



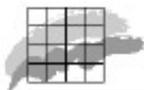
**National Environmental Research Institute**  
Ministry of the Environment · Denmark

# Air Quality Monitoring Programme

Annual Summary for 2003

*NERI Technical Report No. 497*





National Environmental Research Institute  
Ministry of the Environment

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*NERI Technical Report No. 497*  
**2004**

*Kåre Kemp*  
*Finn Palmgren*

## Data sheet

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Abstract: The air quality in Danish cities has been monitored continuously since 1982 within the Danish Air Quality (LMP) network. The aim has been to follow the concentration levels of toxic pollutants in the urban atmosphere and to provide the necessary knowledge to assess the trends, to perform source apportionment, and to evaluate the chemical reactions and the dispersion of the pollutants in the atmosphere. In 2002 the air quality was measured in four Danish cities and at two background sites. NO<sub>2</sub> and PM<sub>10</sub> were at several stations found in concentrations above the new EU limit values, which the Member States have to comply with in 2005 and 2010. While the concentrations for most other pollutants have been strongly decreasing since 1982, only a slight decrease has been observed for NO<sub>2</sub>.

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## Summary

The Danish Air Quality Monitoring Programme (LMP IV) has been revised in accordance with the Framework Directive and the first three daughter directives of SO<sub>2</sub>, NO<sub>x</sub>/NO<sub>2</sub>, PM<sub>10</sub>, lead, benzene, CO and ozone. Only a PM<sub>10</sub> monitor at an urban background location in Odense is missing. The data sets for year 2003 are almost complete for all stations. The monitoring programme consists of 10 stations plus 2 extra stations under the Municipality of Copenhagen.

The limit value of the annual average of NO<sub>2</sub> was in 2003 exceeded at three street stations. At one station (Copenhagen/1103) the limit value + the margin of tolerance (56 µg/m<sup>3</sup> in 2003) was exceeded. The trend seems to have been constant after several years of decrease.

The ozone level was in 2003 - more or less - the same at all rural and urban background stations and no clear trend is observed. The information threshold on 180 µg/m<sup>3</sup> was not exceeded. The target values were not exceeded, but the long-term objectives of max 8 hours on 120 µg/m<sup>3</sup> were exceeded at all urban background and rural stations. The long term objective for AOT40 at 6000 µg/m<sup>3</sup> \*hours were exceeded in a few cases.

The limit value of PM<sub>10</sub> on 50 µg/m<sup>3</sup>, not to be exceeded more than 35 times per year and to comply with in 2005, was in 2003 exceeded at 2 out of 4 street stations. At all stations both proposal limits values to be met in 2010 (annual average value on 20 µg/m<sup>3</sup> and 50 µg/m<sup>3</sup> not to be exceeded more than 7 times per year) were exceeded at all stations (including the rural station Keldsnor). PM<sub>10</sub> is 60-70% of TSP. The trend of TSP has been clear decreasing the last 15 years, except at HCAB.

The SO<sub>2</sub> and lead levels are still decreasing and far below the limit values. The limit values for benzene and CO are not exceeded and the levels are close to the levels in year 2002.

Actual data, quarterly reports, annual summaries and summaries over many year are available at the homepage of NERI on "luft.dmu.dk".



# 1 Introduction

## *LMP IV*

The fourth Danish Air Quality Monitoring Programme (LMP IV) was started in 2000. The programme comprises an urban monitoring network with stations in four largest Danish cities, *Figure 2-1*. The results are used for assessment of the air pollution in urban areas. The programme is carried out in a co-operation between the National Environmental Research Institute (NERI), the Danish Environmental Protection Agency, the Environmental Protection Agency of the Municipality in Copenhagen, the Municipality of Århus, the County of Funen (for the city of Odense) and the Municipality of Aalborg. NERI is responsible for the practical programme. The results are currently published in quarterly reports in Danish and they are summarised in annual reports in English and Danish. This report includes results from the LMP network and a local network in Greater Copenhagen organised by the Environmental Protection Agency of the Municipality in Copenhagen. Statistical parameters and actual data are accessible at the Web address: [luft.dmu.dk](http://luft.dmu.dk). Selected actual data are also available at tele-text, Danish National Television.

## *Other air quality networks in Denmark*

Two other air quality monitoring networks are in operation in Denmark. The Environmental Protection Agency of the Municipality in Copenhagen is responsible for a network in the central part of Copenhagen. A number of pollutants are measured at two sites. The measurements are comparable with the LMP measurements and the two programmes are under the same quality control/quality assurance and supplement each other in Copenhagen. A network in rural areas (the Danish Background Monitoring Program) was established in 1978, *Figure 2-1*. NERI runs this programme. At present gas and aerosol measurements are performed at six stations, and various ions are determined in precipitation collected at 12 sites. The aim is i.a. to study acidification and eutrofication of the forests, farmland, Danish sea and freshwater areas.

## *New limit values implemented by the EU Commission*

The present Danish limit values are identical with the limit values laid down in the EU directives. The new EU legislation consists of the framework directive (EC 1996), giving general rules for network design and limit value strategies, and a number of daughter directives giving limit values, target values, alert thresholds, reference methods and monitoring strategies for specific pollutants. The limit values are close to the recommendations (WHO, 2000) based on the known health effects of the pollutants. The limit values shall in most cases be reached in 2005 or 2010. Until then a so-called margin of tolerance are added to the limit values. The margin of tolerance is gradually reduced to zero at the date of compliance. Daughter Directives for NO<sub>2</sub>, SO<sub>2</sub>, particulate matter (PM<sub>10</sub>) and Pb (EC, 1999), CO and benzene (EC, 2000) and O<sub>3</sub> (EC 2002) are presently adopted. A Directive for Cr, As, Cd and PAH is under preparation. In the following chapters the measured results are compared to the limit values. Please refer to the Directives for a detailed description of the exact definitions of the limit values, margin of tolerance, target values and alert thresholds.



## 2 Measurements

### Station locations

The measuring strategy is in short to place one or more pairs of stations in each city. One of the stations is located close (at the sidewalk) to a street lane with a high traffic density. The other is located within a few hundred meters from the street station, and is representative for the urban background pollution; it is not influenced by a single or a few streets or other nearby sources. In most cases the background stations are placed on rooftops. Further two stations monitor the pollution outside the city areas. Further information about the program and results is found at the Web address: [LUFT.DMU.DK](http://LUFT.DMU.DK).

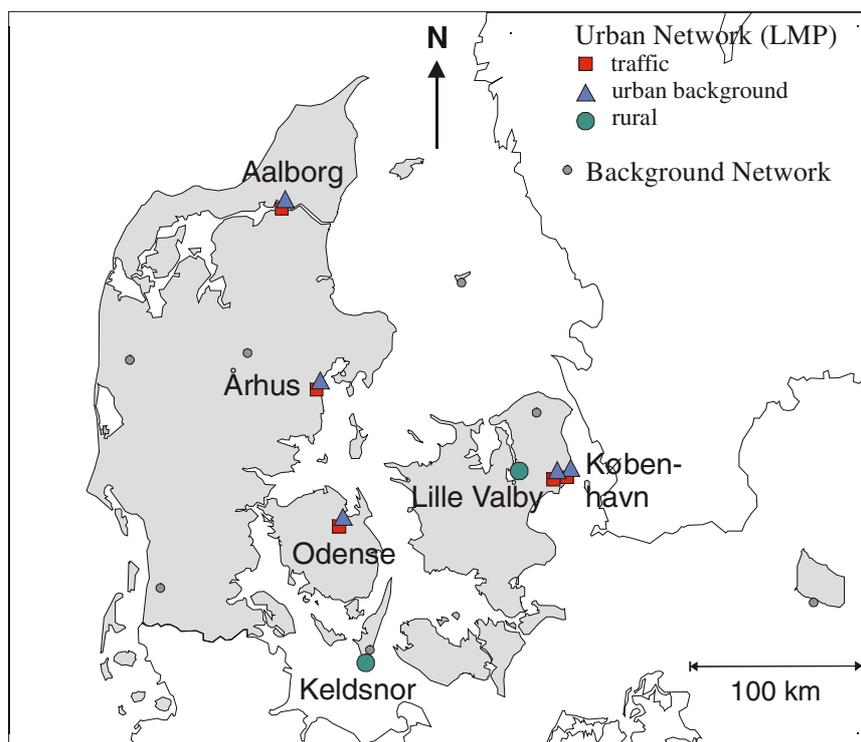


Figure 2-1 Monitoring stations in the two nation-wide air quality networks.

