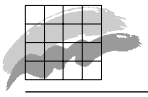
National Environmental Research Institute
Ministry of the Environment · Denmark

# Air Quality Monitoring Programme

Annual Summary for 2001

***NERI Technical Report, No. 427***



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***NERI Technical Report, No. 427***
***2002***

*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 2001 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 will be fully implemented 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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# 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 a urban background location in Odense is missing. The data sets for year 2001 is complete for many stations. The monitoring programme consists of 10 stations plus 2 extra stations under the Municipality of Copenhagen.

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 2000.

The ozone level is 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/$m^3$ and of AOT40 on 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 7 times per year and to comply with in 2010, was exceeded at all street stations. The corresponding annual average limit value on 20 µg/$m^3$ was 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 limit value of the annual average of $NO_2$ was exceeded at a few street stations and the decreasing trend continues.

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. 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's 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 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.

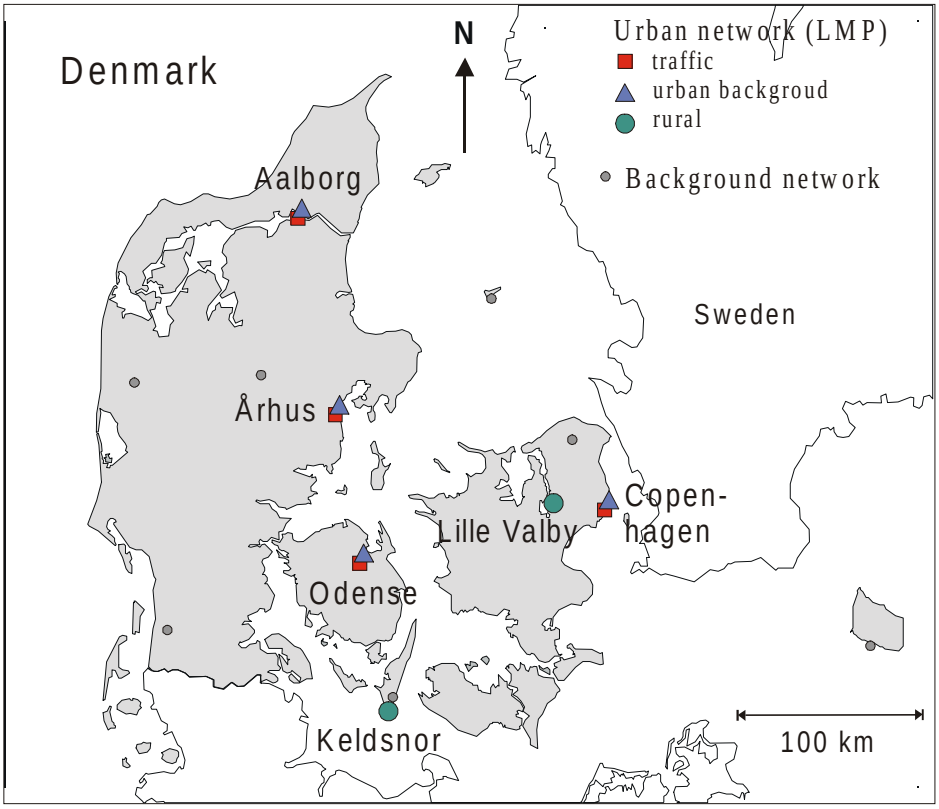


*Figure 2-1* Monitoring stations in the two nation-wide air quality networks.

*Table 2-1* Active stations in the LMP IV network in 2001.

| Name | Street / location | type | Remarks |
|---|---|---|---|
| Copenhagen / 1257 | Jagtvej | Street | |
| Copenhagen / 1259 | H.C.Ørsted Institute | Urban background | $PM_{10}$ started April 2002 |
| Århus / 6153 | Banegårdsgade | Street | Measurements started June 2001 |
| Århus / 6159 | Valdemarsgade | Urban Background | Measurements started Aug. 2001 |
| Odense / 9155 | Albanigade | Street | $PM_{10}$ started Feb. 2001 |
| Odense / 9159 | Town hall in Odense | Urban background | $PM_{10}$ expect start medio 2002 |
| Aalborg / 8151 | Vesterbro | Street | |
| Aalborg / 8159 | Dept. for Envir. and Urban Affairs | Urban background | |
| Lille Valby / 2090 | - | Rural | |
| Keldsnor / 9055 | - | Rural | $PM_{10}$ started Oct. 2001 |

- $NO$, $NO_x$, $PM_{10}$ and elements (heavy metals) in $PM_{10}$ were measured at all stations (the $PM_{10}$ measurements were not fully implemented in 2001 - see *Table 2-1*)
- $O_3$ was measured at all urban background stations and Copenhagen / 1257
- CO was measured at all street stations and Copenhagen / 1259
- Benzene and Toluene were measured at Copenhagen / 1257 and Odense / 9155
- $SO_2$ was measured at Aalborg / 8151 and at Copenhagen / 1259 (DOAS). 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 $PM_{10}$ all parameters were recorded as ½-hour averages. $PM_{10}$ and elements in $PM_{10}$ were measured as 24 hour averages. At the two 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 oxide (NO) 2001. All parameters are calculated with hourly averages.

