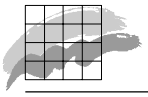
National Environmental Research Institute
Ministry of the Environment · Denmark

Air Quality Monitoring Programme

Annual Summary for 2002

NERI Technical Report No. 450

Kåre Kemp
Finn Palmgren



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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_2 and PM_{10} 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_2.

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Contents

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_2, NO_x/NO_2, PM_{10}, lead, benzene, CO and ozone. Only a PM_{10} monitor at an urban background location in Odense is missing. The data sets for year 2002 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_2 was in 2002 exceeded at three street stations. At one station (Copenhagen/1103) the limit value + the margin of tolerance (58 µg/m^3 in 2002) was exceeded. The trend seems to have been stabilised after several years of decrease.

The ozone level was in 2002 - 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^3 was not exceeded. The target values were not exceeded, but the long-term objectives of max 8 hours on 120 µg/m^3 were exceeded at all urban background and rural stations. The long term objective for AOT40 at 6000 µg/m^3 *hours were exceeded in a few cases.

The limit value of PM_{10} on 50 µg/m^3, not to be exceeded more than 35 times per year and to comply with in 2005, was in 2002 exceeded at 3 out of 4 street stations. At all stations both limits values to be met in 2010 (annual average value on 20 µg/m^3 and 50 µg/m^3 not to be exceeded more than 7 times per year) were exceeded at all stations (including the rural station Keldsnor). PM_{10} is 60-70% of TSP. The trend of TSP has been clear decreasing the last 15 years.

The SO_2 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 2001.

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. 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 measures 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_2, SO_2, particulate matter (PM_{10}) and Pb (EC, 1999), CO and benzene (EC, 2000) and O_3 (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.

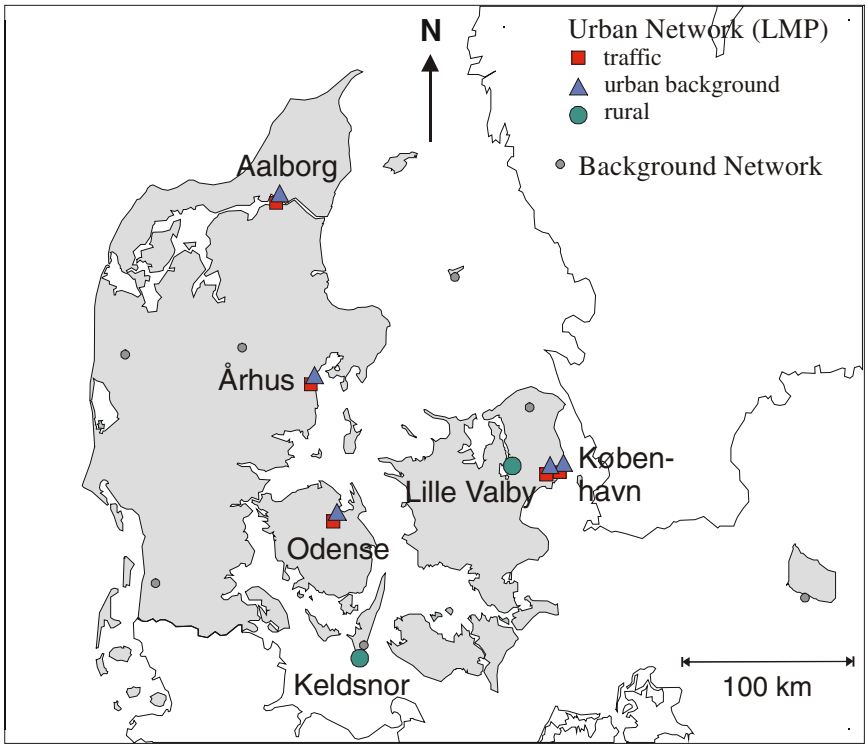

Figure 2-1 Monitoring stations in the two nation-wide air quality networks.

Table 2-1 Stations in the LMP IV network and the Copenhagen network included in this report in 2002.

Name	Street/location	Type	Remarks
Copenhagen/1257	Jagtvej	Street	
Copenhagen/1259	H.C. Ørsted Institute	Urban background	PM_{10} started April 2002
Copenhagen/1103	H.C. Andersens Boulevard	Street	Copenhagen Municipality
Århus/6153	Banegårdsgade	Street	
Århus/6159	Valdemarsgade	Urban Background	Measurements started Aug. 2001
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_x, PM_{10} and elements (heavy metals) in PM_{10} were measured at all stations (the PM_{10} not started yet at Odense/9159, TSP measured in stead of PM_{10} at Copenhagen/1103)
- O_3 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_2 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_{10} and TSP all parameters were recorded as ½-hour averages. PM_{10}, TSP and elements in the particles were measured as 24 hour averages. At the three stations in Copenhagen also ½-hour averages of PM_{10} 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_2) 2002. All parameters are calculated with hourly averages.

Unit: µg/m^3	Number	Average	Median	98. percentile	19. highest
Traffic:					
Copenhagen/1257	8659	47	45	101	122
Copenhagen/1103	8598	61	59	119	142
Århus/6153	8659	44	41	100	125
Odense/9155	8575	37	29	103	133
Aalborg/8151	8453	33	29	85	111
Urban Background:					
Copenhagen/1259	8037	20	16	58	75
Århus/6159	8712	26	22	72	96
Odense/9159	8701	18	15	50	68
Aalborg/8159	8624	17	14	54	94
Rural:					
Lille Valby/2090	8349	12	9	38	50
Keldsnor/9055	8717	9	6	37	51
Limit values	>7884	40			200

Table 3-2 Nitrogen oxide (NO) 2002. All parameters are calculated with hourly averages.

