EEA Core Set of Indicators - CSI 004

Exceedance of air quality limit values in urban areas

May 2005 assessment

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European Environment Agency

Key policy question: What progress is being made towards to the limit values for SO2, NO2 and PM10 and the target values for ozone as defined in the air quality Framework Directive and its Daughter Directives ?

Key message:

- Particulate Matter (PM_{10})

In the period 1997-2002,25-55% of the urban population is potentially exposed to ambient air concentrations of fine particulate matter (PM_{10}) in excess of the EU limit value set for the protection of human health (50 microgramme/m^3daily mean not be exceeded more than 35 days a calendar year).

- Nitrogen dioxide (NO_2)

In the period 1996-2002, 25-50% of the urban population was potentially exposed to ambient air nitrogen dioxide (NO_2) concentrations above the EU limit value set for the protection of human health (40 microgramme NO_2/m^3annual mean).

No exceedances of the short-term limit value (200 microgramme NO2/m^3as an hourly value, not to be exceeded more than 18 times a calendar year) have been observed.

- Ozone (O_3)

In the period 1996-2002,20-30% of the urban population in Europe is exposed to ambient ozone concentrations exceeding the EU target value set for protection of human health (120 microgramme O_3/m^3daily maximum 8-hourly average, not to be exceeded more than 25 times a calendar year).

- Sulphur dioxide (SO_2)

The fraction of the urban population in EEA-31 that is potentially exposed to ambient air concentrations of sulphur dioxide in excess of the EU limit value set for the protection of human health (125 microgrammeSO_2/m^3daily mean not to be exceeded more than three days a year), has decreased to less than 1%, and as such close to meeting the EU limit value set.

❍ Particulate Matter (PM10)

PM10 in the atmosphere can result from direct emissions (primary PM10) or emissions of particulate precursors (nitrogen oxides, sulphur dioxide, ammonia and organic compounds) which are partly transformed into particles by chemical reactions in the atmosphere (secondary PM10).

Monitoring of PM10 has only started recently and available data before 1997 is not representative for Europe. For the period 1997-2002, the number of monitoring stations is still relatively small and it may not be representative for all parts of Europe (Buijsman et al., 2004). Notwithstanding these limitations, it is clear that a significant proportion of the urban population (25-55%) is exposed to concentrations of particulate matter in excess of the EU limit values set for the protection of human health (Figure 03).

The observed time series are too short and the natural meteorological variability is too large to draw any firm conclusion on a possible trend in the data. Preliminary analyses indicate a downward change in the highest daily mean PM10 values although for the majority of stations the observed change is statistically not significant. In Figure 11 the 36th highest daily mean is shown; compliance with the short-term limit value is assured when this value is below 50 microgramme/m3.

Emissions of the gaseous precursors for secondary PM10 are being reduced by enforcement of EU legislation and UN-ECE CLRTAP protocols. Abatement techniques to reduce precursor emissions often also reduces the primary particulate emissions. Other measures (e.g. traffic measures from Auto-Oil-I and II, waste incineration directives) should further reduce PM10 emissions.

Despite the likely future reductions in emissions, concentrations of PM10 in most of the urban areas in the EEA are expected to remain well above the short-term limit values in the near future.

❍ Nitrogen dioxide (NO2)

The main source of nitrogen oxides emission to the air is the use of fuels; road transport, power plants and industrial boilers accounts for more than 95% of the European emissions.

About 30% of the urban population lives in cities with urban background concentrations in excess of the 40 microgramme NO2/m3 limit value (Figure 02). However, it is expected that also in cities where the urban background concentration is below the limit value limit values are exceeded at hot spots in particular in locations with high density of traffic.

Enforcement of current EU legislation (Large Combustion Plant and IPPC Directive, Auto-Oil programme, the NEC directive) and CLRTAP protocols have resulted in a reduction of nitrogen oxides (NOx) emissions. Until now this reduction is not reflected in the annual means observed at the urban background stations. In Figure 10 it is shown that a large fraction of the sitesis in exceedance.

Peak nitrogen dioxide levels occur often in busy streets in cities where road traffic is the main source. Since the introduction of catalysts at the end of the 1980s, their growing penetration in the car fleet and other measures have contributed to reducing emissions (-25% since 1980 in the EU15). The result has been a downward trend in the number of exceedances of the short-term limit value. Peak levels depend on meteorological conditions; year-to-year fluctuations are 10 to 20 % or more even if emissions are constant.

