Air pollution by benzene, carbon monoxide, PAHs, and heavy metals

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Cover page: *The quality of petrol and diesel fuel used for road transport has been greatly improved over the years. Together with the introduction of the EURO emission standards for road traffic these measures resulted in decreasing concentrations for most of the pollutants discussed in this report.*

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Summary

This report provides an assessment of the current environmental status with respect to a number of pollutants dealt with by air quality legislation of the European Union, namely, arsenic, cadmium, lead, nickel, carbon monoxide, benzene and benzo(a)pyrene.
The available air quality information (both emission data as well as ambient concentration) for heavy metals and benzo(a)pyrene for the EU27 is too scattered of too low quality to allow estimates of population exposure to be made. Coverage of carbon monoxide nd benzene data is better but requires further work to move to population exposure estimates.
The available information shows that concentrations of the heavy metals are in excess of the target or limit values at a limited number of location s(less than 4%); At the majority of the locations concentrations are below the lower assessment threshold. Exceedances of the limit values of carbon monoxide and benzene are observed at a limited number of locations. About 5 million people lives in urban zones exceeding the limit value of carbon monoxide, for benzene a corresponding number of 15 million is found.
Most concern is on exceedances of the target value of benzo(a)pyrene: this level is exceeded at about one third of the monitoring points, both urban and rural background. There is some concentration of impact around central Europe, e.g. 45% of Czech population subject to concentrations above the target value, although zones as far apart as the UK and Greece are also affected.

Table of contents

1. Introduction

The purpose of this technical paper is to provide an assessment of the current environmental status with respect to the heavy metals dealt with by European air quality legislation, together with carbon monoxide, benzene, and polycyclic aromatic hydrocarbons (PAHs). The assessment is to provide an evaluation of current air concentrations of these pollutants, to evaluate the quality and quantity of the data available to support implementation of legislation (particularly the 2nd (2000/69/EC) and 4th (2004/107/EC) daughter directives, and to begin exploration of potential health consequences.

This paper is a follow up to the 2007 overview of the preliminary assessments of air quality in respect of pollutants dealt with by the 4th daughter directive, specifically arsenic, cadmium, nickel, and PAHs. The preliminary assessments reviewed in 2007 were the first evaluation by Member States of air quality in respect of the named pollutants. Now in 2008 we are one year from the requirement for formal reporting of these pollutants (2008 status to be reported in September 2009). On a voluntary basis 14 Member States have already provided information over 2007 with respect to the pollutants of the 4th DD (de Leeuw and Vixseboxse, 2008). An intention of this report is that it assists Member States to better attain air quality management, reporting and assessment requirements at that time.

2. Legislative requirements

'Limit Values' (LV's) and 'Target Values' (TV's) have been established by the daughter directives for air concentrations of each pollutant, intended as maximum values for protection of health and the environment. Below these, Upper Assessment Threshold (UAT) and Lower Assessment Threshold (LAT) values have been set. Exceedances of UAT and LAT determine the assessment requirements for regulated pollutants. Measurement of air quality is to be a mandatory part of assessment systems in zones and agglomerations exceeding UAT. In zones and agglomerations with concentration levels of controlled pollutants below UAT and above or equal to LAT a combination of measurements and modelling techniques may be used to assess ambient air quality. When concentration levels are below LAT, monitoring is not longer mandatory and other objective estimating techniques (e.g. modelling, indicative measurements) may be used for assessments. Originally set out in the daughter Directives which followed from the Air Quality Framework Directive 96/62/EC, and now assimilated in the recent comprehensive Directive 2008/50/EC on ambient air quality and cleaner air for Europe (so-called 'CAFÉ Directive; the 4th Daughter Directive is still to be incorporated), Table 1 gives the limit, target and threshold values established. The first year Member States must report on the air quality assessment of the pollutants dealt with in the 4th DD is 2008 (reporting date 30 September 2009). Networks monitoring these pollutants have been operational for a number of years.