Unit: µg/m^3	Number	Average	Median	98. percentile	19. highest
Traffic:					
Copenhagen/1257	8659	45	32	160	344
Copenhagen/1103	8598	76	60	243	423
Århus/6153	8659	40	27	175	320
Odense/9155	8574	33	12	179	337
Aalborg/8151	8456	52	33	222	370
Urban Background:					
Copenhagen/1259	8037	4	2	27	72
Århus/6159	8712	9	4	82	210
Odense/9159	8701	4	2	28	91
Aalborg/8159	8624	6	2	43	197
Rural:					
Lille Valby/2090	8352	2	1	10	52
Keldsnor/9055	8717	1	0	7	21

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_2) 2002. All parameters are calculated with hourly averages.

Unit: µg/m^3	Max. 3 hours	Date:hour	Max. hour	Date:hour
Traffic:				
Copenhagen/1257	128	021021: 6	146	021021: 6
Århus/6153	149	020828:13	178	020828:15
Copenhagen/1103	123	020827: 5	149	021021: 6
Odense/9155	309	021217: 8	383	021217: 8
Aalborg/8151	106	020410:20	127	020411: 7
Urban Background:				
Copenhagen/1259	78	020330:19	93	020330: 19
Århus/6159	93	020402: 5	157	021021: 7
Odense/9159	74	021101:15	84	020912: 7
Aalborg/8159	95	021212: 7	132	020410: 6
Rural:				
Lille Valby/2090	54	020103: 8	61	020409: 8
Keldsnor/9055	54	020106: 5	71	020421:17
Alert threshold	400	-	-	-

Table 3-4 Episodic results for Nitrogen oxide (NO) 2002. All parameters are calculated with hourly averages.

Unit: µg/m^3	Max. 3 hours	Date:hour	Max. hour	Date:hour
Traffic:				
Copenhagen/1257	471	021021: 5	709	021021: 6
Copenhagen/1103	456	020103: 7	871	020919: 5
Århus/6153	394	021021: 5	715	021021: 7
Odense/9155	639	021217: 9	909	021217:10
Aalborg/8151	422	021212:12	486	021212: 8
Urban Background:				
Copenhagen/1259	95	020107: 7	190	021127:17
Århus/6159	253	021218:19	669	021021: 7
Odense/9159	142	021015:21	205	020912: 7
Aalborg/8159	271	021212: 8	368	021212: 9
Rural:				
Lille Valby/2090	86	020103: 9	192	020103:10
Keldsnor/9055	24	020110:18	47	020421:17

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

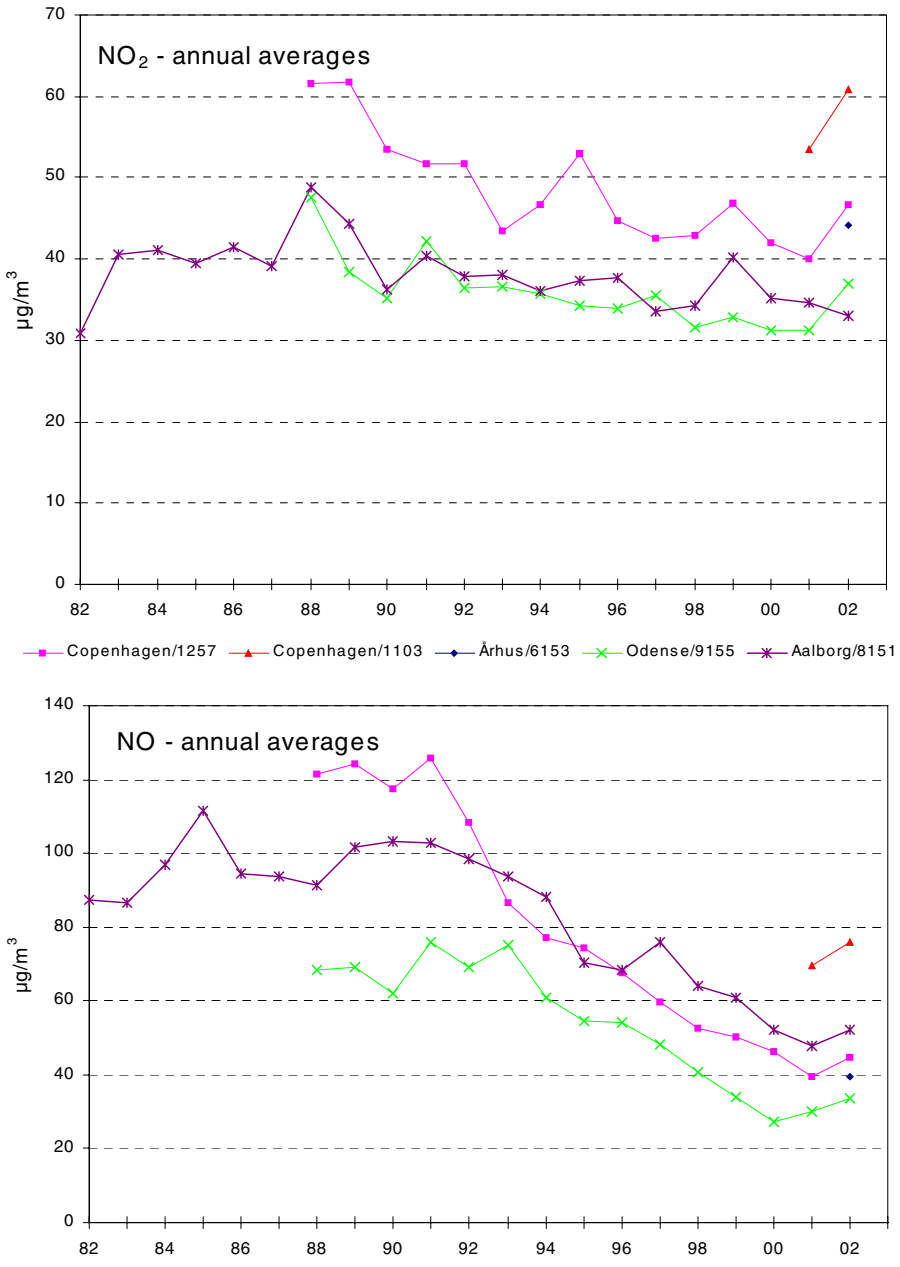

Figure 3-1 The graphs show the time series for the annual average values measured at street stations. Previous results from Copenhagen/1103 can be found at the Web-pages of the Copenhagen Environmental Protection Agegenncy (www. Miljoe.kk.dk).