In total 24 countries (22 EEA member countries and 2 collaborating non-member countries) have submitted information on nitrogen dioxide concentrations in urban areas to the air quality database AirBase, however, the majority of information on nitrogen dioxide concentrations is limited to the EU15 countries. The limit value tends to be less widely exceeded in the Central and Eastern European countries.

❍ Ozone (O3)

Although reductions in emissions of ozone precursors appear to have led to lower peak concentrations of ozone in the troposphere, the current target level is frequently exceeded for a substantial part of the urban population of the EEA31. Figure 04 shows estimates for 2001 indicating that 9% of the urban population experiences no exceedance of the 120 microgramme O3/m3 level; about 30% of the urban population was exposed to concentrations above the 120 microgramme O3/m3 level during more than 25 days. The target level is exceeded over a wide area and by a large margin.

Several studies have shown that the ozone peak values (given as 98-percentiles) tend to decrease over the past 5-10 years. However, data available from AirBase for a consistent set of stations over the period 1996-2001 shows hardly any variation for the 26th highest maximum daily 8-hour mean. Figure 12 shows this 26th highest value; if it drops below 120 microgramme O3/m3, there is compliance with the target value. The annual mean ozone concentrations tend to increase slightly which is in agreement with previous studies. The ozone effects induced by short term exposure to high concentrations might therefore be reduced. However, there is some evidence for chronic damage to the human lung from prolonged ozone exposure. With increasing annual levels, these potential effects will increase as well.

The reductions in ozone precursor emissions that should result from enforcement of the NECD and the CLRTAP Protocols are unlikely to reduce ozone concentrations to below the current target value and long-term objective over the whole of the EEA area. In north-west Europe about 25 exceedance days of the 120 microgramme O3/m3 limit are still expected in 2010.

❍ Sulpher dioxide (SO2)

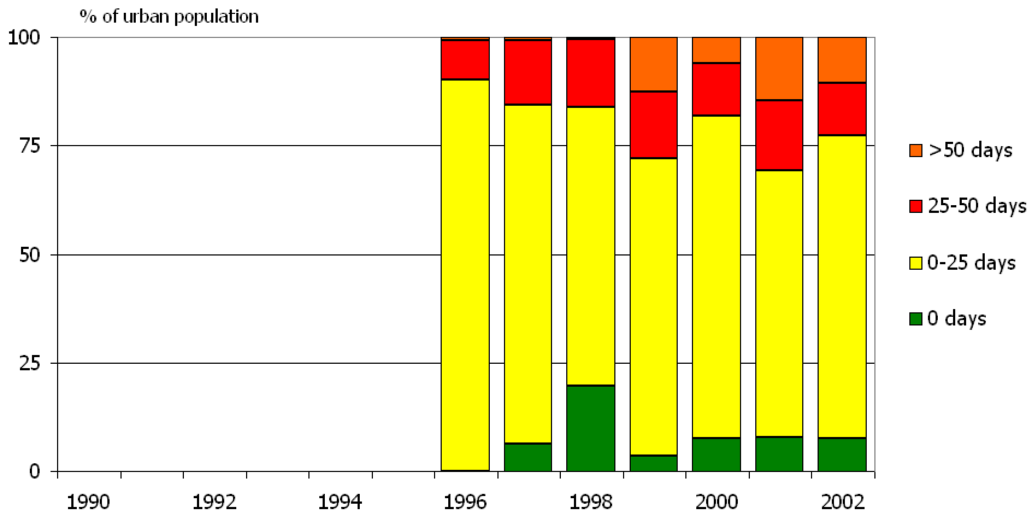
Sulphur in coal, oil and mineral ores is the main sources of sulphur dioxide to the atmosphere. Up to 1960s, coal and oil combustion in large and small sources was the typical situation in many European cities, resulting in very high sulphur dioxide and PM concentrations. Since then, the combustion of sulphur-containing fuels have largely been removed from urban and other populated areas, first in western Europe and now also increasingly in most central and eastern European countries. Large point sources (power plants and industries), remain the predominate source of sulphur emissions. These sources usually with high stacks are most often away from population centres.

