GREATER CAIRO AIR QUALITY PROFILE

A Report for EEPP (EEAA)

Consultant: Prof. Dr. M. M. Nasralla

.

January 2001

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Introduction

This report deals with Greater Cairo air quality profile. In fact, Greater Cairo is the most polluted place in Egypt. It houses about 50% of the industrial activities, generation of electricity from thermal power stations and motor vehicles allover the country. Consequently, air pollution becomes a serious problem in the area. Haze and smoke plumes become a common phenomenon in Greater Cairo air. Furthermore, acute air pollution cases occur in Cairo under favorable meteorological conditions. The most recent air pollution "episode" occurred during autumn 1999 and early winter 2000 (October 1999 – January 2000). Consequently, an air quality management program based on scientific basis becomes an urgent matter to conserve air quality in big industrial and urban centers of Egypt. Air pollution control strategy should account for the existing situation and the future developments. Legislation is an inherent part of any of such strategies. However, it was found through the application of the environmental pollution Law 4/1994 during the last few years that the executive regulation should be revised and improved to meet the requirements of air quality improvement (Loeb and Nasralla reports for EEPP). The current air pollution situation should be reviewed and properly evaluated in order to set a realistic control strategy. Consequently, applicable emission standards can be attained on practical basis. Therefore, this report is the outcome of a consultation undertaken for EEPP (EEAA) to conduct a profile of current air pollution situation in Greater Cairo.

CAIRO

1. General information

Geography: Cairo (Al-Qāhira) is fan shaped and bounded by Nile delta to the north. The city of Cairo is situated principally on the eastern bank of the River Nile a few kilometers south of Rosetta and Domietta branches at an elevation of 74 m above mean sea level (Latitude 30°08' N. Longitude 31°34' E). The current city is approximately 1,000 years old.

The central urban area of Cairo is primarily a commercial area comprising thousands of small workshops, industries and bakeries. Greater Cairo consists of three governorates; Cairo, Giza and Kalubia. Giza (or Al-Jiza) is a large residential sector situated to the west of the city.

Demography: Cairo is the capital of Egypt and is the most populous city in Africa. An extensive industrialization program and improved transport facilities introduced over the past 40 years have accelerated urbanization of the Greater Cairo area. In 1950 Cairo had a population of 2.4 million. The 1996 population of Greater Cairo was 10.72 million. By the year 2005 Cairo is expected to have a population of 11.3 million. Cairo's annual urban growth rate was 1.2 per cent in 1996 compared with 2.08 percent in Egypt (CANS, 1998).

Climate: Cairo has a desert climate characterized by very dry heat. Monthly mean temperatures range from 13°C in January to 28°C in July. The maximum daily temperature in July can reach 43°C. annual mean rainfall is only 22.3mm, the monthly maximum (6mm) occurring in December. Average relative humidity is 59 per cent. The average total annual duration of sunshine is 3,504 hours (GOM, 1981-1990). The prevailing wind direction in Cairo, all over the year is from around north. More than 57% of the winds are from between 32° and 040° on annual basis as shown in the wind rose (Figure 1). The mean annual wind speed is 5.2m/s. More than 90% of the cases are equal or the less than 8m/s (GOM 1981-1990). Nights are generally cool and during the winter quite damp; radiational cooling often leads to shallow, stable inversions. Surface inversion is a predominant case during winter nights (Hassnein et al., 1976), (Figure 2). A Nile breeze is also characteristic of night-tine climate. Pollution is generally exacerbated by low wind speeds, lack of rain, tall buildings, narrow streets and traffic congestion in Cairo. More unstable wind conditions later in the summer tend to reduce pollutant concentrations.

***Industry**:* Cairo houses 52% of Egypt's industries and accounts for 32% of the electricity generated from thermal power stations in the whole country. Industries are mainly located at Shoubra El Kheima, northern of Cairo, and Helwan area to the south of the city as well as adjacent to residential areas in some urban districts. These activities consume over 40% of the Egypt’s energy yet only 18 percent of the country’s population.

Table 1: Source of Energy in Cairo, Fuel in thousand tones, electricity in GWH, 1998.

Energy source	Sulphur content%	Transportation	Electricity	Industry	Commercial, Residential and others	Total
Fossil Fuel						
Petrol	0.05	1173	-	-	-	1173
Kerosene	0.15	-	-	6	241	247
Diesel and Solar (Furnace fuel)	0.9	962	-	993	-	1955
Mazout (Heavy fuel oil)	2.7	-	2083	1890	-	3973
Natural gas	-	0.5	1528	286	344	2158.5
Electricity (GWH)		152	-	6540	14168	20860

Table l shows consumption of energy in Cairo. This table shows that although the use of fuel containing more than 1.5 percent sulphur is restricted by law at urban districts or adjacent to residential areas, about 4 million tons heavy oil (2.5% - 3% S) is used by industry and electricity power stations. Almost 52 percent of this amount is used at Cairo's power stations. Heavy oil and natural gas are the major fuels used for power generation in Cairo, accounting for 60% and 40% respectively. The use of natural gas in the industry is yet limited to 9% of fuel used in the industrial establishments.

Table 2 shows the power generation and fuel use in Cairo power stations.

Table 2: power generation and fuel use in electricity power stations in Cairo (1998)

Power station	Power generated GWH	Fuel x 10^3 equivalent tons, consumption
Shoubra El-Kh	7395.6	1673
West Cairo 1	16.46	413.9
West Cairo 2	3180.5	692.4
South Cairo 1	2357.9	531.1
South Cairo 2	1235.8	226.6
Wadi Houf	58.9	23.1
El Tebbin 1	241.3	87.5
El Tebbin 2	36.9	13.8

Cairo' s main industries are iron and steel, textiles, vehicles manufacturing, cement, chemical, petroleum refineries, fertilizer, refrigerator manufacturing, bricks, ceramics, lead secondary smelting, and food processing. The number of registered industrial establishments is 12600. The biggest 420 of these industrial enterprises are controlled by public sector.

Helwan is the biggest industrial area of Egypt employing over 70,000 workers; the population of the area is about one million. This area houses 3 cement companies. This industry was emitting about 850 tons of kiln dust daily during 1994 to the atmosphere of Helwan. Using electrostatic precipitators to control dust emissions reduced this amount to less than 50 tons daily during 1997 (Nasralla et al., 1998). In addition, it is also the site of iron and steel industries, lead and zinc smelting, foundries, ceramic industries, car industries, coke and fertilizers, textiles, bricks, chemical industries. Power for these industries is provided by 5 electricity power stations located in the area.

The northern industrial area, Shoubra E1-Kheima, consists of over 1000 industrial units of various sizes and employs 105,000 workers, most of whom are also residents in the area. Industries include petroleum refining, ferrous metallurgical work, foundries, lead smelters, ceramics, glass, bricks, textiles and plastics. There are also two power stations; one of them is a large thermal power station generating 7359 GWH and using 46% of the fuel used by power stations (Table 2).

The industrial activities located in the urban area and adjacent to the heavily populated residential areas include metallurgical work, bricks and food industries at Imbaba, limestone and lime work at Dar El-Salam, food industries and chemical industries at El-Amiria, lead smelters at E1Wayli, bricks, lime and pottery at El-Basateen, leather work at Ein-Elsira and many others. The urban districts house more than four thousands of workshops, foundries and more than 1500 backhouses. Cairo air quality is also influenced by limestone quarrying lime work surrounding the city.

***Transport**:* The main mode of public transport in Cairo is the bus. The modal share of motorized trips in Cairo was 15 percent cars, 15 percent taxi and 70 percent bus in 1980. Yet, since l980 the number of motor vehicles in Cairo has increased from about 400,000 to more than 1.27 million in 1998. The number of motorized trips per day has increased from 3.9 million in 1980 to 12.3 million by the year l998. At present Cairo city has two main metro links. The metro links El-Marg in the north of the city with Helwan and links Giza southwest with shoubra E1Kheima (NE). The share of motorized trip in l998 was 61% bus, 12.2% taxi, 10.6 metro, 13.8 private cars and 2.4% motocycles (table 3).

