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The air pollution monitoring network for Egypt

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The air pollution monitoring network for Egypt

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Abstract: The Egyptian Environmental Affairs Agency (EEAA) has been supported by Danida to establish an Environmental Information and Monitoring Programme (EIMP) for Egypt. The national air pollution monitoring programme developed by EIMP consists of a total of 42 measurement sites covering most of Egypt. 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.

Suspended dust (measured as PM_{10} and TSP) is the major air pollution problem in Egypt. Annual average concentrations of PM_{10} range between 100 and 200 µg/m^3 in urban and residential areas and between 200 and 500 µg/m^3 near industrial areas. The natural background concentration of PM_{10} in Egypt has been evaluated to represent levels close to or around the Air Quality Limit value of 70 µg/m^3 as a daily average. 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.

1 Introduction

The Environmental Information and Monitoring Programme, EIMP, was established for Egyptian Environmental Affairs Agency (EEAA) based on funds from the Danish International Development Assistance (Danida). As part of the EIMP programme a national air pollution-monitoring programme consisting of a total 42 measurement sites has been developed and established. Experts from the Norwegian Institute for Air Research (NILU) were appointed responsible for the development of the air quality monitoring programme.

The design of the EIMP Air Quality Monitoring network includes:

- Data collectors; sensors and monitors
- Data transfer systems and data quality assurance/control procedures
- Data bases and
- Data distribution systems.

The Centre of 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 Greater Cairo area,
- 8 sites in Alexandria area,
- 7 sites in Delta,
- 3 sites in Canal area and
- 10 sites in Upper Egypt and Sinai

A brief presentation of the most important air pollution components indicates that the main problem in Egypt is linked to suspended dust (TSP, PM_{10} and black smoke). Occasionally we also record high levels of SO_2, Ozone, CO and NO_2.

2 Suspended dust

Particles originate from a variety of sources such as cars, trucks, buses, factories, construction sites, unpaved roads, stone crushing, and burning of waste and wood. In Egypt a considerable amount of particles are also generated by wind action over the desert areas surrounding the big cities such as Cairo.

2.1 Thoracic particles, PM_{10}

Thoracic particles that may be transported to the lung after breathing is from a health point of view the most interesting indicator for ambient dust. These particles are less than 10 micrometer in diameter and are called PM_{10}.

Concentrations of suspended dust measured as PM_{10} are exceeding national and international air quality limit values at all sites in Egypt. Monthly average concentrations are commonly recorded at between 200 and 300 µg/m^3. Typical annual average concentrations are presented for 25 sites in Figure 1.

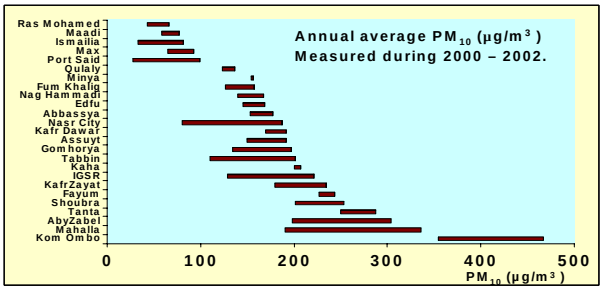

Figure 1: The range of annual average PM_{10} concentrations measured at 25 sites in Egypt (2000 - 2002)

In the greater Cairo area the air quality limit value (AQL) of 70 µg/m^3 as a 24-hour average concentration was exceeded between 45 and 98 % of the time in 2002. Similar periods of exceeding were found in 2000 and 2001.

2.2 Black smoke (soot)

Also the black smoke concentrations are frequently found to exceed the Air Quality Limit value of 150 µg/m^3 as a 24-hour average concentration. Figure 2 presents the frequency of exceedance of the AQL value at five selected sites in Egypt.

At industrial sites such as in ComOmbo (downwind from a sugar factory) and in the southern Tabbin area (brick factories) the black smoke concentrations were above the AQL value during 8 to 43 % of the time annually from 2000 to 2002.