As a result of the important reductions of sulphur dioxide achieved in the last decade, the fraction of the urban population exposed to concentrations above the EU limit value is reduced to less than 1% (Figure 01). The reduction in sulphur dioxide peak concentrations is more clearly seen in the trend of the 4th highest daily sulphur dioxide concentration on each urban station in the period 1996-2002 (figure 09). Compliance with the limit value for the daily mean is assured when the 4th highest concentration is below 125 microgramme SO2/m3. A further decline in concentrations is expected for the coming years. However, peak concentrations above EU limit values still occur, especially close to sources and in cities. Peak levels strongly depend on meteorological conditions; year-to-year fluctuations are 10-20 % or more even for constant emissions.

Several factors have contributed to the decrease of sulphur dioxide concentrations. The first (1985) and the second (1994) sulphur protocol under the UN-ECE Convention on LRTAP, together with EC limit values set in the previous Air Quality Directive (89/427/EEC amending 80/779/EEC) have resulted in major European emission reductions and correspondingly decreasing ambient concentrations. Political changes in the beginning of 90's in the central and eastern European countries connected with economic restructuring, decline from heavy industry and even adoption of abetment measures on large point sources has contributed to decreasing winter smog episodes in central and western European countries. Measures such as the Large Combustion Plants Directive, the IPPC Directive, Directives regulating emissions from transport, the National Emission Ceilings Directive, and the reductions agreed under CLRTAP are expected to further reduce sulphur dioxide levels. Programs for the reduction of sulphur emission from ships are also underway.

For 24 of the EEA-31 countries and three other non-EEA countries information on sulphur dioxide concentrations in urban areas is available in the air quality database AirBase (Buijsman et al., 2004). However, the majority of the information on sulphur dioxide concentrations results from station in EU15 countries. The limit values tend to be more widely exceeded in the Central and Eastern European countries.

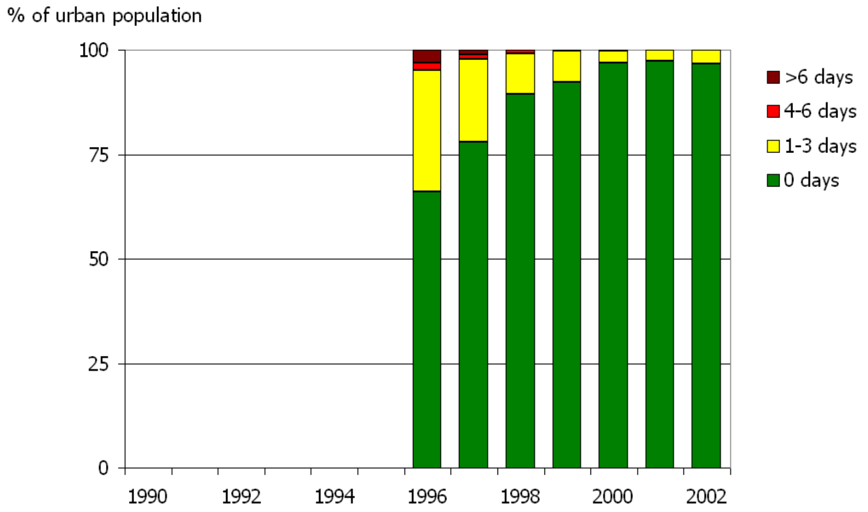
Fig. 1: Exceedance of air quality target values for O3 in urban areas



Data source: Airbase (ETC/ACC)

Note: Over the years 1996 - 2002 the total population for which exposure estimates are made, increases from 50 to 110 million people due to an increasing number of monitoring station reporting under the Exchange of Information Decision. Data prior to 1996 with a coverage of less than 50 million people are not representative for the European situation. Year-to-year variations in exposure classes are partly caused by the changes in spatial coverage.