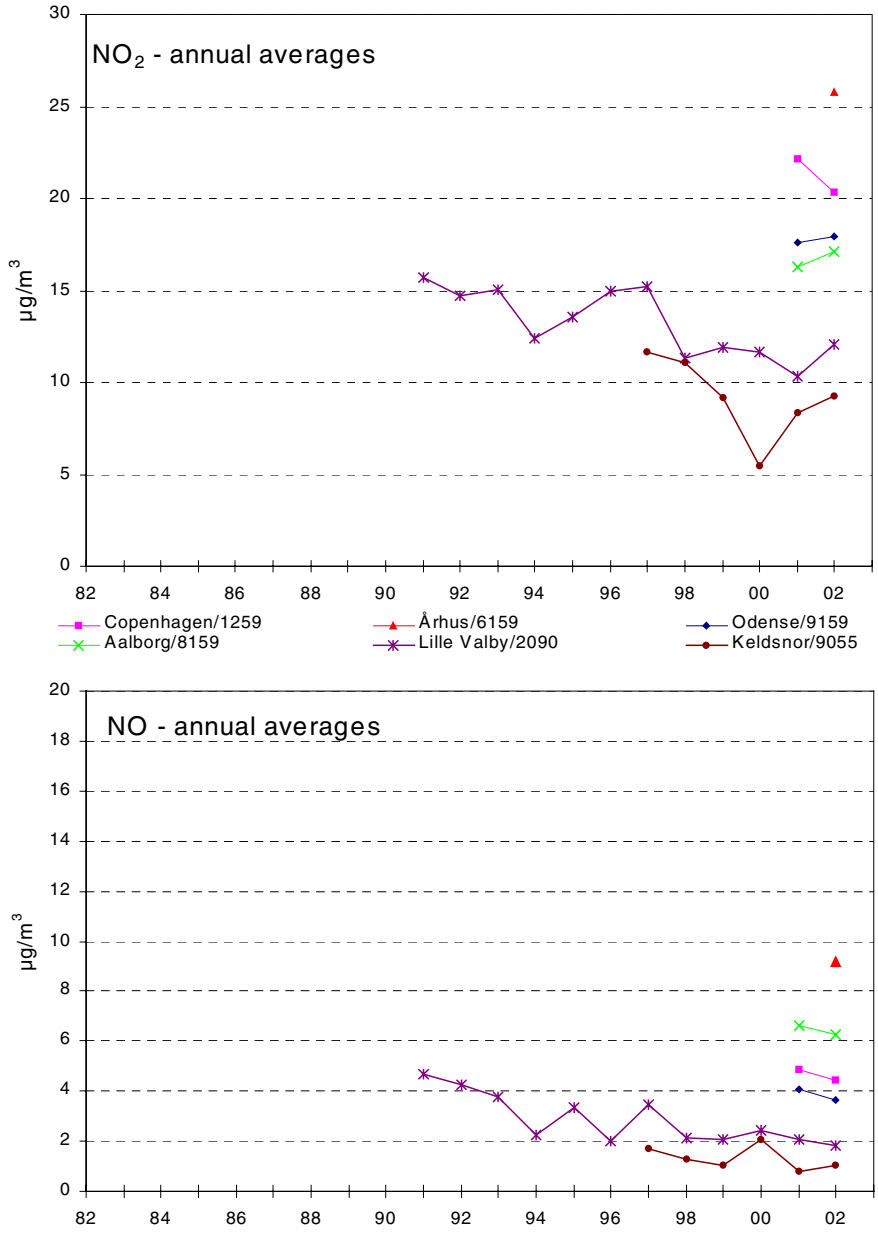

Figure 3-2 The graphs show the time series for the annual average values measured at urban background and rural stations.

4 Ozone

4.1 Annual statistics

Table 4-1 Ozone (O_3) 2002. 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^3	Number of results	Average	Median	Max. 8 hours	26. highest 8 hour	Max. 1 hour	AOT40 µg/m^3.h
Urban Background:							
Århus/6159	8729	50	53	125	97	141	4560
Odense/9159	7672	52	54	132	104	157	8970
Aalborg/8159	8160	51	54	120	93	131	2299
Rural							
Lille Valby/2090	8347	54	56	144	104	155	5382
Keldsnor/9055	8734	63	66	150	116	161	9104
Traffic							
Copenhagen/1257	8664	29	28	73	64	90	1
Copenhagen/1103	6781	29	25	105	72	143	374
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^3) in 2002: 0.

Number of information to the public due to exceedance of the alert threshold (240 µg/m^3) in 2002: 0.

