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A Study of Air Pollutants During Episodes

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Abstract

During the last few months Egypt was exposed to high levels of Air Pollutants due to several factors. Meteorological conditions combined with emissions of air pollutants gave rise to high concentrations in central part of Cairo. The concentrations of different pollutants varied considerably in space and time.A national Air Quality Network has been established by Egyptian Environmental Affairs Agency (EEAA) in co-operation with Danish International Development Assistance (Danida) to monitor the status of the air environment of Egypt.The Air Quality network consists of 42 stations located in the Greater Cairo area (14 sites), Alexandria (8 sites), Delta and Canal area (10 sites), Upper Egypt (9 sites) and Sinai (1 site).The network design, preparations and installation was carried out by EIMP during the period from 1997 till the end of 1999. The operations, data retrieval, Quality Assurance/Quality Control (QA/QC) as well as calibrations and data reporting are undertaken by two institutes: the Center of Environmental Hazard Mitigation (CEHM) at Cairo University and the Institute of Graduate Studies and Research (IGSR) at Alexandria University.The recorded data occasionally showed high concentrations exceeding the Air Quality Limit values as given by Law No. 4 of Egypt. Suspended particles (given by PM_{10}) is normally the main problem in Egypt. Under normal conditions the concentrations of PM_{10} is very high in Egypt compared to the Air Quality Limit value. During what so called Air Pollution episodes it may exceed the limit values by more than a factor ten.
Other pollutants may exceed the limit values by a factor 2 to 8 during theses episodes.There are several reasons for these cases:

- Specific large scale meteorological conditions give rise to strong inversions over Cairo,
- High humidity combined with low wind speeds prevail during the inversions situations,
- Emissions of air pollutant at the surface coming from open air waste burning, traffic and small enterprises,
- Sand storm from desert area around Cairo

The concentration levels of different pollutants may vary depending on the type of episode and the variability in source strength.

1. EIMP Air Quality Monitoring Programme

One of the major goals of EEAA is to keep a good level of the Air Environment related to local/international standards. Based on this goal EEAA in co-operation with DANIDA has established Air Quality Monitoring Network consists of 42 measurements sites

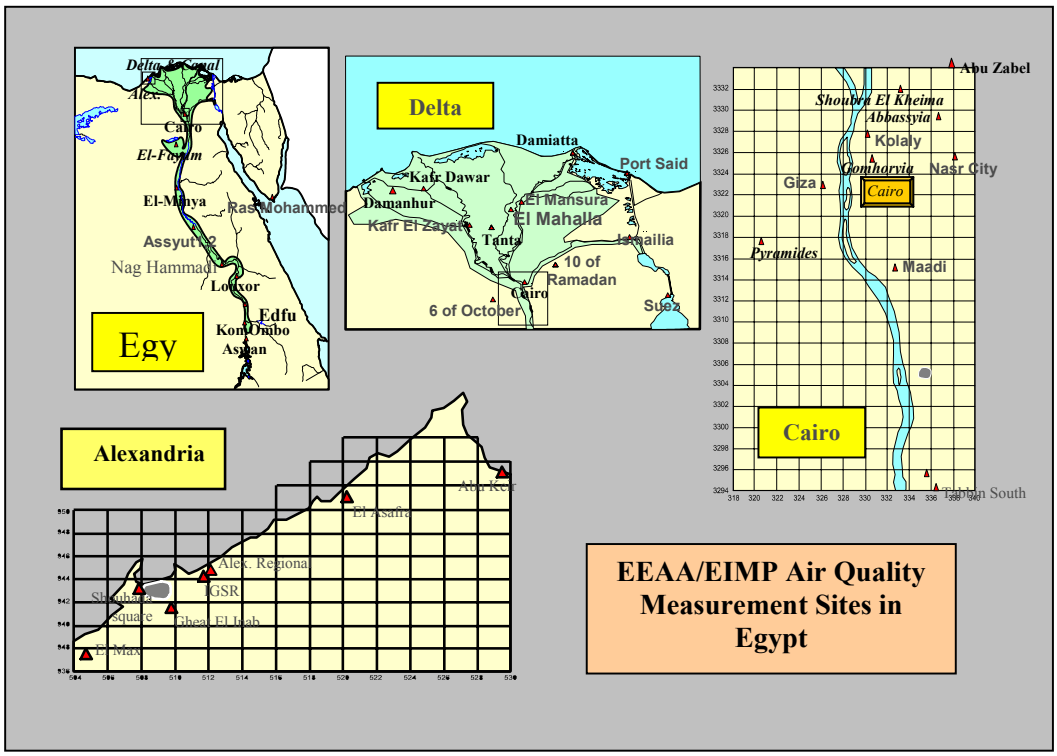


Figure1: The EEAA/EIMP Air Quality Measurement Sites in Egypt.

The network has been established to provide an image for the Air Environment for the decision makers and normal people.

The network is being operated by Center of Environmental Hazard Mitigation (CEHM) in Greater Cairo, Canal area and Upper Egypt. and by Institute of Graduate Studies and Research (IGSR) in Alexandria and Delta area. CEHM is operating 27 sites and IGSR is operating 15 sites distributed in different no of area description.

Distribution of Sites and Area type is presented in Table no.1

ea Type	Cairo	Alex.	Delta& Canal	Upper Egypt	Sinai	Total
Industrial	3	3	3	2		11
Urban	1	1	3	4		9
Residential	4	2	2	2		10
Street/Road	3	1				3
Regional/Backgr.	1	1			1	3
Mixed areas	2		2	1		5
Total	14	8	10	9	1	

A total of 14 sites are located in Greater Cairo area, 8 sites in Alex., 10 sites in Delta and Canal area, 9 sites in Upper Egypt and 1 site in Sinai.

In addition to the above mentioned monitoring and sampling sites, about 20 sites have been selected for undertaking passive sampling for SO_2 and NO_2 on monthly and quarterly basis.

2. Air Quality Limit values

The assessment of the air quality is presently being linked to the air pollution levels and to the populations distribution. To protect the health, the concentrations of selected harmful air pollutants should be limited and related to given ambient air quality standards.
Several investigations have been performed by Egyptian Environmental Affairs Agency to estimate the impact to human health from various air pollutants.
Air Quality limit values are given in the Executive Regulations of the Environmental Law no. 4 of Egypt (1994). These Air Quality Limit values are presented in Table2.

Table 2: Ambient Air Quality Limit values as given by Law no.4 for Egypt (1994) compared to the World Health Organization (WHO) Air Quality guideline values.

