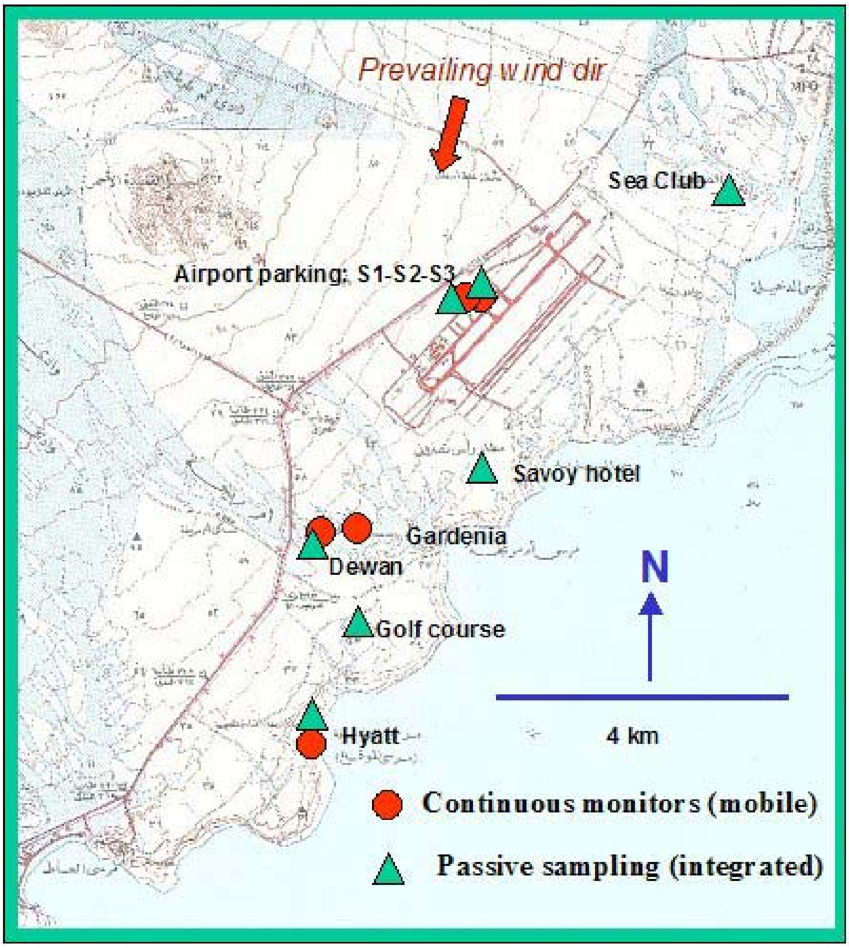


Figure 1: The location of monitors, located in the mobile van, and passive samplers used during the measurement campaign.

In addition to the mobile laboratory, which will undertake measurements every hour, samples of SO_2, NO_2 and VOC have been collected at various positions around the planned terminal area, as shown in .Figure 1.

2.2.1 Preliminary results, passive sampling

An example of measurements undertaken using passive samplers at the Terminal building of the existing Sharm El-Sheikh airport is presented in Figure 2. The passive samplers represent an integrated average over the period of sampling. The concentrations shown below are thus 11-day averages.

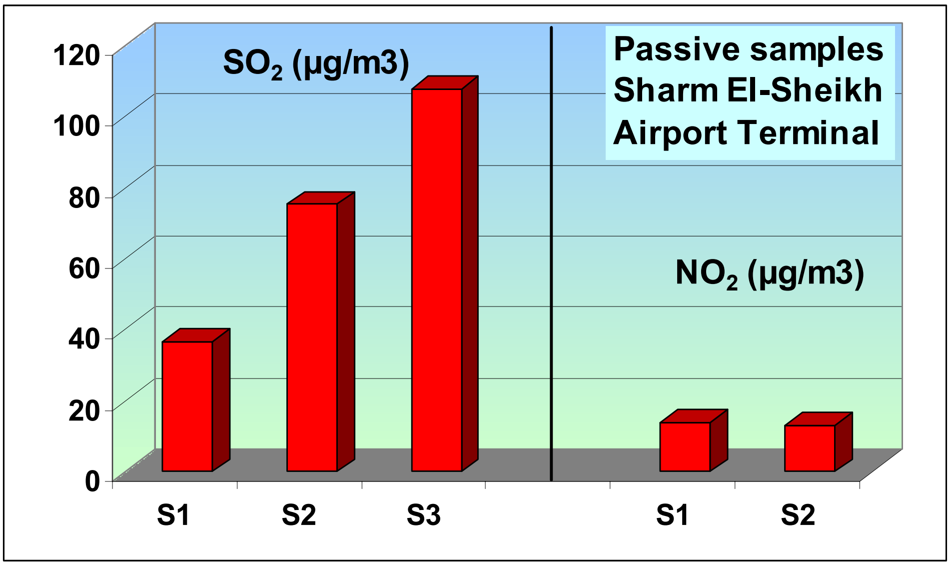


Figure 2: Passive samples of SO_2 and NO_2 collected at the Airport Terminal in Sharm El-Sheik, from 23 Sep to 4 Oct 2003. S1 to S3 are sampling positions around the parking area of the Terminal building.

The NO_2 concentrations were only slightly higher than the background level measured at Ras Mohamed (see below), but lower than NO_2 concentrations measured in Nawa Bay.

The SO_2 concentrations at the Terminal building were surprisingly high. This may be due to the high number of buses operating from this airport. Sampling point S3 is near the area where buses stop to unload tourists. The measurements were collected near the bus acceleration area. All buses are operated on sulphur rich diesel. This action has probably created high SO_2 concentrations due to the use of diesel.

2.2.2 Preliminary results, one-hour averages

Continuous measurements have been performed at different sites in the airport area as shown in Figure 1. The mobile station used for these measurements is shown in the picture.

At the time this report was prepared the raw data had not been processed completely. The second series of measurements in the parking area at the Airport Terminal had started on 13 October 2003, and only one day of measurements was available when Figure 3 was produced.

Figure 3 show the highest one-hour average concentrations measured at 5 positions for the mobile station. The time used at each location varied from three days to one week. The second airport parking period (at the top of the figure) only includes one day. Measurements continued after these data were collected.

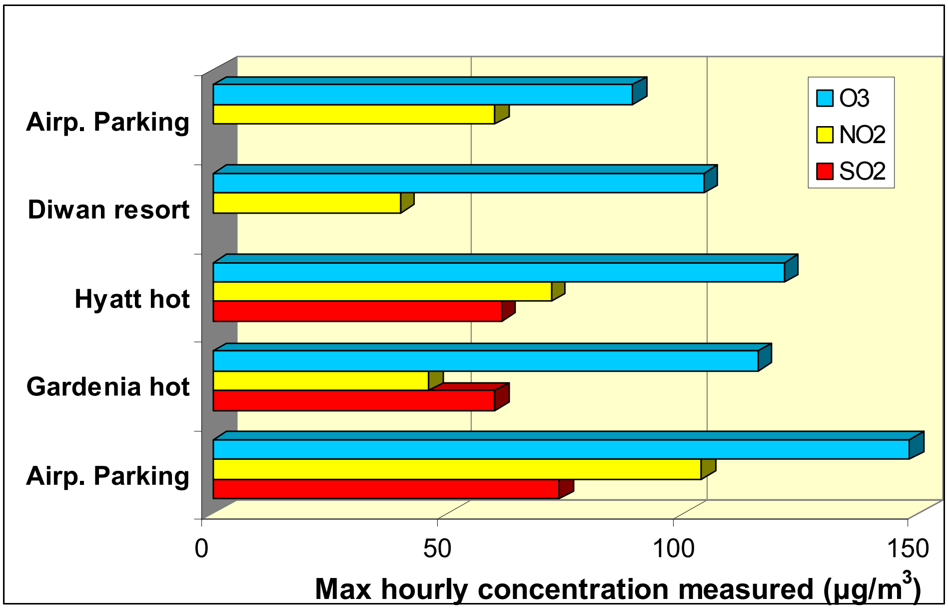


Figure 3: The highest one-hour average concentration of SO2, NO2 and ozone measured at the different sites during a few measurement campaign days in September-October 2003.