Table 1 Target and Threshold Values originally introduced by Daughter Directives 1999/30/EC, 2000/69/EC, and 2004/107/EC

	As ng/m^3	Cd ng/m^3	Pb mg/m^3	Ni ng/m^3	Benzene mg/m^3	B(a)P ng/m^3	CO mg/m^3
Limit Value (LV)			0.5		5		10
Target Value (TV)	6.0	5.0		20		1	
Upper Assessment Threshold (UAT)	3.6	3.0	0.35	14	3.5	0.6	7
Lower Assessment Threshold (LAT)	2.4	2.0	0.25	10	2	0.4	5
Year LV or TV to be met	2012	2012	2005	2012	2010	2012	2005

All as mean calendar year, except CO which is maximum daily 8-hr mean

'**Limit value**' (LV) shall mean a level fixed on the basis of scientific knowledge, with the aim of avoiding, preventing or reducing harmful effects on human health and/or the environment as a whole, to be attained within a given period and not to be exceeded once attained.

'**Target value**' (TV) shall mean a level fixed with the aim of avoiding, preventing or reducing harmful effects on human health and/or the environment as a whole, to be attained where possible over a given period.

3. Assessment of air quality status for heavy metals, CO, benzene & PAH

This section gives a review of air quality, of emission status and changes, and of data quality for each of the pollutants in turn.

3.1. Arsenic

i. Introduction and standards

For most people, food or drinking water is the major source of exposure. Exposure to inorganic arsenic can cause various health effects such as irritation of the stomach, decreased production of red and white blood cells, irritation of the skin and lung.

ii. Air quality and comparison with standards

The reported 2006 concentration data suggests that attainment of the target value (annual mean of 6 ng/m^3) might be a limited problem: at 2 of the 198 stations reporting to AirBase an exceedance has been observed (see Figure 1). These stations are located in the Czech Republic and the Slovak Republic. A third station located in Bulgaria reports also an exceedance but this station did not fulfil the data coverage criterion of 14%[1]. The voluntary 2007 reporting shows (de Leeuw and Vixseboxse, 2008) that in six (out of 178) air quality management zones in 4 (out of 13 reporting) Member States, exceedances of the arsenic target value is reported; the highest reported concentration is 8.5 ng/m^3 at an industrial station in Austria. Two exceedances in the Czech Republic have been based on model calculations. Local industry is indicated as a reason for the exceedances.

The emission projections for 2010 and 2020 indicate in these countries a larger reduction (up to 70%) than the approximately 40% averaged for the whole of Europe (Hettelingh and Sliggers, 2006). These emission reductions suggest that the compliance problems will largely be solved by 2020 under current legislation.

At the majority of the stations a concentration below the lower assessment threshold of 2.4 ng/m^3 as annual mean is observed. The data available in AirBase is not sufficient to show any long-term or recent trend in the concentrations

Review of air quality measurements undertaken by EMEP in recent years at background sites also suggests limited exceedance of the various criteria. AirBase data suggests a factor of two between (sub)urban background and rural background stations. Using a higher factor of 3 as a severe case to scale from the background observations by EMEP to possible urban concentrations indicates no exceedance in 2006, one exceedance of the target value in Spain in 2005, and two in Slovakia in 2003. The UAT may have been reached most years in Austria and Slovakia, with occasional exceedance up to 2003 in Germany, Netherlands and UK. The LAT may have been reached since 2005 also in Poland and Czech Republic, Belgium and Sweden.

Examination on the same basis (using an urban increment scaling factor of 3) of annual observations regularly reported to OSPAR (e.g. Barrett, 2008) for the North Sea coastlines indicates potential exceedance of the assessment thresholds in 6 of 7 years; three of the seven years since 2000 (LAT and UAT) on the eastern England coast, of the LAT for one different year in Belgium, and of the LAT in two further years on the German coastline. Focus is on either the Dover Straits or the German Bight.

[1] With exception of B(a)P concentrations are frequently below the lower assessment threshold which allows the use of other techniques to assess air quality. Following the data quality objectives set in the 4th DD only stations having a data coverage of at least 14% have been included in the assessments

Potential exceedance of the Target Value last occurred in 1995 (Denmark, German Bight). The issue is clearly not a major one, and appears geographically limited.