Table 3: Number of Vehicles and Trip distribution by mode in Greater Cairo, 1997

	Bus and minibus	Taxi	Metro	Private cars	Motocycles
Number of Vehicles	19498	77243	2 lines	925120	170313
Million person per day	7.5	1.5	1.3	1.7	0.3
% Person trip per day	61	12.2	10.6	13.8	2.4

Other Important Sources of air pollution in the area include the open burning of municipal solid waste. Incinerated solid waste amounted 700 thousand tons to one million tons annually.

Activities surrounding Greater Cairo and possibly affecting the air quality are numerous. These include agricultural waste burning in delta Nile valley during autumn. Industrial activities north of Greater Cairo (Kaliob, Mustorod and Abu Zaabal) include iron and steel, chemicals, phosphate fertilizers, petroleum refineries, clay bricks, smelters, foundries, steel work, boilers (food and textile industries) and many other small activities. Other industries located out of Giza city west of Greater Cairo include brick industries along the western bank of river Nile, north and south of Giza governerate, sugar and allied chemicals at Hawmedia; wood industries, smelters, chemical industry, and other small industrial activities at Abu Rawash and the industrial area west of Giza. Mining, lime work and stone quarrying at Mokkatum, Katamia, Tora south of Cairo as well as sand quarrying S-W of Giza. Moreover, the air quality of Cairo is largely affected by natural dust carried out by wind from the surrounding desert and hills.

2. Monitoring

The Ministry of Health (MoH) monitors air pollution in Cairo. Sulphur dioxide (SO_2) and smoke monitoring commenced in 1973; in addition, total suspended particulate matter (SPM/TSP) monitoring was initiated on a regular basis at various sites in 1985. The MoH's Imbaba Center provides the facilities for the analysis of SO_2 and TSP for greater Cairo. Smoke measurements are carried out at the MoH Central office. Only a limited number of staff are available for specialized air pollution monitoring. Air quality monitoring in Egypt conducted by the Ministry of Health was assessed by WHO, (Commins, 1987 and Nasralla, 1996). It was found that the measurements of SO_2 were affected by partial neutralization of the absorbed SO_2 in the bubblers by ammonia. This method will be replaced by pararosoniline colorometric method according to the standard methods manual prepared for MoH by WHO (Nasralla, 1 998).

Recently another monitoring program has been developed by Environmental Information and Monitoring Program (EIMP) in the Egyptian Environmental Affairs Agency (EEAA) to monitor PM_{10} sulphur dioxide, carbon monoxide, nitrogen dioxide and ozone by using automatic monitors in 8 stations. Figure 3 shows the location of monitoring stations in Greater Cairo. In addition to the MoH and EIMP monitoring programs. CAIP (EEAA), Universities and National Research Centre (NRC) carry out monitoring programs for special purposes. The work of National Research centre is directed mainly toward research studies. CAIP monitoring program is a temporary program serving the purposes of the project with reference to lead emissions and lead pollution control. Consequently, this program monitor PM_{10}, $PM_{2.5}$ and lead in 36 stations allover Greater Cairo as well as background areas (Fig 4).

The objectives of these programs vary from one program to the other and sometimes objectives are unclear. This is one of the most obvious deficiencies of air quality monitoring network in Cairo. The monitoring network also lacks a comperhensive auditing and QA/QC programs. Reports usually do not reflect the primary objectives of the monitoring network. Both monitoring networks of MoH and EIMP face severe problems with instrumentation, spare parts, maintenance, well-trained staff, QA/QC, data analysis and reporting. Objectives should be set clearly and the work has to be carried out to achieve these objectives. **Modeling** is preferably to be included in these programs to relate pollutants to their sources. The next task of this consultation (setting the framework for control strategy) will include the proposed corrective measures to be undertaken for improvement of air quality monitoring network and modeling.

3. Air Quality Situation

Sulphur Dioxide

Sulphur dioxide is one of the common air pollutants found in the atmospheres of urban and industrial areas. Sulphur dioxide can cause damaging effects for human health, material and vegetation. Moreover, sulphur dioxide can oxidised in the atmosphere and consequently transform to fine particles of sulphates. It was found that **atmospheric** reactions are the prime source of ambient sulphates in Cairo urban atmosphere (Nasralla et al 1992). Furthermore, sulphates found to constitute about 9% of PM_{10} in Cairo city centre (Figures 5 and 6) sulphates were mainly encountered in particulates of diameters less than 2.5 µm where it may reach 15% of these fine particulates (Rhodes, Nasralla and Lawless, 1996).

***Emission**:* There is no SO_2 emission inventory available for Cairo. While natural gas-fired power plants emit very little SO_2 it can be estimated from the fuel consumption data given in table 1, that SO_2 emission from fuel combustion reaches 251,646 tons annually. Transportation may emit 18,489 tons per annum. As the sulphur content of diesel is much higher than in petrol, nearly 90 percent of all vehicle SO_2 emissions come from diesel-powered buses using fuel contains 0.9 per cent sulphur. The use of heavy oil in power plants and industry resulted in 214,542 tons per annum representing 85 per cent of SO_2 emission from fuel combustion in Cairo. Burning 2000 tons per day municipal solid waste may add 7000 tons SO_2 per annum into Cairo air, (Nasralla, 1999). There are, of course, numerous other sources for SO_2 emissions such as industrial sources (including iron and steel production, smelters, foundries, oil refineries and chemical industries). These sources certainly emit considerable additional amounts of SO_2. It is recommended that a full and detailed SO_2 inventory for Cairo be carried out as soon as possible.

Ambient Concentrations: The Egyptian MoH has been monitoring SO_2 in Cairo since 1973. Acidimetric titration (hydrogen peroxide) the main monitoring method employed by MoH program in Greater Cairo. However, it was shown that due to high atmospheric ammonia concentrations and high temperatures this method was unreliable (Nasralla et al., 1984; Commins, 1987). The more reliable colorimetric (pararosaniline) method and continuous monitors (UV) are now favoured. As the hydrogen peroxide titration method is still used at the sites monitored by MoH, these data are not presented here due to doubts over their reliability. The published work by NRC reported that the annual mean concentrations of sulphur dioxide in Cairo urban atmosphere ranged from 40 $\mu g/m^3$ at Madinet Nasr to 84$\mu g/m^3$ at city centre during l991/1992. Higher concentrations of sulphur dioxide were recorded during 1995/1996 where the annual mean concentrations were 59 $\mu g/m^3$ in Dokki atmosphere, 51 in Madinet Nasr atmosphere and 91 $\mu g/m^3$ at the atmosphere of the city centre. These concentrations may be compared with the WHO guideline of 50$\mu g/m^3$ not to be exceeded as annual mean and the Egyptian air quality standard of 60$\mu g/m^3$ (table4). The highest annual mean concentrations were recorded in Shoubra El-Kheima industrial area reaching 108$\mu g/m^3$ during 1995/1996 followed by the city centre having 91$\mu g/m^3$ sulphur dioxide in their atmospheres (Figure 5). The maximum allowable concentrations for the human exposure during 24h according to the recommendation of WHO is 125$\mu g/m^3$ and the Egyptian air quality standard is 150$\mu g/m^3$ (Table 5). The maximum concentrations over 24h at Sh. El-Kheima and central urban districts during 1995/1996 exceeded these limits except at Madinet Nasr and Dokki. 24h maximum SO_2 concentration reached more than 300µg/m3 in both, the city centre and the industrial district. Moreover, Fig 6 shows that high concentrations of sulphur dioxide persisted in Cairo atmosphere during summer months and lower concentrations in winter. This is possibly due to the need for more energy production during summer months. The EIMP (EEAA) monitoring

Table 4: Egyptian Air Quality Standards, µg / m^3

Pollutant	Maximum Limit	Averaging Time
Sulphur Dioxide (SO_2)	350	1 Hour
	150	24 Hour
	60	**Annual**
Carbon Monoxide (CO)	30 mg/m^3	1 Hour
	10 mg/m^3	8 Hour
Nitrogen Dioxide (NO_2)	400	1 Hour
	150	24 Hour
Ozone (O_3)	200	1 Hour
	120	8 Hour
Black Smoke (BS)	150	24 Hour
	60	Annual
Total Suspended Particulate (TSP)	230	24 hour
	90	Annual
Suspended Particulate less than 10 µm in diameter (PM_{10})	70	Annual
Lead (Pb)	1	Annual

The USA air quality standard for PM_{10} of 150 mg/ m^3 for 24h has been used for comparison or is this report .