4.2 Trends

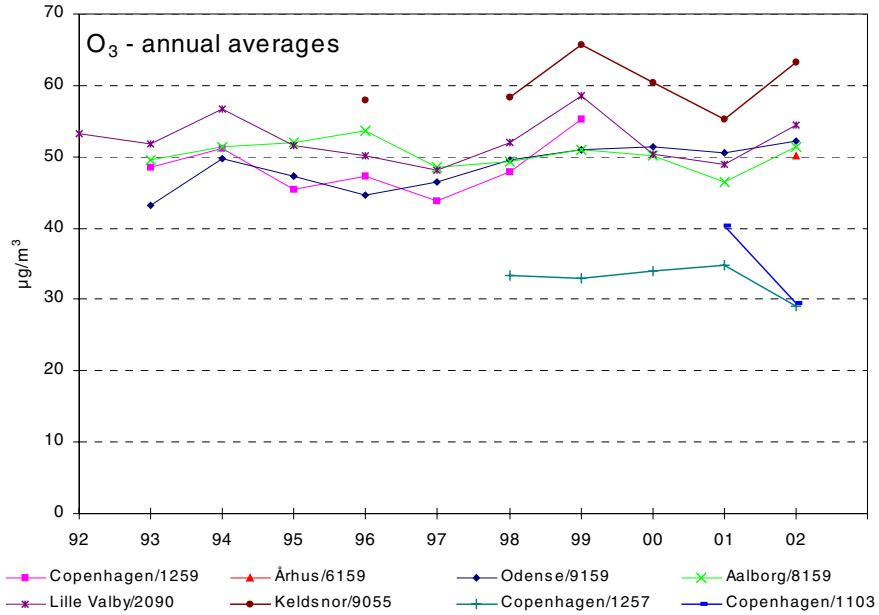

Figure 4-1 Annual average values. Previous results from Copenhagen/1103 can be found at the Web-pages of the Copenhagen Environmental Protection Agegenncy (www. Miljoe.kk.dk).

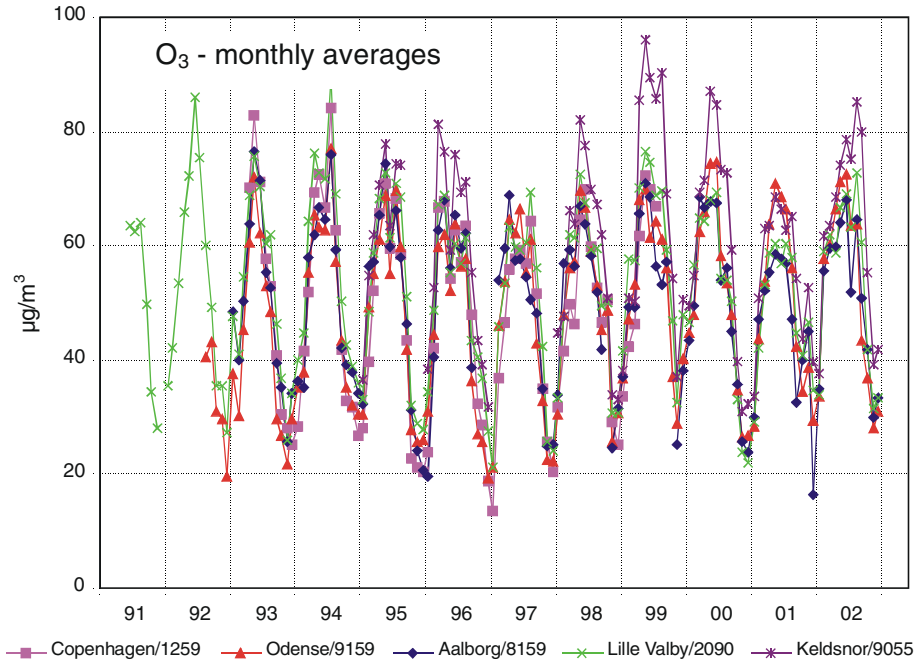

Figure 4-2 Monthly average values for urban background and rural stations.

5 Carbon monoxide

5.1 Annual statistics

Table 5-1 Annual statistics for carbon monoxide (CO) 2002. All parameters are calculated with hourly average. The 8-hour values are calculated as a moving average based on hourly results.

Unit: µg/m^3	Number	Average	Median	98-percentile	99.9-percentile	Max. 8-hours	Max hour
Traffic:							
Copenhagen/1257	8669	1037	877	2781	6140	4605	9553
Copenhagen/1103	8670	922	813	2392	3982	2928	6210
Århus/6153	7918	606	525	1741	3575	2562	4715
Odense/9155	8702	750	548	2387	3885	3322	5504
Aalborg/8151	8718	862	705	2537	3921	3465	4684
Urban Background:							
Copenhagen/1259	8045	328	284	786	1528	1174	2381
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