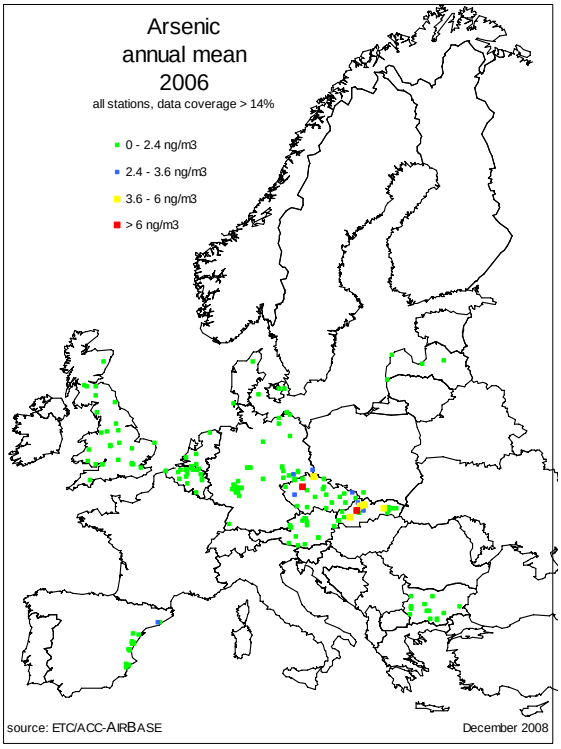

Figure 1 Annual mean value of arsenic, 2006. Concentrations of 2.4, 3.6 and 6 ng/m^3 corresponds to the lower assessment threshold, upper assessment threshold and target value, respectively. Source: AirBase.

iii. Emission changes and comparison with air quality

Arsenic emissions had halved between 1990 to 1995, then dropped another 10% by 1999 and emission levels have remain relatively stable since then (see Figure 2). Arsenic emissions are produced by fossil fuel combustion and waste incineration, with energy being the largest sector and unallocated the second largest until 2000 and by 2006 over 90% of emissions are identified to be from the energy sector.

The majority of European countries had very low levels of arsenic emissions or have reduced emissions substantially from 1990 to 2006. There are, however, a few exceptions: Spain's emissions have remained similar throughout the period between 16 to 21 tonnes/yr; and Italy's emissions, after an initial decreased by 1995 have increased from 37 tonnes/yr in 1990 to 42 tonnes/yr, which accounts for 20% of the EU27 annual emissions.

The main anthropogenic source of arsenic to the atmosphere is the burning of fossil fuels and waste incineration. Within the EU27 atmospheric emissions are expected to decrease with about 40% between 2000 and 2010 assuming current legislation. A further 10% decrease is estimated by 2020: making -50% compared to 2000 (Hettelingh et al., 2006).

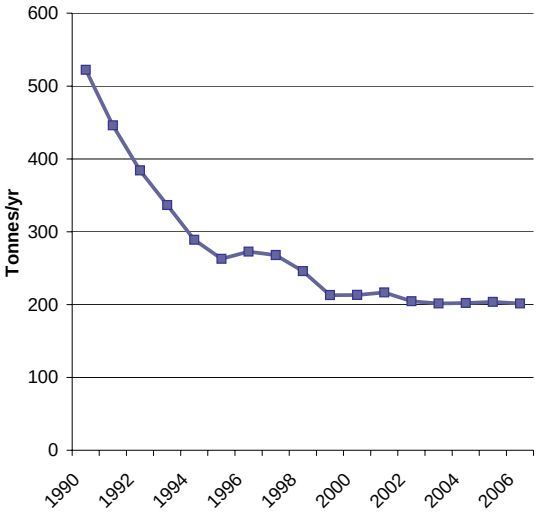

Figure 2 Arsenic emissions 1990-2006, EU27 (tonnes/yr). Source: Webdab

iv. Data availability and quality

A total of 198 stations have reported data to AirBase across central and north-west Europe. Thus, there are relatively few stations currently reporting. For substantial areas there are still no data reported to AirBase on airborne arsenic levels (see Figure 1).

Arsenic has to be determined in the PM_{10} fraction according to EN 12341. The reference method for its analysis is atomic absorption spectroscopy or ICP mass spectroscopy. A Member State may also use any other methods which it can demonstrate give results equivalent to the reference method.