The ozone concentrations ranged between 85 and 150 µg/m^3. The highest concentration is similar to the background concentrations measured at mid-day and in the afternoon at Ras Mohamed (see below).

The NO_2 concentrations were highest at the parking area of the Airport. The peak concentration is measured during peak hour traffic. The average concentration is not higher than "background" levels measured around Sharm El-Sheikh (Naewa bay).

The highest one-hour average SO_2 concentration measured during part of the campaign was 70 µg/m^3 . This was at the parking area at the Airport. However, there are evidently other sources to SO_2 in the area.

2.2.3 Background air quality

Measurements of ozone and PM_{10} have been undertaken as part of the EIMP/EEAA programme at Ras Mohamed at the southern tip of Sinai Peninsula since 1999. Samples of SO_2 and NO_2 have been collected both at Ras Mohamed and in Sharm El-Sheikh (Naewa Bay) using passive samplers.

Figure 4 show typical daily average PM_{10} concentrations measured at Ras Mohamed in 2001, 2002 and 2003.

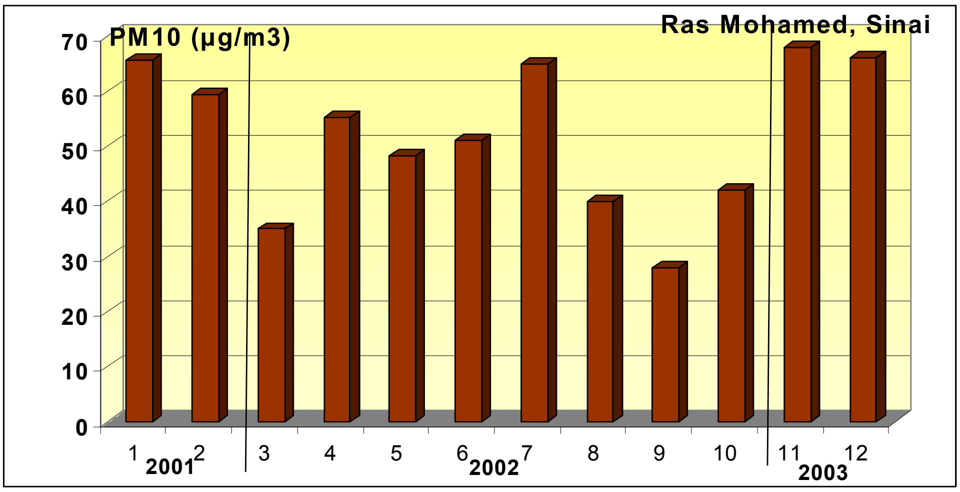


Figure 4: Daily average PM_{10} concentration measured at 12 randomly selected days in 2001 to 2003 at Ras Mohamed, Sinai.

The background PM_{10} concentrations as measured at Ras Mohamed varied between 28 and 68 µg/m^3 . The annual average background concentration of PM_{10} measured at Ras Mohamed in 2002 was 45 µg/m^3 . The average concentrations of SO_2 and NO_2 is given in the Table 1 below.

Table 1: Annual average concentrations of SO_2 and NO_2 measured by passive samplers on a monthly basis in Sharm El-Sheikh and at Ras Mohamed, Sinai, 2000-2002.

Site	Year	Number of samples	Average SO_2 ($\mu g/m^3$)	Average NO_2 ($\mu g/m^3$)
Sharm El-Sheikh	2000	4	60	33
	2001	3	34	32
	2002	3	29	38
Ras Mohamed	2000	11	16	13
	2001	5	30	9
	2002	9	23	9

The average background SO_2 concentrations at the southern Sinai area seem to be about 23 $\mu g/m^3$: In Sharm EL-Sheikh the average SO_2 concentration was 43 $\mu g/m^3$.

The background NO_2 concentrations at Ras Mohamed was about 10 $\mu g/m^3$, while it was more than 3 times this in Sharm El-Sheikh. There is clearly a local source for NO_2 in Sharm El-Sheikh, which probably is related to road traffic.

Background ozone measurements have been collected at Ras Mohamed since 2000.

Figure 5 shows a typical diurnal pattern of ozone concentrations measured at the EIMP/EEAA site in Ras Mohamed. The afternoon maximum concentrations reach about 150 $\mu g/m^3$ during the summer season.

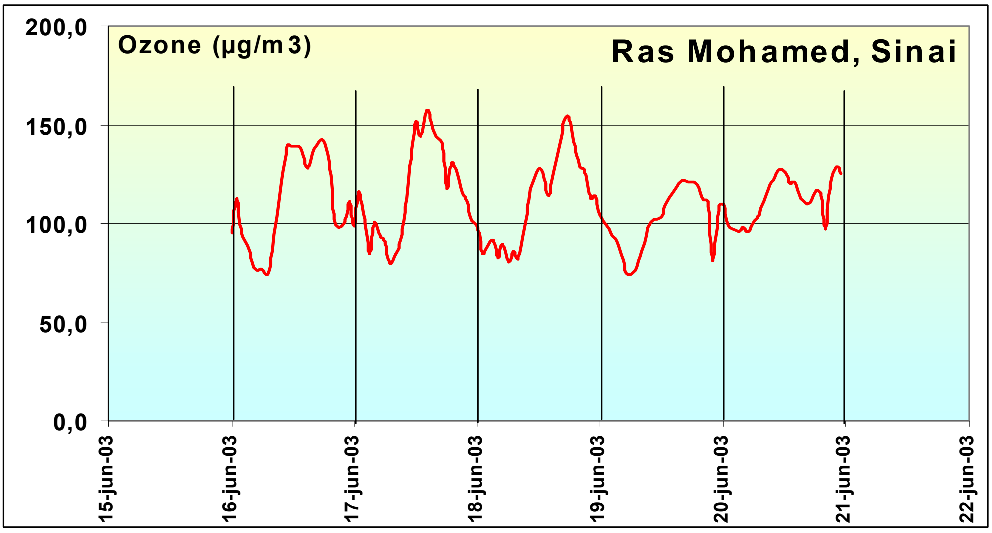


Figure 5: Typical concentrations of ozone measured at Ras Mohamed in June 2003. (EIMP/EEAA programme, Quarterly report)

The annual average afternoon concentrations at Ras Mohamed reached about 110 µg/m^3 , while the urban sites show maximum concentrations of ozone less than at the background data, as shown in Figure 6.

These measurements are also in agreement with the results of the campaign measurements performed in September-October 2003 as presented above. The reason for lower ozone concentrations measured occasionally at the Airport parking area, is the influence of NOx, which uses ozone to produce NO_2.