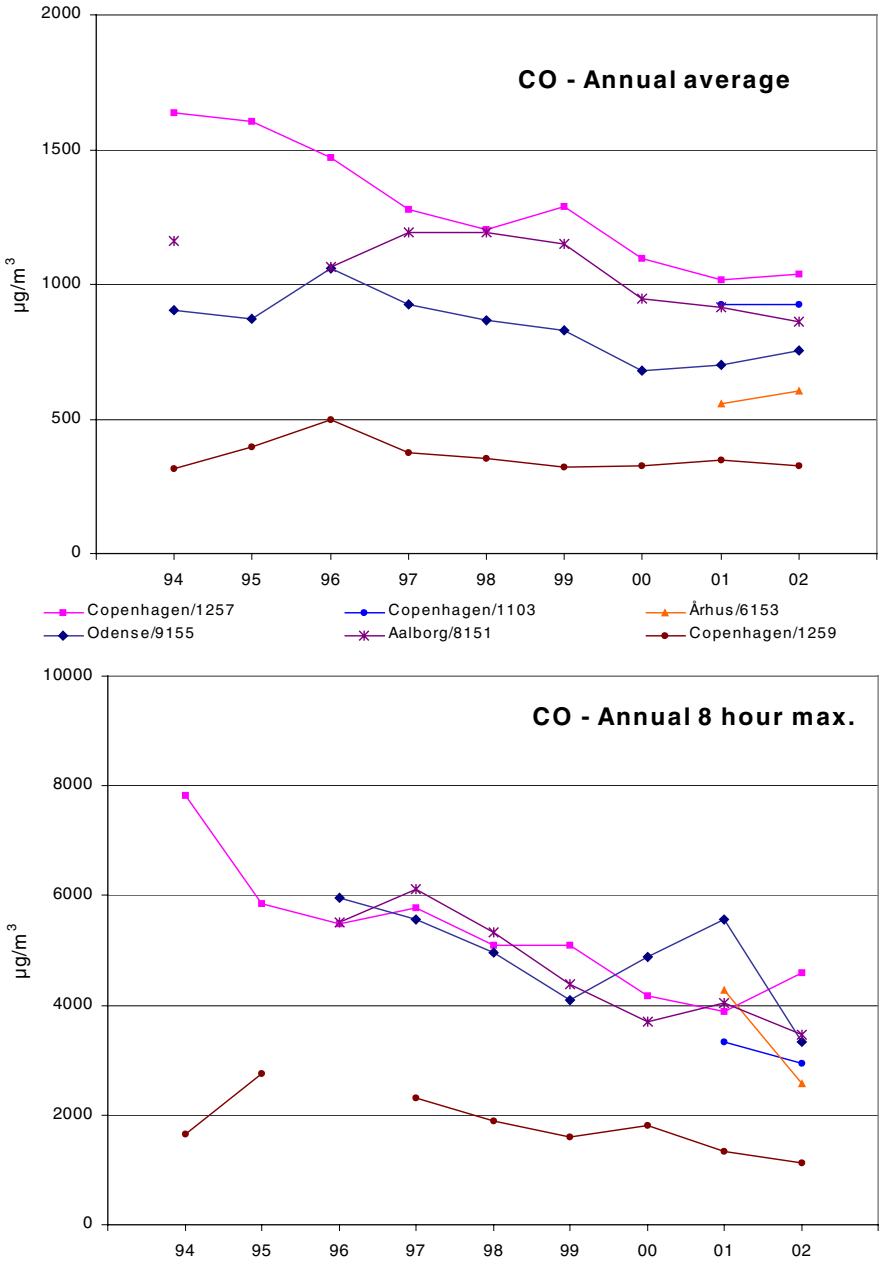

Figure 5-1 Annual average values and highest 8-hour average. Previuos results from Copenhagen/1103 can be found at the Web-pages of the Copenhagen Environmental Protection Agegenncy (www. Miljoe.kk.dk).

6 Benzene and Toluene

6.1 Annual statistics

Table 6-1 Annual statistics for Benzene 2002. 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.

Unit: µg/m^3	Number of results	Average	Max. 8 hours	Max. 1 hour
Copenhagen/1257	6998	3.6	18	38
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 2002. The 7 days results are calculated as a moving average based on daily averages.

Unit: µg/m^3	Number of results	Average	Max. 7 days	Max. 1 hour
Copenhagen/1257	6998	15.8	83	254
Guideline value	-	-	260	-

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

7 Particles (TSP, PM_{10})

7.1 Annual statistics

The PM_{10} mass in the following are determined by weighing the exposed filters after conditioning for at least seven days at 52% RH and 23 ^{0}C.

Table 7-1 Annual statistics for PM_{10} 2002. 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^3	Number of results	Average	36.highest result	90 percentile	95 percentile	8.highest result	Max. day
Traffic							
Copenhagen/1257	324	36	57	58	68	87	135
Copenh./1103 +)	357	77	122	123	142	159	202
Århus/6153	336	30	48	49	57	64	111
Odense/9155	349	33	54	55	64	74	127
Aalborg/8151	340	32	51	52	64	72	102
Urban background							
Copehhagen/1259	223	25	36	44	51	52	83
Århus/6159	276	24	37	40	48	51	58
Aalborg/8159	298	25	40	42	54	64	88
Rural							
Lille Valby/2090	311	27	45	48	60	67	106
Keldsnor/9055	326	30	48	48	58	70	178
Limit values	>329	40(20)	50	-	-	(50)	-

+) **N.B.** TSP (Total Suspended Particulate matter). At street stations the TSP concentration is around 1.4 times the PM_{10} 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_{10} measurement was started at all stations except Copenhagen/1103 where the TSP sampling was con-

tinued. The TSP is around 30 % higher than PM_{10} at the street stations, and the difference is less at rural sites.

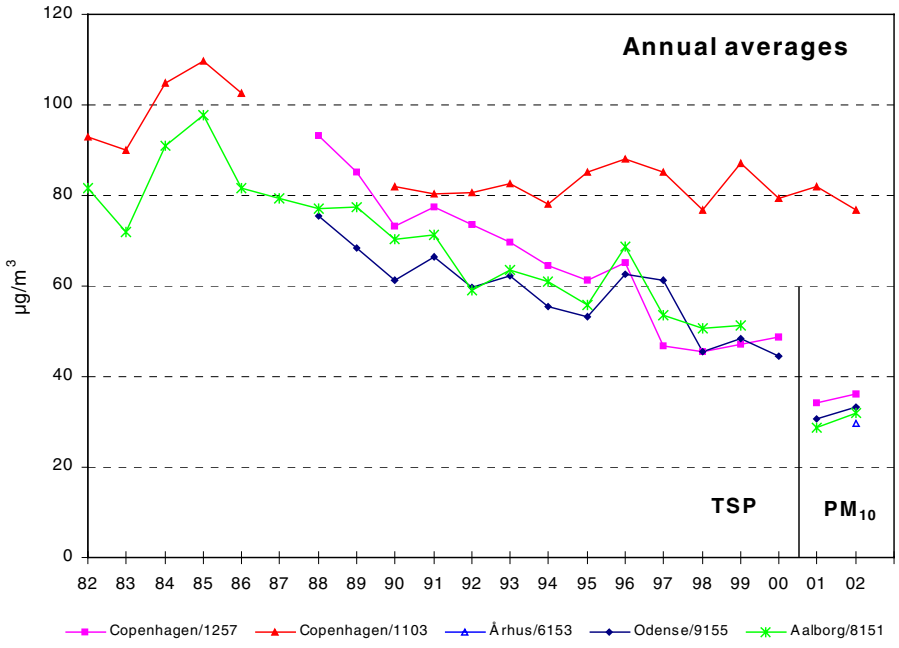

Figure 7-1 Annual averages for TSP and PM_{10} measured at street stations. Results from 200 and earlier are for TSP, while later results are for PM_{10} - except for Copenhagen/1103, where TSP measurements are continued.