Pollutant	*Averaging* time	*Maximum Limit Value*	
		WHO	**Egypt**
Sulphur Dioxide	*1 hour*	*500 (10 min)*	*350*
	24 hour	*125*	*150*
	Year	*50*	*60*
Nitrogen Dioxide (NO2)	*1 hour*	*200*	*400*
	24 hour	*-*	*150*
	Year	*40-50*	*-*
Ozone (O3)	*1 hour*	*150-200*	*200*
	8 hours	*120*	*120*
Carbon monoxide(CO)	*1 hour*	*30000*	*30000*
	8 hours	*10000*	*10000*
Black Smoke(BS)	*24 hours*	*50*	*150*
	Year	*-*	*60*
Total Suspended Particles(TSP)	*24 hours*	*-*	*230*
	Year	*-*	*90*
Particles less than 10µm(PM10)	*24 hours*	*70*	*70*
Lead (Pb)	Year	*0.5-1*	*1*

Indoor air Closed and semi-closed public places according to the environmental Law should also have adequate ventilation systems appropriate to their sizes and capacities, as well as to the type of activities exercised therein, to ensure the renewal of air, its cleanness and the maintenance of a suitable level of temperature.

Table no. 3 indicates the quantities of air necessary for ventilating public places to avoid problems in breathing of air :

Table (3): Air needed for ventilating of closed and semi-closed places

Quantity Of External Air? dm3/min/person	Type of Place and activity
140-280	Places with high ceiling, banks, lecture halls, places of workshops, large public places, theater, non-smoking rooms
280-420	Apartments, hairdressers, hotel rooms, rooms with limited smoking
420-560	Cafeterias, small restaurants, hospital rooms, restaurants, rooms with medium level of smoking
560-850	Offices , clinics, rooms with high levels of smoking
850-1700	Night clubs or crowded rooms with high levels of smoking

?Without the use of Air Conditioners

-Suitable spaces for each person shall not be less than 4.25m3

-Suitable floor area for each person shall not be less than 1.4m2

3.Historical background of Air Pollution in Egypt:

3.1-Sulphur Dioxide

Very few representative data have been collected in the past concerning SO_2 concentrations in Egypt. A few number of measurements undertaken in 1991/92 indicated that monthly mean level of SO_2 in the Cairo atmosphere to be in the range of 100-300µg/m³.

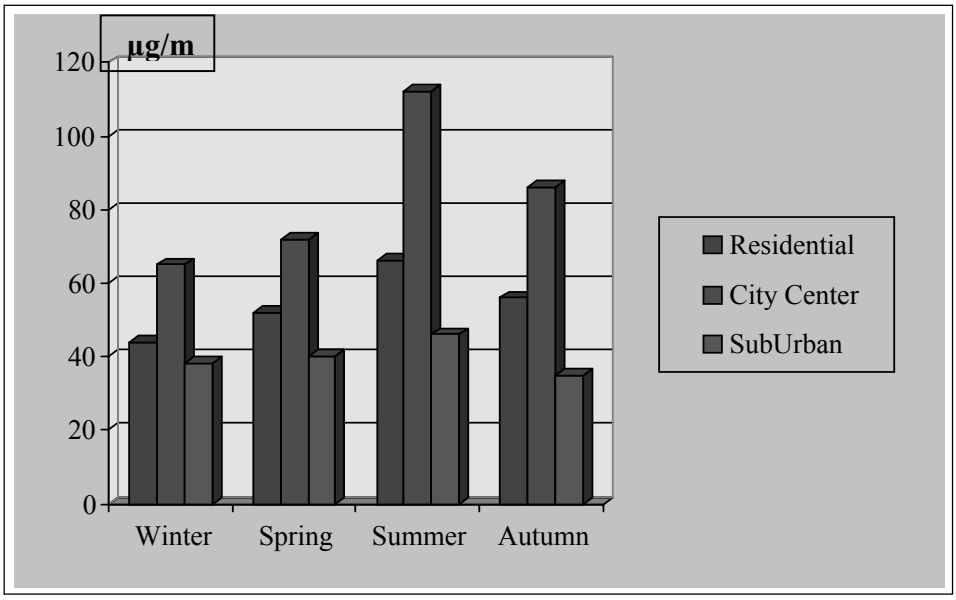


Figure 2: Historical Overview for SO_2 concentrations in Cairo.

Table 3 shows that the annual mean concentrations of SO_2 in the measurement stations during 1991/1992 were 40µg/m3 in the suburban area, 55µg/m3 in residential area and 84 µg/m3 in the atmosphere of the city center .
Table 3 also shows that the 24-hour concentrations in the air of the urban area may peak to more than 300µg/m³.

Table4: Sulphur dioxide concentrations in Cairo City atmosphere 1991/1992

	Cairo city		
Season	**Residential**	**City Center**	**Suburban**
Winter	44	65	38
Spring	52	72	40
Summer	66	112	46
Autumn	56	86	35
Mean	55	84	40
Monthly Max	76	127	54
24 hr Max	120	308	86

3.2.Total suspended Matter (TSP)

The measured annual TSP levels during 1989 to 1991 of about 500-1100µg/m3 are far in excess of WHO guideline of 60-90µg/m3. Moreover it may be noted that, the maximum 24 hr concentration sometimes peaked to more than 1000µg/m3 in the urban districts.

3.3.Oxides of Nitrogen

During 1979, Monthly mean NO_2 concentrations in the city center of Cairo were 380µg/m3 in January – March, 400µg/m3 in April – July, and 570-760µg/m3 in August-December.The marked maximum NOx concentrations during May and June are connected with increased traffic.

4.Reasons of Air Pollution Episodes

Reasons of Air Pollution Episodes can be divided into two main categories based on the polluting sources into Natural and Man-Made Episodes.

An exclusive example for the natural episodes is the episodes which we have faced during the last year (adverse weather conditions with low and variable winds, high humidity and strong temperature inversion at few hundred meters above the surface combined with the usual emissions of Air Pollutants).
Sand Storm also is considered as an episode from the above type which is mainly generated from high wind speed covering large open area(may be the western desert).

The man-made episodes usually consists of open waste burning with high emissions in the direction of prevailing wind direction with slightly high wind speed.

sometimes the two reasons combined together to generate intensive episode with relatively high concentrations of air pollutants (mainly black smoke). Three examples were hitting Egypt with high concentration of Air Pollutants will be presented in the following chapter.

12 March Episode:
During the day of 12 March Cairo was facing adverse weather conditions with usual emissions causing the concentrations of Air Pollutants to increase in most of the Air Quality Measurement Sites.

Weather and Meteorology
At that time a low-pressure area was covering large part from Asia driving westerly and south westerly winds to blown on the eastern part of middle east, that is why local wind directions from around south was observed .

At night, Temperature inversion was observed at height about 200m over the surface which make the pollutants settled down over the surface.

In the morning the wind start to blow from north causing the emissions to come back to Cairo.