| Unit: µg / m$^3$ | Number | Average | Median | 98. percentile | 19. highest |
|---|---|---|---|---|---|
| *Traffic:* | | | | | |
| Copenhagen / 1257 | 8327 | 39 | 25 | 157 | 283 |
| Århus / 6153 | 4720 | 46 | 27 | 202 | 329 |
| Odense / 9155 | 8500 | 30 | 12 | 173 | 270 |
| Aalborg / 8151 | 8684 | 48 | 28 | 209 | 390 |
| *Urban Background:* | | | | | |
| Copenhagen / 1259 | 7526 | 4 | 2 | 31 | 78 |
| Århus / 6159 | 3556 | - | - | - | - |
| Odense / 9159 | 8116 | 5 | 2 | 30 | 99 |
| Aalborg / 8159 | 8536 | 7 | 3 | 47 | 250 |
| *Rural:* | | | | | |
| Lille Valby / 2090 | 8561 | 2 | 1 | 11 | 45 |
| Keldsnor / 9055 | 8676 | 1 | 0 | 4 | 13 |

*Table 3-2* Nitrogen dioxide ($NO_2$) 2001. All parameters are calculated with hourly averages.

| Unit: µg / m$^3$ | Number | Average | Median | 98. percentile | 19. highest |
|---|---|---|---|---|---|
| *Traffic:* | | | | | |
| Copenhagen / 1257 | 8323 | 40 | 38 | 87 | 106 |
| Århus / 6153 | 4720 | 43 | 42 | 92 | 108 |
| Odense / 9155 | 8500 | 31 | 26 | 81 | 100 |
| Aalborg / 8151 | 8684 | 35 | 31 | 87 | 115 |
| *Urban Background:* | | | | | |
| Copenhagen / 1259 | 7526 | 22 | 20 | 56 | 73 |
| Århus / 6159 | 3556 | - | - | - | - |
| Odense / 9159 | 8116 | 18 | 15 | 48 | 68 |
| Aalborg / 8159 | 8536 | 16 | 13 | 52 | 88 |
| *Rural:* | | | | | |
| Lille Valby / 2090 | 8560 | 10 | 8 | 34 | 53 |
| Keldsnor / 9055 | 8668 | 8 | 6 | 28 | 44 |
| Limit values | >7884 | 40 | | | 200 |

The limit values are implemented through EU Council Directive (EC 1999).

## 3.2 Episodes

*Table 3-3* Episodic results for Nitrogen oxide (NO) 2001. All parameters are calculated with hourly averages.

| Unit: µg / m$^3$ | Max. 3 hours | Date:hour | Max. hour | Date:hour |
|---|---|---|---|---|
| *Traffic:* | | | | |
| Copenhagen / 1257 | 350 | 011116:16 | 448 | 010914: 6 |
| Århus / 6153 | 650 | 011127: 8 | 1046 | 011127: 9 |
| Odense / 9155 | 320 | 011211: 7 | 464 | 011211: 8 |
| Aalborg / 8151 | 414 | 011211:13 | 579 | 011211: 11 |
| *Urban Background:* | | | | |
| Copenhagen / 1259 | 136 | 011207:16 | 265 | 011129: 10 |
| Århus / 6159 | 375 | 011127: 8 | 569 | 011127: 9 |
| Odense / 9159 | 218 | 010112: 9 | 305 | 010112: 11 |
| Aalborg / 8159 | 334 | 011211:11 | 431 | 011211: 9 |
| *Rural:* | | | | |
| Lille Valby / 2090 | 120 | 011129: 9 | 168 | 011129: 11 |
| Keldsnor / 9055 | 26 | 011014: 9 | 29 | 011014: 11 |

*Table 3-4* Episodic results for Nitrogen dioxide ($NO_2$) 2001. All parameters are calculated with hourly averages.

| Unit: µg / m$^3$ | Max. 3 hours | Date:hour | Max. hour | Date:hour |
|---|---|---|---|---|
| *Traffic:* | | | | |
| Copenhagen / 1257 | 104 | 010509: 8 | 141 | 010322: 10 |
| Århus / 6153 | 126 | 011127: 8 | 224 | 011127: 9 |
| Odense / 9155 | 104 | 010510: 6 | 121 | 010510: 8 |
| Aalborg / 8151 | 119 | 010327: 6 | 165 | 010510: 16 |
| *Urban Background:* | | | | |
| Copenhagen / 1259 | 85 | 011129: 9 | 113 | 011129: 10 |
| Århus / 6159 | 98 | 011127: 8 | 144 | 011127: 9 |
| Odense / 9159 | 77 | 010303:23 | 84 | 010304: 1 |
| Aalborg / 8159 | 103 | 010110: 8 | 143 | 010320: 6 |
| *Rural:* | | | | |
| Lille Valby / 2090 | 62 | 010321:22 | 71 | 010322: 0 |
| Keldsnor / 9055 | 48 | 011127:18 | 65 | 011127: 19 |
| Alert threshold | 400 | - | - | - |

The Alert threshold is given in EU Council Directive (EC, 1999). 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".