This background ozone will be sufficient to transform the NOx emissions (mostly NO) effectively to NO_2 in the atmosphere. We have thus for estimates of maximum impact of NOx emissions in the next chapter assumed that all NO is transformed to NO_2.

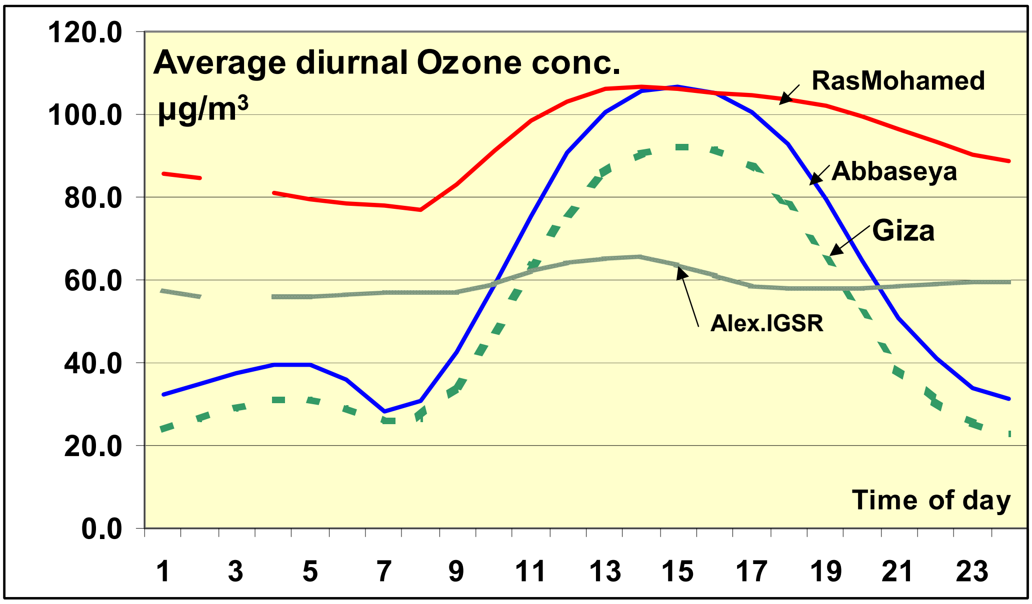


Figure 6: Annual average diurnal variation of ozone at different sites in Egypt (2000-2002).

The other air pollutant compounds SO_2, NO_2 and VOC was not measured continuously at Ras Mohamed and has been evaluated based on field sampling using EEAA/NILU passive sampling technique.

2.3 Possible emission sources and compounds

The main sources of air pollution will come from aircraft engines, surface vehicles of all kinds, ground support systems, power plants, fuel tank areas, fire training activities and refuelling activities. The main air pollutant compounds acting as the most important indicators for air pollution in the surrounding areas will be:

- Nitrogen oxides (NOx, and especially nitrogen dioxide NO_2), mainly from road traffic, aircrafts and power production,

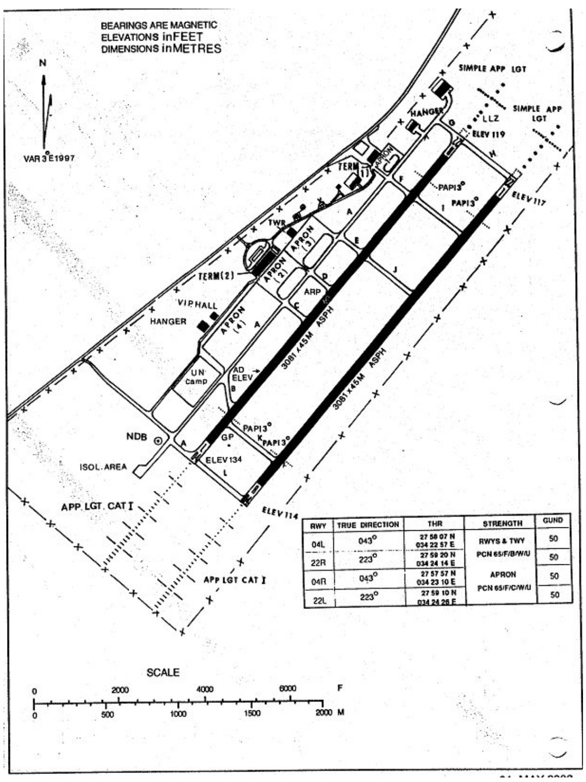
- Sulphur dioxide (SO_2), from power plants, waste burning, fires and diesel vehicles
- Hydrocarbons (HCs) consisting of different subgroups of different compounds such as benzene, toluene and xylene (BTX) and volatile organic compound (VOC), from fuel storage areas and fuelling, a source of odours,
- Particulate matter (indicator PM_{10}, particles with diameter < 10 μm), from diesel vehicles and general activities, burning and transport,
- Carbon Monoxide (CO) from road traffic, cars idling at Terminal,
- Carbon Dioxide (CO_2), from all burning of fossil fuels, only a global problem.

For Sharm El-Sheikh airport it will be necessary to perform rough estimates of emission rates and maximum concentrations for the most important indicators.

3 Input to Ch. 5, Environmental impacts; a) Emissions

3.1 Airport layout

The Sharm El-Sheikh airport is located about 650 km south east of Cairo, in the south-eastern part of the Sinai Peninsula at the Gulf of Aqaba. It is located 23 km north-east of the city of Sharm El-Sheikh at 34 deg 23 min 36 sec North, 27 deg 58 min 43 sec East. The elevation about sea level is 43 m.



The runway presently in use is RWY 04L/22R. This is oriented 43 deg (NE) to 223 deg (SW).

The airport capacity is estimated at 1200 passengers per hour. It uses one runway even if a second runway is available. The Terminal hall contain an arrival hall which is designed for the largest styles of airplanes.

3.2 Air traffic density

Passenger forecasts have been presented by several companies. In the following estimates of impact we have used the numbers given by ABB, as they represent a kind of average of all prognoses given.

Table 2: Passenger forecast for Sharm El-Sheikh airport based on data by ABB.

Year	Number passengers (million)	Number of aircrafts	
		Low estimate	High estimate
2002	2,6	20 600	24 294
2005	3,5	27 793	34 167
2020	5,0	63 319	100 783

The traffic is to a certain degree seasonal dependent as seen in Figure 7. The actual numbers of passengers as given by the statistics from 2002 were 2,8 million passengers visiting Sharm El-Sheikh airport, and the total number of flights were 22 500.

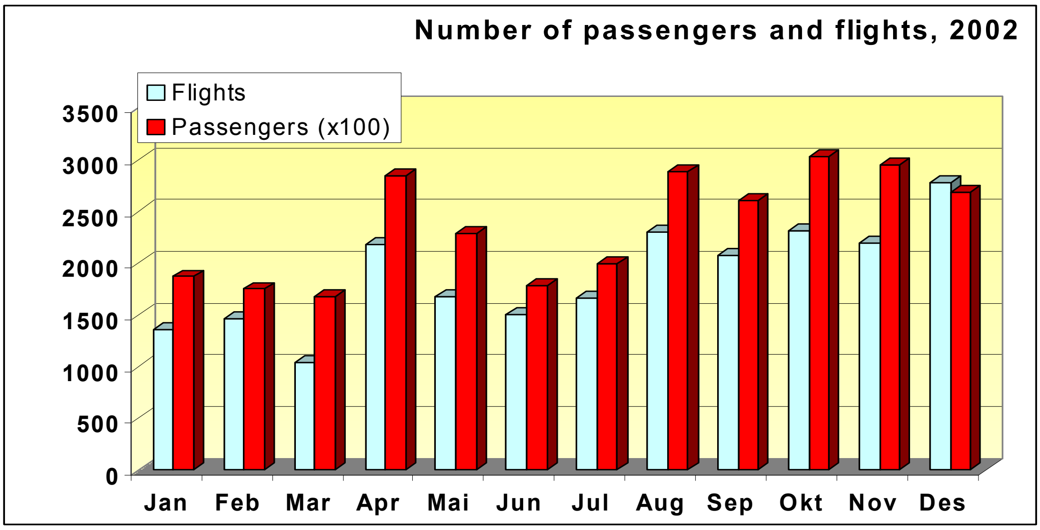


Figure 7: Annual distribution of passengers and flights at Sharm El-Sheikh airport in 2002, arrivals and departures added.