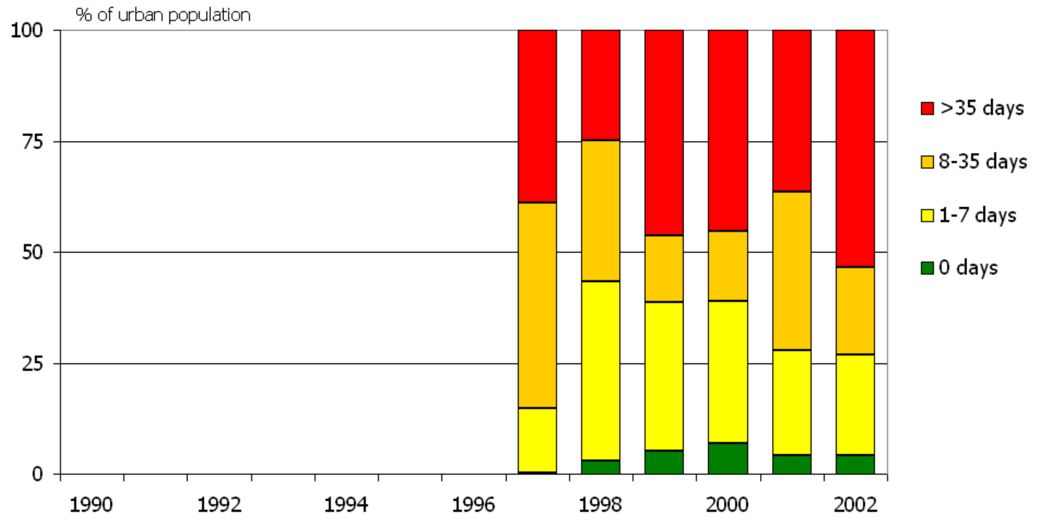
Fig. 2: Exceedance of air quality limit values of SO2 in urban areas



Data source: Airbase (ETC/ACC)

Note: 1: The limit value is 125 microgrammeg SO_2/m^3 as a daily mean, not to be exceeded more than three days in a year.
2: Over the years 1990 - 2002, the total population for which exposure estimates are made, increases from 67 to 136 million people due to an increasing number of monitoring station reporting air quality data. Year-to-year variations in exposure classes are partly caused by the changes in spatial coverage.The number of available data series varies considerably from year to year and is for the first part of the 90s insufficient. Availability of data before 1990 is too low to include in the indicator; data for non-EU countries is largely missing before 1995.

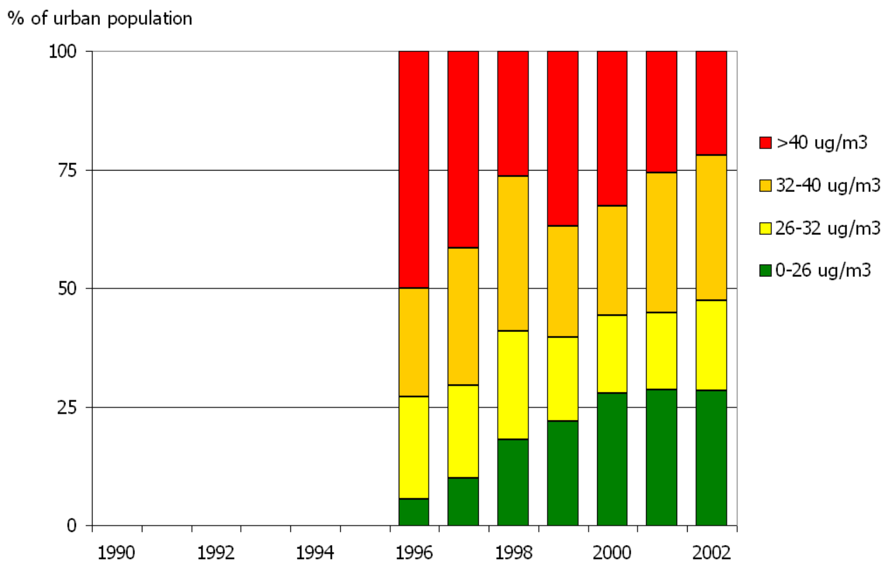
Fig. 3: Exceedance of air quality limit value of PM10 in urban areas



Data source: Airbase (ETC/ACC)

Note: For years before 1997 representative monitoring data is not available. Over the years 1997-2002 the total population for which exposure estimates are made, increases from 34 to 106 million people due to an increasing number of monitoring station reporting air quality data. Year-to-year variations in exposure classes are partly caused by the changes in spatial coverage.

