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# Air Pollution in Egypt

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# Contents

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## 1 INTRODUCTION

The Egyptian Environmental Affairs Agency (EEAA) has been supported by Danida to establish an Environmental Information and Monitoring Programme (EIMP) for Egypt. The EIMP component was launched in 1996 with EEAA as the implementing agency for an environmental information and monitoring programme covering institutional support, coastal waters, air pollution, point sources emissions and the development of reference laboratories for improvement of the quality of monitoring data. The component has so far covered procurement, delivery and commissioning of equipment, training of staff, contracting of monitoring institutions and reference laboratories, data collection and analysis, and data storage/ management. The national air pollution monitoring programme developed by EIMP consists of a total of 42 measurement sites covering most of Egypt.

## 2 THE AIR QUALITY MEASUREMENT PROGRAMME

A total of 42 measurement sites have been selected covering most of Egypt. Two monitoring institutions have been selected for undertaking the field operations and collection of data. The Centre for Environmental Hazard Mitigation (CEHM) at Cairo University and the Institute of Graduate Studies and Research (IGSR) at Alexandria University are operating, on behalf of EEAA, a total of 14 sites located in the greater Cairo area, 8 sites in Alexandria, 10 sites in the Delta and Canal area, 9 sites in upper Egypt and 1 site in Sinai. The monitoring program has been designed and established by EIMP. The monitoring laboratories both at CEHM and at IGSR are submitting quarterly reports as a support for the data collection [2] and [3]. These reports briefly describe data quality, data availability and the air quality. A Reference Laboratory has been set up at the National Institute for Standardisation (NIS) [5].

### 2.1 Selected sites

The EIMP Air Quality Monitoring Programme is providing information to support and facilitate the assessment of air quality in the selected areas. The information provided by the EIMP Programme will:

- Provide a general description of Air Quality, and its development over time (trend)
- Enable comparison of Air Quality from different areas
- Produce estimates of individual source contributions
- Indicate the exposure of air pollution to the population
- Evaluate levels of pollution compared to national and international limit values
- Represent input to future information and assessment of air quality

The number of sites and area types are presented in Table 1.

Table 1. Number of sites in different types of areas

| Area type | Cairo | Alex. | Delta and 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 | | | | | 3 |
| Regional/backr. | 1 | 1 | | | 1 | 3 |
| Mixed areas | 2 | 1 | 2 | 1 | | 6 |
| Total | 14 | 8 | 10 | 9 | 1 | 42 |

The design, development, construction and installation of the measurement programme started in 1997 and were completed in July 1999 [6, 7]. CEHM is operating 27 Monitoring and Sampling sites in Cairo, Canal area, Upper Egypt and Sinai while 15 sites are being operated by IGSR in Alexandria and Delta.