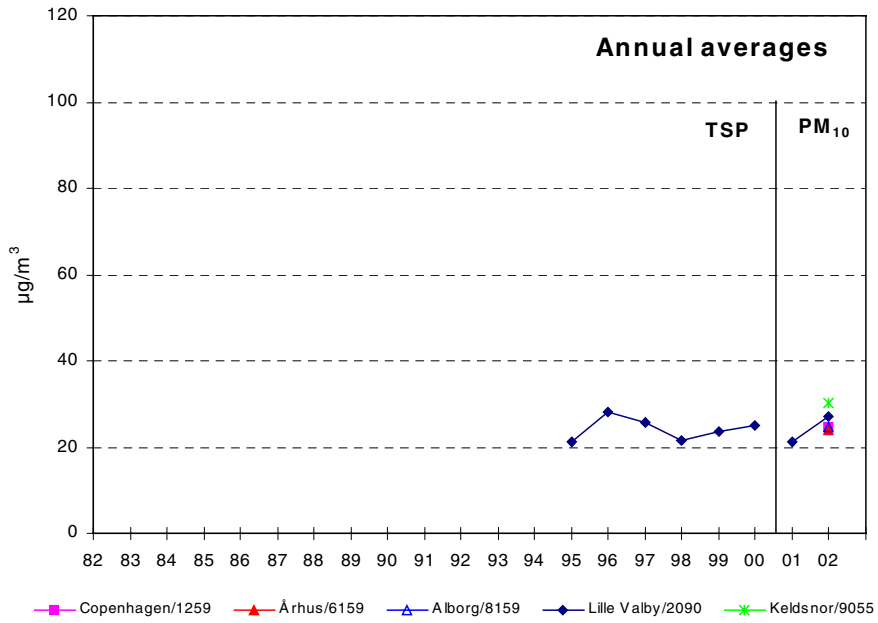

Figure 7-2 Annual averages for TSP and PM_{10} measured at urban background and rural stations.

8 Heavy Metals

8.1 Annual statistics

Table 8-1 Annual statistics for Vanadium (V), Chromium (Cr), Manganese (Mn), Nickel (Ni), Cupper (Cu), Zink (Zn), Arsenic (As), Selenium (Se), Cadmium (Cd) and Lead (Pb) measured in PM_{10} during 2002. The lifetime 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 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^3	V	Cr	Mn	Ni	Cu	Zn	As	Se	Cd	Pb
Traffic										
Copenhagen/1257	7.17	7.96	13.9	4.2	60.3	46	0.7	0.5	<1.5	15.3
Copenhagen/1103 +)	10.0	16.7	77.6	4.6	96.1	113.0	0.6	0.4	< 0.8	25.5
Århus/6153	7.1	4.9	9.9	5.9	25.8	34.2	0.7	0.9	<1.5	8.5
Odense/9155	4.8	5.3	15.7	2.8	34.5	57.1	0.8	0.6	<1.5	11.9
Aalborg/8151	4.3	4.7	9.8	2.8	37.8	43.5	0.6	0.5	<1.5	9.3
Urban background										
Copenhagen/1259	6.5	-	6.7	3.1	9.2	23.9	0.6	0.5	<1.5	7.1
Århus/6159	5.5	-	5.9	4.6	6.6	23.2	0.7	0.5	<1.5	5.6
Aalborg/8159	3.7	-	6.2	2.2	5.8	23.2	0.7	0.5	<1.5	5.5
Rural										
Lille Valby/2090	4.5	-	5.5	2.1	4.2	23.9	0.9	0.5	<1.5	6.2
Keldsnor/9055	6.6	-	3.4	2.8	3.9	23.3	0.5	0.7	<1.5	6.9
Limit values				*)			*)		*)	500
Guideline value	1000		150						5	
Life time risk level at $1:10^5$				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_{10} results are in most cases comparable because the heavy metals primarily are found in fine particles.

*) Some kind of threshold values will be implemented within a few years.

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 2002 or 2003.