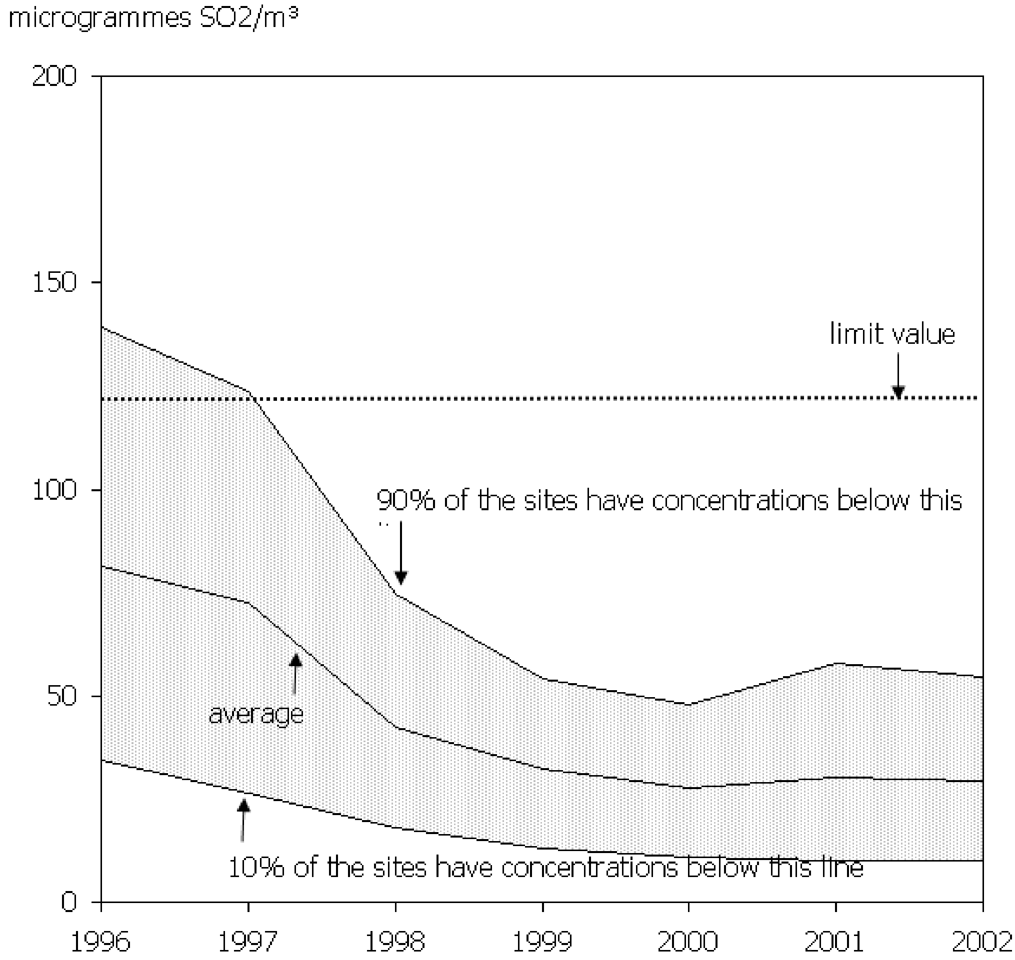
Fig. 4: Exceedance of air quality limit values of NO2 in urban areas



Data source: Airbase (ETC/ACC)