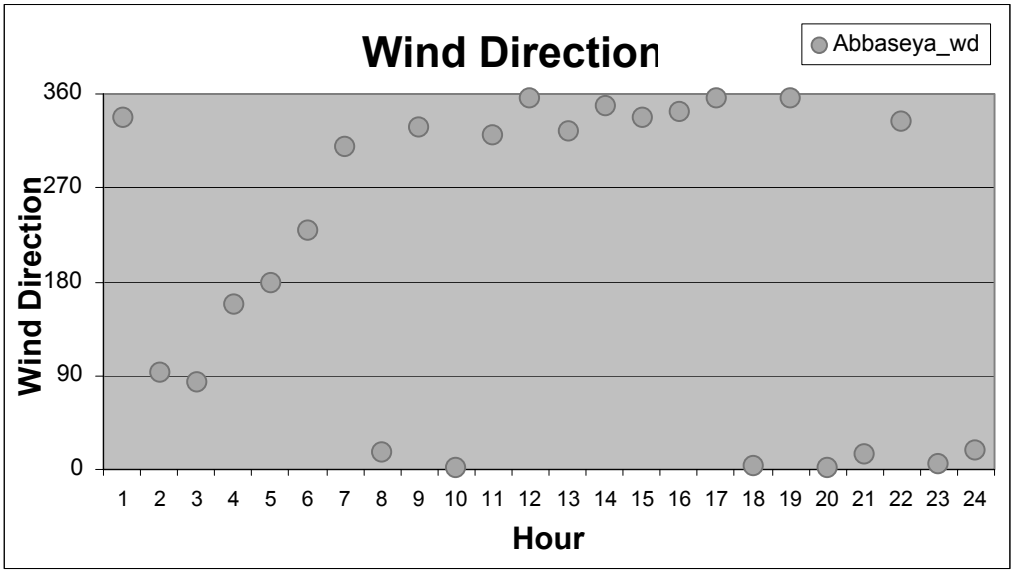


Figure3: Wind direction at Abbassyia station as seen from EIMP measurements.

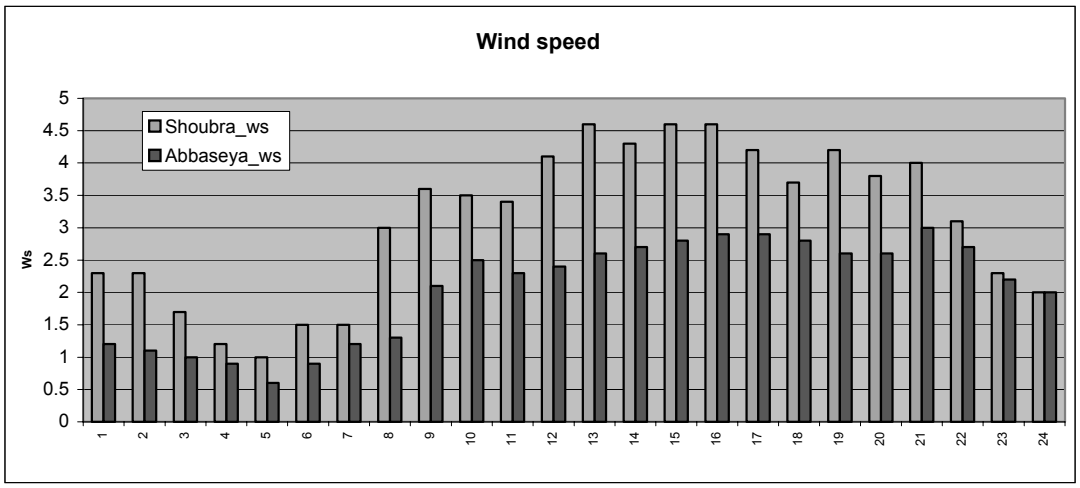


Figure4 : Wind speed at Shoubra and Abbassyia measurement sites

Air Pollutants Concentrations

SO_2 Concentrations

Although high concentrations were observed in most of the measurement sites, the concentration did not exceed the Air Quality Limit value of 350 $\mu g/m^3$.

It is also interesting to observe that high concentrations recorded at Shoubra and Abbassyia which give strong evidence for the wind direction which was blown from around north at the same time.

The maximum concentrations observed at Kolaly station was around the rush hours time 12 O'clock which may be due to local sources from diesel buses running around the station

Slightly low concentrations were observed in Tabbin station during 12 march

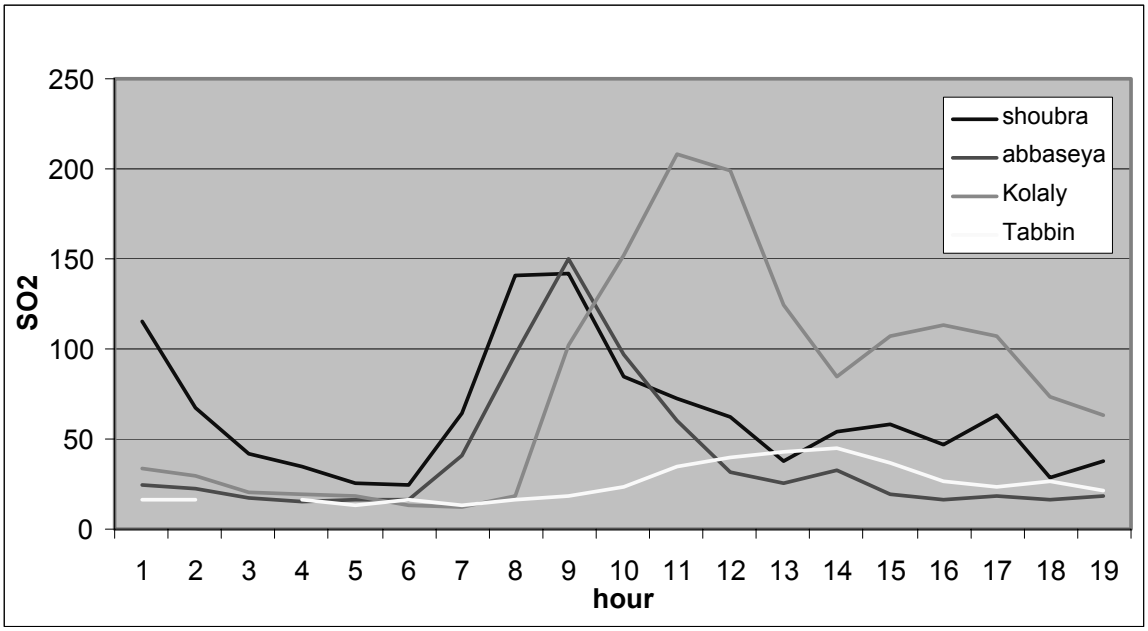


Figure5: The recorded SO2 concentrations at Greater Cairo area

PM_{10} Concentrations

Thoracic particles have Very high concentrations observed at Kolaly and Tabbin at the rush hours due to the local sources at the two station.