The largest monthly number of passengers transported to Sharm El-Sheikh was recorded in October 2002, which had 303 000 passengers. The number of flights in the same month was 2312 aircrafts. The largest number of flights were recorded in December 2002 at 2777.

The daily average number of flights in December were 90. The current airport capacity is estimated to 13 aircrafts at Apron per hour. This will be the aircraft peak hour capacity. Prognoses for traffic densities indicated that this capacity will be met in 2007.

The basis for all emission estimates in this report is the prognoses given for air traffic density at the Sharm El-Sheikh Airport for 2005 and 2020. The numbers used in the model estimates later are given in Table 3.

Table 3: Estimated number of flights and passengers at Sharm El-Sheikh airport for 2005 and 2020. Annual averages as well as peak hour traffic is presented.

	Year	flights	passengers	pass per h	Capacity
Annual	2005	30000	3500000	438	
	2020	65000	5000000	625	
Peak	2005	11	1283		1200
	2020	22	1692		1700

For Sharm El-Sheikh airport the prognoses given by ABB have shown that there might be about 5 million passengers in 2020. This is about 30 % of the prognosis for traffic at the new Cairo International Airport.

3.3 Aircraft emissions

3.3.1 Emission factors

Emissions from aircraft originate from fuel burned in aircraft engines. The fuel use and emissions will be dependent on the fuel type, aircraft type, engine type, engine load and flying altitude.

Two types of fuels are used. *Gasoline* is used in small piston engined aircraft only. Most aircraft run on kerosene, and the bulk of fuel used for aviation is kerosene. Turbojet engines use only energy from the expanding exhaust stream for propulsion, whereas turbofan and turboprop engines use energy from the turbine to drive a fan or propeller for propulsion.

Most emissions at Sharm El-Sheikh airport will originate from Civil IFR (Instrumental Flight Rules) flights, which covers the scheduled flights of "ordinary" aircraft.

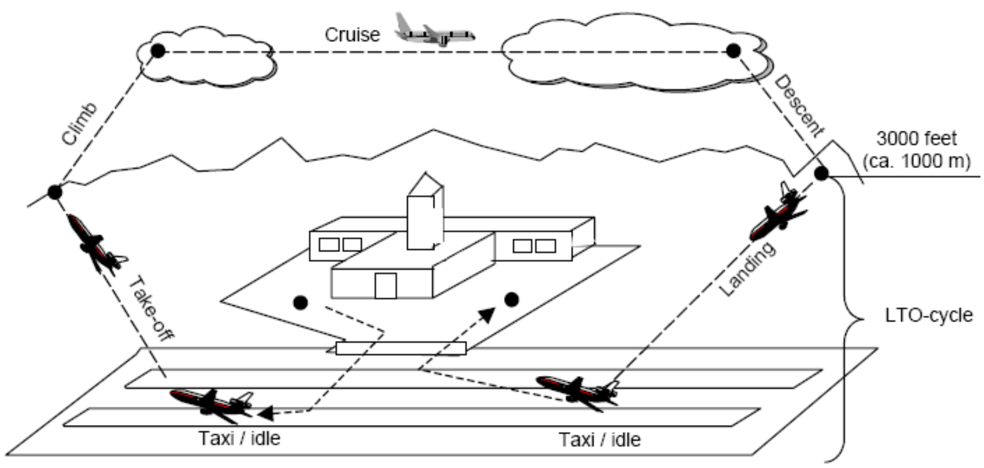


Figure 8: Aircraft operations divided into different cycles.

Operations of aircraft are usually divided into two main parts as shown in Figure 8 (EEA 2000):

- The *Landing/Take-off* (LTO) *cycle* which includes all activities near the airport that take place below the altitude of 3000 feet (1000 m). This therefore includes taxi-in and out, take-off, climb-out, and approach landing.
- *Cruise* which here is defined as all activities that take place at altitudes above 3000 feet (1000 m). No upper limit of altitude is given. Cruise, in the inventory methodology, includes climb to cruise altitude, cruise, and descent from cruise altitudes.

Emissions that will impact on the local air quality only take place in the LTO cycle. Greenhouse gas emissions are also interesting in the cruise cycle. These emissions are combustion products and by-products and includes mainly CO2 and NOx . Also methane, nitrous oxide and other by-product gases may be of interest.

Table 4: Default fuel use and emission factors for average aircraft for the LTO cycle and for cruise. (Source. IPCC Guidelines on National Greenhouse Gas Inventories)

		Emission factor average aircraft (kg/LTO)				
	Fuel	SO2	CO	Nox	NMVOC	CO2
LTO Average fleet	2500	2.5	50	41	15	7900
LTO old fleet	2400	2.4	101	24	66	7560
Cruise (kg/ton)		1	5	17	2.7	3150

Based on the prognoses for traffic at the Airport in 2020 we have assumed that the peak hour traffic equals 22 flights per hour. Using the emission factors from a typical average composition of aircrafts (EEA, 2000) we have estimated the emissions for each operational mode as presented in Table 5.

Table 5: Estimated emission rates of SO_2, CO, NOx, and NMVOC during peak hour traffic at the Sharm El-Sheikh Airport 2020.

		Emission rate at peak hour, 2020 (kg/h)			
Peak hour	N flight	SO2	CO	Nox	NMVOC
Arrival	22	8,9	108,2	154,6	14,7
Taxe		3,5	412,3	51,6	128,5
Taxe		3,5	542,7	68,0	169,2
T-O		39,0	36,8	627,8	17,6

For estimating impact of air pollution we assume that the short-term peak hour situation will be the most critical. The nature of operations and traffic at an airport of Sharm El-Sheikh's size will give relatively less adverse effects from the long term average concentrations.

We have thus concentrated most of the modelling of future impacts on the peak hour traffic for year 2020. If this comes out acceptable, the other options; long term averages and activities year 2005 will also be acceptable when air pollution is concerned.

3.4 Road traffic emissions

A very limited amount of road traffic data have been made available for this study so far. Based on the peak hour prognoses for traffic rates; passengers and flights, we have estimated the number of peak hour passengers to be 1692.

The fraction of type of cars has also been estimated based on simple interviews at the airport. It is assumed that most of the tourists are transported from and till the airport by minibuses and buses.

The input data for modelling emissions is presented in Table 6.

Table 6: Distribution of cars on the airport road during peak hour (based on data for 2020 prognoses.