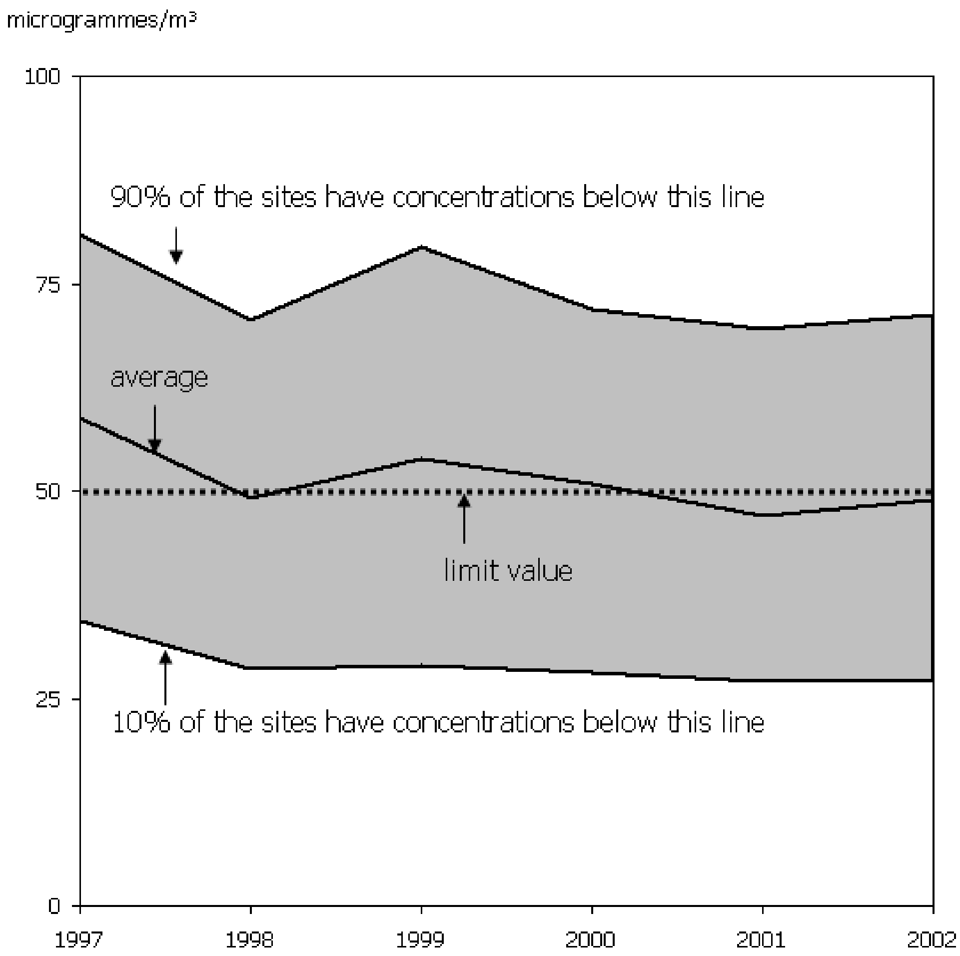
Note: Over the years 1996 -2002 the total population, for which exposure estimates are made, increases from 56 to 111 million people due to an increasing number of monitoring station reporting air quality data. Data prior to 1996 with coverage of less than 50 million people are not representative for the European situation. Year-to-year variations in exposure classes are partly caused by the changes in spatial coverage. Only urban background stations have been included in the calculations.

Fig. 5: Peak sulphur dioxide concentration (4th highest daily 24h-mean) observed at urban stations



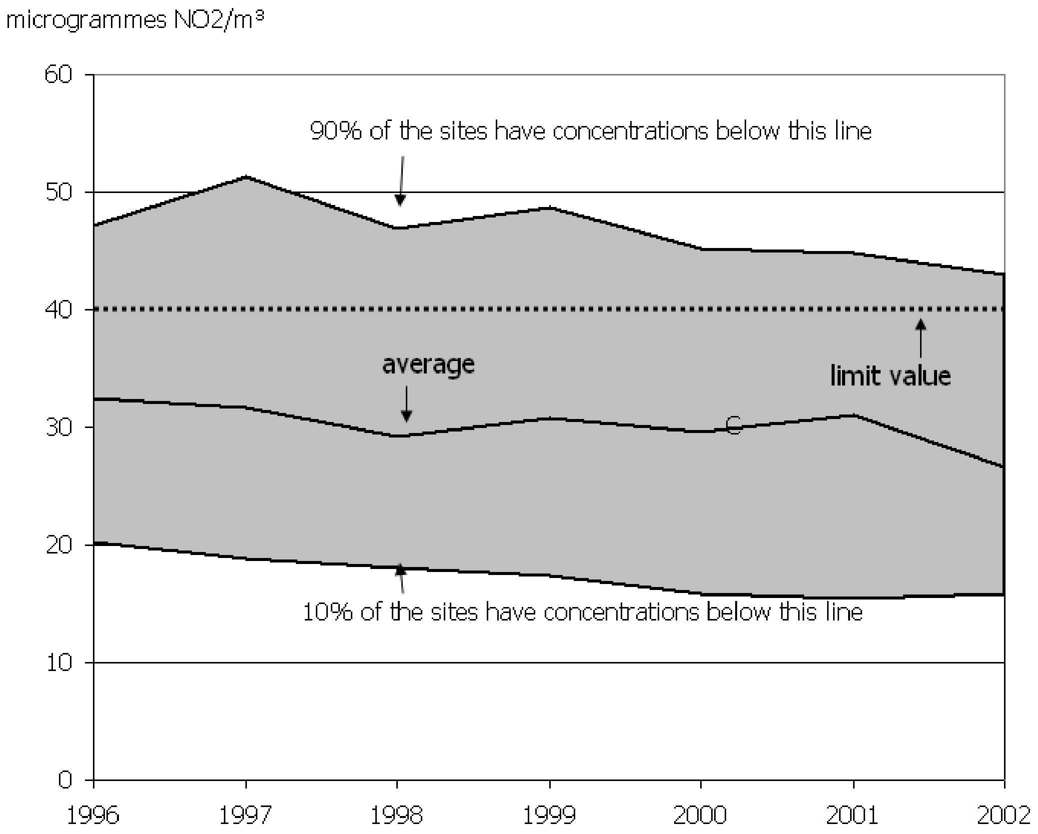
Data source: Airbase (ETC/ACC)