Table 5 : Frequency (number of days) of SO_2 according to their 24h concentrations (Fum El-Khalig) (μg/m^3)

Month	Index	< 0.5	0.5–1	1–1.5	1.5–2	> 2	Highest
	Conc	<75	75-150	150-225	225-300	> 300	Level
July 1999		-	2	9	8	3	347
Aug 1999		14	3	-	-	-	
Sept 1999		9	15	-	-	-	
Oct 1999		13	17	1	-	-	
Nov 1999		4	13	8	1	-	
Dec 1999		2	12	15	1	1	351
Jan 2000		14	17	-	-	-	
Feb 2000		16	3	-	-	-	
Mar 2000		28	-	-	-	-	
Apr 2000		24	1	-	-	-	
May 2000		28	-	-	-	-	
June 2000		28	-	-	-	-	

program started l998 shows that SO_2 concentrations exceeded the annual Egyptian air quality standards in all sites except at Tabbin and Maadi suburban district.

However, it may be noted that there is a general trend of decrease in sulphur dioxide concentration in Cairo air with reference to the industrial area of shoubra El-Kheima during the last few years. Moreover, SO_2 exceed the air quality standard at central areas by about 20% during the year 2000. This is possibly due to the increase of using natural gas in power stations and some of other activities. Figure 6a shows that SO_2 concentrations during the year 2000 dropped to 69 and 65 μg/m^3 in the air of the city centre and Shoubra El-Khiema respectively compared to 91 and 108 ug/m^3 recorded in 1995 /96.

The annual mean concentration of SO_2 in the background area outskirt of Nasr City (NE Cairo) during 1999 and 2000 were 16 and 18 μg/m^3 respectively.

Table 5 shows the frequency of daily sulphur dioxide concentrations in Cairo central district (Kolaly). This table also shows that sulphur dioxide sometimes reached over 300 μg/m^3 as an average for one day, double the air quality standard of 150 μg/m^3. Here it should be noted that contrasting the particulate matter, SO_2 kept below the 24h air quality standard most of the monitored day except during Cairo's air pollution episode "Autumn 1999". In fact the increases of using natural gas in power stations, small and big industries, traffic fleet and other purposes and reducing sulphur content of used oil can greatly improve the situation and keep sulphur dioxide concentrations below the air quality standards.

Here, it should be noted that diesel engined buses using solar (gas oil) of 0.9% S contribute significantly to sulphur dioxide concentrations in Cairo central urban district. This is clear from the diurnal variation of SO_2 at Kolaly (city centre) where the monitoring station is very close to a bus station (Fig 7).

Particulate matter

Emissions*:* There is no SPM emission inventory available for Cairo. There are natural emission sources of particulate matter (such as wind-blown dust) as well as anthropogenic sources (e.g., motor vehicle exhaust, industrial particulate. A large contributor to natural SPM levels are the north-easterly winds in spring and the fresh-to-strong hot "Khamasin" southerly wind which are usually loaded with high levels of natural sand and dust. However, there are no estimates of the contribution of natural SPM to total ambient SPM levels.

There are many anthropogenic SPM emission sources, especially from incomplete combustion processes, industry (iron and steel, cement, etc...), and traffic. Smoke emission from cars and buses has been estimated to be 1,800 tones per annum in 2000. This is a more than sevenfold increase since 1980. About 88 per cent of these emissions come from cars. Traffic SPM sources are believed to be relatively small compared with other SPM sources, but their impact on SPM pollution at roadside locations is probably severe.

Ambient concentrations: Suspended particulate are measured by the MoH network as both black smoke (BS) and TSP. Although poor correlation found in other countries between TSP or BS and health effects, they can be used as good indicators for total particulate load and incomplete combustion particles in air. Consequently, they can serve as good indicators to follow air pollution trends and control.

The annual mean concentrations of black smoke in 10 districts of Greater Cairo (except Helwan city and Madinet Nasr) ranged from 60 $\mu g/m^3$ to 126 $\mu g/m^3$ during 1999 (Figure 8). In other words, the concentrations of smoke in all sites (except 2 sites) reached concentrations above the WHO annual guideline of 40 - 60 $\mu g/m^3$ and usually above the Egyptian Air Quality standard. Daily mean smoke levels in most districts exceeded the WHO guideline of 125 $\mu g/m^3$. The maximum 24h concentration of smoke in Cairo city usually exceeds the recommended WHO guidelines reaching more than 500 $\mu g/m^3$ at city centre and some times reaching more than 4 times the air quality standard of 150 $\mu g/m^3$ as a maximum over 24h at the residential areas of Abu Soud and Abbasia (Anmexes). These high levels of smoke concentrations are mainly due to the incomplete combustion of fuel in vehicles and the industrial activities with reference to heavy oil and the emission from the old cars and buses running in Cairo streets. The annual mean concentrations of TSP during 1999 in Cairo atmosphere ranged between 350 $\mu g/m^3$ at Helwan city to about 550 $\mu g/m^3$ at Ameria and Attaba square (city centre) far exceeded the WHO guideline of 60 - 90 $\mu g/m^3$ (Figure 9). These concentrations are 4 to 7 times the Egyptian Air Quality Standard (90 $\mu g/m^3$, annual mean). 24h mean concentrations of particulates (TSP) sometimes reached about 1000 $\mu g/m^3$ in some locations in Cairo compared to the Egyptian air quality standard of 230 $\mu g/m^3$ for 24h Annexes. However, the concentrations of particulate in Helwan industrial district has steadily decreased during the last five years due to the control of kiln dust emitted from cement industries through the using of electrostatic precipitators. This makes the concentrations of dust in this heavily polluted area similar and in some locations less than that recorded in Cairo central

Table 6 : Statistical Study for PM_{10} Concentrations in Cairo Kolaly Station ($\mu g/m^3$)

Month	Monthly mean	Highest 24 hour average	No of Exceedance/ 150 ($\mu g/m^3$)
Dec-98	500	1042	14
Jan-99	The station was closed due to problems in Electricity and has been restatred again on July 1999		
Feb			
Mean/Winter			
Mar – 99	-	-	-
Apr – 99	-	-	-
May – 99	-	-	-
Mean/Spring			
Jun - 99	-	-	-
Jul – 99	206	257	2
Aug – 99	157	238	7
Mean/Summer	182		
Sep – 99	169	282	21
Oct – 99	302	486	30
Nov – 99	272	619	23
Mean/Autumn	248		
Dec – 99	247	443	23
Jan – 2000	182	428	18
Feb – 2000	169	293	15
Mean-Winter	199		
Mar – 2000	134	315	13
Apr – 2000	179	666	10
May – 2000	104	139	0
Mean/Spring	139		
Jun – 2000	141	231	9
Jul – 2000	146	346	19
Aug – 2000	140	247	4
Mean/Summer	142		
Sep – 2000	206	281	4
Oct – 2000	206	445	19
Nov – 2000	293	685	28
Mean/Autumn	235		

area (Fig 9). However, attention should be given to fugitive emission of particulates and emissions from other industries such as iron and steel industry, brick industry, ceramics, coke plant and other sources located in Helwan industrial area.