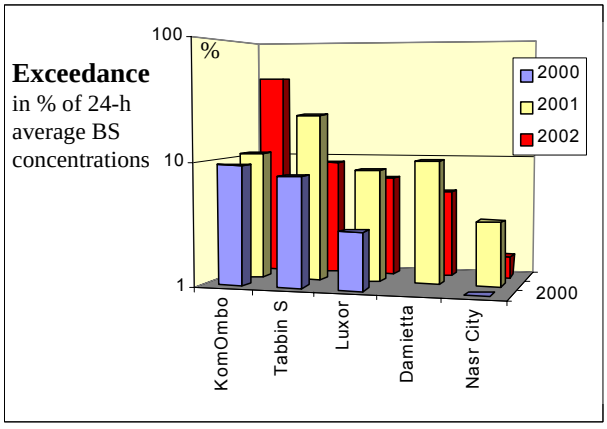

Figure 2: The frequency (in %) of exceeding the Air Quality Limit value of 150 µg/m^3 as daily average concentration at 5 selected sites in Egypt during 2000, 2001 and 2002.

Measurements of black smoke in Luxor, Damietta and in a street in NasrCity show that exceeding of the daily limit values occurred also at these sites (1 to 8 % of the time).

2.3 Total suspended particles

The annual average TSP concentrations measured at 5 sites in Egypt from 2000 to 2002 is presented in Figure 3.

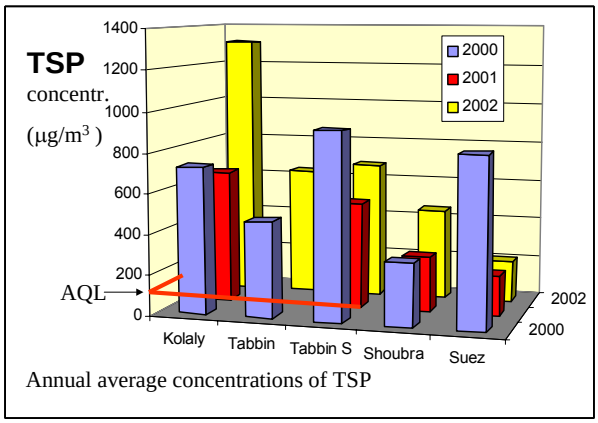

Figure 3: Annual average TSP concentrations measured in 2000, 2001 and 2002.

The Air Quality Limit (AQL) value for Egypt, 90 µg/m^3 as annual average, was exceeded at all sites. Sites surrounded by traffic, industries and high activity, such as Kolaly in Cairo city, Tabbin with cement factories and other industrial activities had very high TSP concentrations. At Suez there was a significant improvement in TSP concentrations when the bus station that surrounded the site moved out of the city.

High TSP concentrations may in many cases also be generated by wind blown dust, e.g. during the Khamsin period.

3 Sulphur dioxide, SO_2

The SO_2 concentrations measure at a variety of sites in Egypt occasionally exceed the AQL values as given by Law no. 4. SO_2 is, however, not an air pollution problem of the same magnitude in Egypt as suspended particles. The limit values are most often exceeded in or near industrial areas and in some few cases inside urban areas as in the Cairo city centre. As an example the exceedances of the 24-hour average concentrations are presented for 5 sites in Figure 4.

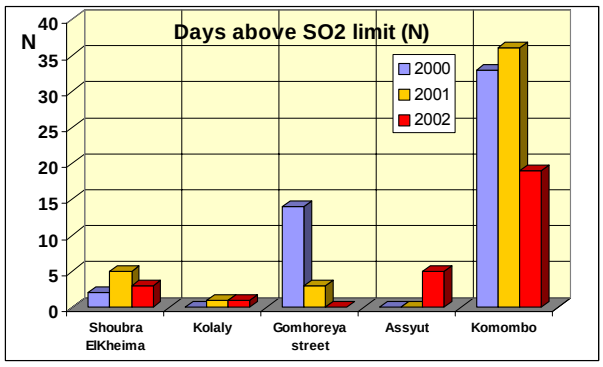

Figure 4: The number of days when the AQL values for SO_2 (24-h average) have been exceeded in 2000, 2001 and 2002 at 5 selected sites in Egypt.