Table 2-1 Stations in the LMP IV network and the Copenhagen network included in this report for 2003.

Name	Street/location	Type	Remarks
Copenhagen/1257	Jagtvej	Street	
Copenhagen/1259	H.C. Ørsted Institute	Urban background	O <sub>3</sub> started July 2003
Copenhagen/1103	H.C. Andersens Boulevard	Street	Copenhagen Municipality
Århus/6153	Banegårdsgade	Street	
Århus/6159	Valdemarsgade	Urban Background	
Odense/9155	Albanigade	Street	
Odense/9159	Town hall in Odense	Urban background	
Aalborg/8151	Vesterbro	Street	
Aalborg/8159	Dept. for Envir. and Urban Affairs	Urban background	
Lille Valby/2090	-	Rural	
Keldsnor/9055	-	Rural	

- NO, NO<sub>x</sub>, PM<sub>10</sub> and elements (heavy metals) in PM<sub>10</sub> were measured at all stations (the PM<sub>10</sub> not started yet at Odense/9159, TSP measured in stead of PM<sub>10</sub> at Copenhagen/1103)
- O<sub>3</sub> was measured at all urban background stations, Copenhagen/1257 and Copenhagen/1103
- CO was measured at all street stations and Copenhagen/1259
- Benzene and Toluene were measured at Copenhagen/1257
- SO<sub>2</sub> was measured at Aalborg/8151 and at Copenhagen/1103. The main purpose is to monitor episodic high concentration.
- The meteorological parameters - temperature, wind speed and direction, relative humidity and global radiation - are measured at all urban background stations.

#### *Averaging time*

Apart from PM<sub>10</sub> and TSP all parameters were recorded as ½-hour averages. PM<sub>10</sub>, TSP and elements in the particles were measured as 24 hour averages. At the three stations in Copenhagen also ½-hour averages of PM<sub>10</sub> were recorded.

#### *Other information*

Short descriptions of the measured pollutants are given in the appendix. The actually applied measurement methods are listed at the Web address: LUFT.DMU.DK

## 3 Nitrogen oxides

### 3.1 Yearly Statistics

Table 3-1 Nitrogen dioxide (NO<sub>2</sub>) 2003. All parameters are calculated with hourly averages.

Unit: µg/m <sup>3</sup>	Number	Average	Median	98. percentile	19. highest
<i>Traffic:</i>					
Copenhagen/1257	8632	47	44	104	133
Copenhagen/1103	8643	59	55	127	162
Århus/6153	8346	46	43	103	135
Odense/9155	8712	35	29	95	120
Aalborg/8151	8420	35	32	87	122
<i>Urban Background:</i>					
Copenhagen/1259	8292	23	19	65	99
Århus/6159	8513	27	23	75	105
Odense/9159	8539	20	16	58	75
Aalborg/8159	8627	18	14	58	86
<i>Rural:</i>					
Lille Valby/2090	8417	12	9	41	62
Keldsnor/9055	7638	10	7	44	65
Limit values	>7884	40			200

Table 3-2 Nitrogen oxide (NO) 2003. All parameters are calculated with hourly averages.

Unit: µg/m <sup>3</sup>	Number	Average	Median	98. percentile	19. highest
<i>Traffic:</i>					
Copenhagen/1257	8632	45	29	184	319
Copenhagen/1103	8644	63	44	247	401
Århus/6153	8346	42	26	181	315
Odense/9155	8711	34	14	194	352
Aalborg/8151	8420	49	29	228	368
<i>Urban Background:</i>					
Copenhagen/1259	8285	4	1	34	79
Århus/6159	8513	12	3	103	213
Odense/9159	8538	6	2	41	138
Aalborg/8159	8627	7	4	56	200
<i>Rural:</i>					
Lille Valby/2090	8417	2	1	15	64
Keldsnor/9055	8717	1	1	9	31

The limit values are implemented through EU Council Directive (EC 1999) and a national Regulation from the Ministry of Environment (Miljøministeriet 2003A).

## 3.2 Episodes

Table 3-3 Episodic results for Nitrogen dioxide (NO<sub>2</sub>) 2003. All parameters are calculated with hourly averages.

Unit: µg/m <sup>3</sup>	Max. 3 hours	Date:hour	Max. hour	Date:hour
<i>Traffic:</i>				
Copenhagen/1257	142	030328: 23	189	030422: 7
Århus/6153	179	030329: 0	210	030329: 2
Copenhagen/1103	145	030416: 19	211	031210: 8
Odense/9155	121	031023: 6	158	031113: 7
Aalborg/8151	120	030422:16	216	030829: 7
<i>Urban Background:</i>				
Copenhagen/1259	110	030328:22	113	030328: 22
Århus/6159	131	030416: 19	135	030416: 21
Odense/9159	92	030325:20	104	030325: 21
Aalborg/8159	85	031016: 6	136	030829:: 7
<i>Rural:</i>				
Lille Valby/2090	68	030213: 13	72	030327: 21
Keldsnor/9055	78	030329: 2	82	030329: 4
Alert threshold	400	-	-	-

Table 3-4 Episodic results for Nitrogen oxide (NO) 2003. All parameters are calculated with hourly averages.

Unit: µg/m <sup>3</sup>	Max. 3 hours	Date:hour	Max. hour	Date:hour
<i>Traffic:</i>				
Copenhagen/1257	411	031001: 5	511	030213: 7
Copenhagen/1103	536	031017: 5	825	031017: 6
Århus/6153	451	030213: 7	877	031210: 8
Odense/9155	426	031210: 6	648	031210: 8
Aalborg/8151	390	030929: 7	508	030929: 7
<i>Urban Background:</i>				
Copenhagen/1259	91	031017: 6	139	030213: 8
Århus/6159	266	031210: 7	578	031210: 8
Odense/9159	149	031014: 6	269	030930: 6
Aalborg/8159	338	031016: 6	399	030929: 7
<i>Rural:</i>				
Lille Valby/2090	74	031017: 7	131	031129:15
Keldsnor/9055	83	031211: 6	88	031211: 7

The Alert threshold is given in EU Council Directive (EC, 1999) and implemented through a national Regulation from the Ministry of Environment (Miljøministeriet 2003A).

With reference to the definition of the alert threshold, the lowest one-hour values are calculated for all consecutive three-hour periods. The highest of these one-hour values are listed in the table in the column "Max. 3 hour". The alert threshold will, in practice, never be exceeded in Denmark.