## 3.3 Trends

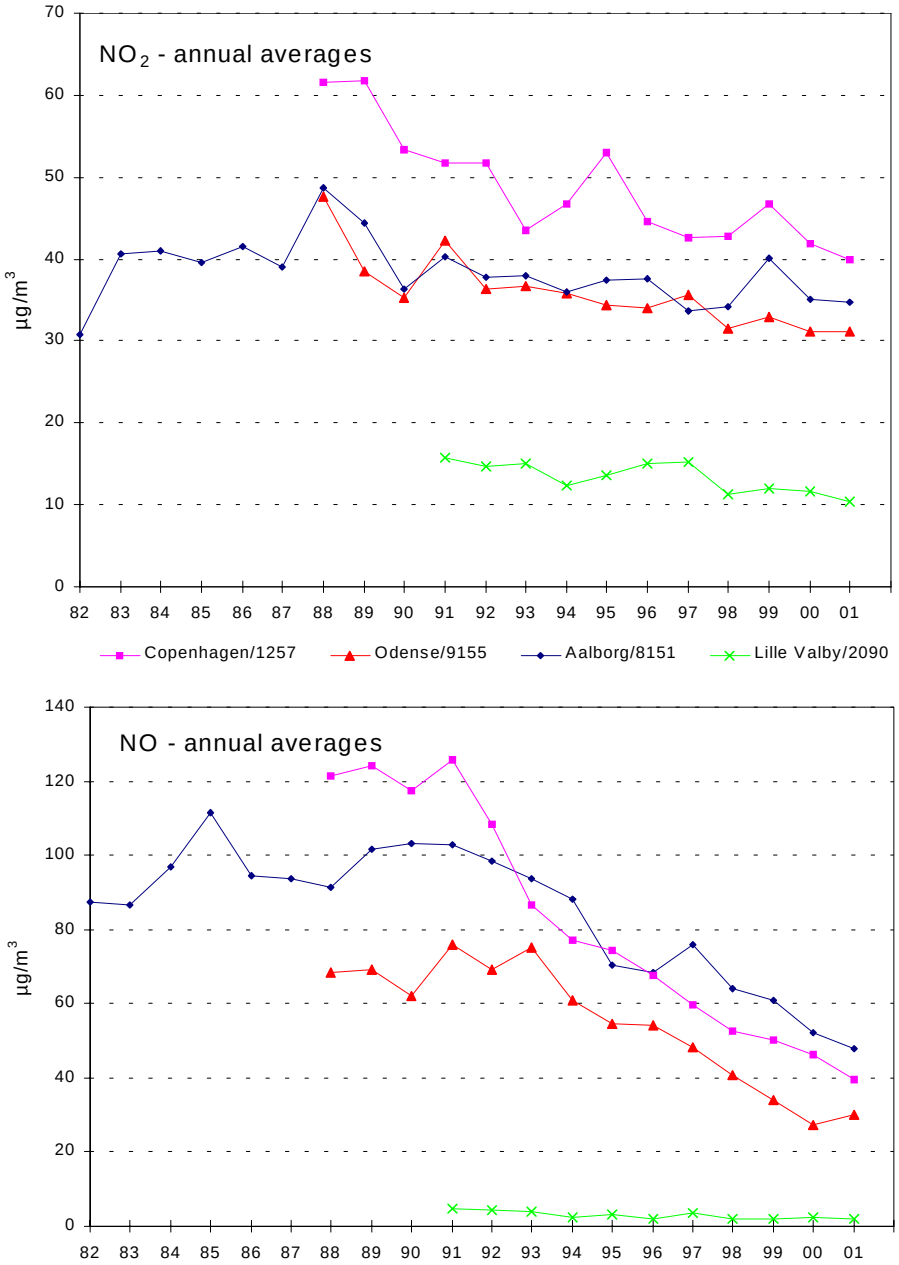


*Figure 3-1* The graphs show the time series for the annual average values.