Over 25% of stations explicitly state in the information submitted under the Exchange of Information (EoI) Decision returns for 2006 that PM_{10} is sampled. For the remainder the method is unknown. Some 13% of stations report use of X-ray fluorescence (XRF) for analysis of arsenic, although it is doubtful that the method has sufficient limits of detection for present-day ambient levels. Around 70% of stations use AAS or ICP-MS.

3.2. Cadmium

i. Introduction and standards

Environmental exposure to cadmium causes damages in particular in kidneys and bones. An increased risk of lung cancer has been reported following inhalation exposure at the working place. The International Agency for Research on Cancer (IARC) has classified cadmium and cadmium compounds as group 1 human carcinogens, having concluded that there was sufficient evidence that cadmium can produce lung cancers in humans and animals exposed by inhalation. However, because of the identified and controversial influence of concomitant exposure to arsenic in the epidemiological study, no reliable unit risk can be derived to estimate the excess lifetime risk for lung cancer.

The finding of renal effects in areas contaminated by past emissions of cadmium indicates that the cadmium body burden of the general population in some parts of Europe cannot be further increased without endangering renal function. In general, food is the main source of cadmium intake, for a non-smoker the uptake via inhalation is in the order of 10%.

In order to prevent any further increase of cadmium in agricultural soils likely to increase the dietary intake of future generations, an air quality guideline of 5 ng/m^3 is established (WHO Air quality guidelines 2000). The fourth Daughter directive sets a target value for cadmium of 5 ng/m^3 as annual mean to be met by 2012.

ii. Air quality and comparison with standards

At about 4% of the stations, all located in Bulgaria and Romania, the target value has been exceeded in 2006. At 90% of the stations the concentrations are below the lower assessment threshold (see Figure 3). The data available in AirBase is not sufficient to show any long-term or recent trend in the concentrations. The voluntary reporting under the FWD-questionnaire shows that in 2007 the target value of cadmium is exceeded in 4 of the 178 zones in two MS . In 47 zones (from the 53 reporting zones) concentrations are below the LAT. The exceedance in the Czech Republic is based on modelling while the exceedances in Bulgaria have been confirmed by measurements. The highest concentration measured is 17.4 ng/m^3 (more than three times the TV) at an urban background station. Traffic and local industry are the main reason for exceedance. Information on the 2007 situation in Romania has not been received.

Review of measurements undertaken by EMEP since the year 2000 at background sites also indicates limited exceedance of the various criteria. Using a high factor of 3 to scale from the background observations by EMEP to possible urban concentrations indicates the Target Value may have been reached only once since 2000, in Belgium in 2001 (such levels reached most years previously in central and north-west Europe). Similarly, the UAT does not appear to have been reached since 2002 in Belgium, and the LAT since 2000 in Austria.

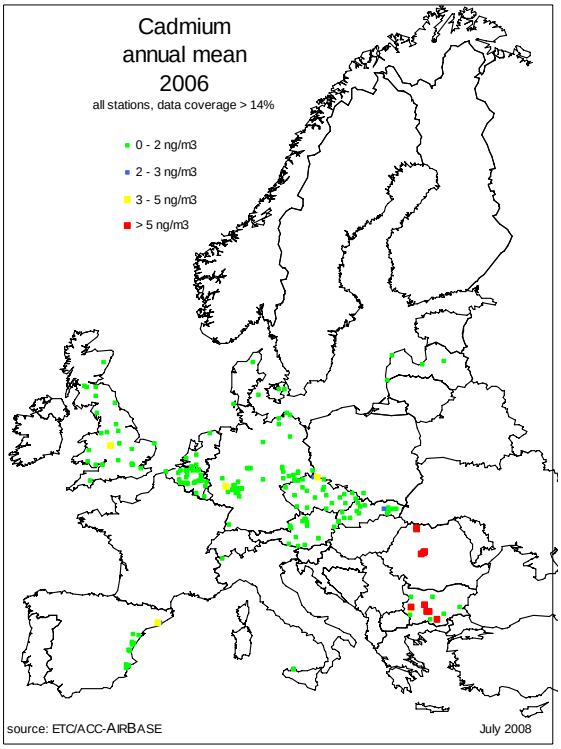

Figure 3 Annual mean value of cadmium, 2006. Concentrations of 2, 3 and 5 ng/m^3 corresponds to the LAT, UAT, and target value, respectively. Source: AirBase.