### 3.3 Trends

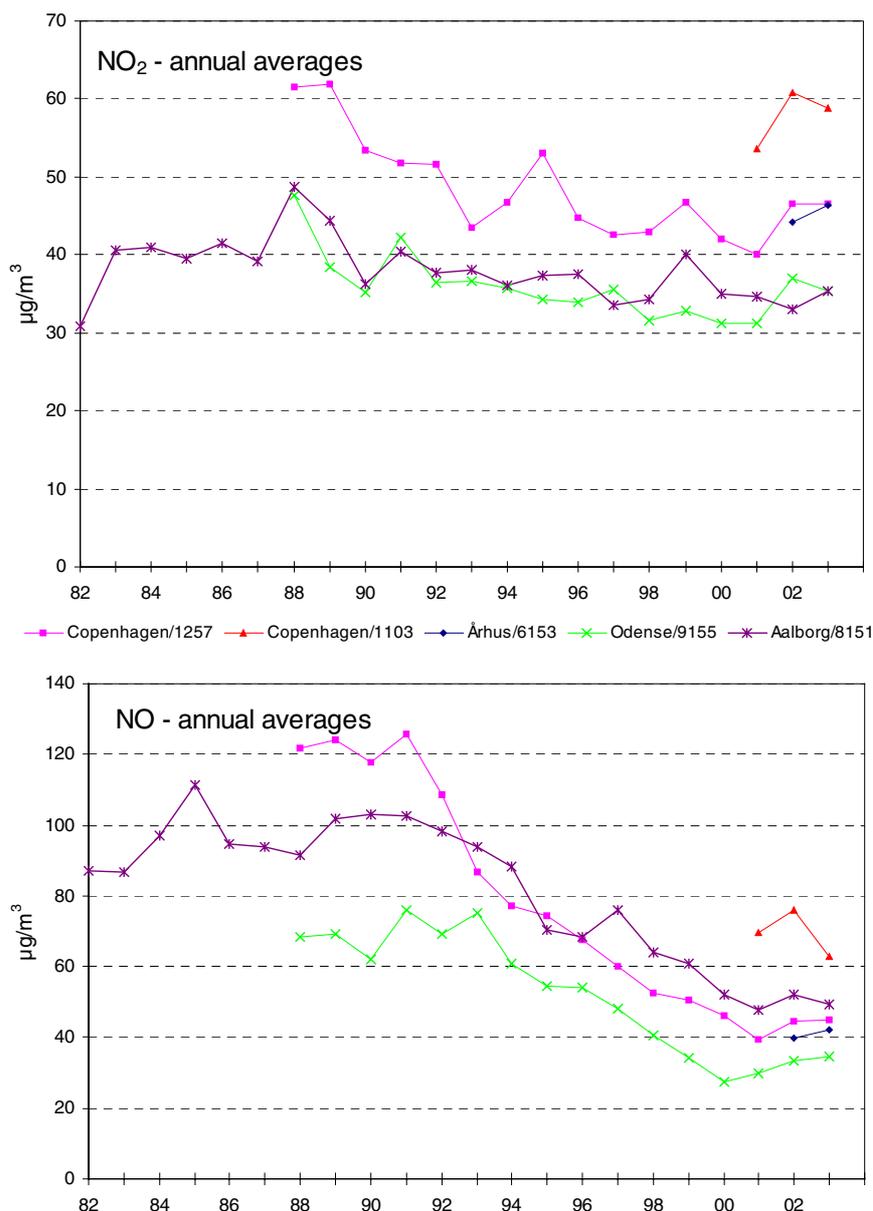


Figure 3-1 The graphs show the time series for the annual average values measured at street stations. Previous results from Copenhagen/1103 can be found at the Web-pages of the Copenhagen Environmental Protection Agency ([www. Miljoe.kk.dk](http://www.Miljoe.kk.dk)).

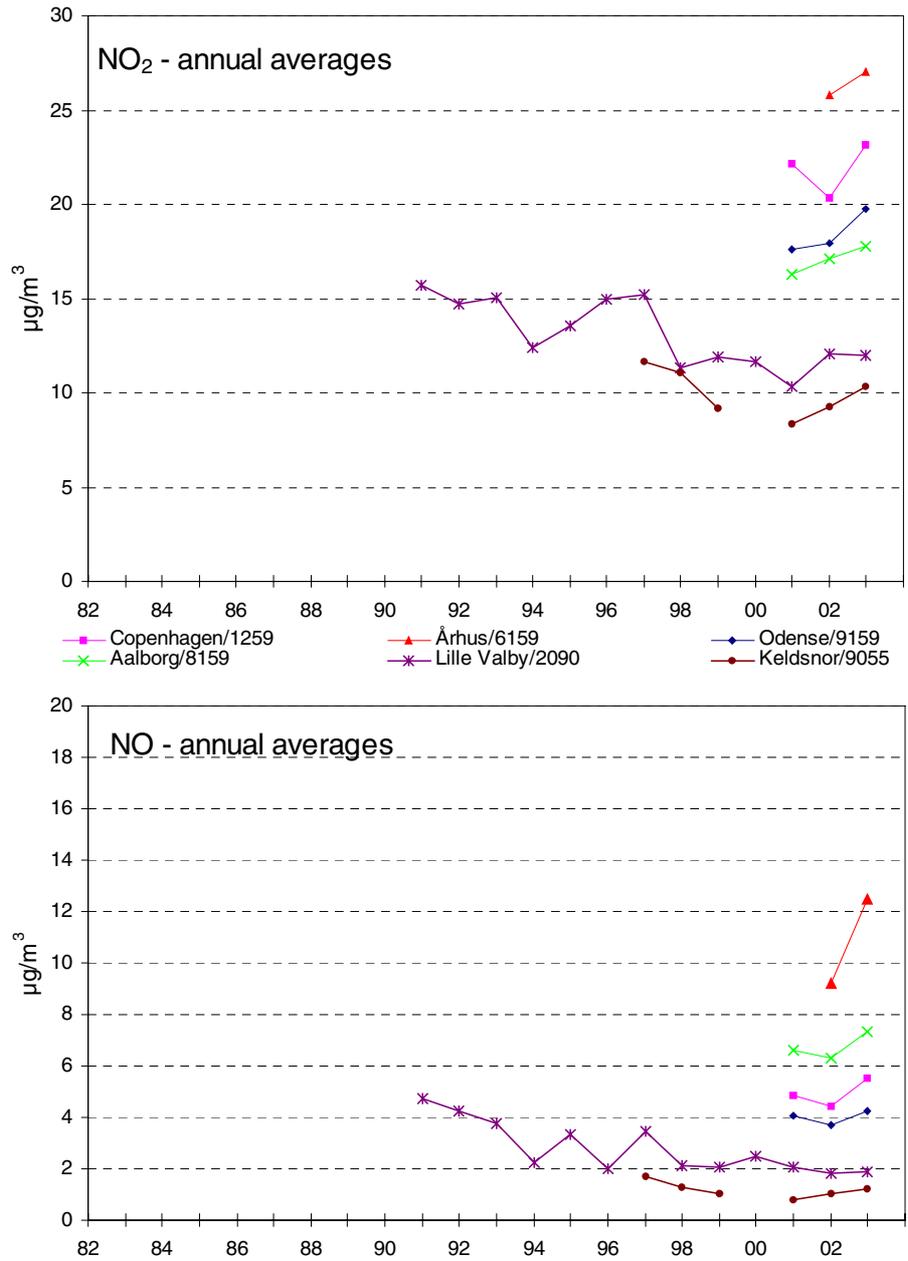


Figure 3-2 The graphs show the time series for the annual average values measured at urban background and rural stations.



## 4 Ozone

### 4.1 Annual statistics

Table 4-1 Ozone (O<sub>3</sub>) 2003. All parameters are calculated with one-hour average values. The eight hour values are calculated as a moving average based on hourly measurements. For the "26. highest 8 hour" value is used the highest daily 8 hour values calculated as described in the EU Directive 2002/3/EC.

Unit: µg/m <sup>3</sup>	Number of results	Average	Median	Max. 8 hours	26. highest 8 hour	Max. 1 hour	AOT40 µg/m <sup>3</sup> .h
<i>Urban Background:</i>							
Århus/6159	7862	49	52	129	97	138	3973
Odense/9159	8471	55	56	143	110	160	10790
Aalborg/8159	8619	54	57	140	104	146	7599
<i>Rural</i>							
Lille Valby/2090	8436	57	58	148	106	167	9569
Keldsnor/9055	8729	61	63	146	107	171	7388
<i>Traffic</i>							
Copenhagen/1257	8647	36	34	98	80	109	815
Copenhagen/1103	8213	30	28	102	70	109	182
Target value	>7884	-	-	-	120	-	18 000
Long term objective	>7884	-	-	120	-	-	6 000

The target values and long time objectives are given in the EU Council Directive (EC, 2002) and implemented through a national Regulation from the Ministry of Environment (Miljøministeriet 2003B).

Number of information to the public due to exceedance of the information threshold (180 µg/m<sup>3</sup>) in 2003: 0.

Number of information to the public due to exceedance of the alert threshold (240 µg/m<sup>3</sup>) in 2003: 0.