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

8.2 Trends

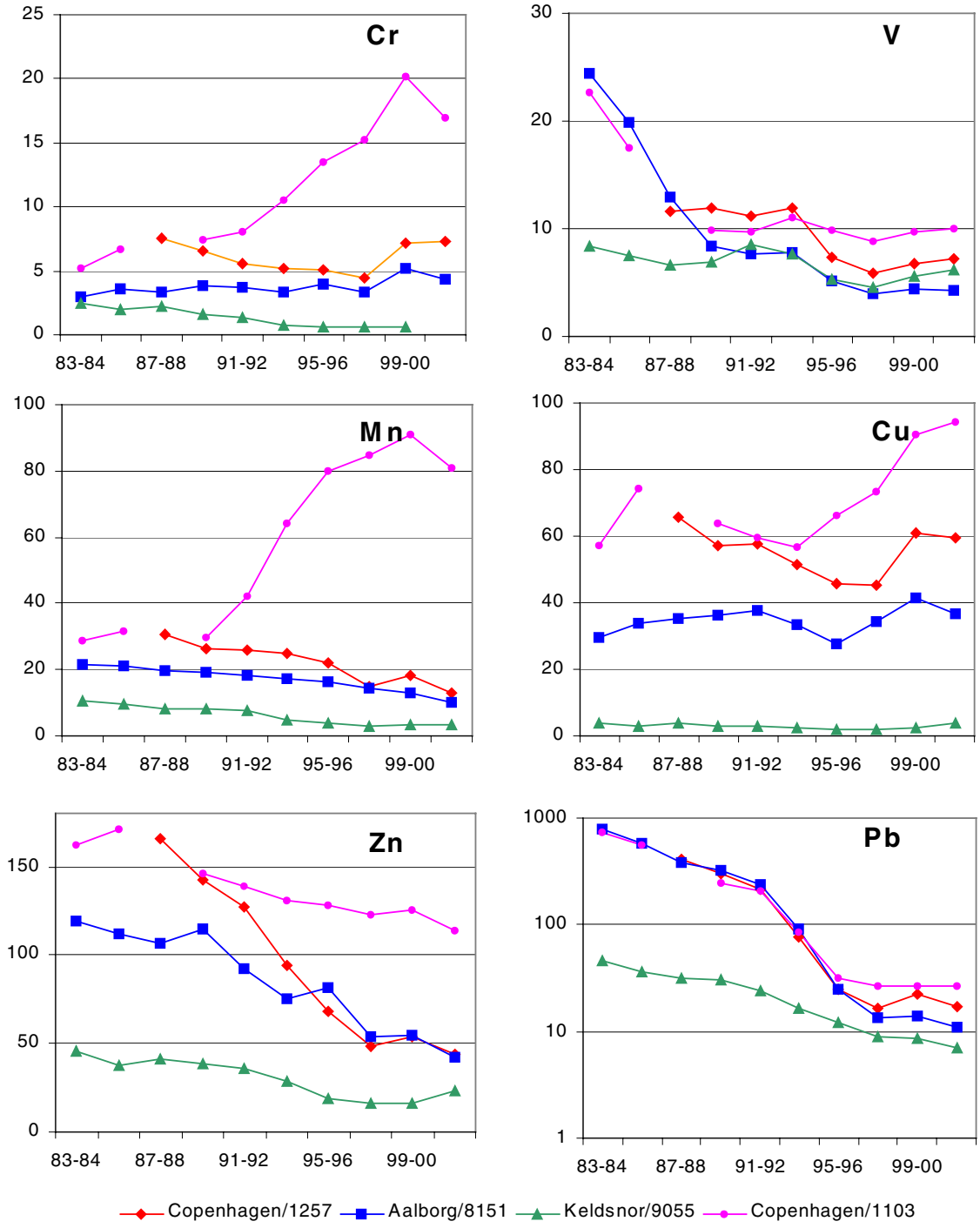

Figure 8-1 Biannual averages from selected stations for some Heavy Metals in particulate matter. Until 2000 in TSP and later in PM_{10} – except for Copenhagen/1103 where TSP measurements continue. y-axis units are ng/m^3. (Note that the scale for Pb is logarithmic.)

9 Sulphur Compounds

9.1 Annual statistics

Table 9-1 Annual statistics for SO_2 2002. All parameters are calculated based on hourly averages.

Unit: µg/m^3	Number of results	Average year	Average winter	Median	98-percentile	Max. Hour	4. highest day
Traffic							
Copenhagen/1103	8086	3.8	3.8	2.8	13	43	9
Aalborg/8151	8689	3.8	3.9	2.9	13	29	9
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_{10} 2002. Measurements are daily averages.

Unit: µg(S)/m^3	Number of results	Average
Traffic		
Copenhagen/1257	330	1.02
Copenhagen/1103	359	1.22
Århus/6153	336	1.00
Odense/9155	351	1.05
Aalborg/8151	354	0.90
Urban background		
Copenhagen/1259	234	0.91
Århus/6159	292	0.95
Aalborg/8159	315	0.84
Rural		
Lille Valby/2090	320	0.92
Keldsnor/9055	328	1.10