EIMP continuously monitor PM_{10} in 4 sites (Figures 10 and 11) PM_{10} and $PM_{2.5}$ in Cairo air are measured since 1999 (CAIP, 1999). These measurements show high levels of PM_{10} in Cairo air. The PM_{10} concentration for 24h may reach more than 600 $\mu g/m^3$ (Table 6). This is more than 4 times the USA air quality standard for PM_{10} of 150 $\mu g/m^3$ (24h). The lowest recorded annual concentration in any monitored district during 1999/2000 (CAIP, 2000) outside of Cairo is 112 $\mu g/m^3$, 1.4 times the maximum allowable concentration according the Egyptian legislation. The annual mean concentrations of PM_{10} in Cairo city centre during 1999/2000 reached 179 $\mu g/m^3$ according to EIMP and 239 $\mu g/m^3$ according to CAIP. Higher concentrations of PM_{10} of 300 $\mu g/m^3$ recorded by CAIP at shoubra El-Khima, (Fig 12) (see Appendices). These concentrations are 4-5 times the USA air quality standards and much higher than the Egyptian standard. Seasonal variation of PM_{10} (Fig. 11) shows that the highest levels of PM_{10} in Cairo city centre and Tabbin are pronounced during Autumn and Winter respectively. This is possibly due to the prevailing weather conditions during these seasons. This high level of PM_{10} in Cairo air is not only due to the high rate of emissions from industrial and combustion processes but also because of the influence of natural causes. The mean value of PM_{10} in a background station northern of Cairo reached more than 70 $\mu g/m^3$ (Rhodes et al 1996). This is causing a serious problem to set a standard for particulate matters in Cairo air. High levels of $PM_{2.5}$ are also recorded in Cairo atmospheres due to the incomplete combustion of fuel with reference to small industries using heavy oil and the emissions of smoke from old and poorly maintained cars and buses as well as natural causes.

Carbon monoxide

Emissions: an inclusive carbon monoxide (CO) emission inventory has not been established for Cairo. Generally, in urban areas exhaust of petrol motor vehicles is the largest CO emission source. In Cairo, CO emissions from cars and buses have been estimated to be 223,000 tons per annum in the year 2000 more than three fold increase from 1980 (Faiz et al, 1990). About 99 percent of traffic CO emissions are from cars, as buses have very low CO emission rates. There is no estimation for CO emissions from other sources. Power stations generally have very efficient combustion systems and thus emit relatively low amounts of CO. However, open incineration of about 2000 tons of municipal solid waste adjacent to Cairo urban area may result in the emission of 32000 tons per annum.

Ambient concentrations: The first long-term routine CO monitoring network has been only started very recent. EIMP (EEAA) set 3 monitoring stations for carbon monoxide in 1998. The EIMP results of 1998 showed that the 8 h air quality standard of 10 mg/m^3 was exceeded at city centre location (El Gomboria street) for 25% of the monitored time and the same limit was also exceeded for 18% of the time at Fum E1 Khalig.

Analysis of monitoring data according to the proposed air quality index shows that the 8h average concentration of carbon monoxide exceeded the air quality standards at Fum El-Khalig during several days of October 1999 to November 2000 (Table 7). This table also shows that CO

Table 7 : Frequency (number of days) of Max 8h CO Fum El-Khalig, (mg/m^3)

Concentration	**Less 5**	**5 to 10**	**10 to 15**	**15 to 20**	**More than 20**
Sep – 99	24	4	0	0	0
Oct – 99	8	19	2	2	0
Nov – 99	1	13	7	1	4
Dec – 99	1	16	8	3	3
Jan – 00	2	22	7	0	0
Feb – 00	4	7	1	0	0
Mar - 00	17	10	0	0	0
Apr - 00	19	11	0	0	0
May - 00	26	2	0	0	0
Jun – 00	30	0	0	0	0
Jul - 00	13	18	0	0	0
Aug - 00	12	18	1	0	0
Sep – 00	0	29	1	0	0
Oct – 00	0	24	7	0	0
Nov - 00	0	2	18	9	0

Table 7a : Frequency (number of days) of Max 8h CO
Gomhoryia, (mg/m^3)

Concentration	**Less than 5**	**5 to 10**	**10 to 15**	**15 to 20**	**More than 20**
Sep – 99	Due to problems in the location of the monitor was shut down				
Oct – 99	**And re-installed again on jan 2000**				
Nov – 99					
Dec – 99					
Jan – 00	0	11	7	8	1
Feb – 00	0	13	13	2	1
Mar – 00	7	18	4	0	0
Apr – 00	0	20	7	1	2
May – 00	3	25	2	0	0
Jun – 00	13	17	0	0	0
July-2000	13	16	0	0	0
Aug – 00	5	23	1	0	0
Sep – 00	0	1	5	19	4
Oct – 00	0	5	14	12	0
Nov – 00	0	0	0	0	20

concentrations exceeded the 8h air quality standard of 10 mg/m^3 during 41% and 45% of the days of November and December 1999 respectively. Furthermore, a concentration of 34 mg/m^3 Carbon monoxide (more than the air quality standard for 1h) persisted for 8h in the air of Fum El-Khalig during Cairo's episode 1999.

Figure 13 shows the typical diurnal variation of CO at Gomhoria station (city centre) where CO concentrations peaked during daytime with increasing traffic activities to levels significantly higher than the 8h air quality standard. Moreover, specific research studies on CO pollution from motor vehicles have been carried out over the last ten years. For instance, measurements of CO during January 1994 at 1.7 m level above curb edge in Ramsis square with heavy traffic density showed hourly CO concentrations of 20 to 46 ppm compared to the WHO guideline 1 hr of 30 mg/m^3, and the air quality standards for 8 hours of 10 mg/m^3 was exceeded during all hours of the afternoon and the evening, figure 14 (Nasralla, 1997). High concentrations of more than air quality standard, were also recorded in other busy squares and streets. The projected further increase in motor vehicle traffic without any emission control will lead to even higher levels of ambient CO in the future. Imposing a service program and emission limits can result in an improvement of Cairo air with respect to carbon monoxide.

Lead

Emissions: Airborne lead generally takes the form of a particulates that are in the inhalable size range. The major sources of atmospheric lead in Egypt atmosphere are exhaust emissions from motor vehicles and the industrial

TABLE 8 : 1999 LEAD EMISSIONS SUMMARY (CAIP, 2000)

Estimate of Lead Emissions from Sources in the Greater Cairo Area				
Activity	**Number of Facilities**	1999 Production	1999 Lead Emissions (metric ton)	Percentage of Total Lead Emissions
Secondary Smelting	11	52,020 (metric tons lead ingot)	1,815	78.7%
Lead-Acid Battery Production	33	416,600 (batteries)	3.41	0.14%
Secondary Copper **Processing**	207	16,080 (metric tons)	8.04	0.34%
Portland Cement[1] Manufacturing	3	13,500,000 (metric tons cement)	3.39	0.14%
Mazout Combustion[2]	Not Applicable	4,180,000 (metric tons mazout consumed)	477	20.7%
Total			2,307	100%
1- Production Data Source: CAIP survey. 2- Production Data Source: Ministry of Petroleum				

emissions from secondary lead smelters handling car batteries. These smelters are distributed in several districts in Cairo such as Tebbin. Shoubra El-Kheima, Ameria and El-Waylee.

It was estimated that motor vehicles lead emissions before 1997 was in order of 700 to 1000 tones per annum into Cairo atmosphere. Lead emission from secondary lead smelters to Greater Cairo air is estimated at 1815 tones per annum (CAIP, 2000). Table 8 gives the lead emission summary according to CAIP (2000). Although the emission from secondary lead smelters is local but its impact on local air quality and food grown at these sites might be severe.