## 4.2 Trends

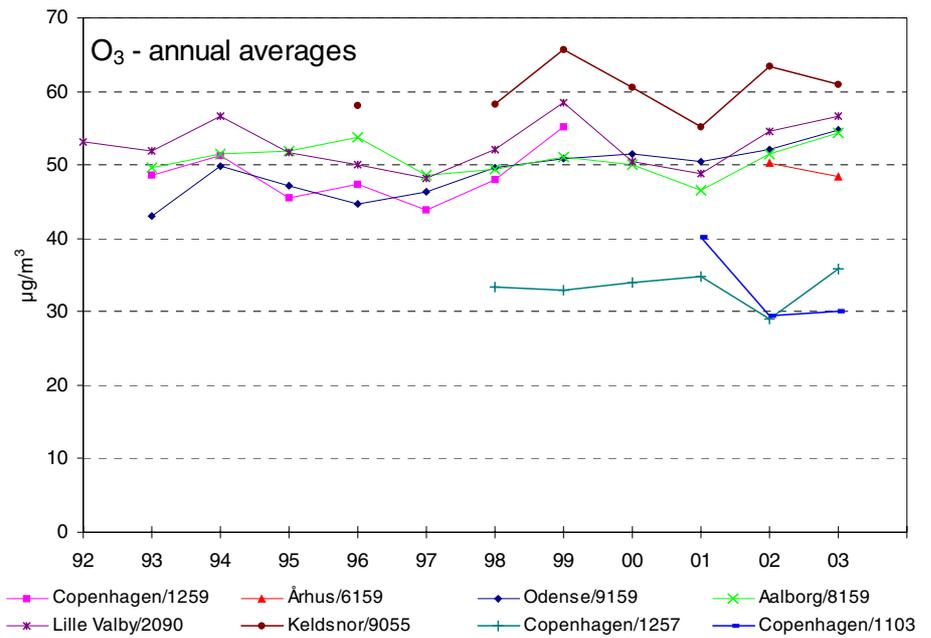


Figure 4-1 Annual average values. Previous results from Copenhagen/1103 can be found at the Web-pages of the Copenhagen Environmental Protection Agency ([www.Miljoe.kk.dk](http://www.Miljoe.kk.dk)).

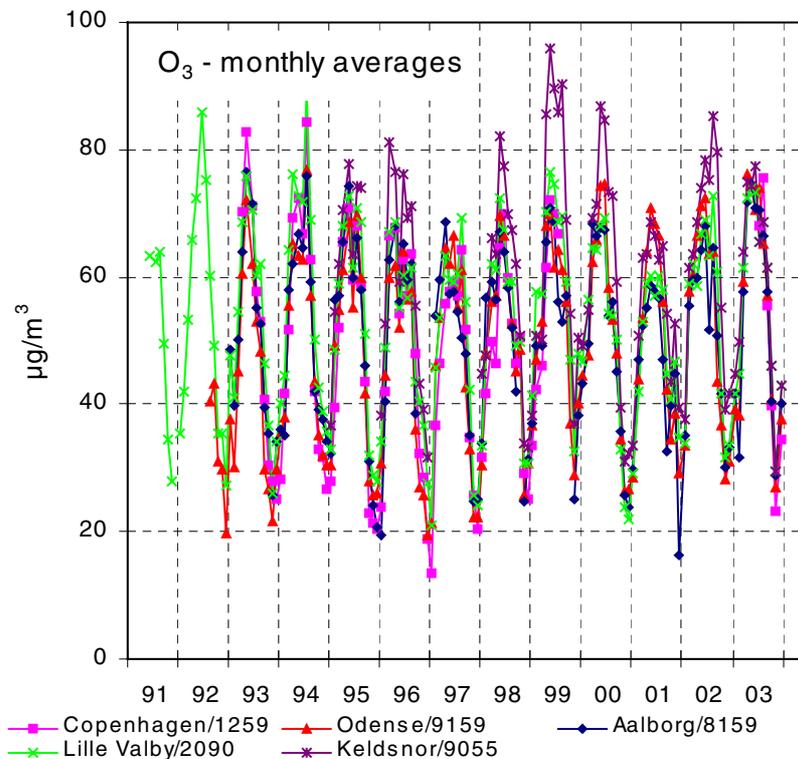


Figure 4-2 Monthly average values for urban background and rural stations.

## 5 Carbon monoxide

### 5.1 Annual statistics

Table 5-1 Annual statistics for carbon monoxide (CO) 2003. All parameters are calculated with hourly average. The 8-hour values are calculated as a moving average based on hourly results.

Unit: $\mu\text{g}/\text{m}^3$	Number	Average	Median	98-percentile	99.9-percentile	Max. 8-hours	Max hour
<i>Traffic:</i>							
Copenhagen/1257	8520	980	825	2802	5159	3588	6701
Copenhagen/1103	8648	897	755	2492	4319	4069	5294
Århus/6153	8358	577	476	1553	2896	2524	4596
Odense/9155	7613	742	520	2587	4833	3835	7391
Aalborg/8151	7392	884	682	2585	4040	3485	4920
<i>Urban Background:</i>							
Copenhagen/1259	6894	361	316	851	1620	1425	1949
Limit value	-	-	-	-	-	10 000	-
Guideline values	-	-	-	-	-	10 000	30 000

The limit value is implemented through EU Council Directive (EC, 2000) and a national Regulation from the Ministry of Environment (Miljøministeriet 2003B).

The guideline values are proposed in WHO, 2000. (Air Quality Guidelines for Europe, Second Edition, WHO Regional Publications, European Series, No. 91, Copenhagen 2000).

## 5.2 Trends

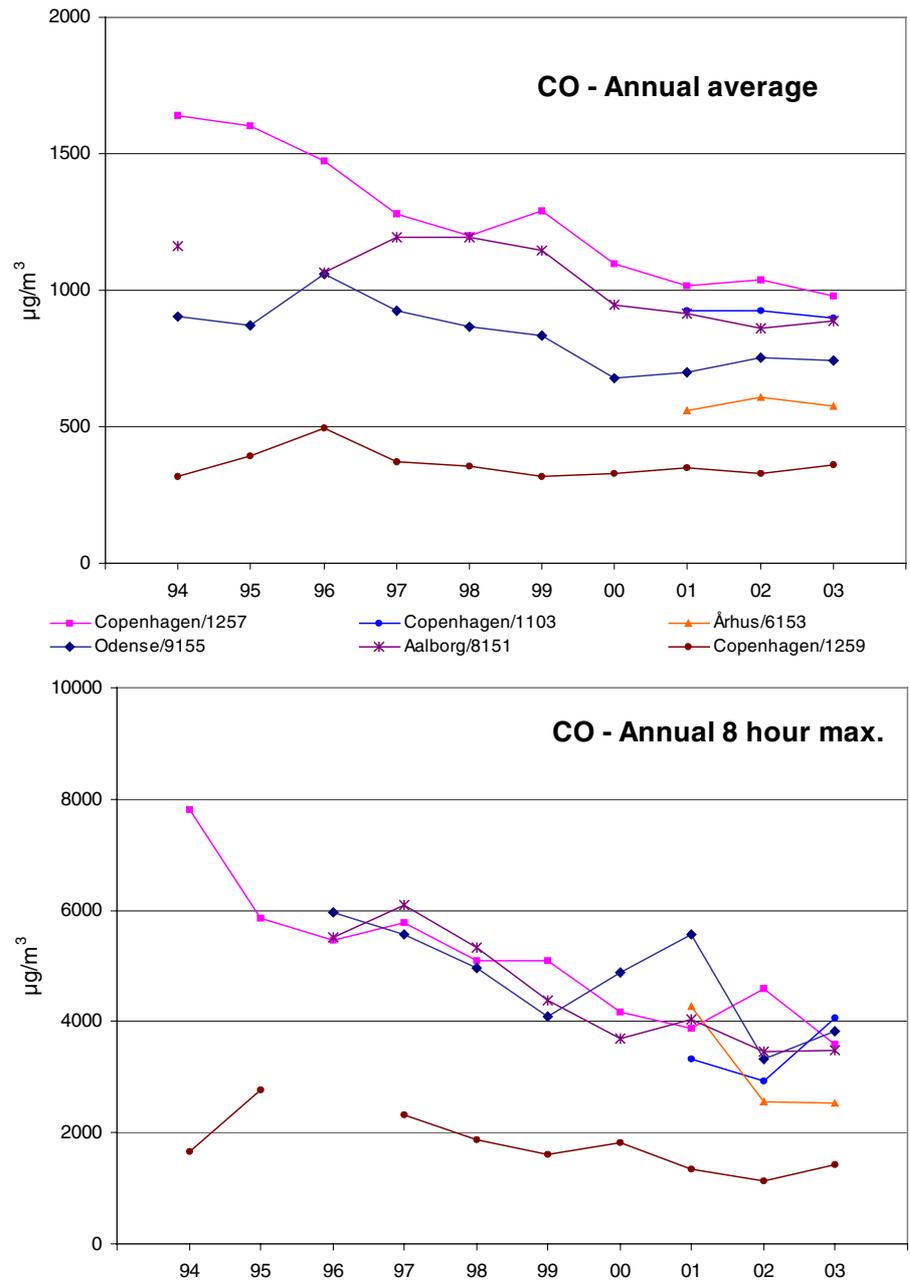


Figure 5-1 Annual average values and highest 8-hour average. Previous results from Copenhagen/1103 can be found at the Web-pages of the Copenhagen Environmental Protection Agency ([www. Miljoe.kk.dk](http://www.Miljoe.kk.dk)).