# 4 Ozone

## 4.1 Annual statistics

*Table 4-1* Ozone ($O_3$) 2001. 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 | Av-erage | Median | Max. 8 hours | 26. highest 8 hour | Max. 1 hour | AOT40 µg/m$^3$.h |
|---|---|---|---|---|---|---|---|
| *Urban Background:* | | | | | | | |
| Copenhagen/1259 | - | - | - | - | - | - | - |
| Århus/6159 | 3559 | - | - | - | - | - | - |
| Odense/9159 | 8021 | 51 | 51 | 140 | 98 | 155 | 6775 |
| Aalborg/8159 | 8046 | 46 | 49 | 94 | 80 | 109 | 632 |
| *Rural* | | | | | | | |
| Lille Valby/2090 | 8590 | 49 | 51 | 131 | 88 | 169 | 2292 |
| Keldsnor/9055 | 8685 | 55 | 58 | 128 | 91 | 143 | 2254 |
| 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).
Number of information to the public due to exceedance of the information threshold (180 µg/m$^3$) in 2001: 0.
Number of information to the public due to exceedance of the alert threshold (240 µg/m$^3$) in 2001: 0.

## 4.2 Trends

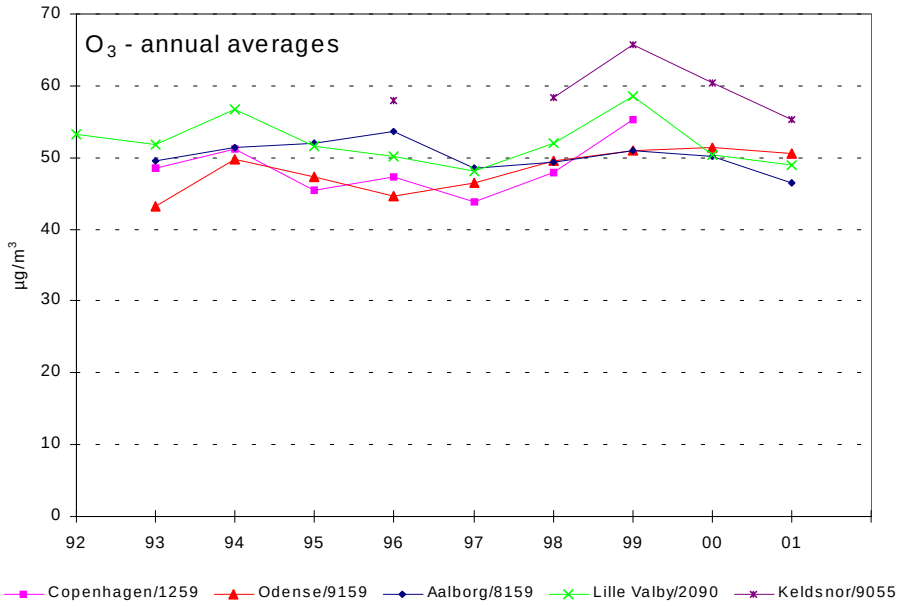


*Figure 4-1* Annual average values

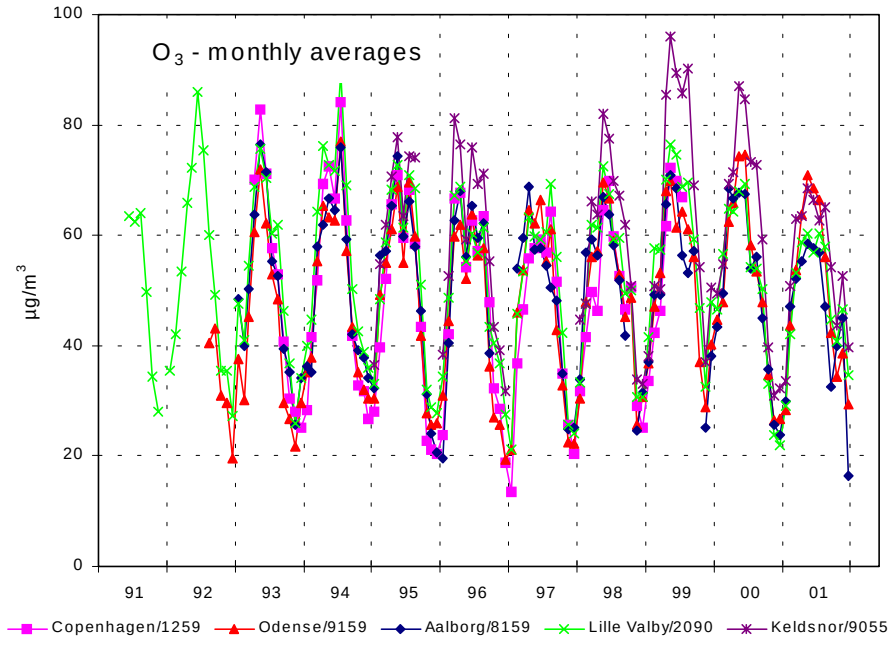


*Figure 4-2* Monthly average values

# 5 Carbon monoxide

## 5.1 Annual statistics

*Table 5-1* Annual statistics for carbon monoxide (CO) 2001. 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 | 8407 | 1018 | 853 | 2884 | 4954 | 3872 | 6929 |
| Århus / 6153 | 4517 | 557 | 420 | 1982 | 5341 | 4284 | 6515 |
| Odense / 9155 | 8610 | 700 | 485 | 2515 | 5905 | 5713 | 7520 |
| Aalborg / 8151 | 8682 | 915 | 701 | 2716 | 4532 | 4047 | 5518 |
| *Urban Background:* | | | | | | | |
| Copenhagen / 1259 | 8535 | 346 | 313 | 774 | 1596 | 1337 | 2811 |
| Limit value | - | - | - | - | - | 10 000 | - |
| Guideline values | - | - | - | - | - | 10 000 | 30 000 |