The continuous data observed at the two station exceeded the Air Quality Limit value of daily average by factor of 2-3 which was presenting risk for the population health in the City.

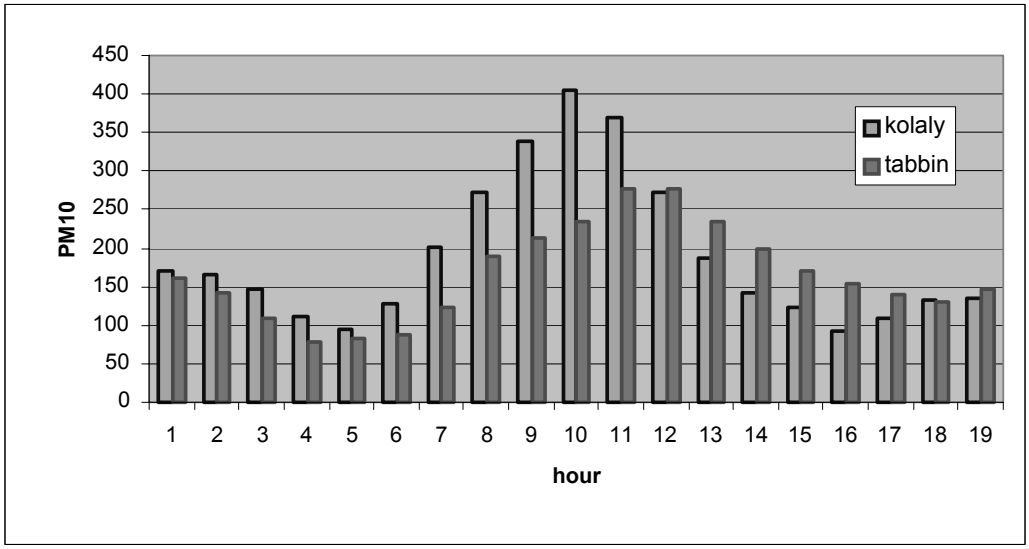
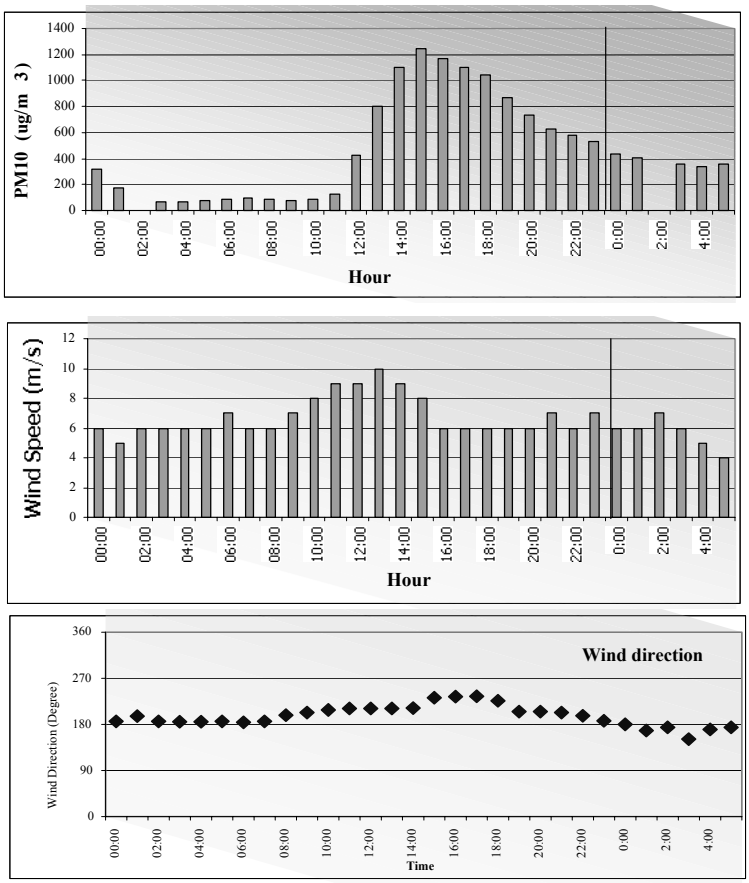
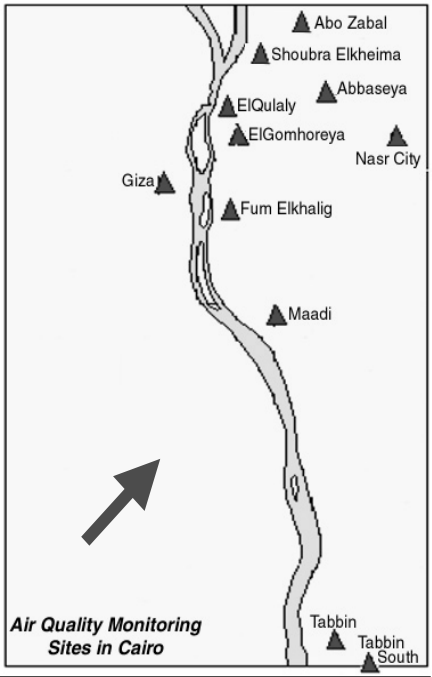


Figure6 : The PM_{10} concentrations at Kolaly and Tabbin stations.

18 January Episode (High concentration of PM_{10}):

The following figures represent the PM_{10} and meteorological data for Tabbin and Kolaly stations on January 18, 2000.





Location og measurement sites and an indication of the average wind direction at day time on 18 January 2000

Figure 7: Pm10 and meteorology measured on 18 January 2000:
a) Hourly average concentrations of PM_{10} measured at Tabbin
b) Hourly wind speed measured at Tabbin
c) Hourly wind direction measured at Tabbin