Industrial areas like Shoubra ElKheima (several industries) and Kom Ombo (where the measurements are taken only 1 km downwind from a sugar factory) have revealed frequent exceedance of the limit values, while the urban stations inside Cairo only occasionally have exceeded the limit values.

Long-term average concentrations estimated from passive sampling of SO_2 are presented in Figure 5.

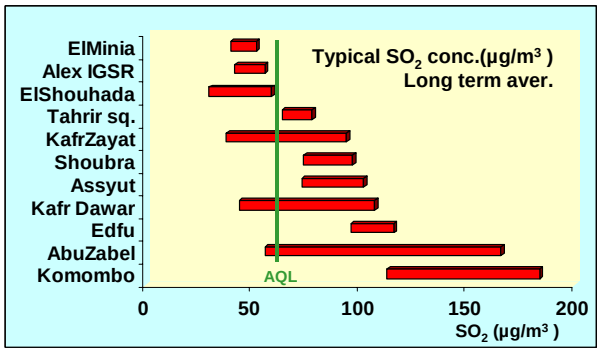

Figure 5: Typical ranges of long-term average (annual) concentrations of SO_2 measured by passive samplers at 11 selected sites in Egypt.

Again we see that sites impacted by industrial emissions are exposed to the highest concentrations of SO_2. Even at Tahrir Square, in the city centre of Cairo, the SO_2 level was slightly higher than the limit values.

4 Carbon monoxide, CO

Inside the city centre of Cairo traffic jam often occur and the typical daily average concentrations of CO thus will exceed the Air Quality Limit values. Figure 6 indicates the frequency of exceedance of the 8-hour average concentration of 10 mg/m^3.

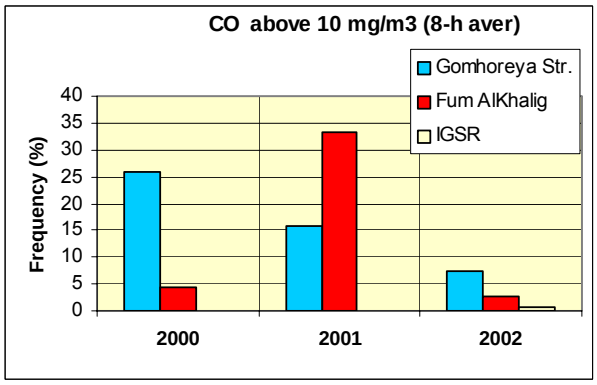

Figure 6: The occurrence of 8-hour average CO concentrations above the AQ limit value of 10 mg/m^3 measured at one street canyon and two roadside stations.

In the streets of Cairo, such as around the old opera square (Gomhoreya street) and at the highly traficated FumAlKhalig area the daily 8-hour average CO concentration was exceeded in 5 to 33 % of the time.

5 Nitrogen dioxide, NO_2

NO_2 is being measured by the EIMP programme at 22 sites in Egypt. Annual average concentrations ranged in 2002 between 25 and 83 µg/m^3 .In the streets of Cairo the average concentrations were between 75 and 83 µg/m^3.

The one-hour average limit value of 400 µg/m^3 was not exceeded in 2002. However, the 24-hour average limit value of 150 µg/m^3 was exceeded during one to five days in the streets of Cairo. Passive sampling data indicate that there may be other areas with high traffic density where the limit values occasionally were exceeded.

6 Ozone, O_3

Measurement data indicate that ground level ozone together with small particles is one of the major air pollution problems of Egypt. We therefore have to understand the formation and occurrence of ozone.

Ozone (O_3) at the surface is most often created by a chemical reaction between oxides of nitrogen and volatile organic compounds (VOC) in the presence of heat and sunlight.