Type of car	Fraction	N passengers	N cars
private & taxi (gasoline)	0,07	118	59
light diesel (taxi)	0,05	85	42
light heavy (mini buses)	0,48	812	90
heavy vehicles (buses)	0,4	677	27
Lorries			10
Total	1	1692	229

The emission factors are sensitive to the final results of the model estimates. A different composition of traffic, older cars and a different average speed may alter the results.

We have used emission factors for cars given by the European Union emission database CORINAIR and by US EPA.

For the peak hour traffic the total emissions of NOx, CO, VOC, SO_2 and particles are presented in Table 7.

Table 7: The estimated total emissions (kg/h) of the main pollutants during peak hour traffic at the Sharm El-Sheikh Airport, 2020.

	Total emissions peak hour (kg/h)				
Driving 50 km/h	**Nox**	**CO**	**VOC**	**SO2**	**Particle**
Private cars	5,7	30,8	0,3	0,0	1,0
Taxis	1,8	1,7	0,1	21,2	0,4
Mini buses	29,1	22,6	0,0	54,1	2,0
Large buses	20,6	9,9	0,0	24,4	2,2
Lorries	6,8	2,1	0,0	9,0	0,8
Idling					
Private cars	0,3	13,6	1,2	0,0	0,2
Taxis	0,2	0,4	0,2	0,3	2,1
Mini buses	1,1	30,6	2,8	0,0	0,2
Large buses	1,5	2,6	0,3	0,3	1,4
Lorries	0,6	0,9	0,1	0,1	0,5
Total emissions	**67,6**	**115,1**	**5,2**	**109,5**	**10,8**

We see that the emissions from buses and minibuses contributes from 55 to 73 % of the total emissions dependent of component. The highest contribution occurs during driving mode (on the road) for NOx and SO_2.

4 Input to Ch. 5; b) Estimated concentrations

4.1 Air Quality Limit values for Egypt

To evaluate the existing and estimated concentrations of air pollutants in the Sharm El-Sheikh area we have related the concentrations to Air Quality Limit values as given in the Executive Regulations of the Environmental Law no. 4 of Egypt (Egypt 1994). These Air Quality Limit values are presented in Table 8.

Table 8: Ambient Air Quality Limit values as given by Law no.4 for Egypt (1994) compared to the World Health Organisation (WHO) air quality guideline values.

Pollutant	Averaging time	Maximum Limit Value	
		WHO	Egypt
Sulphur dioxide (SO_2)	1 hour	500 (10 min)	350
	24 hours	125	150
	Year	50	60
Nitrogen dioxide (NO_2)	1 hour	200	400
	24 hours	-	150
	Year	40-50	
Ozone (O_3)	1 hour	150-200	200
	8 hours	120	120
Carbon monoxide (CO)	1 hour	30 000	30 000
	8 hours	10 000	10 000
Black Smoke (BS)	24 hours	50 *	150
	Year	-	60
Total Suspended Particles (TSP)	24 hours	-	230
	Year	-	90
Particles <10 µm (PM_{10})	24 hours	70 **	70
Lead (Pb)	Year	0.5-1,0	1

* Together with SO_2 ** Norwegian Air Quality Limit value

4.2 Concentrations downwind from the runway

4.2.1 Average concentrations

Concentrations due to aircraft movements at Sharm El-sheikh airport has been based on the airport activity forecasts summarised in Table 3.

A simple statistical model combined with a Gaussian based dispersion model has been used to estimate the maximum expected concentrations downwind from the runways and in the areas surrounding the parking areas and around the Terminal buildings at Sharm El-Sheikh airport. The highest ground level concentrations due to emissions from the aircraft is assumed to occur at the point on the runway where take-off take place. Already at 100 m from this point the estimated concentrations will be well below the national and international air quality limit values.

At about 100 m downwind from the runway at take-off the average concentrations estimated for the activity in 2020 will be about:

- Nitrogen dioxide (NO_2): 4,7 µg/m^3
- Carbon monoxide (CO): 33,7 ug/m3
- Non methane hydrocarbons (VOC). 2,7 µg/m^3

The CO concentrations and the VOC concentrations in the taxi area and on the runway itself may be higher. A very conservative estimate has indicated that the CO concentration on the runway during taxing can reach 270 µg/m^3. This is still only 10 % of the limit value.

VOC from storage tanks and filling systems have not been included in the estimates. However, with modern technologies we do not believe that the concentrations will exceed more than 10 to 50 µg/m^3 outside the runway.

4.2.2 Peak hour concentrations from flight activities

We have assumed a peak hour activity with 11 flights per hour in 2005 and 22 flights per hour in 2020. The emission rates (factors) used for the different cycles have been estimated based on the taxing and airport procedures assumed for Cairo Airport. The estimated emission rates used for peak hour flights are presented in Table 5.

In the worst case with wind blowing along the runway we have estimated the absolute maximum concentration of NO_2 at the end of the runway to be about 250 µg/m^3 as seen in Figure 1. Already at 1 km the concentrations caused by the aircraft emissions are down at less than background levels.

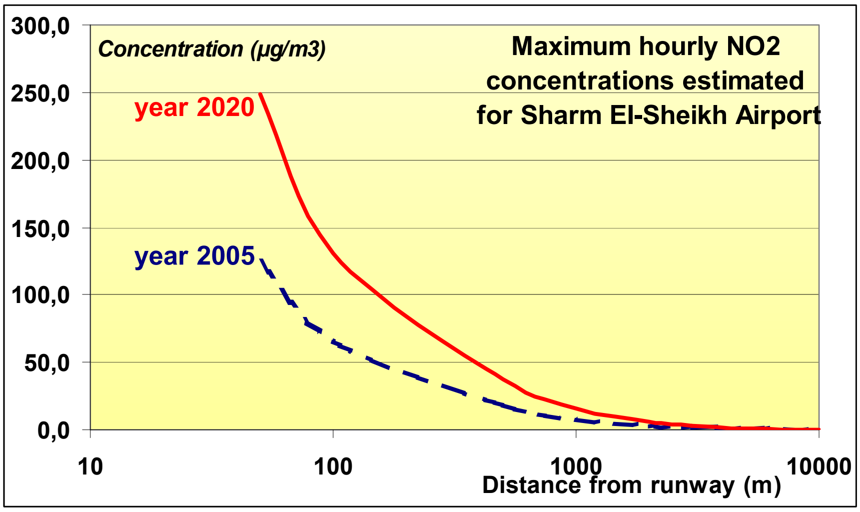


Figure 9: The estimated NO_2 concentration downwind from the runway at the Sharm El-Sheikh airport during peak hour traffic in 2005 and in 2020.

We have also used other models assuming a steady wind along the runway at 3 m/s. These estimates resulted in maximum hourly NO_2 concentrations of about 200µg/m^3 .

The estimated concentrations of SO_2 are about 10% of those estimated for NO_2. The maximum level will be less than 5% of any limit values.

CO concentrations will occur at the runway as a result of taxing and idling. The CO concentrations downwind from the runway during peak hour flight activity in 2020 is presented in Figure 10.