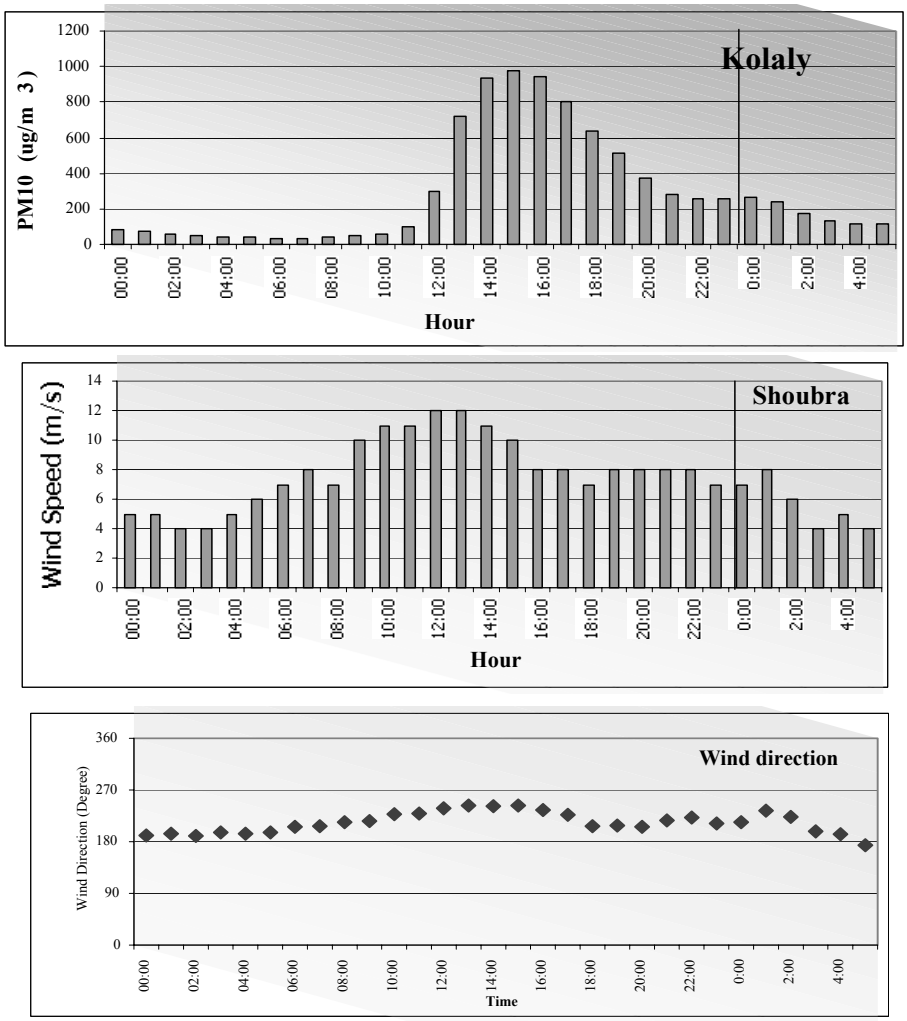


Figure 8:PM_{10} and wind measured on in 18 January 2000
a) Hourly concentration of PM_{10} measured at Qulaly
b) Hourly wind speed measured at Shoubra
c) Hourly wind direction measured at Shoubra

On 18 January 2000, the wind speed increase from 6 to 12 m/s blowing from around south-south west at Tabbin and Shoubra ElKheima. The PM_{10} concentration increased from 400 µg/m^3 to 1200 µg/m^3 in Tabbin and Qulaly between 12:00 and 15:00 indicating that dust may have been transported from the desert areas.

For SO_2 concentrations:
Due to high wind speed blowing around south-south west occurred in 18 January 2000 caused a decrease in SO_2 concentration at Kolaly and Abbaseya and an increase in Tabbin station.

SO_2 concentration increased at Tabbin station could be due to the brick factories and lead smelters that are located south of the station.
At the others two stations Kolaly and Abasseya the SO_2 concentration decrease due to the high wind speed that increase the dispersion of SO_2 concentration.

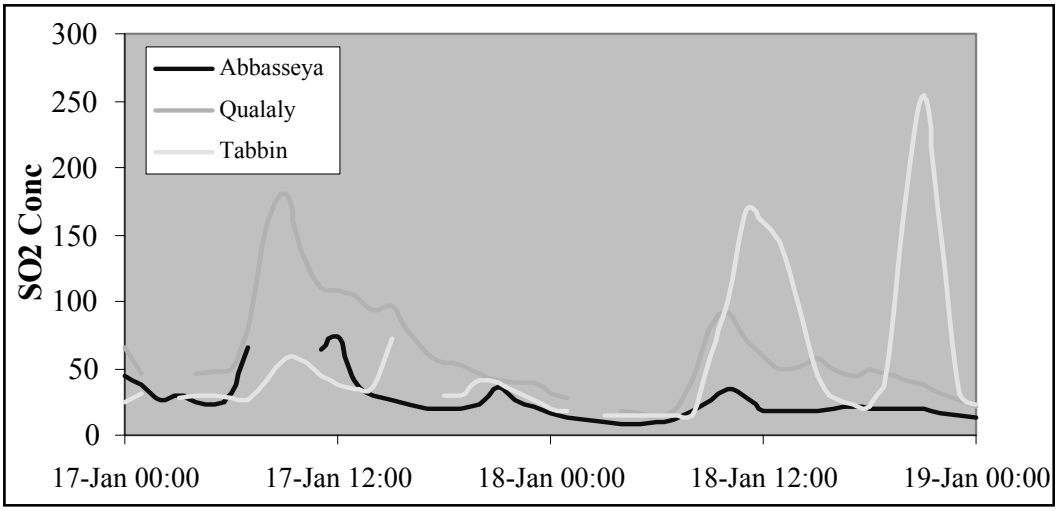


Figure 9: SO_2 Concentration at Abasseya, Kolaly and Tabbin stations in 18 Jan 2000.