The limit value is implemented through EU Council Directive (EC, 2000). 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

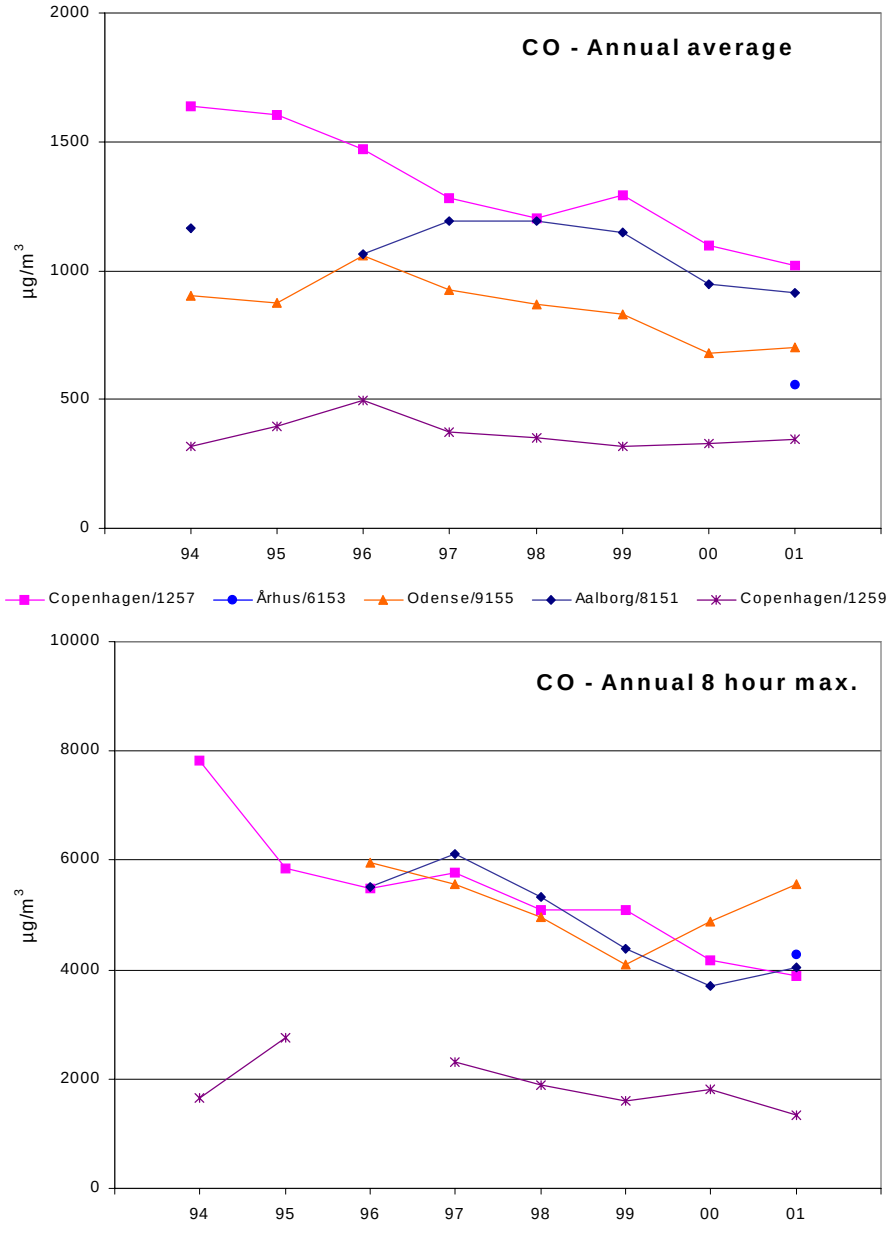


*Figure 5-1* Annual average values and highest 8-hour average.