## 6 Benzene and Toluene

### 6.1 Annual statistics

*Table 6-1* Annual statistics for Benzene 2003. All values are calculated as 1 hour averages. The 8 hours results are calculated as a moving average. The life time risk level is defined as the concentration that through a lifelong exposure is estimated to give a excess risk of  $1:10^5$  for developing cancer. The results are preliminary – minor changes may occur.

Unit: $\mu\text{g}/\text{m}^3$	Number of results	Average	Max. 8 hours	Max. 1 hour
Copenhagen/1257	7393	3.6	16	33
Limit value	>7784	5	-	-
Life time risk level at $1:10^5$		1.7		

The limit value is implemented through EU Council Directive (EC, 2000) and a national Regulation from the Ministry of Environment (Miljøministeriet 2003B).

*Table 6-2* Annual statistics for Toluene 2003. The 7 days results are calculated as a moving average based on daily averages. The results are preliminary – minor changes may occur.

Unit: $\mu\text{g}/\text{m}^3$	Number of results	Average	Max. 7 days	Max. 1 hour
Copenhagen/1257	7393	15.4	79	124
Guideline value	-	-	260	-

The guideline and lifetime risk level are established by WHO (WHO, 2000).



## 7 Particles (TSP, PM<sub>10</sub>)

### 7.1 Annual statistics

The PM<sub>10</sub> mass in the following are determined by weighing the exposed filters after conditioning for at least seven days at 52% RH and 23 °C.

Table 7-1 Annual statistics for PM<sub>10</sub> 2003. All parameters are calculated as daily averages. The limit values in parenthesis are indicative values valid from 2010. They will be reviewed before 2010.

Unit µg/m <sup>3</sup>	Number of results	Average	36.highest result	90 percen-tile	95 percen-tile	8.highest result	Max. day
<i>Traffic</i>							
Copenhagen/1257	340	33	52	53	70	77	123
Copenh./1103 +)	335	75	122	125	159	189	251
Århus/6153	343	29	48	49	62	76	146
Odense/9155	300	37	57	61	82	110	280
Aalborg/8151	278	31	47	54	68	75	94
<i>Urban background</i>							
Copenhagen/1259	360	24	39	39	51	66	129
Århus/6159	298	26	41	45	57	67	173
Aalborg/8159	269	24	37	43	59	66	88
<i>Rural</i>							
Lille Valby/2090	302	24	40	42	56	61	90
Keldsnor/9055	302	27	44	46	57	82	100
Limit values	>329	40(20)	50	-	-	(50)	-

+) **N.B.** TSP (Total Suspended Particulate matter). At street stations the TSP concentration may be up to 2 times the PM<sub>10</sub> concentration. The values cannot be compared to the limit values.

The limit values are implemented through EU Council Directive (EC, 1999) and a national Regulation from the Ministry of Environment (Miljøministeriet 2003A).

At some stations there are too few measurements to a valid comparison with the limit values. In these cases the 90-percentile will give a better impression of the compliance with the limit value that must not be exceeded more than 35 times every year.

### 7.2 Trends

Up till 2000 the particulate matter was measured as Total suspended particulate matter (TSP) corresponding to particles with a diameter up to around 25 µm. The exact cut-off depended however strongly on the wind velocity. From 2001 PM<sub>10</sub> measurement was started at all stations except Copenhagen/1103 where the TSP sampling was con-

tinued. The TSP is average 30-50% higher than  $PM_{10}$  at the street stations, while the difference is less at rural sites.

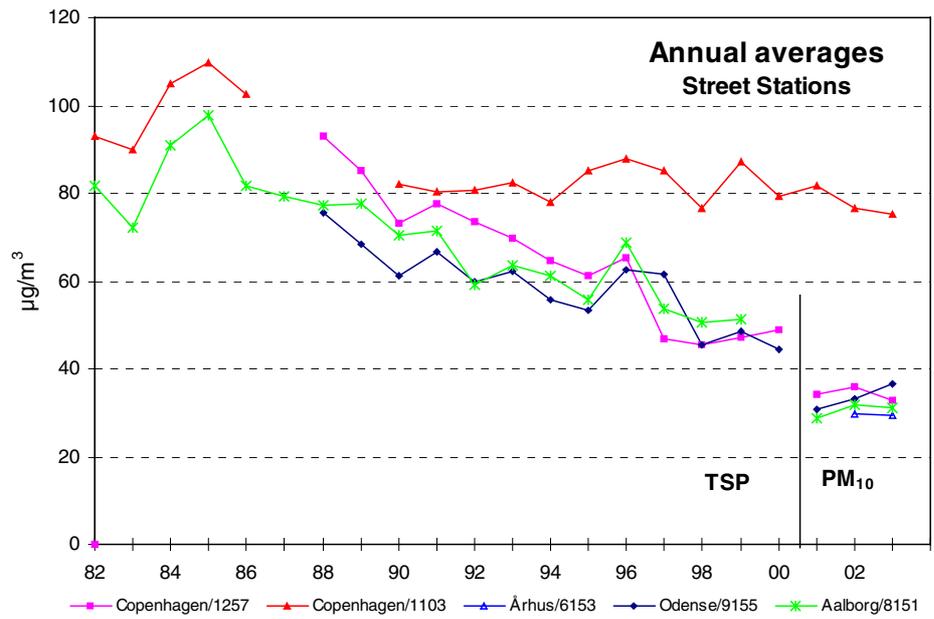


Figure 7-1 Annual averages for TSP and  $PM_{10}$  measured at street stations. Results from 200 and earlier are for TSP, while later results are for  $PM_{10}$  - except for Copenhagen/1103, where TSP measurements are continued.

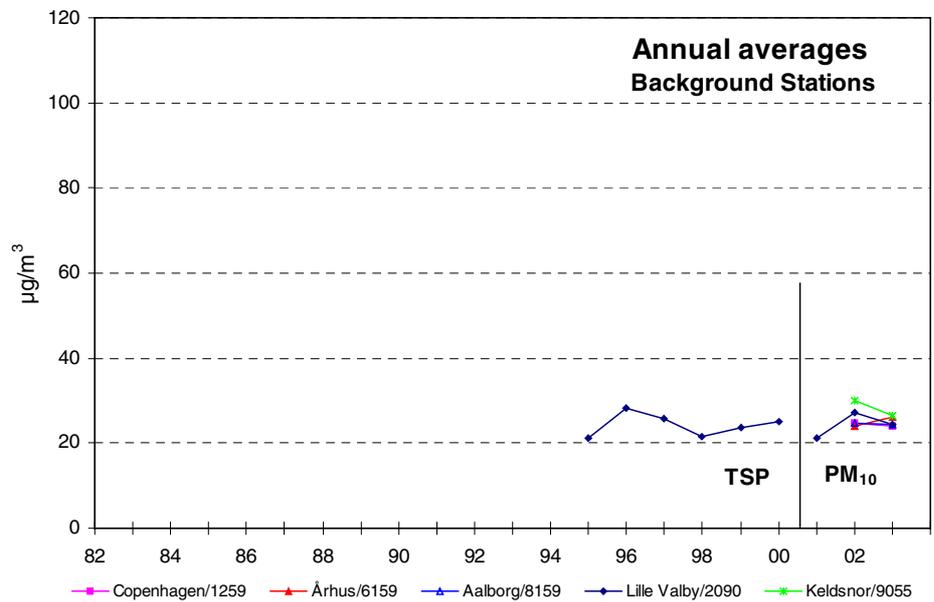


Figure 7-2 Annual averages for TSP and  $PM_{10}$  measured at urban background and rural stations.