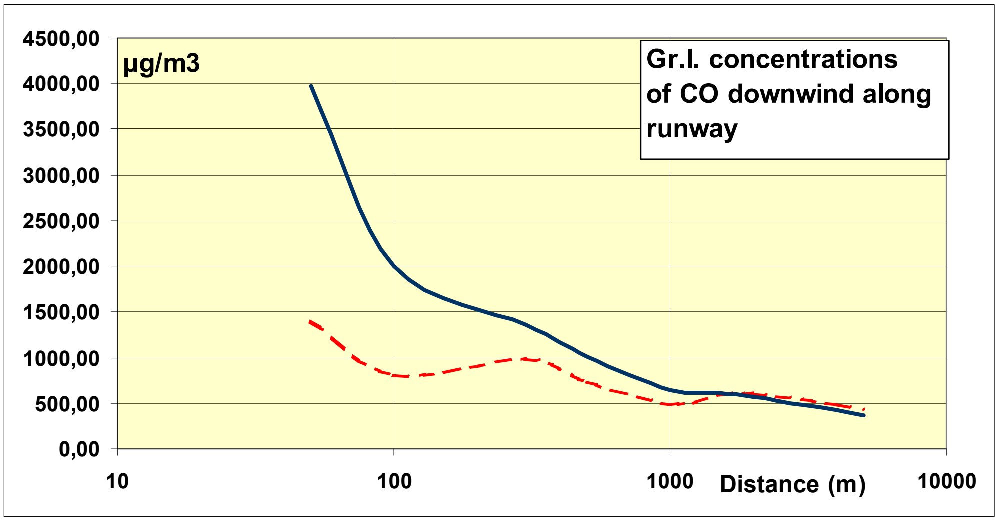


Figure 10: Estimated one-hour average concentrations of CO at peak hour flight activity in 2020 assuming wind along the runway.

The highest CO concentration expected at the runway has been estimated at 4 mg/m^3. The limit value given for one-hour averages is 30 mg/m^3. It is difficult to identify a meteorological condition at the air port in Sharm El-Sheikh that could lead to exceeding of the limit values.

4.3 Estimated impact from road traffic

The highest impact around international airports are normally found at or near the Terminal building due to road traffic, idling and accelerations. CO concentrations are normally high at the loading/unloading zone at the terminals. NO_2 concentrations are highest in the driving area and specifically near the acceleration areas. At Sharm El Sheikh the situations may be slightly different due to the facts that;

- The parking area is fairly open and is exposed to good atmospheric dispersion conditions
- The ratio of gasoline cars to buses is small; most of the tourists/passengers are transported by buses

This may lead to lower concentrations of NO_2 and CO, which were the main problem at the Cairo International Airport. On the other hand we have seen from the baseline measurements that the SO_2 concentrations in some areas of the loading/unloading zone may be high. This is especially true for the acceleration area where the buses starts for leaving the airport.

The highest ground level concentrations of CO estimated in the parking areas of Sharm El-Sheikh airport is presented in Figure 11 as one-hour averages. We have assumed a traffic rate corresponding to the peak hour traffic as presented in Table 6.

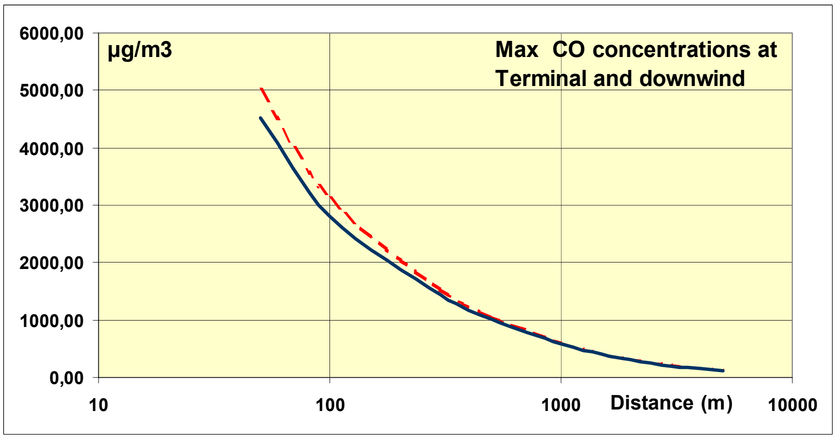


Figure 11: Maximum downwind concentrations (1-h average) of CO in the parking area of the Terminal building at Sharm El-Sheikh airport, 2020.

The highest concentrations of CO are found within the parking and loading areas at the Terminal building and will be less than 5 mg/m^3. Already at 100 m from the unloading zone the one hour average CO concentrations will be less than about 3 mg/m^3, which is 10% of the limit value.

The maximum one hour average concentrations for other compounds are estimated in the Terminal area downwind from the parking and unloading zone based on simple flux models. The highest concentrations expected are:

- Nitrogen dioxide (NO_2): 304 µg/m^3
- Carbon monoxide (CO): 5 mg/3
- Non methane hydrocarbons (VOC). 88 µg/m^3
- Sulphur dioxide (SO_2) 216 µg/m^3
- suspended particles 92 µg/m^3

These concentrations are also the highest estimated concentrations for any of the areas considered as a result of the airport activities alone. Remember that the background PM_{10} (suspended particle) concentrations in the area are about 60 µg/m^3 as a daily average.

The air pollution concentration along the Peace Road leading to the airport will be insignificant. The atmospheric dispersion conditions are normally very good in the area. The total emissions of SO_2 and NO_2 will be about 100 and 65 kg/h respectively, along the roads leading from the airport to the different hotels.

If this traffic were to run back and forth continuously along Peace Road between the airport and Naewa Bay, an absolute maximum estimated concentration near the road only about 5 m from the road side. These concentration will be about 150 $\mu g/m^3$ for NO_2 and 240 $\mu g/m^3$ for SO_2. It is, however, clear that these concentrations will never be reached taking into account a realistic traffic pattern. More realistic concentrations estimated near the airport roads based on the estimated emission rates and simple flux models are; 71 $\mu g/m^3$ NO_2 and 120 $\mu g/m^3$ SO_2.

4.4 Impact of the total airport activities

As seen from the estimates presented above, the total air pollution impact from the future Sharm El-Sheikh airport will not result in any adverse health impacts. The concentrations are normally much below the air quality limit values given in Law no. 4 of Egypt (Table 8) and by the World Health Organisation guideline values.

The maximum annual average concentrations estimated for year 2020 is presented in Table 9.

Table 9: Estimated annual average concentrations of NO_2, CO and NMVOC in the maximum impact areas of the Sharm El-Sheikh airport in 2020.

		Concentrations (µg/m3)				
Average	**Contribution from**	**NO2**	**CO**	**HC**	**SO2**	**Particles**
Annual	Traffic along road	18	19	0	30	2
	At Terminal building	30	533	1	15	2
	At end of runway	5	34	3		
Max hourly peak traffic	Traffic along road	71	74	1	121	7
	At Terminal building	304	5072	88	216	93
	At end of runway	250	600	25		

The most “critical” case is the maximum one-hour average NO_2 concentration in the unloading and parking zone at the Terminal building. The maximum concentration may reach 75 % of the air quality limit for Egypt, and is higher than the WHO guideline value.

The limit value for particles (PM_{10}) is given as a 24-h average, and this will not be violated due to airport activities alone.

The other indicators and compounds will be well below any limit values given in laws or regulations.

5 Input to Ch. 7.2; Mitigation measures

Based on the outcome of the concentration estimates presented for Sharm El-Sheikh airport there will probably not be an urgent need to start evaluation an optimal abatement plan for the airport activities at this point in time. Even for the fully developed airport 2020 it seem to meet the air quality limit values given in Law no.4 of Egypt.

However, there are reasons to look at the impact from the road traffic bringing passengers to and from the airport. The NOx exposure predicted at the Terminal area may be reduced considerably by implementing three-way catalytic converters in all cars. The change from using diesel in all mini buses and buses may also reduce some of the impact. The SO_2 impact will disappear almost completely in this case.