Ambient concentrations: During 1993/1994, lead concentrations much higher than the Egyptian air quality standard (1 $\mu g/m^3$ annual mean) were recorded in Cairo. Annual mean lead concentration of 4 $\mu g/m^3$ in the ambient air at about 9 m above the ground surface was found at Cairo city centre (Table 9).

Much higher lead concentrations were recorded in busy streets and squares at the breathing level of those working or passing in Cairo streets. For example, concentrations of lead at 1.7 m above the curb edge in Ramsis Square reached more than 12 $\mu g/m^3$ during the peak hour (1400 h to 1500 hr) during several days of 1994 (Nasralla, 1997).

Lead was completely phased out from petrol distributed in Cairo in late 1997. Consequently lead concentrations in the atmosphere of Cairo city center and residential areas decreased markedly during l997/1998 and 1999/2000 reaching $< 50\%$ of those recorded during 1993/1994 (Figure 15). For example, the concentration of lead in Nozha and Dokki (residential areas) dropped to less than the air quality standard. In Attaba, the annual mean concentration of lead found during 1997/1998 was 2.9 $\mu g/m^3$ compared to the 4 $\mu g/m^3$ recorded during 1993/1994 and decreased to 1.6 $\mu g/m^3$ during 1999. The high level of 4.0 $\mu g/m^3$ found in Ameria during 1997/1998 is possibly due to the industrial activities in the district. In fact, concentrations of about 10 $\mu g/m^3$ were recorded in Shoubra El-Kheima and Tebbin close to lead smelters (Nasralla, 1997). These smelters are also confirmed by the recent study during 1999/2000 (CAIP, 2000). CAIP reported high lead concentrations close to secondary lead results in Shoubra El-Khema. (Fig 16). Here, it should be noted that closing down the biggest lead smelting operation in Egypt located at Tabbin (GMC) resulted in a significant decrease in lead concentration in the atmosphere of Tabbin.

Table 9- Lead concentrations during 1993 to 1999 in Cairo air, µg/m^3

	Attaba	Giza	Shoubra El-Keima	Nozha	Imbaba	Dokki	Ameria	Tabbin
93/94	4	1.7	3.2	1.3	2.1	1.2	-	-
97/98	2.9	0.7	-	0.5	1.1	0.4	4.0	1.4
98/99	1.6	0.4	-	0.2	0.4	0.3	1.3	1.1

Source: Nasralla (1997 and 1999), MoH (1999 and 2000)

Nitrogen Dioxide

***Emissions**:* Nitrogen oxides are emitted into air from all type of combustion processes as well as some specific industries. At present, there is no comprehensive emission inventory for the oxides of nitrogen (NOX) in Cairo. Oxides of nitrogen emissions from motor vehicles in Cairo estimated to be 10 600 tones on the year 2000 (Faiz, 1 990).

Ambient concentrations: The Egyptian Environment Affairs Agency (EIMP) started monitoring nitrogen dioxide in Cairo in late 1998. Information is also available on Cairo from research work in the National Research Centre supported by the Academy of Science and Technology (Nasralla, 1997)

During 1995, nitrogen dioxide concentrations in the city centre area with heavy traffic density (Ramsis Square) at 1.7 m above curb edge ranged between l60 µg/m^3 and 410 µg/m^3. Furthermore a marked maximum nitrogen oxides concentrations were recorded during July are connected with the increase of traffic and production of energy during summer and probably enhanced by temperature inversions during those months (Nasralla, 1997 and Mellegy, 1997). Typical diurnal variations of NO_2 monitored by EIMP are shown in Figures 18. This diurnal cycle reflect the emission pattern,

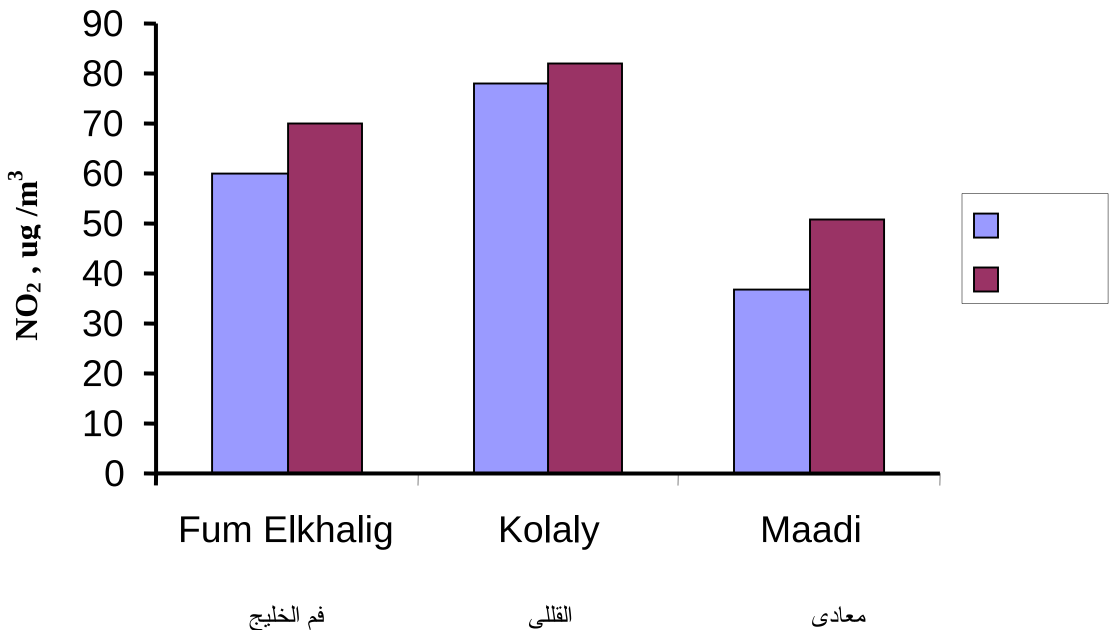

Fig 17 The Annual mean concentrations of nitrogen dioxide in Cairo

<u>**تركيزات ثانى اكسيد النيتروجين فى هواء القاهرة**</u>

oxidation process of NO to NO_2 and night inversions which sometimes coupled with very low wind speed.

Continuous monitoring of NO_2 in the air of central area and residential districts show that nitrogen dioxide concentrations never exceed the air quality standards except for only two days during the whole year at Kollaly where the daily value reached 151 and 164 $\mu g/m^3$ as mean values. Figures 18 and 19 show the seasonal and annual mean concentrations in monitored areas. Here, it should be noted that the highest one hour concentration recorded at Kollaly was 308 $\mu g/m^3$ Compared to air quality standard of 400 $\mu g/m^3$.

Here it should be noted that nitrogen dioxide in the presence of hydrocarbons and sunlight is the key element in the formation of ozone in the atmospheres of urban areas leading to photochemical smog formation. The most evident end products of the photochemical smog is the aerosol material which accumulate to reduce visibility and causes severe health effects.

Ozone

Ozone (O_3) is a secondary pollutant, which is a product of complex atmospheric reactions of nitrogen oxides and reactive volatile organic compounds (VOC) under the influence of sunlight. In Egypt, there is only a partial emission estimate of nitrogen oxides and no emission inventory for volatile organic compounds. Detailed source inventories for NO_x and H_c should be carried out in order to control ozone formation in Cairo air.

The diurnal cycle of ozone concentrations in Cairo atmosphere clearly proves that ozone is locally produced in Cairo atmosphere through photochemical reactions reaching its maximum concentrations during summer.

The problem of ozone pollution mainly occurs in Cairo during summer months and early autumn (Tables 10-12 and Figures 20 and 21). Concentrations of ozone exceeded the WHO guideline and the Egyptian air quality standard of 0.1 ppm for 1h exposure, during summer in all monitored sites in Cairo reaching 0.18 ppm in the atmosphere of Maadi. The level of 0.1 ppm, maximum allowable for 1h, may prevail for 8h in Maadi and not only for 1h (Nasralla 1997).