## 8 Heavy Metals

### 8.1 Annual statistics

Table 8-1 Annual statistics for Vanadium (V), Chromium (Cr), Manganese (Mn), Nickel (Ni), Copper (Cu), Zinc (Zn), Arsenic (As), Selenium (Se), Cadmium (Cd) and Lead (Pb) measured in PM<sub>10</sub> during 2003. The lifetime risk level is defined as the concentration that through a lifelong exposure is estimated to give a excess risk of 1:10<sup>5</sup> for developing cancer. The filters are occasionally contaminated with Cr, Ni, Cu and Zn. The out-layers for these elements are excluded before average calculation. At urban background and rural stations the contamination with Cr still contributes with a comparable amount to the average values.

Unit: ng/m <sup>3</sup>	V	Cr	Mn	Ni	Cu	Zn	As	Se	Cd	Pb
<i>Traffic</i>										
Copenhagen/1257	7.2	6.3	14.3	4.5	70.5	46.6	0.7	0.5	< 1.3	15.1
Copenhagen/1103 +)	10.0	14.7	66.1	4.9	100.4	107.8	0.7	0.4	< 0.6	20.9
Århus/6153	6.1	3.7	11.3	5.5	34.7	37.9	1.0	0.6	< 1.3	11.5
Odense/9155	5.2	5.7	19.3	4.2	46.5	81.4	1.2	0.6	< 1.4	19.5
Aalborg/8151	4.4	5.8	10.7	3.0	39.9	47.8	0.8	0.5	< 1.3	9.9
<i>Urban background</i>										
Copenhagen/1259	6.9	1.5	6.1	3.4	12.7	22.5	0.8	0.5	< 1.3	8.7
Århus/6159	5.1	1.4	6.9	4.3	7.8	22.7	1.0	0.6	< 1.3	7.8
Aalborg/8159	4.0	1.8	5.7	2.3	6.8	19.6	0.8	0.5	< 1.3	6.6
<i>Rural</i>										
Lille Valby/2090	4.5	< 1.4	4.8	2.1	5.3	23.9	1.0	0.6	< 1.4	7.3
Keldsnor/9055	6.7	< 1.4	3.4	2.7	4.7	31.6	0.7	0.7	< 1.4	8.1
Limit values				*)			*)		*)	500
Guideline value	1000		150						5	
Life time risk level at 1:10 <sup>5</sup>				25			6.6			

+) Measured in TSP (Total suspended particulate matter). Most of the heavy elements are present in particles. The heavy metals are primarily found in fine particles. The TSP and PM<sub>10</sub> results are in most cases comparable because the heavy metals primarily are found in fine particles.

\*) Target values are expected to be implemented during 2004 or 2005.

The limit value for Pb is found in EU Council Directive (EC, 1999). An EU Council Directive including i.a. Ni, As and Cd is expected to be adapted in 2004.

The guidelines and life time risk for the carcinogenic metals are established by WHO (WHO, 2000).

## 8.2 Trends

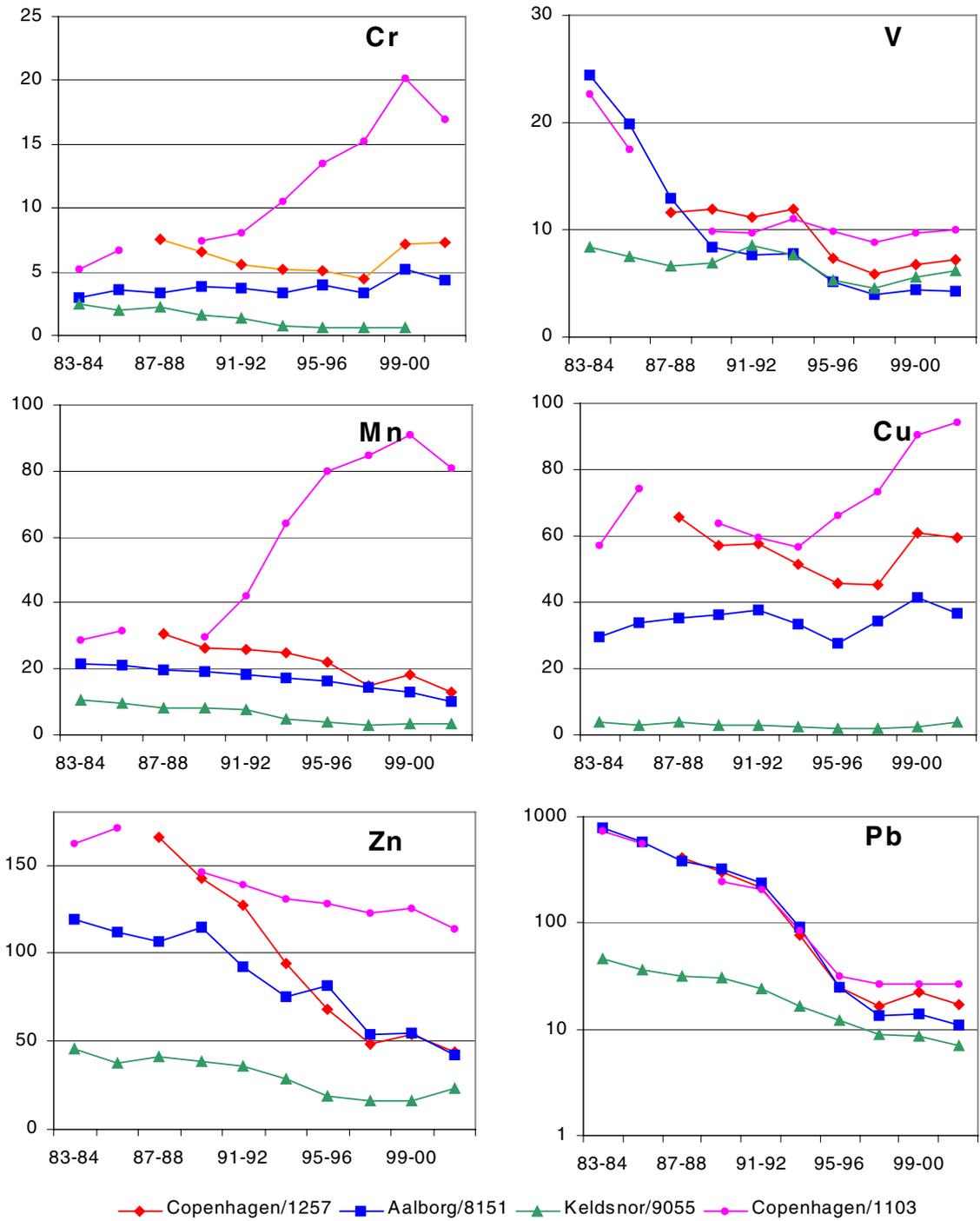


Figure 8-1 Biannual averages from selected stations for some Heavy Metals in particulate matter. Until 2000 in TSP and later in  $\text{PM}_{10}$  – except for Copenhagen/1103 where TSP measurements continue. y-axis units are  $\text{ng}/\text{m}^3$ . (Note that the scale for Pb is logarithmic.)

## 9 Sulphur Compounds

### 9.1 Annual statistics

Table 9-1 Annual statistics for SO<sub>2</sub> 2003. All parameters are calculated based on hourly averages.