Most modern cars are equipped with catalytic converters, which also will help to reduce carbon monoxide (CO) and VOC emissions in addition the reduction of NO_X emissions.

A total Air Quality Management System for the Sharm El-Sheikh airport will include three phases:

- Assessment
- Control
- Surveillance

The first assessment of the air quality linked to airport activities has been presented in this report. The control phase will depend of all environmental impacts assessed and will have to be developed in co-operation between the environmental experts and the developer. The third phase, the surveillance phase, consists of the establishment of a monitoring system as well as institutions and infrastructures to handle this. A plan for such development included a rough cost estimate is presented in the following chapter.

6 Input to Ch. 7.3, Future monitoring plan

To follow up the development of a new airport in Sharm El-Sheikh and its possible impact to the environment, it is required that an air quality monitoring programme is being installed in the possible maximum impact area at the Airport.

An important objective for the Airport air quality monitoring platform is to enable on-line data and information transfer with direct quality control of the collected data. Several monitors and sensors that make on-line data transfer and control possible are available on the market. For some compounds and indicators, however, this is not the case.

A general objective for the air quality measurement programme is to adequately characterise air pollution for the area of interest, with a minimum expenditure of time and money. The measurement and sampling techniques to be used in each case will be dependent upon a complete analysis of the problem.

6.1 Compounds and indicators

The compounds and indicators to be selected for the permanent air quality monitoring stations should be specific for the typical compound emitted from the airport activities.

The main core of the on-line air quality monitoring programme will be based on these permanently located measurement sites. This is necessary to meet the main objectives of the Cairo Airport air quality monitoring and assessment programme.

The compound selected should be possible to measure with reasonable accuracy. It should be adequately documented and linked to possible health impact, building deterioration, impacts related to the specific activity in question (normal release, accidental release, specific pollutants or potential damages in the near surroundings of the releases.

The most commonly selected air quality indicators for traffic urban air pollution are:

- nitrogen dioxide (NO_2),
- sulphur dioxide (SO_2),
- carbon monoxide (CO),
- particles with aerodynamic diameter less than 10 μm (or 2,5 μm), PM_{10} ($PM_{2,5}$),
- ozone.

The compounds listed above are referred to as the priority pollutants by the US EPA. They are also given in the Air Quality Daughter Directives of the European Union with specific limit values for the protection of health and the environment. The first three are also given in the World Bank limit values for ambient air pollution. The World Health Organisation guideline values also includes the above indicators as well as others. Selected air quality standards have been given by Law no. 4 of Egypt for NO_2, SO_2, CO, PM_{10}, TSP, black smoke and ozone.

For some of the activities linked to aircraft fuel storage as well as road traffic we will suggest to include hydrocarbons measured as:

- Volatile organic compounds (VOC)
- Benzene, Toluene and Xylene (BTEX) or as
- Non methane hydrocarbons (NMHC)

VOCs will participate in the production of photochemical smog, normally measured by ozone as an indicator.

Other pollutants may also have to be considered, such as:

- Ammonia (NH3)
- Poly cyclic Aromatic Hydrocarbons (PAH) with a specific selected indicator such as Benzo(a)pyrene (BaP)
- Heavy metals such as Pb, Cd, As, Hg, Ni etc

For estimating greenhouse gas emissions indicators such as CO_2 and N2O could be included. However, it will normally only be required to undertake an emission inventory of the greenhouse gas emissions. This inventory will have to be updated on an annual basis.

6.2 The measurement programme

The anticipated impact of air pollution around the Sharm El-Sheikh airport will probably be limited to the closest surroundings of the terminal building. It is therefore suggested that a fairly limited programme of measurements are installed. The ambient air quality monitoring system should include:

- 1 complete measurement stations housed inside a shelter close to the Terminal
- 1 Automatic Weather Station (AWS) located at air quality shelter
- 10 sampling points for passive sampling

6.2.1 The automatic monitoring station

Automatic air quality monitors will be located inside an air conditioned shelter at the permanently located automatic air quality measurement stations.

6.2.1.1 Shelter

The shelter will include necessary power requirements (220 - 240 V) and an option for stabilization of the electric power supply. It will have a minimum number of electric circuits: 3, each protected with switch breakers. The shelter will be fully air conditioned to meet a requested indoor temperature of 25 to max 30 °C, preferably stable within ± 1 °C. It may be necessary to use split unit air condition. Rack for monitors will be installed and equipment for securing calibration gas cylinders to the shelter wall inside the shelter.

The shelter should be steel plated, painted white, with no windows and door lock. It should be isolated sufficient to maintain the requested indoor temperature in Sharm El-Sheikh.

Excess air from the air intake manifold and monitors must be ventilated outside the shelter.

The air quality instruments inside the shelter will be based on available automatic monitors. In this option we have only used fully automatic equipment, so that all information collected at this station may be available on-line at a central database or via Internet solutions to the different companies interested.

6.2.1.2 Automatic monitors available

Methods and instruments for measuring air pollutants continuously must be carefully selected, evaluated and standardised. Several factors must be considered:

* *Specific*, i.e. respond to the pollutant of interest in the presence of other substances,
* *sensitive* and range from the lowest to the highest concentration expected,
* *stable*, i.e. remain unaltered during the sampling interval between sampling and analysis,
* *precise, accurate* and representative for the true pollutant concentration in the atmosphere where the sample is obtained,
* adequate for the *sampling time* required,
* *reliable and feasible* relative to man power resources, maintenance cost and needs,
* zero drift and calibration (at least for a few days to ensure reliable data),
* response time short enough to record accurately rapid changes in pollution concentration,
* ambient temperature and humidity shall not influence the concentration measurements,
* maintenance time and cost should allow instruments to operate continuously over long periods with minimum downtime,
* data output should be considered in relation to computer capacity or reading and processing.

Most of the measurement methods presented below are considered the international reference methods:

Sulphur dioxide (SO_2)

SO_2 should be measured from the fluorescent signal generated by exciting SO_2 with UV light.

Nitrogen oxides (NO and NO_2)

The principle of chemiluminescent reactions between NO and O_3 will be used for measuring NO_x. NO and total NO_x is being measured.

Ozone (O_3)

An ultraviolet absorption analyser is being used for measuring the ambient concentrations of ozone. The concentration of ozone is determined by the attenuation of 254 nm UV light along a single fixed path cell.

Suspended particles; TSP, PM_{10} and $PM_{2.5}$

Gravimetric methods including a true micro weighing technology has been used to measure ambient concentrations of suspended particulate matter. For automatic monitoring an instrument named "Tapered Element Oscillating Microbalance (TEOM)" has been most frequently used. Using a choice of sampling inlets, the hardware can be configured to measure TSP, PM_{10} or $PM_{2,5}$.

Measurement on filter tape using the principles of beta attenuation for estimating 30 minute or one hour average concentrations of PM_{10} or PM2,5 have been operated with an air flow of about 18 l/min.

Carbon monoxide (CO)

The CO analyser often used in urban air pollution studies is a non-dispersive infrared photometer that uses gas filter correlation technology to measure low concentrations of CO accurately and reliable by use of state-of-the-art optical and electronic technology.

Hydrocarbons and VOC

Hydrocarbons (NMHC, Methane and THC) should be measured using a flame ionisation detector (FID). Experience from measurements performed by the EIMP programme have proven that here may be problems in the continuous power supplies. Short power breaks may interrupt these continuous measurements, and they will have to be started manually.