VOC + NOx + Heat + Sunlight → Ozone

Motor vehicle exhaust and industrial emissions, gasoline vapours, and chemical solvents are some of the major sources of NO_x and VOC, which help to form ozone. Sunlight and hot weather cause ground-level ozone to form in harmful concentrations in the air.

In the greater Cairo area the transport time during hot summer days is long enough so that large amounts of harmful ozone is being created in the area. Afternoon maximum concentrations as recorded at Giza (Cairo University) and at a roof station at Abbaseya are typical examples of this kind of regional formation of ozone. Both these sites represent the kilometre scale urban areas away from local sources.

Figure 7 illustrates the annual average diurnal variation of ozone at 4 selected sites in Egypt.

The regional background measurements undertaken at Ras Mohamed at the southern tip of Sinai indicate that the background ozone level is on the average higher than the levels measured in Cairo and Alexandria.

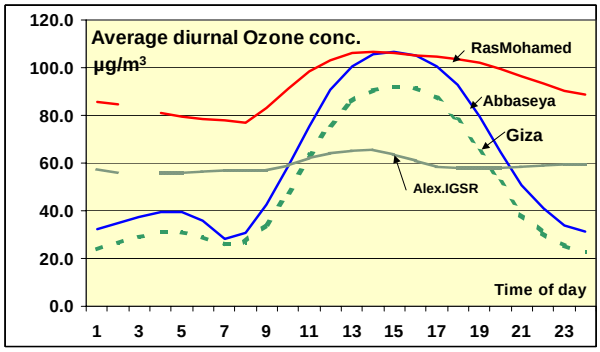

Figure 7: Annual average diurnal variation of ozone measured at 4 sites in Egypt 2000-2002.

In Alexandria we see from Figure 7 that the ozone levels are influenced by NOx emissions from traffic in the city. The "fresh" NOx emissions are "using" ozone. The concentrations are therefore relatively low as the site clearly is located inside the urban boundary layer.

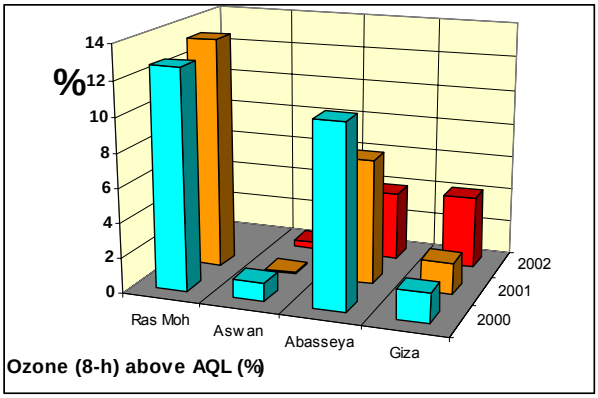

Figure 8: The frequency (%) of 8-hour average ozone concentrations exceeding the AQL of 120 µg/m^3 .

The 8-hour average limit value (120 µg/m^3) was exceeded more frequently than the one-hour average limit values, as the relatively high ozone concentrations during the summer season seem to last for several hours.

At Ras Mohamed the 8-hour average concentration was exceeded during 13,4 % of the time in 2001, at Abbaseya 10,5 % of the time in 2000 and at Giza and Aswan up to about 4 % of the time. During the summer season exceedances are found more frequently.

7 Summary and conclusions

Suspended dust (measured as PM_{10} and TSP) is the major air pollution problem in Egypt. Annual average concentrations of PM_{10} range between 100 and 200 µg/m^3 in urban and residential areas and between 200 and 500 µg/m^3 near industrial areas. Daily average concentrations of more than 6 times the Air Quality Limit value for Egypt are being recorded occasionally in the urban areas of Cairo. The natural background concentration of PM_{10} in Egypt has been evaluated to represent levels close to or around the Air Quality Limit value of 70 µg/m^3 as a daily average.

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.

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