Unit: µg/m <sup>3</sup>	Number of results	Average year	Average winter	Median	98-percentile	Max. Hour	4. highest day
<i>Traffic</i>							
Copenhagen/1103	8648	5.1	6.2	3.4	22	103	10
Aalborg/8151	8426	4.1	4.7	2.8	15	108	16
Limit values	>7884	20	20			350	25

The limit values are implemented through EU Council Directive (EC, 1999) and a national Regulation from the Ministry of Environment (Miljøministeriet 2003A).

Table 9-2 Annual averages for particulate sulphur (S) measured in PM<sub>10</sub> 2003. Measurements are daily averages.

Unit: µg(S)/m <sup>3</sup>	Number of results	Average
<i>Traffic</i>		
Copenhagen/1257	352	1.18
Copenhagen/1103	355	1.20
Århus/6153	347	1.22
Odense/9155	306	1.30
Aalborg/8151	303	1.01
<i>Urban background</i>		
Copenhagen/1259	362	1.07
Århus/6159	312	1.04
Aalborg/8159	294	1.01
<i>Rural</i>		
Lille Valby/2090	315	1.05
Keldsnor/9055	316	1.17

## 9.2 Trends

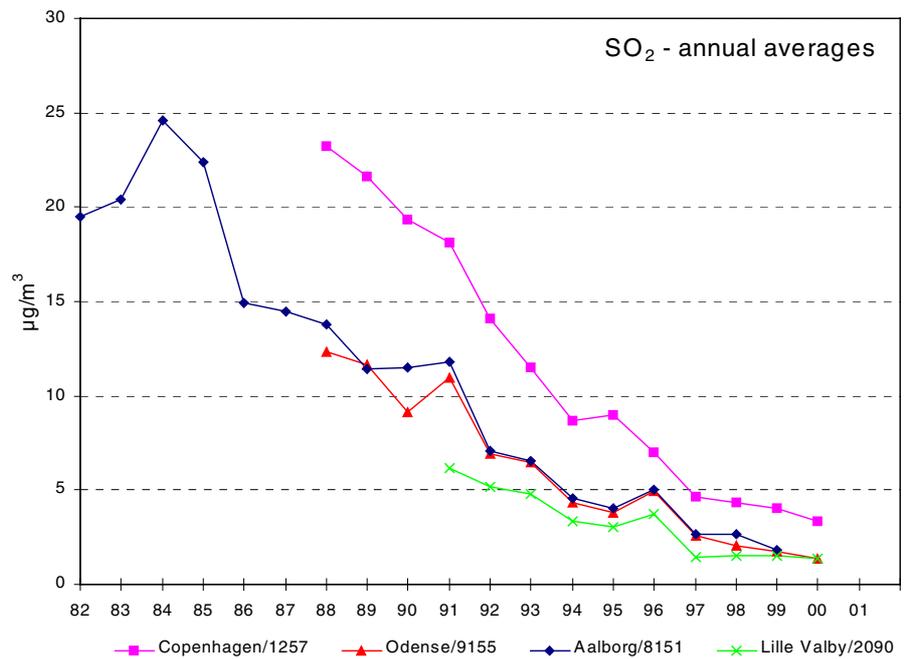


Figure 9-1 Annual averages for SO<sub>2</sub> and particulate sulphur

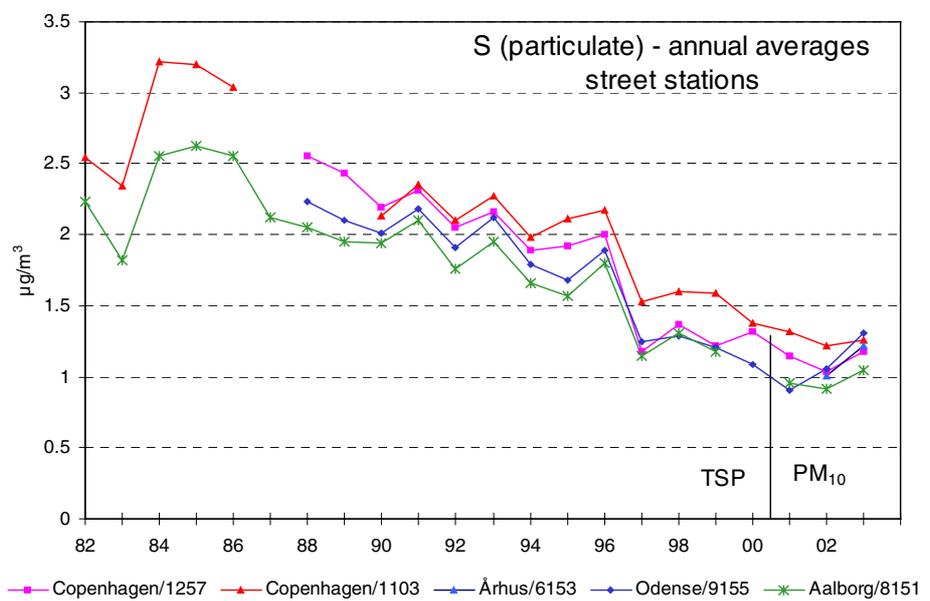


Figure 9-2 Annual averages particulate sulphur for street stations. The particulate sulphur from 2000 and earlier is determined in TSP, and the 2001 results and later are for PM<sub>10</sub> - except for Copenhagen/1103, where TSP measurements are continued.

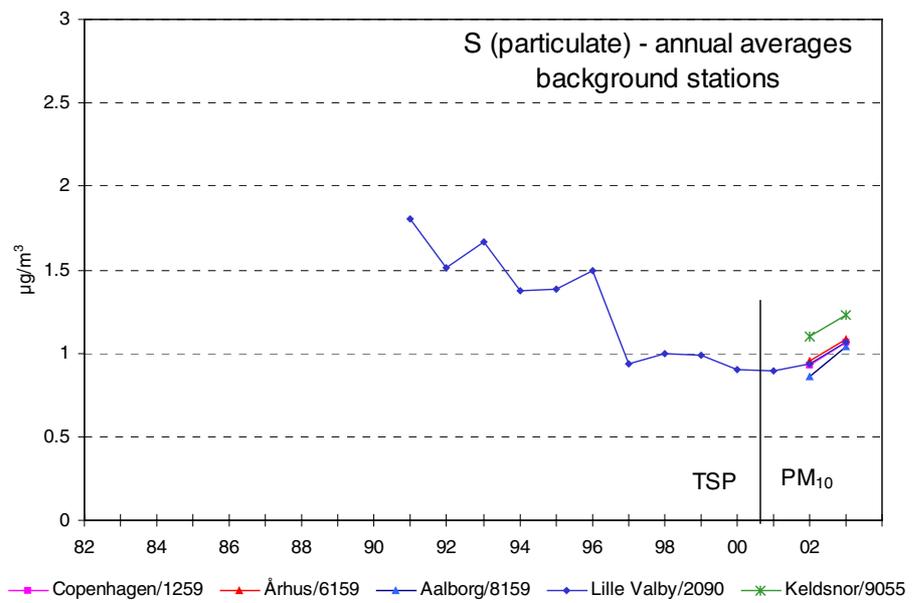


Figure 9-3 Annual averages particulate sulphur for urban background and rural stations. The particulate sulphur from 2000 and earlier is determined in TSP, and the 2001 results and later are for PM<sub>10</sub>.



## 10 References

*EC (1996):* Directive 96/62/EC of September 27 on ambient air quality assessment and management. J. Europ. Commun. L296/55.

*EC (1999):* Directive 1999/30/EC of 22 April 1999 relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air. J. Europ. Commun. L163/41.

*EC (2000):* Directive of the European Parliament and of the council 2000/69/EC of 16 November 2000 on limit values for benzene and carbon monoxide in ambient air. J. Europ. Commun. L313/12.

*Directive 2002/3/EC* of the European Parliament and of the Council of 12 February 2002 relating to ozone in ambient air Official Journal L 067 /14.

*Miljøministeriet (2003A):* Bekendtgørelse om grænseværdier for luftens indhold af visse forurenende stoffer. Bekendtgørelse nr. 58 af 23. Januar 2003. (In Danish). Ministry of Environment; Copenhagen, Denmark.