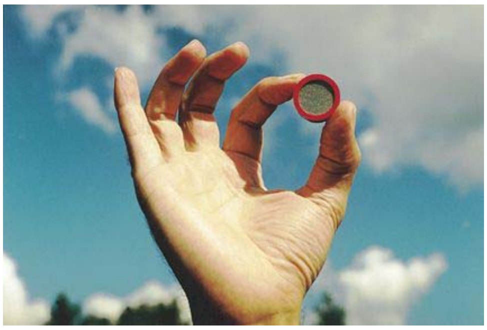
In the EIMP programme we have thus concentrated on using manual sampling in steel canisters.

Another preferred method would be to use the modern BTEX monitors, as it then will be possible to compare the levels with international standards.

6.2.2 Passive and hand-held simple samplers

In addition to the permanent network of air quality monitors w will propose to use some simple inexpensive sampling using passive samplers.

Simple samplers for surveillance of time integrated SO_2 and NO_2 concentration distributions has been developed. The samplers are inexpensive in use, simple to handle and have a good overall precision and accuracy. They have been used in traffic studies, industrial areas, in urban areas and for studies of indoor/outdoor exposures. Investigations using passive samplers have been undertaken to develop spatial concentration distribution.



Part of the baseline studies at the Cairo Airport was based upon the use of passive samplers.

One of the internationally recognised sampler was developed by the Swedish Environmental Research Institute (IVL) and has been used in several cases by NILU. The sampler includes an impregnated filter inside a small plastic tube.

Other passive diffusion samplers have also been tested at a number of sites where volatile organic compounds (VOC's) are the principal.

The passive samplers can be operated outside the permanent or mobile stations and will thus need any shelters, electricity or data collection systems. However, they will have to be analysed in a laboratory after exposure in the field for typically one or two weeks. EEAA has establish a monitoring institution in Cairo where analyses of passive samplers are performed.

It will be recommended that such sampler results are co-ordinated and compared to automatic data from the permanent network. It may thus be advisable to handle such sampling from the shelters already available in field.

6.3 A chemical laboratory

The chemical analysis of PM, SO_2 and NO_2 have to performed in a laboratory. All these analyses are being undertaken by EEAA assigned laboratories in Cairo.

Particulate matter have to be analysed gravimetric by high sensitive scales in climate controlled rooms. The chemical analysis of SO_2 and NO_2 in extracts from impregnated filters are performed with ion chromatography.

6.4 Quality Assurance/Quality Control system (QA/QC)

Quality assurance/quality control (QA/QC) procedures, developed to handle the ambient air quality monitoring programme, contain several levels of controls.

In field operations will be established:

- Station Manuals including Standard Operating Procedures (SOP) for instrument installations, maintenance, controls etc.,
- zero span checks and calibration routines.

At the data centre or at an assigned Monitoring Laboratory data are controlled following quality assurance routines as described i.e. in ISO 17025 from the International Standardisation Organisation;

- at daily retrieval (e.g. using the AirQUIS system),
- through simple statistical and graphical evaluations to check validity and representativeness of data,
- as part of the reporting of data.

The quality control procedures give the data credibility. The data become reliable, which is essential when using the data for reporting, controls and planning. To be used with confidence for scientific and environmental management purposes the data must also be comparable and compatible.

6.4.1 Data transfer systems

All data from the instruments mentioned above may be collected by a data logger and transferred directly to a database for processing, control and presentations.

There are many different options existing on the market for efficient data communication from monitors to a database. The various conditions at the locations decide the best solutions. Several factors such as availability of telephone networks, quality and speed of the network, the amount of data to be transferred, the frequency of transfer, satellite options etc.

Automatic Data Acquisition Systems (ADACS) are available from a number of companies and instrument providers. The NILU developed AirQUIS system will provide all necessary software and hardware system for data quality assurance, data presentations and reporting.

6.5 Monitoring Cost estimates

A rough cost estimate for the equipment included data retrieval systems, QA/QC and a GIS based database have been presented in the following. The costs are not binding as we have based the estimate on the available prices for a specific set of instruments and database.

6.5.1 Instruments

A complete set of instruments for two on-line monitoring stations, two simple sampling stations for PM_{10}, SO_2 and NO_2 as well as 10 sites for passive sampling have been roughly estimated, and presented in Table 10.

The total costs of instruments will roughly be **209 000,- US dollars**.

This includes monitors, calibrators, shelters, racks and intake structures and data loggers for all equipment in the shelters. It includes also a BTEX monitor at a price of about 30 000 US$ alone.

Table 10: Investment Cost estimate for developing an air quality monitoring programme at Sharm El-Sheikh airport.

Sites	**Instruments**		**Cost estimate US$**
On-line monitoring	Monitors, calibrators, gases		157800
	Automatic Weather Station		20000
	Shelter fully equipped		14200
	Samplers, TSP/PM10, passive		9500
	Rack and intake		4000
Passive	10 sites - per year		3500
	Total instrumentation		**209000**

6.5.2 Database

A cost estimate for an operational database and reporting system have been based on the GIS based AirQUIS database given as a special offer from NILU. The GIS based database system includes all statistics, data presentation tools and a report generator system.

A summary of the reduced prices, prepared for EEAA on a specific request are given in the following.

The total cost for the Air Quality Measurement Module including the basic Kernel and the GIS system has been offered at the following prices:

The basic measurement module:	7800 US$
Hardware and computers:	5750 US$
Installation and training:	6930 US$
Total cost for the AirQUIS system installed and trained	**20 480 US $**

If requested the annual cost for maintenance and support will be 2500 US$

If a complete emission inventory module and atmospheric dispersion models, which are part of other modules in the AirQUIS system, is requested, additional costs may be given.

6.5.3 Installations, QA/QC developments and training

The installation costs will strongly depend on who, how and where this is being performed.

NILU can offer a turn key development where all instruments are prepared, tested and installed ready made in shelters with all racks, intake, air condition systems, hardware and software, data loggers, data retrieval systems, benches etc. and shipped for easy installations at the site in Sharm El-Sheikh.

NILU will in this case develop the necessary QA/QC systems and perform training of operators.

Another possibility is to install by local expertise from Cairo. To estimate the alternative cost related to these operations is difficult at present.

6.5.4 Annual operations

The operational costs will have to be added to the above investment costs.

Annual costs for operations, data collection, analyses and reporting will depend upon the institutions involved. It is possible to train anew institution to perform all operations.

Costs will have to be estimated when the detailed organisational procedures have been established.

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Norwegian Institute for Air Research (NILU)
P.O. Box 100, NO-2027 Kjeller, Norway

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EEA Building, 30 Misr Helwan Street, Maadi
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ABSTRACT
The Air Pollution Impact Assessment for a new Sharm El-Sheikh International Airport has been based on measurements and modelling of ground level concentrations due to emissions from road traffic and aircraft operations. The main air pollution problem in the background atmosphere is suspended particles originating mainly from natural wind blown dust.

The total air pollution impact from the future Sharm El-Sheikh airport will not result in any adverse health impacts. The concentrations are normally much below the air quality limit values given in Law no. 4 of Egypt (Table 8) and by the World Health Organisation guideline values.

The most "critical" case is the maximum one-hour average NO_2 concentration in the unloading and parking zone at the Terminal building. The maximum concentration may reach 75 % of the air quality limit for Egypt, and is higher than the WHO guideline value.

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