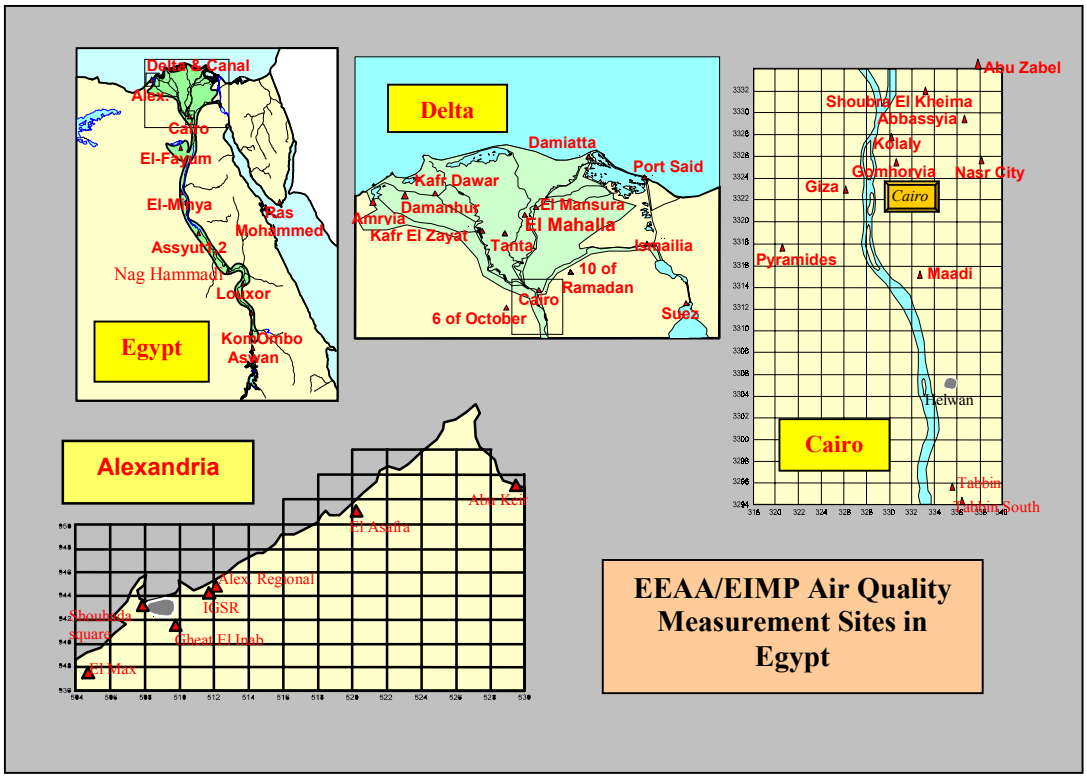


Figure 1. The EEAA/EIMP Air Quality Measurement Sites in Egypt

## 2.2 Indicators

A set of environmental indicators have been selected by the EIMP Programme to:

- Provide a general picture
- Be easy to interpret
- Respond to changes
- Provide international comparisons
- Allow development of trend analyses.

To enable a balanced interpretation of the measured data, the results are being compared to international and national Air Quality Limit values, Standards or guidelines [8]. The guidelines as given by World

Health Organization include a selection of a few priority pollutants [11]. The indicators selected by EIMP were:

- Sulphur dioxide ($SO_2$)
- Nitrogen dioxide ($NO_2$) and/or NOx (Nitrogen oxides),
- Total Suspended Particulate matter (TSP), or better $PM_{10}$ (suspended particles with diameter less than 10 micrometer).
- Ozone ($O_3$)
- Carbon monoxide (CO)
- Lead (Pb)

Not all parameters are being measured by the EIMP/EEAA Programme at all sites. This depends on site specification and typical dominating sources in the specific area. Also VOC (Volatile Organic Compounds) and Dust Fall are being measured in some sites in Egypt.

## 3 AIR QUALITY LIMIT VALUES

Air Quality Limit values are given in the Executive Regulations of the Environmental Law no. 4 of Egypt [1]. These Air Quality Limit values are presented in Table 2.

Table 2. Ambient Air Quality Limit values as given by Law no.4 for Egypt (1994) [1] compared to the World Health Organisation (WHO) air quality guideline values [11]

| 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

Dust fall (DF), which are measured as part of the programme, have no Air Quality Limit value. However, some countries normally state that when dust fall values exceed 10 g/m$^2$ per 30 days, the area may be considered unclean (polluted).

## 4 SUSPENDED DUST, THE MAIN PROBLEM

Large areas of Egypt are exposed to suspended particles in air at levels far beyond Air Quality Limit values given in Law no. 4 of Egypt. Some of these areas may represent a health risk to the population.

The highest levels of small particles (less than 10 micrometer) were found in industrial areas and close to traffic sources. Combustion processes; open air burning, industrial sources and traffic most probably create the thoracic particles (small particles <10 μm ). Larger particles originate from wind blown dust from desert areas.