# 6 Benzene and Toluene

## 6.1 Annual statistics

*Table 6-1* Annual statistics for Benzene 2001. All values are calculated as 1 hour averages. The 8 hours results are calculates 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.

| µg / m$^3$ | Number of results | Average | Max. 8 hours | Max. 1 hour |
|---|---|---|---|---|
| Copenhagen / 1257 | 6276 | 3.4 | 15 | 25 |
| Odense / 9155 | 5647 | 3.0 | 25 | 37 |
| Limit value | >7784 | 5 | - | - |
| Life time risk level at $1:10^5$ | | 1.7 | | |

*Table 6-2* Annual statistics for Toluene 2001. The 7 days results are calculates as a moving average based on daily averages.

| µg / m$^3$ | Number of results | Average | Max. 7 days | Max. 1 hour |
|---|---|---|---|---|
| Copenhagen / 1257 | 6276 | 15.4 | 22 | 131 |
| Odense / 9155 | 5647 | 12.2 | 28 | 190 |
| Guideline value | - | - | 260 | - |

The limit value is implemented through EU Council Directive (EC, 2000).
The guideline and lifetime risk level are established by WHO (WHO, 2000).

# 7 Particles (TSP, $PM_{10}$)

## 7.1 Annual statistics

*Table 7-1* Annual statistics for $PM_{10}$ 2001. 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 per-centile | 95 per-centile | 8.highest result | Max. day |
|---|---|---|---|---|---|---|---|
| *Traffic* | | | | | | | |
| Copenhagen / 1257 | 262 | 34 | 48 | 54 | 62 | 67 | 216 |
| Århus / 6153 | 140 | 32 | - | - | - | - | - |
| Odense / 9155 | 260 | 31 | 45 | 50 | 58 | 64 | 84 |
| Aalborg / 8151 | 292 | 29 | 45 | 48 | 56 | 60 | 84 |
| *Urban background* | | | | | | | |
| Aalborg / 8159 | 170 | 24 | - | - | - | - | - |
| *Rural* | | | | | | | |
| Lille Valby / 2090 | 316 | 21 | 34 | 35 | 44 | 50 | 74 |
| Keldsnor / 9055 | 76 | - | - | - | - | - | - |
| Limit values | >329 | 40(20) | 50 | - | - | (50) | - |

The limit values are implemented through EU Council Directive (EC, 1999).

There are in all cases too few measurements to a valid comparison with the limit values, due to technical problems in the start-up phase. The 90-percentile will in these cases 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. The TSP is around 30 % higher than $PM_{10}$ at the street stations, and the difference is less at rural sites.

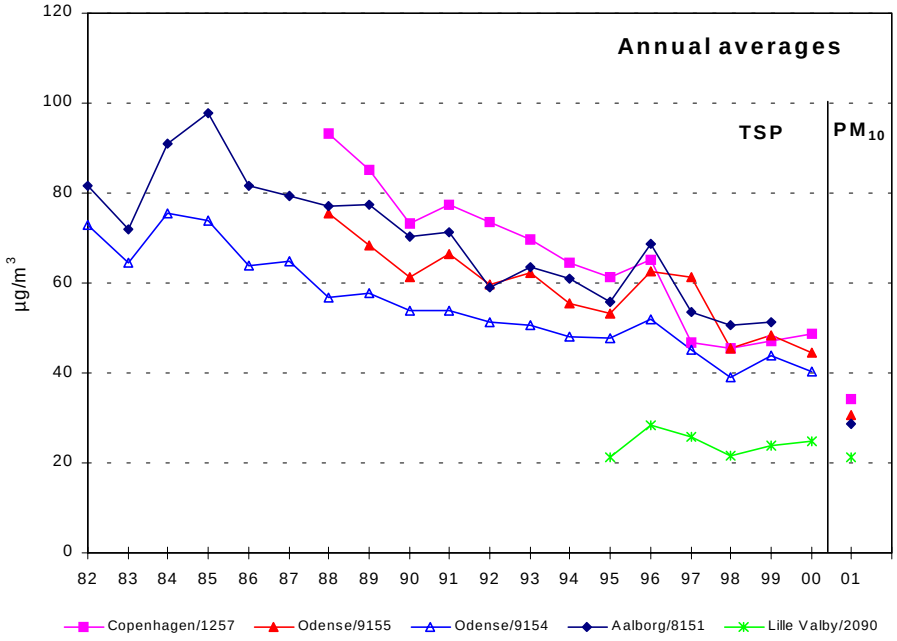


*Figure 7-1* Annual averages for measurements of particulate matter

# 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 2001. 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.

| Unit: ng/m$^3$ | V | Cr | Mn | Ni | Cu | Zn | As | Se | Cd | Pb |
|---|---|---|---|---|---|---|---|---|---|---|
| *Traffic* | | | | | | | | | | |
| Copenhagen / 1257 | 7.1 | 6.1 | 12.2 | 4.3 | 62.2 | 44.8 | 0.8 | 0.5 | < 2.0 | 23.4 |
| Århus / 6153 | - | - | - | - | - | - | - | - | - | - |
| Odense / 9155 | 4.3 | 4.0 | 14.7 | 2.8 | 30.8 | 47.1 | 0.8 | 0.5 | < 2.0 | 11.2 |
| Aalborg / 8151 | 3.9 | 4.2 | 9.7 | 8.6 | 36.2 | 39.8 | 0.7 | 0.5 | < 2.0 | 12.5 |
| *Urban background* | | | | | | | | | | |
| Aalborg / 8159 | - | - | - | - | - | - | - | - | - | - |
| *Rural* | | | | | | | | | | |
| Lille Valby / 2090 | 3.7 | < 2.2 | 2.8 | 2.3 | 4.1 | 17.0 | 0.9 | 0.5 | < 2.0 | 7.2 |
| Keldsnor / 9055 | - | - | - | - | - | - | - | - | - | - |
| Limit values | | | | *) | | | *) | | *) | 500 |
| Guideline value | 1000 | | 150 | | | | | | 5 | |
| Life time risk level at $1:10^5$ | | | | 25 | | | 6.6 | | | |