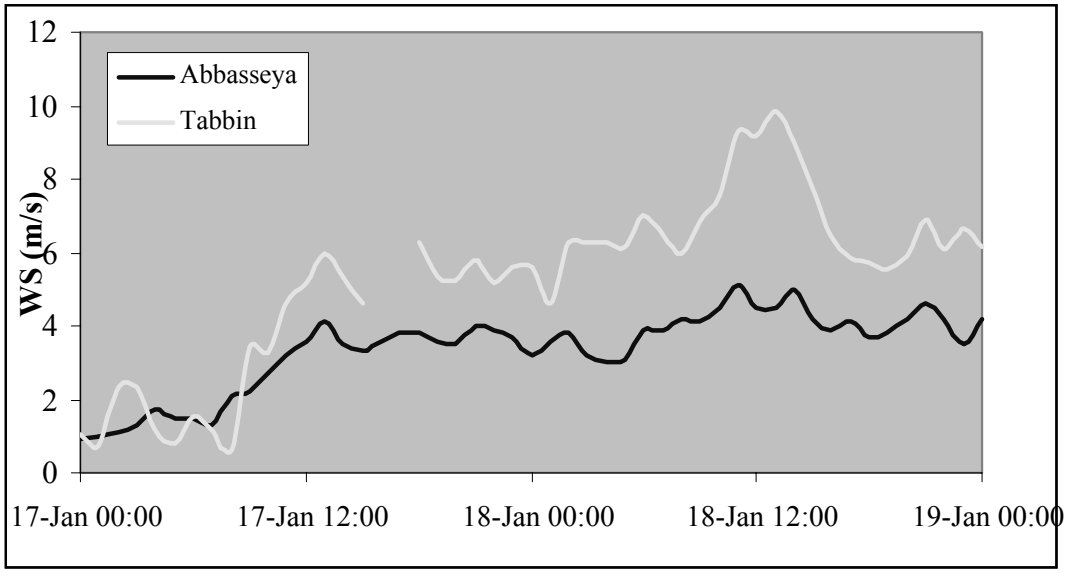


Figure10 : Wind speed measured at Abbaseya and Tabbin station in 18 Jan 2000

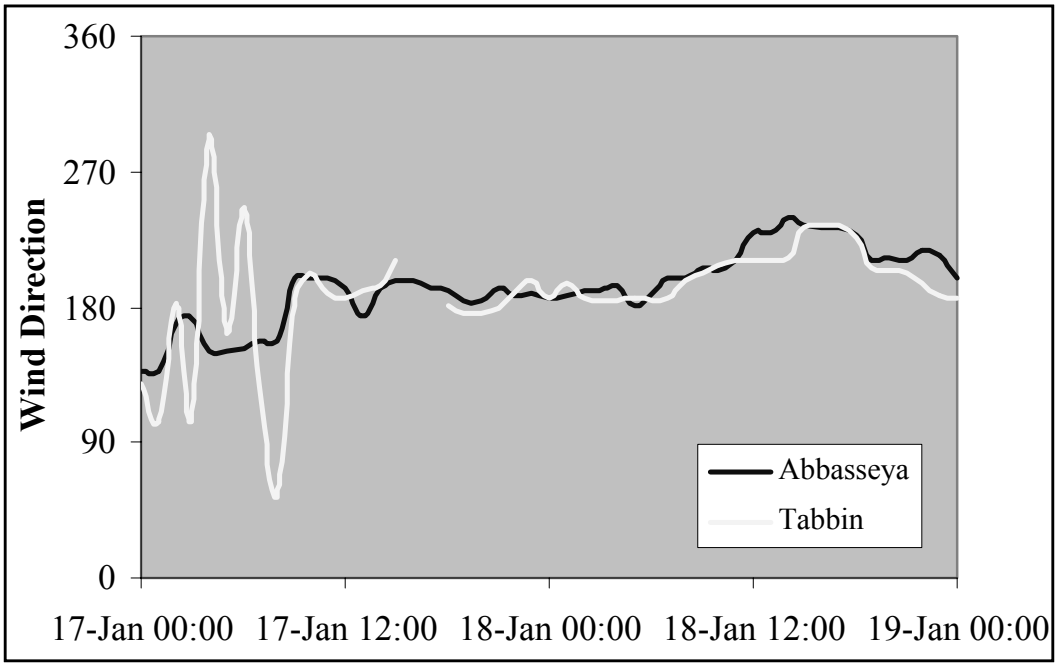


Figure11 : Wind direction measured at Abasseya and Tabbin station in 18 Jan 2000

23 October 1999 Episode

The main reason for the episode experienced by a large part of Cairo, was adverse weather conditions with low and variable winds, high humidity and a strong temperature inversion at a few hundred meters above the surface. The emissions of air pollutants released from a number of different sources near the surface in Cairo area added to a slowly transport of particles emitted from burning in Delta.

PM_{10} Concentrations

PM_{10} concentrations during the episode were extremely high reaching very high levels exceeding the daily Air Quality Limit value given by the Executive regulation of law no. 4 of Egypt by factor of 5 to 10. The smog cloud was consisting of thoracic particles combined with mix of unhealthy air pollutants.

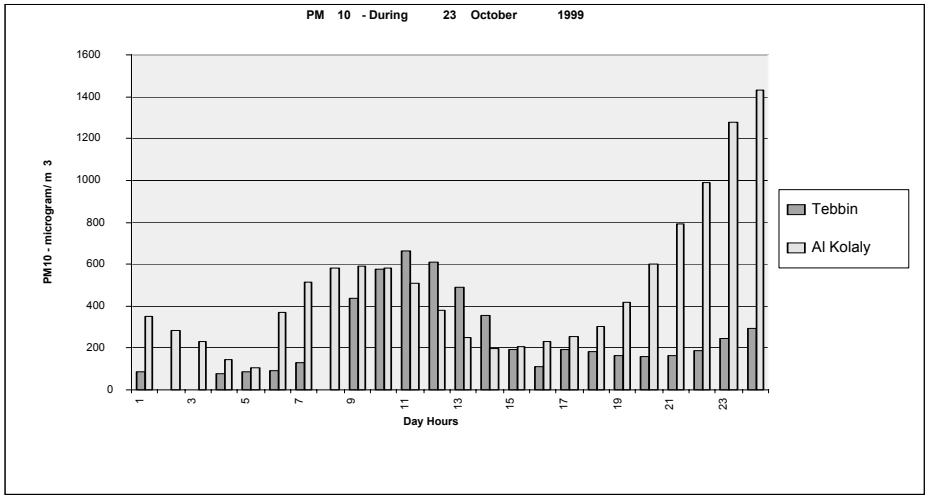


Figure12 : PM_{10} Concentrations at Tabbin and Kolaly station in Cairo.

The change of wind direction also from North to South direction can be presented in the Following figure.

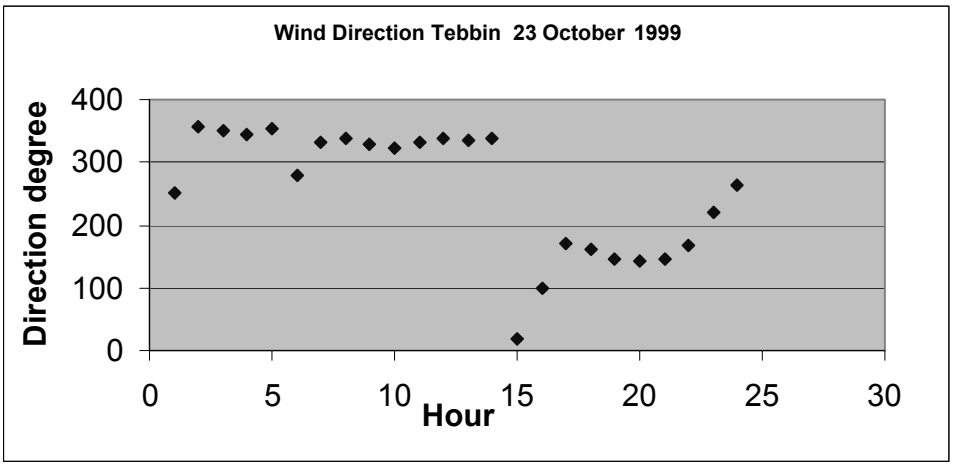


Figure13 : Wind direction at Tabbin station 23 October,1999.