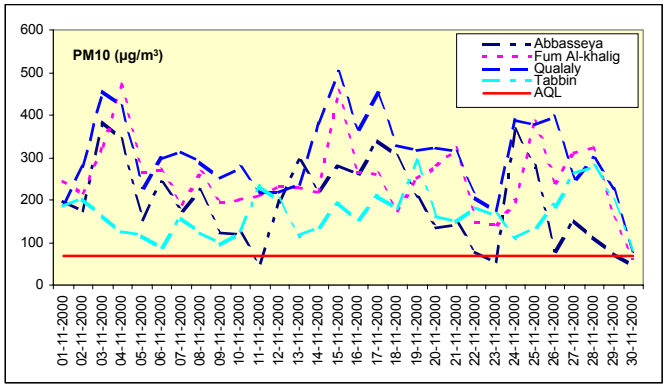


Figure 2. Daily average concentrations of $PM_{10}$ measured at four sites in Cairo; Tabbin , Kolaly ,Fum ElKhalig and Abbaseya,in November2000

An example of measured $PM_{10}$ concentration in the Cairo area is shown for November 2000. Compared to the 24 hour average concentration limit value of 70 µg/m$^3$ we see that almost all days at all sites have concentrations exceeding this level. A typical conclusion from the measurements is that the highest levels of small particles (less than 10 micrometer) were found in industrial areas and close to traffic. Combustion normally creates smaller particles than wind blown dust from desert areas.

Also the TSP concentrations are exceeding air quality limit values, and Figure 3 indicate that TSP concentrations on an annual average basis may be 8 times higher than the limit values.

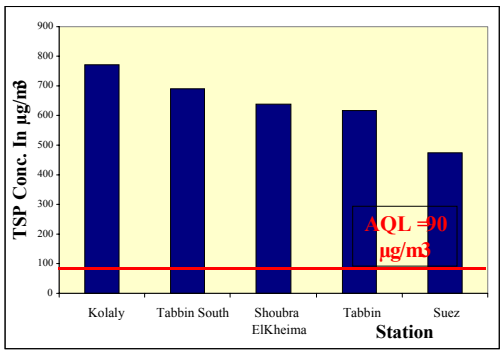


Figure 3. *Annual average concentrations of TSP at 5 sites in Egypt*

## 5 $SO_2$, $NO_2$ AND CO CONCENTRATIONS

The concentration levels of $SO_2$, $NO_2$ and CO have also been observed to exceed the Air Quality limit values, but this occurs only occationally in the most polluted areas. Most of the exceedances are found near industrial areas and in congested streets. Also the large urban centres, such as Cairo, experiences exceedances of the limit values during air pollution episodes caused by certain weather conditions.

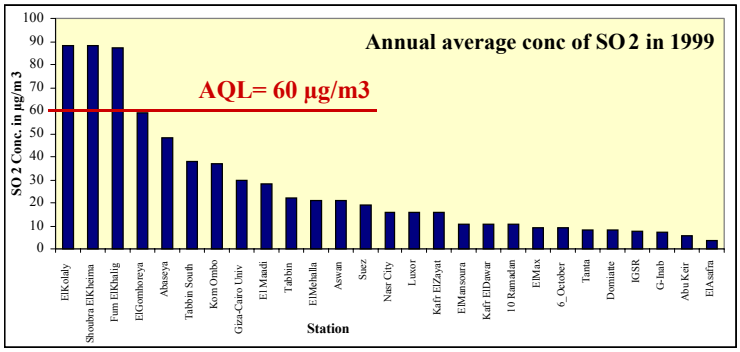


Figure 4. The annual average $SO_2$ concentration of 60 µg/m$^3$ was only exceeded at 3 sites in 1999.

$SO_2$ concentration distributions have also been studied in the Cairo area using inexpensive passive samplers [4]. These measurements have been compared to data from the monitoring sites. The $SO_2$ concentrations measured in Cairo were averaged over a period of two weeks. To discuss the possibility for the air pollution concentrations to exceed a given air quality limit values, the measured levels should be compared to concentrations of $SO_2$ of about 100 µg/m$^3$ [10].

Two areas were identified during this measurement period to have a potential for exceeding the air quality limit values given by Egyptian air quality law. These areas were found around the industrial area Shoubra ELKheima north of the city and in the city centre itself.

Most of the city centre areas of Cairo had concentrations exceeding 50 µg/m$^3$, which is the annual average concentration limit given by World Health Organisation. The results from the passive sampling programme compared reasonable well with measurements performed by the permanent network of monitors and sequential samplers operated by the EIMP/EEAA programme.