*) Limit 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 limit values for 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

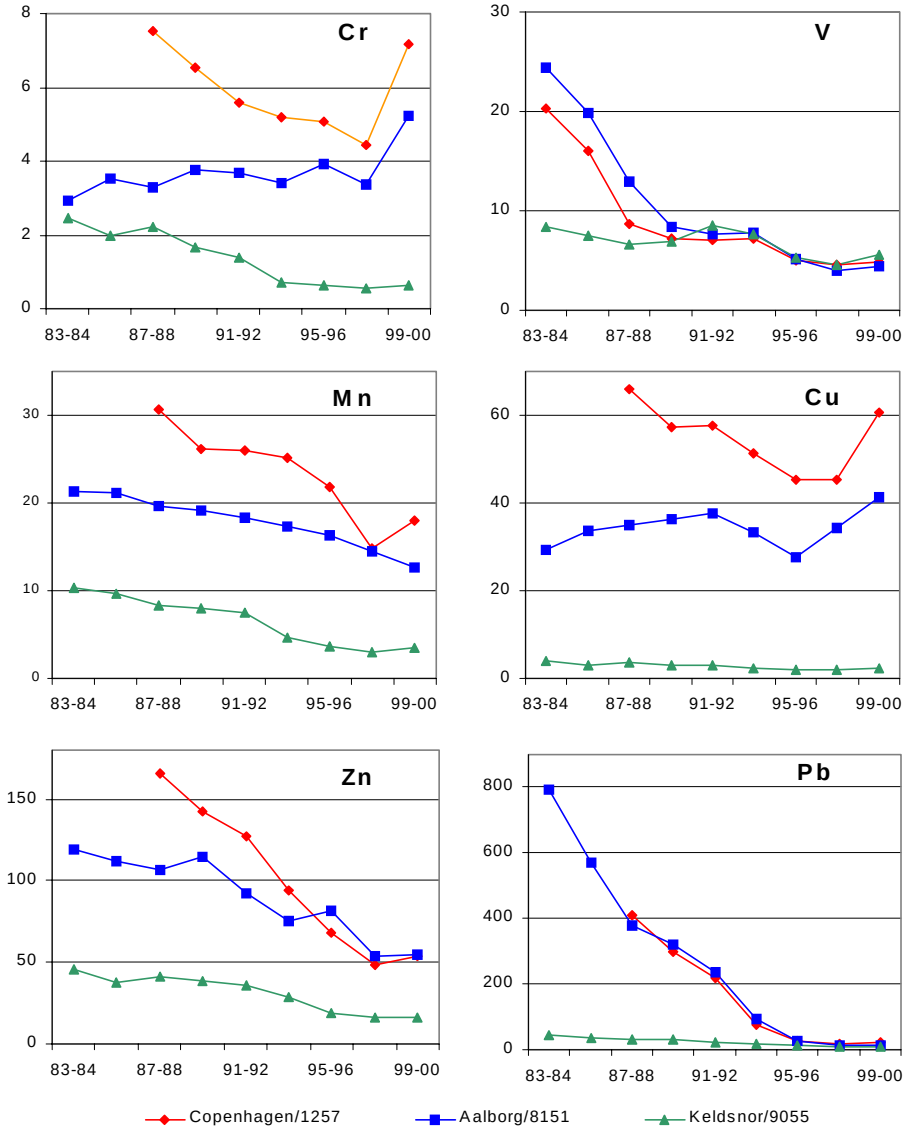


*Figure 8-1* Biannual averages for Heavy Metals in particulate matter measured as TSP. y-axis units are ng / $m^3$

# 9 Sulphur Compounds

## 9.1 Annual statistics

*Table 9-1* Annual statistics for $SO_2$ 2001. 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* | | | | | | | |
| Aalborg / 8151 | 7969 | 3.1 | 3.9 | 2.0 | 13 | 53 | 8 |
| Limit values | >7884 | 20 | 20 | | | 350 | 25 |

The limit values are implemented through EU Council Directive (EC, 1999).