Tables (11 and 12) show the Ozone concentration in Giza (EIMP, 1999 and 2000). These tables confirmed the previously drawn conclusion that high ozone levels persisted in Cairo air during summer and autumn months. Moreover, the concentrations of ozone exceeded the 1h air quality standards not only for 1h but also for 8h during 30% of monitored days in Giza during July 1999. The 8h average ozone concentration reached 380 $\mu g/m^3$ during Cairo's air pollution episode of Autumn 1999 and the maximum 1h value reached 463 $\mu g/m^3$. Further investigation of tables 11 and 12 show that Ozone level exceeded the 1h air quality standard for 84% of monitored days on summer 1999. Consequently, precursors emissions with reference to active hydrocarbons (VOC) should be reduced. This can be accomplished through complete combustion in cars, industry, furnaces ...etc and the control of hydrocarbons evaporation. It was reported that tuning of vehicles can result in a reduction of 40% in hydrocarbons emissions (TIMS, 1996 and Nasralla, 1999) into the atmosphere of Cairo. This can greatly lead to controlling the production of high ozone levels in Cairo air.

Table 10 – Summary of Ozone Concentrations in the Atmospheres of Imbaba and Shoubra, PPM

	Number of monitored days	**Number of days with ozone >0.04 ppm**	**Number of days with ozone >0.1 ppm, 1h**	**Max. Over 1h**	**Number of days with > 0.06 ppm,8h**	**Max Over 8h (ppm)**
Imbaba						
August 93	7	7	1	0.11	3	0.075
Sept 93	14	14	-	0.08	1	0.06
Oct 93	6	5	-	0.05	1	0.065
Dec 93	2	-	-	0.04	-	0.04
Jan 94	10	-	-	0.04	-	0.04
Feb 94	7	-	-	0.04	-	0.04
April 94	9	8	-	0.09	4	0.074
May 94	6	6	-	0.08	5	0.07
June 94	10	10	6	0.13	10	0.100
July 94	10	10	6	0.12	10	0.100
August 94	6	6	3	0.11	6	0.093
Shoubra						
August 95	4	4	4	0.14	4	0.11
Sept 95	7	7	3	0.11	7	0.1

Table 11: Frequency (number of days) of Ozone concentrations
Max 1h daily – Cairo University (Giza) (μg/m^3)

Month	Index	< 0.5	0.5–1	1–1.5	1.5–2	> 2	Highest
	Conc	<120	120-200	200-260	260-320	> 320	Conc
June 1999		1	2	12	13	1	391
July 1999		2	3	3	5	-	
Aug 1999		2	8	2	2	-	
Sept 1999		4	13	4	1	-	
Oct 1999		7	7	4	-	-	
Nov 1999		-	15	3	2	4	463
Dec 1999		22	4	-	-	-	
Jan 2000		23	-	-	-	-	
Feb 2000		27	2	-	-	-	
Mar 2000		18	5	-	-	-	
Apr 2000		20	3	-	-	-	
May 2000		12	14	-	-	-	
June 2000		12	18	-	-	-	

Table 12 : Frequency (number of days) of Ozone, Max 8h, Giza

Month	Index	< 0.5	0.5–1	1–1.5	1.5–2	> 2	Highest
	Conc	<80	80-120	120-160	160-200	> 200	level
July 1999		1	3	2	4	5	260
Aug 1999		1	3	7	3	1	233
Sept 1999		3	2	11	6	-	
Oct 1999		6	5	5	3	1	280
Nov 1999		1	2	10	7	5	380
Dec 1999		18	8	1	-	-	
Jan 2000		19	5	-	-	-	
Feb 2000		13	16	-	-	-	
Mar 2000		6	18	-	-	-	
Apr 2000		8	15	1	-	-	
May 2000		2	21	8	-	-	
June 2000		3	18	9	-	-	

Other investigated air pollutants in Cairo

High levels of benzine were recorded in Giza main streets. Furthermore, high concentrations of heavy metals such as Cd, Ni and chromium as well as PAH were recorded in the central urban and industrial districts. For example benzo (a) pyrene concentrations reached 10 $\mu g/m^3$ at Cairo central district and more than 100 $\mu g/m^3$ south of El-Tabin close to the coke plant. Consequently, hazardous air pollutants should be considered in the air pollution control strategy and the Legislation.

Effects of Air Pollution on Health

The parts of a human body which are affected by air pollution are limited. Under severe cases, air pollution may cause skin and eye irritation. Internal parts of the body such as heart, liver and kidney are apparently not directly affected by air pollutants. Thus the obvious fact remains that the respiratory tract is the principal part of a human body attacked by air pollutants. Air pollution indirectly affect most of the body organs hence several air pollutants are absorbed by blood and consequently reach other parts of the human body.

Effects of Specific Pollutants

a) Carbon Monoxide: carbon monoxide is absorbed in the lungs, where it combines with the haemoglobin. It has the affinity to combine with haemoglobine 240 times greater than that of oxygen to form carboxy-haemoglobin. At COHB levels of 2 to 5%, the central nervous system is negatively affected. At levels greater than 5% there are cardiac and pulmonary function changes.

b) Lead: Inorganic lead acts as an agent to cause a variety of effects on human health including liver and kidney damage, gastrointestinal damage, mental health effects in children, and abnormalities in fertility and pregnancy.

c) Sulphur dioxide found to increase mortality at high concentrations. At lower concentrations, it causes bronchitis and respiratory illness in children.

d) Ozone: Ozone concentrations at levels higher than 200 $\mu g/m^3$ for 1 hour causes pulmonary dysfunction, annoyance and eye irritation. At 250 $\mu g/m^3$ for 1 hour ozone increased asthematic attacks.

e) Nitrogen Dioxide: exposure to high concentrations of NO_2 causes respiratory illness and shallow breathing.

f) Particulate: Fine particulates (< 2.5 µm) may be responsible for increased asthma attacks, aggravation of heart and lung disease, lowered resistance to respiratory disease in children and other air pollution related conditions. In Egypt, studies on air pollution effects on health are very scarce.

Few studies have been conducted to study the effects of air pollution on health in Egypt. However, the study of the residents of Shoubra El-Keima showed that 37.4% of the examined sample (4730 subjects) suffered from chronic obstructive lung diseases (C.O.L.D) and the prevalence increased with age. Furthermore the same study found that 1478 students out of the studied group of 6380 students were suffering from chronic obstructive lung diseases (Table 13). The effects of sulphur dioxide in Cairo are not only limited to human health but extend to economical materials and monuments. Nasralla (1985 and 1997) reported that sulphur dioxide is a major factor in the deterioration of the Sphinx and metals exposed to Cairo atmosphere

Table 13: Prevalence of O.L.D. according to sex among school students in Shoubra El-Keima

Respiratory Diagnosis	Total (A+F)	%	Total (M)	%	Total (F)	%
Negative	4902	76.83	3679	75.45	1223	81.32
Br. Spasm	1061	16.63	856	17.55	205	13.63
Chr. Br.	198	3.11	512	3.12	46	3.06
Br. Asthma	219	3.43	189	3.88	30	1.99
TOTAL	6380	100	5236	100	1504	100

The high levels of particulates combined with the presence of other pollutants with reference to sulphur dioxide resulted in a high rate of morality due to chest diseases in the Helwan area. The statistics of the Ministry of Health indicated that chest diseases were the second cause of death after communicable diseases in the area of Maadi and Helwan. During early 90's. Another study on 1987 showed a significant increase in chest diseases occurred in school children living in Helwan city as compared with those living in Shebin El-Kom (the capital of rural governerate). It was found that 29.2% of school children have obstructive lung diseases compared to only 9% in Shebin El-Kom (Hussain, 1988).