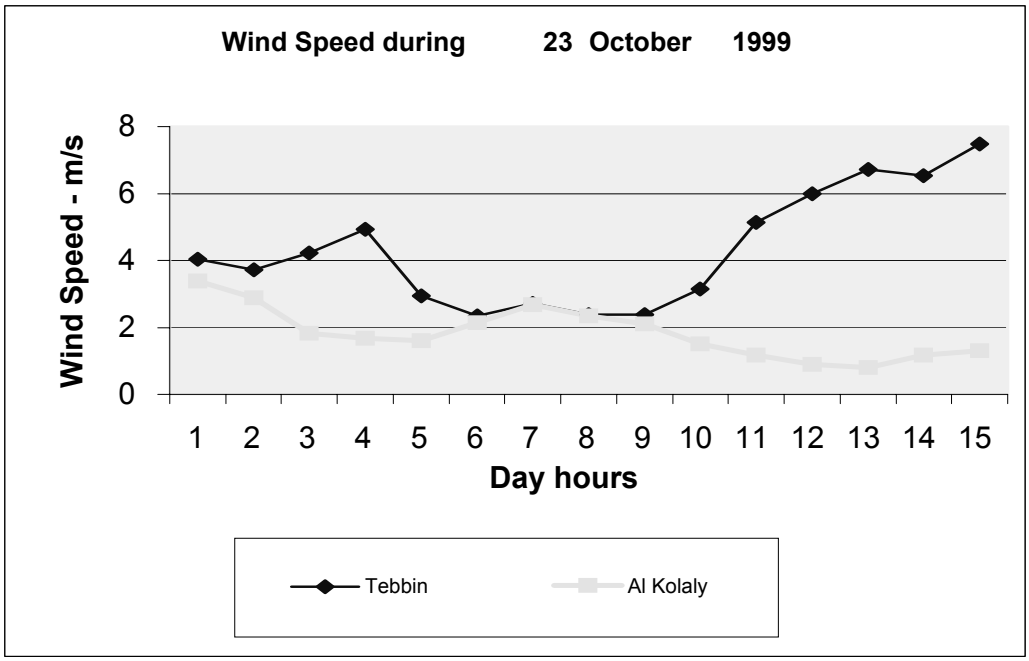


Figure14: Wind speed at Tabbin and Kolaly station (the first half of the day).

SO_2 NO_2 Levels

EIMP readings shows that the concentrations of SO_2 and NO_2 were slightly low comparing to the concentrations of PM_{10} recorded by the network.

The two pollutants did not exceed the Air Quality Limit in the measurement sites.

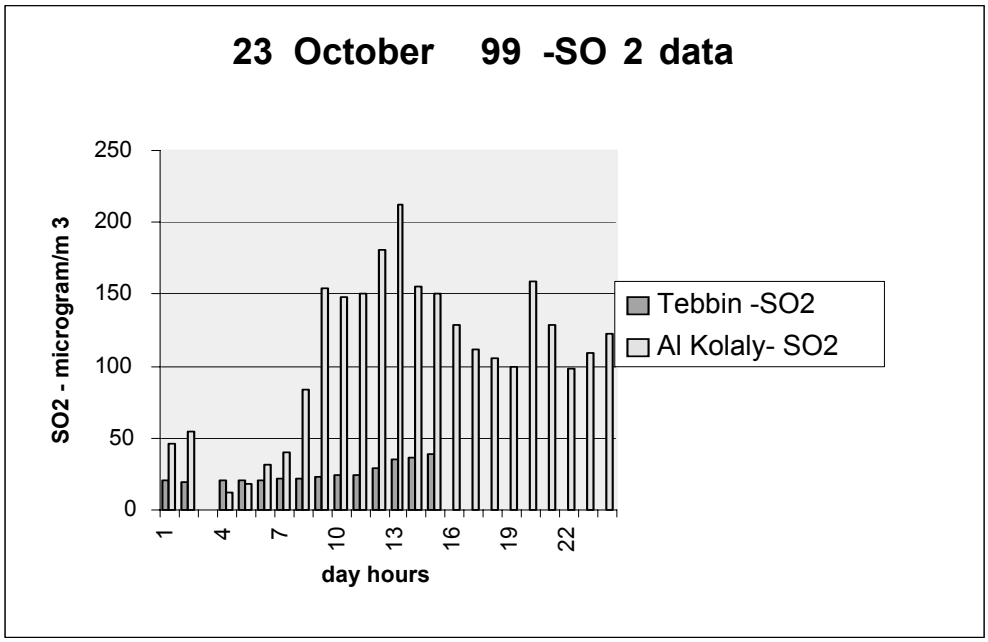


Figure15: SO2 data at Tabbin & Kolaly station.

The most representative station for the City Center is Fum El Khalig station which is located down town where the area is impacted by local sources in addition to the pollutants coming from north during the prevailing north wind is blown. The concentrations of SO_2 and NO_2 can be compared to the recorded concentrations on the days before the episode.

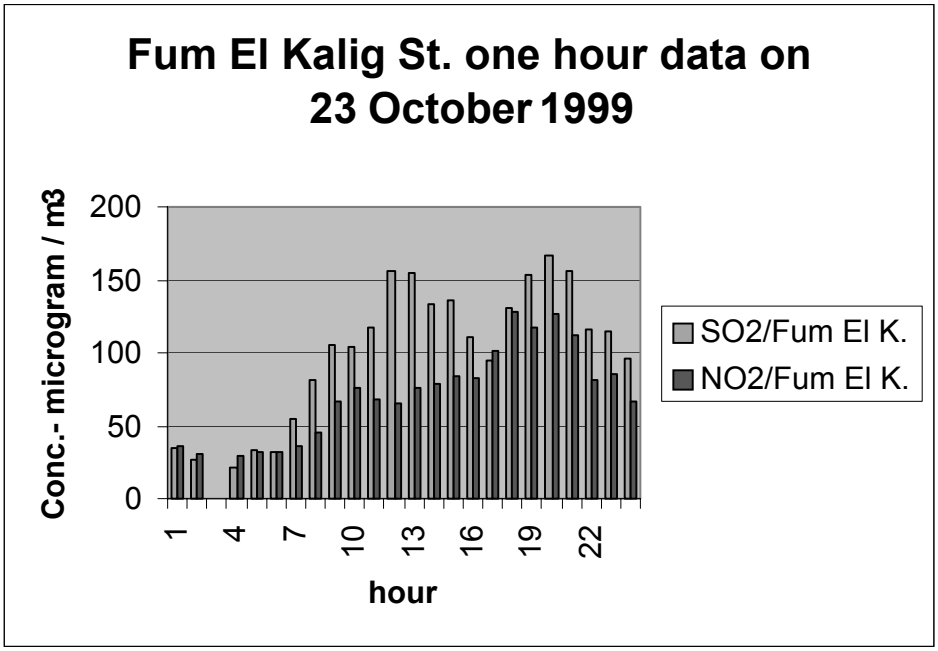


Figure16: SO_2 and NO_2 concentration at Fum El Khalig station.