*Table 9-2* Annual averages for particulate sulphur (S) measured in $PM_{10}$ 2001. Measurements are daily averages.

| Unit: µg(S) / m$^3$ | Number of results | Average |
|---|---|---|
| *Traffic* | | |
| Copenhagen / 1257 | 269 | 1.13 |
| Århus / 6153 | 149 | - |
| Odense / 9155 | 276 | 0.86 |
| Aalborg / 8151 | 315 | 0.89 |
| *Urban background* | | |
| Aalborg / 8159 | 278 | 0.65 |
| *Rural* | | |
| Lille Valby / 2090 | 334 | 0.85 |
| Keldsnor / 9055 | 77 | - |

## 9.2 Trends

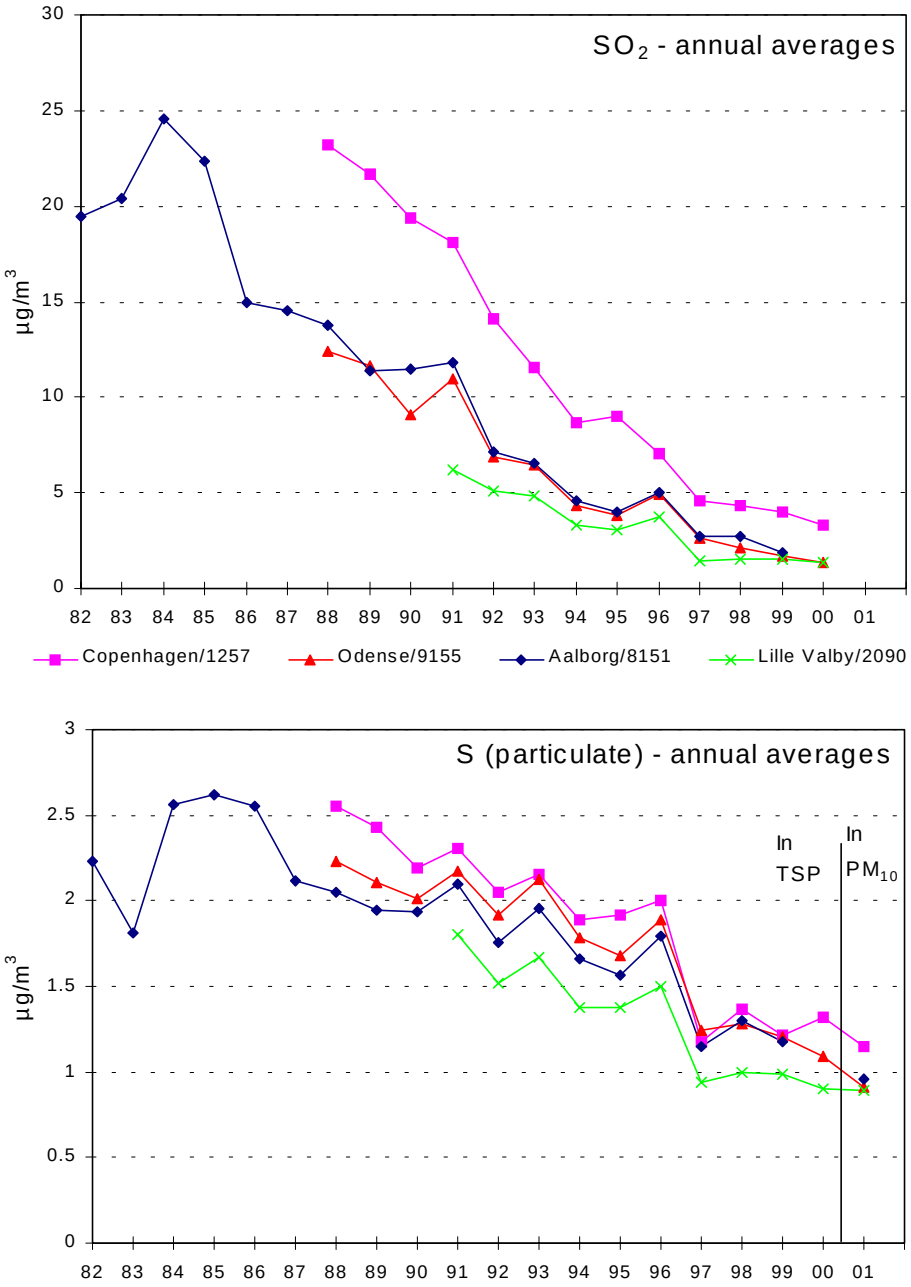


*Figure 9-1* Annual averages for $SO_2$ and particulate sulphur. The results for 2000 and earlier are determined in TSP, and the 2001 results are for $PM_{10}$.

# References

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

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# 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 the atmosphere 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 windblown dust and combustion. $PM_{10}$ 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 distributions. 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 wood. In the atmosphere the $SO_2$ is oxidised to particulate sulphuric acid and sulphate. The conversion time depends strongly of the temperature and humidity in the air, but 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 2001 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 will be fully implemented 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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