High concentrations of Carbon monoxide in Cairo streets resulted in high levels of carboxyheamoglobin in traffic policemen, sometimes reaching more than 10%. In other words the blood of those who are exposed to CO in Cairo streets may have more than 10% impaired heamoglobin. A direct significant relationship between ischaemic heart diseases and

Table 14 Number of days having concentrations of more than Air Quality Standards

Month	NO_2, (Fum El-Khalig)		CO, (Fum El-Khalig)	SO_2, (Fum El-Khalig)		PM10 (Kollaly)	Ozon, Giza
	(24h)	(1h)	(8h)	(24h)	(1h)	(24h)	(8h)
July 99	-	-	-	-	-	2	11
August	-	-	-	-	-	7	11
September	-	-	-	-	1	21	17
October	-	-	4	1	1	30	9
November	1	-	12	9	5	23	22
December	-	-	14	17	6	23	1
January 2000	-	-	7	-	-	18	-
February	-	-	1	-	-	15	-
March	-	-	-	-	-	13	-
April	-	-	-	-	-	10	1
May	-	-	-	-	-	-	8
June	-	-	-	-	-	9	9

USA 24h air quality standard of 150 µg/m^3

carboxyhaemoglobin in Cairo traffic policemen was also reported (Salem, 1990). Furthermore, mean blood lead levels of Cairo traffic policemen during the 80's reached 63 µg/dl (Nasralla et al, 1984). Moreover, the average lead blood in students of a school located in an area polluted with 2.3 $\mu g/m^3$ lead in the district atmosphere reported to average 23.8 µg/dl (Massoud et al, 1988).

4. Conclusions

Air Pollution Situation: Generally, the ambient air pollution situation in Cairo can be characterized by high levels of major air pollutants (SPM, O_3, CO and SO_2). The data indicate that short-term as well as long-term mean pollutant concentrations regularly exceed the WHO guidelines, especially in the city centre. The phase out of lead from petrol greatly reduced Pb in Cairo urban districts. Control strategy should be set to reduce particulate and other air pollutants in Cairo air and the atmospheres of other urban and industrial centers. According to the recorded concentrations discussed in this report (Table14) and EHP health risk analysis, particulates from all sources followed by auto exhaust pollutant (Hc&CO) should have high priority in the control strategy. This will be fully discussed in the report on the strategy framework.

Since Egypt has a desert climate, a considerable amount of SPM results from natural dusts. In addition, because of low rainfall, there is frequent re-entertainment of street dust and other particulates to the air, especially on windy days.

Main Problem: From the monitoring data it must be concluded that the main pollution problem in Cairo results from motor vehicle traffic and from the high density of industrial activities as well as open burning of solid waste in and around the Greater Cairo area. Legislation has been issued on 1995 and the enforcement has been started l998. However, the enforcement of regulations regarding emissions from vehicles and uncontrolled industry is still facing several problems during this early stage of implementation for the law. As Cairo is faced with increasing industrial development and vehicular traffic coupled with relatively little overall control of emissions, the air pollution situation will inevitably deteriorate. Air pollution episode have been reported in Cairo during autumns 1998 and 1999.

Control Measures: Air pollution problems in Cairo are typical of rapidly growing industrialized cities. High levels of air pollutants are emitted by poorly controlled sources, which have not been adequately quantified. The lack of emission inventories make the formation of efficient control strategies difficult.

The large number of motor vehicles in Greater Cairo contribute very significant quantities of both particulate and gaseous pollution. The emission of lead has been greatly reduced through the use of unleaded gasoline since late 1997. Using of clean fuel will greatly reduce the emissions of air pollutants into Cairo air.

Industrial emissions from large stationary sources have already been addressed by pollution control, but the large number of small industrial facilities makes control policies difficult to implement. There is also often a widespread open incineration of municipal solid waste and this needs to be controlled through the implementation of the legislation.

Some of the recommendations for improvement of air quality management are:

- Air pollution monitoring, including objectives, monitored pollutants sampling, analytical quality control, QA/QC program and auditing should be strengthened in order to ensure that continuous and reliable data are produced in the future. Dispersion **modeling** will be very good tools to relate pollutants to their sources.

- Emissions inventories should be carried out for all the major pollutants in the Greater Cairo area;
- Pollution Control Inspectorate should be strengthened to supervise industrial plant location and to check compliance with emission standards;
- Motor vehicles exhaust inspection program should be implemented to reduce emissions of black smoke, Hc and carbon monoxide.
- Compressed natural gas should be encouraged as fuel for captive fleets;
- Traffic congestion should be reduced. An improved traffic flow can be achieved through the introduction of traffic restraint, one-way systems, parking control and specific vehicle bans;
- Dust control technology should be used at all major industrial works including foundries, smellers, iron & steel industry, and not only for cement industry;
- Refuse collection and disposal should be improved, and legislation should be applied to prevent open burning of rubbish adjacent to urban areas;
- Clean fuel with reference to reducing sulphur content of fuel used in Greater Cairo should be considered.
- Strict industrial zoning should be applied for new industries. Polluting industries should be relocated away from residential areas;
- Further use of natural gas, especially by industry and by electric power stations, should be encouraged;

- Executive regulation of law 4/1994 should be revised and all items have to be stated clearly to help the implementation of the law toward reducing the pollution load in Cairo.

References

CAIP (2000), Ambient PM2.5, PM10 and lead measurements in Cairo, Egypt,CAIP reports, EEAA, Cairo.

Central Agency for National Statistics,, (1998), Statistics for 1996, Cairo. .

Egyptian Environment Affairs Agency,EEAA ,(1992), National Environment Action Plan,EEAA,Cairo,Egypt.

EIMP,Egyptian Environment Affairs Agency, (1999, 2000), Air qualityinEgypt based upon EIMP data. EEAA, Cairo.

El-Samra G.H., Abdel- Salam M.S., Zaghloul A., Khalaf-Allah S. (1984), Environmental pollution impacts of industrial activities in Egypt, Egyptian Journal of Occupational Medicine, Vol.8,1 - 14.

Faiz A., Sinha K., Walsh M., and Varma A. (l990), Automotive air pollution: Issues and options for developing countries, World Bank Policy and Research Writing Paper WPS 492, the World Benk, Washington D.C.

GEMS (1992), Air pollution in megacities, World Health Organisation, Geneva.

General Organisation of Meteorology,GOM (1981-1990), Reports on Climatological Data for Egypt.

Hassanien et al (1976) after Sivertsen B. (1992), The Helwan environmental study, NILU, Norway, 0-92047.

Hussein A.S.A. (1998), Possible effect of air pollution on preparatory school children .MSc. thesis, Faculty of Medicine, Cairo Univ, Egypt

Khodr M. (1997), Ph.D. Thesis, Ain Shams University, Cairo, Egypt.

Law 4/1994. Law 4 on the environment, Egyptian Government, Cairo.

Massoud A.A., Kamal A.M., and Fahim HI (1988), Associastion of traffic flow and blood lead level of children 5-10 years old, Egyptian Journal of Medical

Ministry of Health (1995- 1999), Reports on air quality in Egypt, Ministry of Health, Cairo.

N .R.C . (1995- 1999), Reports on air quality and impact of pollution sources on the environment of Cairo, National Research Centre, Cairo.

Nasralla M.M. (1985), Report on air pollution and deterioration of the Sphinx, National Research Centre, Cairo.

Nasralla M.M. (1993), Project 5/2/1 on air pollution in Cairo, NRC, Cairo, Egypt.

Nasralla M.M. (1995), Autoexhaust pollutants in Greater Cairo, a case study, local and regional energy-related environmental issues, World Energy Council, London, U.K.

Nasralla M.M. (1996) Air Pollution and Air Quality Measurments in Egypt, A Report for the Regional Office for Eastern Meditexranean, WHO, Alexandria, Egypt.

Nasralla M.M. (1997), A project report on toxic and carcinogenic air pollutants in Cairo atmosphere, AST/NRC.