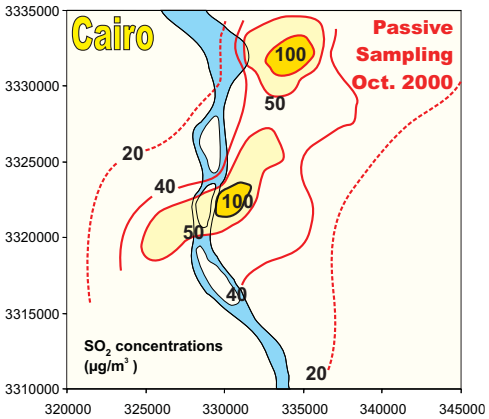


Figure 5. *$SO_2$ concentrations measured by passive samplers in Cairo, 14-28 October 2000*

$NO_2$ concentrations may exceed limit values in congested streets both in Cairo and in Alexandria even if exceedances of $NO_2$ limits are rare. The Air Quality Limits in Law no.4 for CO also include an 8-hour average value of 10 mg/m3. In the streets of Cairo it seems evident that the 8-h average Air Quality Limit value is more often exceeded than the 1-h average values. Traffic jam and traffic congestion in the busiest streets is probably the main reasons for these relatively high CO concentrations.

Some of the main sources identified, as the precursors for the exceeding of the Air Quality Limit values are open-air waste burning, diesel buses and a large number of small industries releasing air pollutants near the surface as well as traffic on the congested streets of Cairo.

## 6 AIR POLLUTION EPISODES

During certain meteorological conditions characterised by low winds and inversion conditions, the city centre of Cairo is experiencing very high concentrations of air pollution. During several of these episodes a major high-pressure area was covering the Middle East. Through these high-pressure areas, smaller frontal systems were moving eastwards across the Mediterranean Sea, north of Egypt setting up a southerly wind or eventually causing the wind to slow down or the direction to change completely inside Cairo. Elevated inversions were established in the subsiding air mass above the Delta and the greater Cairo area.

High air pollution levels were building up in Cairo during the early morning hours (in the night-time surface inversion) and during the daytime (under the inversion ceiling). The air pollutants were slowly transported toward the south until the early afternoon. At the end the local surface winds were turning to move air pollutants back into Cairo from the south.

Emissions from a number of different sources, such as open air waste burning, small enterprises, traffic and general human activities, added to the contribution of particles generated by the burning of rice and cotton straws in the Delta. This, together with the adverse meteorological conditions gave rise to a typical air pollution episode

The most critical pollutants during the episodes were the present of small particles. The concentrations of $PM_{10}$ in central Cairo exceeded the Air Quality Limit value by a factor of 5 to 10. Due to winds and weather the whole Cairo area was covered by smog composed by aerosols containing particles, sulphate, nitrate and a mix of unhealthy air pollutants. From recordings we can see that high concentrations occurred of thoracic particles ($PM_{10}$) as well as of sulphur dioxide ($SO_2$), nitrogen dioxide ($NO_2$), and carbon monoxide (CO).

Except for the particle concentrations, which were very high, the other pollution indicators only barely exceeded the Air Quality Limit values. Both black smoke (soot) and CO were measured at about or above the limit values.

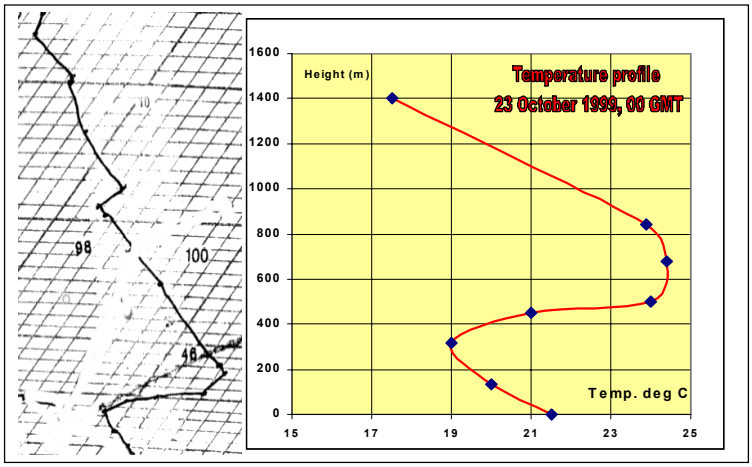


Figure 6. The temperature profile measured over Cairo at 00:00 GMT on 23 October 1999 (Data from the Meteorological Authority station at Helwan).