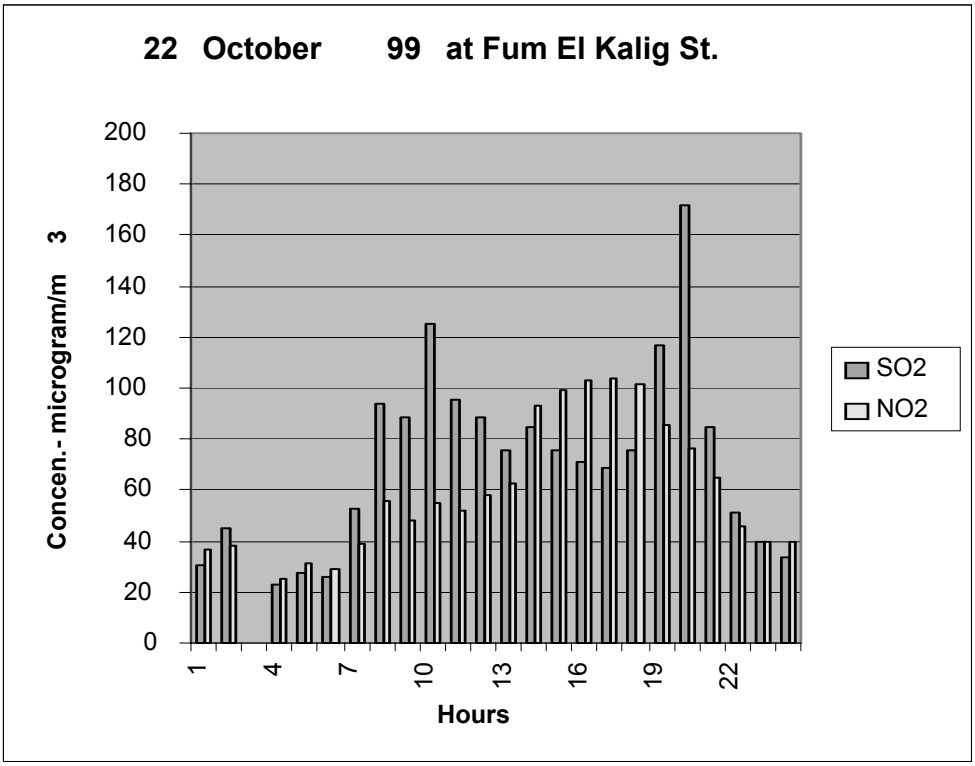


Figure 17: SO_2 and NO_2 concentrations at 22 October 99.

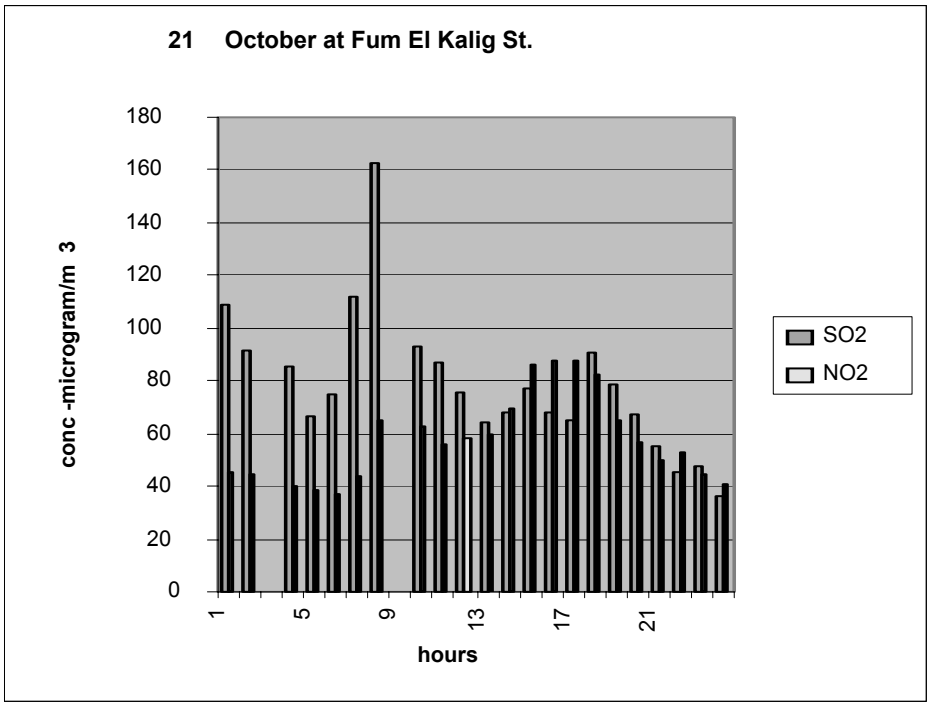


Figure 18: SO_2 and NO_2 concentrations at 22 October 99.

9.Air Pollution Control

The process of Air Pollution Control include several preparation steps. The most important of these steps are listed in the following:

- Identify sources - Quantifying sources emission inventory - Monitoring of air pollution	Assessment
- Assessing the exposure (impact) situation - Identifying sources – exposure relations Estimating the relative importance of the exposure - of various AP sources - Assessing environmental damage - Investigating control (abatement) options - Performing cost-benefit or cost-effectiveness analysis	Control
- Developing a control strategy and an investment plan - Developing institutions/regulations/enforcement - Establishing an Air Quality Information System	Surveillance

Through the work carried out in the local working groups, a large number of proposed actions and measures has been listed and categorized within the following categories:

-Improved fuel quality

-Technology improvements

-Fuel switching

-Traffic management.

-Traffic demand management.

Each of the proposed actions may be described regarding its effect (benefit), costs, policy instruments, and institutions responsible.

The table below gives a summary of the cost-benefit analysis. For all of the selected measures except cleaner fuels in power plants, the calculated benefits are very sustainable.

Table 5: Benefits and costs of selected abatement measures

Abatement Measure	**Benefits**	
	Avoided effects	**Reduced costs mill USD**
Anti Smoke Belching Campaign	160 deaths	16-20
Improving diesel quality, vehicles	94 deaths	10-12
Inspection/maintenance, vehicles	310 deaths	30-40
Clean vehicle standards	895 deaths	94-116

• The cost reported in this table is subjected to small increases

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