Nasralla M.M. (1998), A report on particulates in Helwan and the impact of cement industries on the environment, Tebbin Institute for Metallurgical Studies, Cairo.

Nasralla M.M. (1998), National standard methods of air pollution measurement (in Arabic), Regional Office for Eastern Mediterranean, WHO, Alexandria /Ministry of Health, Egypt.

Nasralla M.M. (1999), Air pollution problems in Egypt. A report for National Action Plan Project, UNDP'/EEAA, Cairo, Egypt.

Nasralla M.M. (1999a), Traffic pollution in Cairo, presented in the Conference on Energy and Environment, Cairo, May 2000.

Nasralla M.M., Ali EA and Moustafa N.M. (1993). Particulate and sulphur compounds in Cairo atmosphere, J. Industrial Medicine, 1993.

Nasralla M.M., Shakour A.A., and Ali E.A. (1984a), Using the British standard to monitor S02 in Egypt air, Second Egyptian Congress of Chemical Engineers.

Nasralla M.M., Shakour A.A., and Said E.A. (1984), Effect of lead exposure on traffic policemen, Egyptian Journal of Indusrial Medicine 8,87-104.

Rhodes C., Nasralla M.M., Lawless P., and Varely R (1996), Source apportionment of airborne particulate matter in Cairo, Egypt, EHP, USAID, Washington.

Sivertsen B., and Ahmed H (1999), Air quality in Egypt, Environment (1999), EEAA, Cairo, Nov24,1999,519.

APPENDICES

PM_{10} concentrations in the atmosphere of various districts of Cairo during 1999 and 2000, µg/m^3 (EIMP)

Year	Winter	Spring	Summer	Autumn	Annual mean
A- El-Kollaly					
1999	-	-	182	248	215
2000	199	139	142	235	180
B- Tabbin					
1999	283	207	252	195	234
2000	229	183	103	148	166
C- Maadi					
1999	-	-	-	142	-
2000	-	92	91	-	-
D- Fum El-Khalig					
1999	-	-	-	-	-
2000	-	-	-	143	-
E- Abbasia					
1999	-	-	-	-	-
2000	-	-	145	209	-

Sulphur Dioxide concentrations in Greater Cairo Air, µg/m^3

1999/2000, EIMP

Year	Winter	Spring	Summer	Autumn	Annual mean
A- El-Kollaly (city centre)					
1999	-	-	74	91	82
2000	79	53	66	77	69
B- Fum El-Khalig (R/C) – Rood side					
1999	94	65	71	75	76
2000	94	38	51	67	63
C- Shoubra El-Khema (Industrial)					
1999	73	88	84	99	86
2000	72	65	57	67	65
D- Tabbin south (Industrial)					
1999	27	51	57	29	41
2000	17	30	47	50	36
E- Tabbin (Industrial)					
1999	16	14	31	23	21
2000	27	23	13	21	21
F- Maadi (Residential)					
	32	24	33	22	28
	26	18	23	27	24
G- Nasr City(Residential)					
	24	13	13	14	16
	17	11	17	27	18

Sulphur Dioxide Concentrations in Greater Cairo Atmosphere, μg/m^3,

1991/1992 and 1995/1996

(Nasralla, 1993 and 1997)

Season	Dokki		City Centre		Madinet Nasr		Shoubra El-Kheima
	1991/92	1995/96	1991/92	1995/96	1991/92	1995/96	1995/96
Autumn	56	64	98	101	35	52	120
Winter	48	45	61	66	38	46	98
Spring	52	50	72	78	40	48	85
Summer	66	74	100	119	46	60	116
Annual Mean	56	59	84	91	40	51	108
Max. Month	76	89	187	138	54	68	162
Max. 24	120	138	308	235	86	95	308

Total Suspended Particulates, TSP in Cairo, µg/m^3

(MoH and NRC)

Location	1994	1995		1996		1997		1998		1999	
	Annual Mean	Max. 24h	Annual Mean	Max. 24h	Annual Mean	Max. 24h	Annual Mean	Max. 24h	Annual Mean	Max. 24h	Annual Mean
Attaba	762	1518	696	1331	863	770	467	1530	589	968	559
Nozha	482	1130	539	614	540	517	378	643	419	590	366
Amiria	-	-	-	621	545	634	467	1560	485	947	561
Dokki	405	695	385	611	352	558	376	609	350	-	-
Imbaba	512	-	-	536	460	-	-	850	381	974	475
Maasara	-	3050	1950	1960	920	1530	870	1210	600	705	407
Helwan	-	1800	792	870	499	785	407	753	410	590	350
Shoubra El-Kema	905	1305	715	-	-	-	-	-	-	-	-

Smoke Concentrations in Cairo Atmosphere, µg/m³ (MoH)

Location	1995		1996		1997		1998		1999	
	Max. 24h	Annual Mean	Max. 24h	Annual Mean	Max. 24h	Annual Mean	Max. 24h	Annual Mean	Max. 24h	Annual Mean
Azbakia	225	121	254	59	549	102	373	106	507	102
El-Sahel	206	60	136	78	227	59	-	-	-	-
Nozha	385	39	151	40	427	58	408	74	310	65
M.Nasr	135	28	370	52	274	48	350	61	432	44
Imbaba	179	47	-	-	175	51	436	66	429	83
Abu-Soud	289	69	543	81	544	88	697	81	621	126
Abbasia	234	76	451	77	492	108	272	60	621	82
Maasara	300	53	158	53	615	103	439	124	562	124
Helwan	138	35	191	65	219	43	400	38	188	28
Tabbin	258	59	238	67	232	83	394	72	343	90

Seasonal and annual mean concentrations of NO_2 in Cairo air, µg/m^3

Year	Winter	Spring	Summer	Autumn	Annual mean
A- Fum El-Khalig					
1999	60	57	59	63	60
2000	65	80	72	-	70
B- El-Kollaly					
1999	-	-	82	73	78
2000	61	76	102	89	82
C- Maadi					
1999	58	42	24	24	37
2000	47	53	51	55	51

Total Suspended Particulates, TSP in Cairo, µg/m^3

(MoH and NRC)

Location	1994	1995		1996		1997		1998		1999	
	Annual Mean	Max. 24h	Annual Mean	Max. 24h	Annual Mean	Max. 24h	Annual Mean	Max. 24h	Annual Mean	Max. 24h	Annual Mean
Attaba	762	1518	696	1331	863	770	467	1530	589	968	559
Nozha	482	1130	539	614	540	517	378	643	419	590	366
Amiria	-	-	-	621	545	634	467	1560	485	947	561
Dokki	405	695	385	611	352	558	376	609	350	-	-
Imbaba	512	-	-	536	460	-	-	850	381	974	475
Maasara	-	3050	1950	1960	920	1530	870	1210	600	705	407
Helwan	-	1800	792	870	499	785	407	753	410	590	350
Shoubra El-Kema	905	1305	715	-	-	-	-	-	-	-	-

Smoke Concentrations in Cairo Atmosphere, $\mu g/m^3$ (MoH)

Location	1995		1996		1997		1998		1999	
	Max. 24h	Annual Mean	Max. 24h	Annual Mean	Max. 24h	Annual Mean	Max. 24h	Annual Mean	Max. 24h	Annual Mean
Azbakia	225	121	254	59	549	102	373	106	507	102
El-Sahel	206	60	136	78	227	59	-	-	-	-
Nozha	385	39	151	40	427	58	408	74	310	65
M.Nasr	135	28	370	52	274	48	350	61	432	44
Imbaba	179	47	-	-	175	51	436	66	429	83
Abu-Soud	289	69	543	81	544	88	697	81	621	126
Abbasia	234	76	451	77	492	108	272	60	621	82
Maasara	300	53	158	53	615	103	439	124	562	124
Helwan	138	35	191	65	219	43	400	38	188	28
Tabbin	258	59	238	67	232	83	394	72	343	90