## 7 TROPSHERIC OZONE OVER EGYPT

High concentrations of surface ozone have been observed both at the background stations and as a result of regionally produced secondary pollutants in the Cairo region.

The ambient concentrations of tropospheric ozone are being measured by the EIMP programme at five sites covering the whole of Egypt. Regional background measurements are undertaken at Ras Mohamed

at the southern tip of the Sinai Peninsula. The sites at Cairo University in Giza and at Abbaseya in the north eastern part of Cairo represent the kilometre scale urban areas away from local sources, while Aswan is located close to the city centre and at a lower latitude.

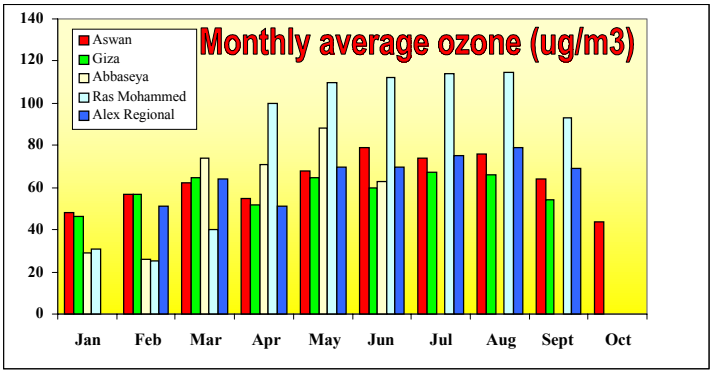


Figure 7. The highest ozone concentrations are measured during the summer months in Egypt

The site in Alexandria is influenced by $NO_x$ emissions from traffic in the city. The site is also clearly inside the urban boundary layer even if the station is located at he roof of the IGSR building 25 m above the surface.

Ozone measurements at the Sinai background site show a significant annual variation with typical winter averages of about 30 µg/m$^3$ and summer averages of around 110 µg/m$^3$. The other sites also show annual variations in ozone, but less profound. The typical ranges between winter and summer levels at regional urban sites are from 40 to 80 µg/m$^3$.

The 8 hour average limit value, however, was exceeded more frequently, as the relatively high ozone concentrations during the summer season seem to last for several hours. At Ras Mohamed the 8 hour average limit concentration of 120 µg/m$^3$ was exceeded during 33.2.% of the time, at Abbaseya 13,2 % of the time and at Giza and Aswan about 4 % of the time during 3 summer months 2000.

## 8 SUMMARY AND CONCLUSIONS

Suspended dust (measured as $PM_{10}$ and TSP) has been demonstrated to be the major air pollution problem in Egypt. $PM_{10}$ concentrations can reach daily average concentrations of more than 400 µg/m$^3$, which is 6 times the Air Quality Limit value for Egypt. On the other hand it seems that the natural background of $PM_{10}$ in Egypt may be close to or around the Air Quality Limit value. These levels can be found also in areas where local anthropogenic sources do not impact the measurements. Further measurements may be used in the future to quantify the relative importance of the different sources.

The concentration levels of $SO_2$ and $NO_2$ have also been observed to exceed the Air Quality Limit values in industrial areas and during some occasions in the big cities. Both the long term (annual averages) and the short-term (1-hour average) Air Quality Limit levels have been exceeded. Eight-hour average CO concentrations in streets and along roads in Cairo frequently exceeded the Air Quality Limit value.

High concentrations of surface ozone have been observed as a result of regionally produced secondary pollutants in the Cairo region. Also the background measurements of tropospheric ozone at Ras Mohamed, at the southern tip of Sinai, show high concentrations of ozone, especially in the summer season.

The urban area of Cairo experiences occasionally very high air pollution levels due to a combination of emissions at ground level during adverse meteorological situations (low wind inversion conditions). Some of the main sources identified, as the precursors for the exceeding of the Air Quality Limit values are open-air waste burning, diesel buses and industries.

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