Fig. 6: Highest daily PM10 concentration (36th highest daily 24h-mean) observed at urban stations



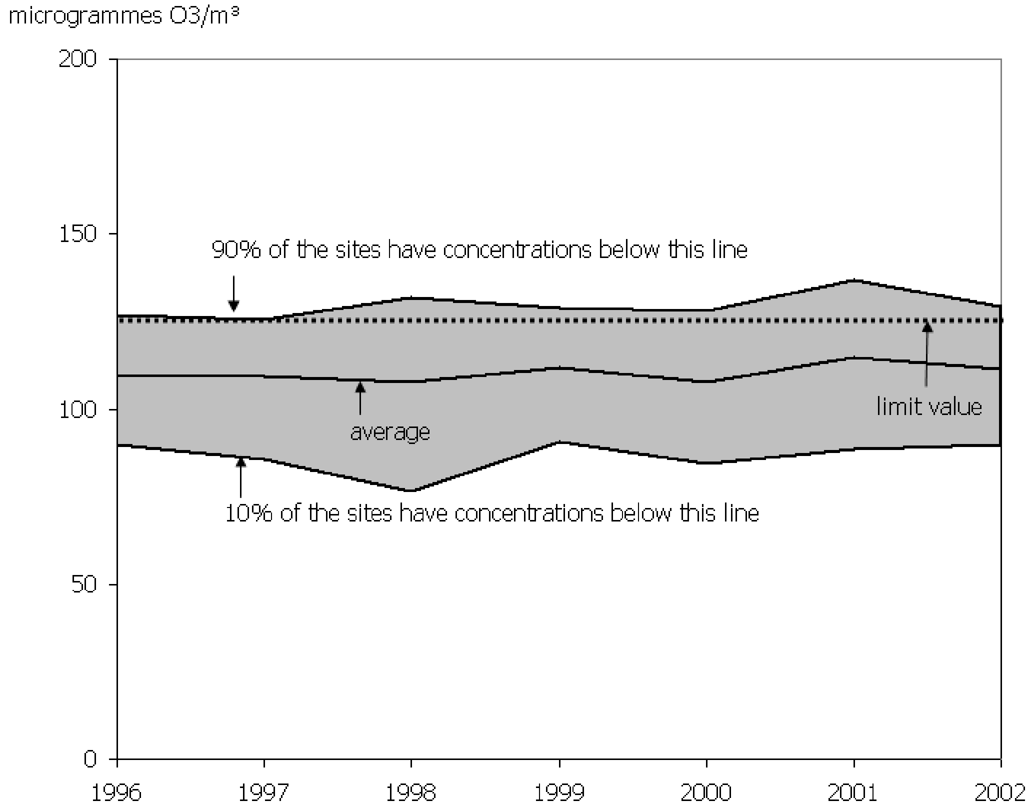
Data source: Airbase (ETC/ACC)

Fig. 7: Annual mean nitrogen dioxide concentration observed at urban background stations



Data source: Airbase (ETC/ACC)

Fig. 8: Peak ozone concentration (26th highest maximum daily 8h-mean) observed at urban background stations



Data source: Airbase (ETC/ACC)