9.2 Trends

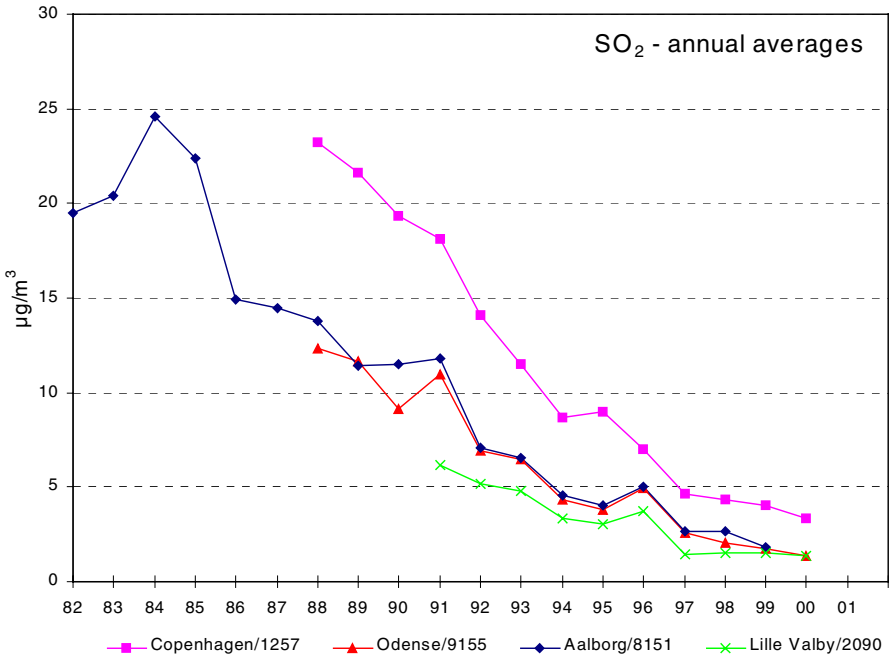

Figure 9-1 Annual averages for SO_2 and particulate sulphur

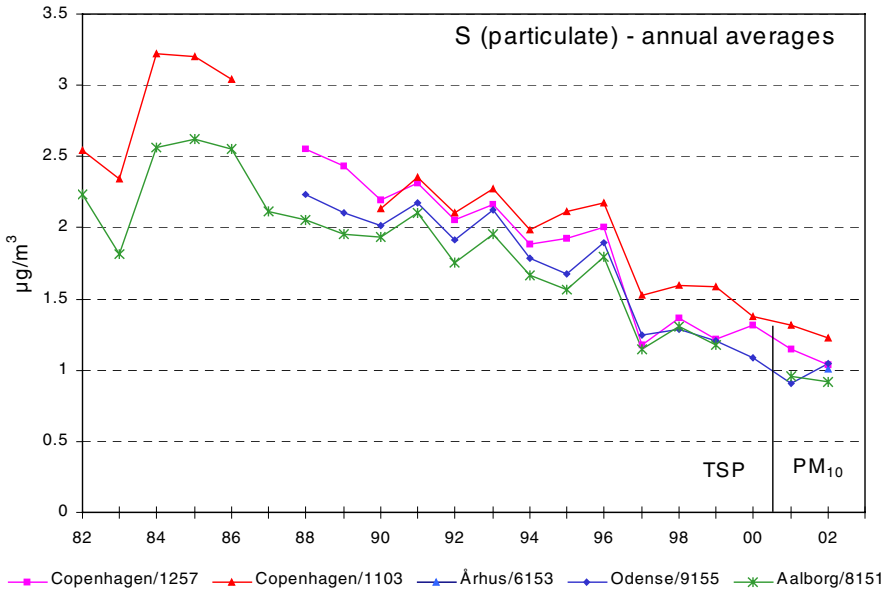

Figure 9-2 Annual averages particulate sulphur for street stations. The particulate sulphur from 2000 and earlier is determined in TSP, and the 2001 results and later are for PM_{10} - except for Copenhagen/1103, where TSP measurements are continued.

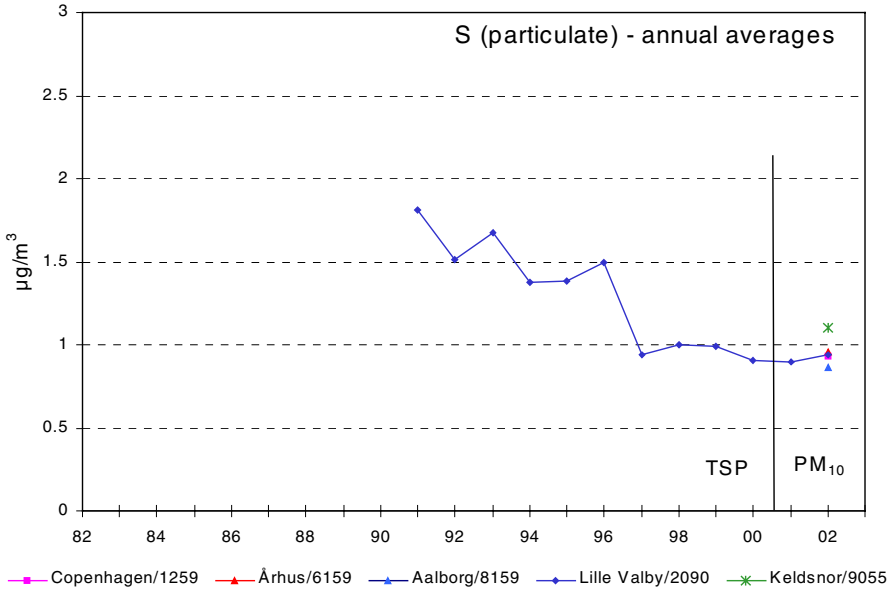

Figure 2 Annual averages particulate sulphur for urban background and rural stations. The particulate sulphur from 2000 and earlier is determined in TSP, and the 2001 results and later are for PM_{10}

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Danish summary - Dansk resumé

Rapporten præsenterer resultaterne fra overvågningsprogrammet for luftkvalitet i danske byer (LMP IV) for 2002. 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 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_2) overskrider grænseværdierne på flere målestationer, og på en enkelt målestation er den tilladte margin overskredet.

- indholdet af partikler mindre end 10 µm (PM_{10}) overskrider grænseværdierne mange steder. Den tilladte margin er ikke overskredet.

- der ikke er fastsat egentlige grænseværdier for ozon (O_3) men kun "målværdier" og "langsigtede målsætninger" (hensigtsværdier). Flere langsigtede målsætninger er overskredet på flere stationer i 2002.

- 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 PM_{10} 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_2)

NO and partly NO_2 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_2 can cause respiratory problems.

Nitrogen dioxide (NO_2)

Most of the NO_2 in the urban atmosphere is produced by oxidation of nitrogen monoxide (NO) by ozone (O_3). The reaction will take place immediate, if sufficient O_3 is present. O_3 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_2 is further oxidised to nitrate and/or nitric acid, which may cause acid precipitation and eutrofication. NO_2 is a toxic gas, which may cause respiratory problems. There are limit values for the allowed concentration of NO_2 in the atmosphere.

Ozone (O3)

O_3 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_3 measured in Denmark originates from sources outside the country. Usually the highest concentrations are found at rural and urban background sites. O_3 is removed by NO at street level. O_3 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_3 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 i 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 VOCs 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. Limit values will be implemented 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 10µm (PM_{10})

The main sources for PM_{10} are resuspended dust and combustion. PM_{10} particles are also created in the atmosphere by oxidation of ni-

trogen 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_{10} 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_2) is formed by burning of fossil fuel and biomass. The SO_2 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_2 with one order of magnitude. SO_2 may cause respiratory problems. There are limit values for the allowed concentration of SO_2 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 2002 the air quality was measured in four Danish cities and at two background sites. NO_2 and PM_{10} 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_2.

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