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*WHO (2000):* Air Quality Guidelines for Europe, Second Edition, WHO Regional Publications, European Series, No. 91, Copenhagen 2000. See also <http://www.euro.who.int/air>



## 11 Danish summary - Dansk resumé

Rapporten præsenterer resultaterne fra overvågningsprogrammet for luftkvalitet i danske byer (LMP IV) for 2003. Formålet med programmet er at fastlægge koncentrationer af skadelige stoffer i luften i danske byer, følge udviklingen af koncentrationerne og vurdere kilderne til de enkelte stoffer. Målingerne bruges til at vurdere effekten af allerede gennemførte tiltag og beregne virkningen af mulige fremtidige tiltag. Desuden tjener resultaterne som videnbasis for en række videnskabelige undersøgelser, fx vurdering af små partiklers effekt på sundheden.

Der er fastsat grænseværdier for flere af de målte stoffer. Grænseværdierne skal overholdes fra 2005 eller 2010. Frem til da er det dog tilladt at overskride disse grænseværdier indenfor en fastsat tolerance margin, som løbende reduceres. En detaljeret beskrivelse af gældende mål- og grænseværdier og deres gennemførelse findes i bekendtgørelser fra Miljøministeriet (se referencerne Miljøministeriet 2003A og 2003B). Bekendtgørelserne er baseret på EU-direktiver (EC 1996, 1999, 2000 og 2003).

De væsentligste konklusioner er at:

- indholdet af kvælstofdioxid (NO<sub>2</sub>) overskrider grænseværdierne på flere målestationer, og på en enkelt målestation HCAB i København er den tilladte margin overskredet.
- indholdet af partikler mindre end 10 µm (PM10) overskrider grænseværdierne mange steder. Den tilladte tolerance margin er ikke overskredet.
- der ikke er fastsat egentlige grænseværdier for ozon (O<sub>3</sub>) men kun "målværdier" og "langsigtede mål" (hensigtsværdier). Flere langsigtede mål er overskredet på flere stationer i 2003.
- De øvrige målte stoffer findes i koncentrationer under grænseværdierne, og for flere stoffer (fx svovldioxid og bly) er indholdet faldet kraftigt siden målingernes start.

Der er bred enighed blandt forskere og rådgivere i EU om, at grundlaget for fastsættelse af grænseværdier for partikler er meget mangelfuldt. Blandt andet er kendskabet til indholdet af naturlige partikler (jord m.m.) i luften meget mangelfuldt. Der er allerede nu fastsat vejledende grænseværdier for partikler i luft gældende fra 2010. I erkendelse af den mangelfulde viden er det imidlertid i EU direktivet om grænseværdier for PM10 bestemt, at de vejledende grænseværdier for 2010 skal tages op til revision i løbet af de nærmeste år.

En stor del af forureningen med partikler og ozon skyldes forureningsudslip fra andre europæiske lande. Løsningen på mange af problemerne må derfor findes på fælles europæisk plan.



# Appendix

## Pollutants measured in the LMP Network

*Nitrogen oxides (NO and NO<sub>2</sub>)*

NO and partly NO<sub>2</sub> are formed by combustion at high temperatures. The main sources are power plants and traffic. At the street stations the traffic is the main source. The application of catalytic converter in the exhaust reduces the emission considerably. NO is relatively harmless, but NO<sub>2</sub> can cause respiratory problems.

*Nitrogen dioxide (NO<sub>2</sub>)*

Most of the NO<sub>2</sub> in the urban atmosphere is produced by oxidation of nitrogen monoxide (NO) by ozone (O<sub>3</sub>). The reaction will take place immediate, if sufficient O<sub>3</sub> is present. O<sub>3</sub> is often the limiting component for a complete oxidation in the street canyons, but practically all NO is oxidised at the urban background and rural stations. Within a few hours the NO<sub>2</sub> is further oxidised to nitrate and/or nitric acid, which may cause acid precipitation and eutrofication. NO<sub>2</sub> is a toxic gas, which may cause respiratory problems. There are limit values for the allowed concentration of NO<sub>2</sub> in the atmosphere.

*Ozone (O<sub>3</sub>)*

O<sub>3</sub> is formed by photochemical reactions (i.e. by the influence of sunlight) between nitrogen oxides and volatile organic compounds (VOC's). The VOC's can be of natural and anthropogenic origin. The major part of the O<sub>3</sub> measured in Denmark originates from sources outside the country. Usually the highest concentrations are found at rural and urban background sites. O<sub>3</sub> is removed by NO at street level. O<sub>3</sub> is a toxic gas, which may cause respiratory problems and damage on crops and forests. There are so-called target values for the concentration of O<sub>3</sub> in the atmosphere.

*Carbon monoxide (CO)*

The main source of CO in urban air is petrol-fuelled cars. The CO is formed due to incomplete combustion. The application of catalytic converter in the exhaust reduces the emission considerably. CO is only slowly removed from the atmosphere. CO is a toxic gas that may prevent the uptake of oxygen in the blood. There are limit values for the allowed concentration of CO in the atmosphere.

*Benzene*

Benzene is present in petrol. It may also be formed in engines due to incomplete combustion. Since 1994 the benzene content in petrol has been reduced by up to a factor of 5. The concentration in the atmosphere is reduced correspondingly. Benzene is a carcinogenic gas. There is a limit value for the average content in the atmosphere.

*Other volatile organic compounds (VOC's)*

Many different VOC's are present in the air. Several of these are emitted by incomplete combustion in e.g. engines and wood burning stoves. Several of the VOC's are carcinogenic. A "target value" is expected to be implemented through an EU Council Directive during 2004 for Benzo(a)pyrene as indicator for PAH (Polycyclic Aromatic Hydrocarbones). Of the VOC's only benzene, toluene and xylenes are measured routinely in LMP IV at present.

*Particles smaller than 10 $\mu$ m (PM<sub>10</sub>)*

The main sources for PM<sub>10</sub> are resuspended dust and combustion. PM<sub>10</sub> particles are also created in the atmosphere by oxidation of nitrogen dioxide and sulphur dioxide. The submicron particles, which are formed by combustion and chemical reactions in the atmosphere, are suspected to be the most harmful for the health. There are still a lack of knowledge about the connection between health effects and particle size. Limit values for the PM<sub>10</sub> concentration in the atmosphere are implemented at present. The limit values will most likely be revised in a few years, when better knowledge about the adverse health effects of fine particles influence on health has been obtained.

*Heavy metals (HM's)*

There are a number of different HM's in the atmosphere. They are emitted from e.g. coal and oil fired power plants, waste incinerators and industries. HM's may also be emitted from traffic due to wear on engines, tires and brake pads. Several HM's are toxic even in low concentrations and a few also carcinogenic. A limit value is implemented for lead. In 2002 or 2003 limit values are expected to be implemented for arsenic, cadmium, nickel and mercury. WHO has proposed guideline values for the toxic non-carcinogenic and estimated life time risks for the carcinogenic HM's.

*Sulphur compounds*

Sulphur dioxide (SO<sub>2</sub>) is formed by burning of fossil fuel and biomass. The SO<sub>2</sub> is oxidised in the atmosphere to particulate sulphuric acid and sulphate. The conversion time depends strongly of the temperature and humidity in the air. It is typically of the order of one day. Sulphuric acid contributes to "acid rain" and the deposition of sulphate causes damage to sensitive ecosystems. During the last 20 years the reduction of sulphur in fossil fuel and improved flue gas cleaning has reduced the concentration of SO<sub>2</sub> with one order of magnitude. SO<sub>2</sub> may cause respiratory problems. There are limit values for the allowed concentration of SO<sub>2</sub> in the atmosphere.

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The air quality in Danish cities has been monitored continuously since 1982 within the Danish Air Quality (LMP) network. The aim has been to follow the concentration levels of toxic pollutants in the urban atmosphere and to provide the necessary knowledge to assess the trends, to perform source apportionment, and to evaluate the chemical reactions and the dispersion of the pollutants in the atmosphere. In 2003 the air quality was measured in four Danish cities and at two background sites. NO<sub>2</sub> and PM10 were at several stations found in concentrations above the new EU limit values, which the Member States have to comply with in 2005 and 2010. While the concentrations for most other pollutants have been strongly decreasing since 1982, only a slight decrease has been observed for NO<sub>2</sub>.