Cadmium air concentrations are modelled by EMEP (Figure 4). The highest concentrations are believed to occur in southern Poland, with otherwise only very localised peak concentrations. Even then, when allowing for a factor 3 scaling from 50km background to potential urban values, concentrations are estimated as being in excess of 1.5 ng/m^3 and thus potentially only approaching the lower assessment threshold in these areas. Examination of OSPAR observation data for the North Sea countries points to potential exceedance of the LAT in Belgium for two of the years since 2000, although data quality issues prevent a definitive judgement.

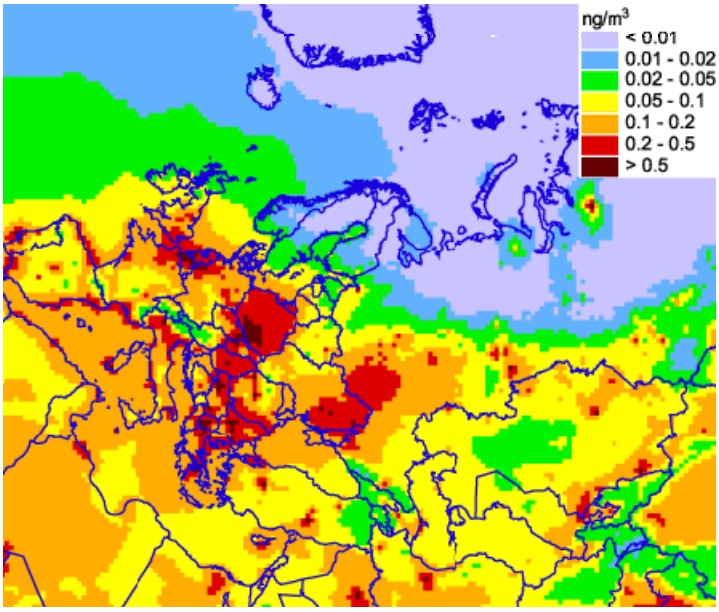

Figure 4 Modelled air concentrations of cadmium (ng/m^3) (EMEP, 2008)

iii. Emission changes and comparison with air quality

A decrease of 50% between 1990 and 2006 has occurred (see Figure 5), a mean fall of 4% per annum. Emissions arise largely from burning of fossil fuels and from waste incineration, and although they had fallen by a third and a half respectively since 1990, the energy and waste sectors represented 75% and 12% of total emissions, respectively, in 2006. Poland's contribution is currently the most significant, representing a third of all EU27 emissions.

Further declines are anticipated. Emissions of cadmium in the EU27 in 2000 estimated at 177 tonnes will fall under current legislation to 100 tonnes in 2020 (Hettelingh et al, 2006). Generally, the largest decrease will occur between 2000 and 2010; between 2010 and 2020 stable or slightly increasing emissions are expected unless additional measures are taken. Emission changes will vary strongly between Member States, e.g. an increase of 25% in Cyprus, a decrease of over 70% in Estonia and Romania.

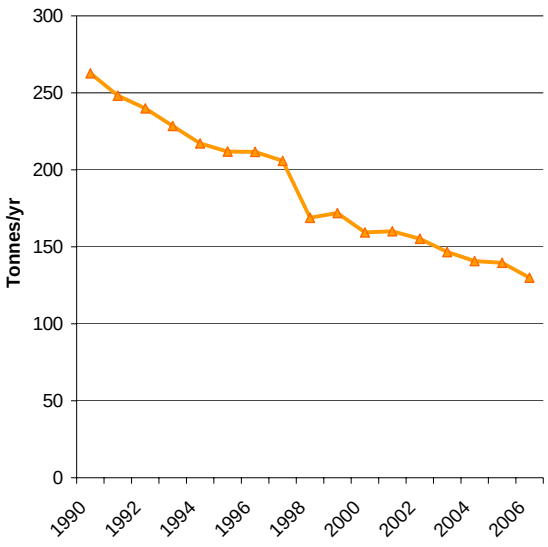

Figure 5 Cadmium emissions 1990-2006, EU27 (tonnes/yr). Source: Webdab

iv. Data availability and quality

In AirBase 260 stations are reporting cadmium concentrations, at 225 stations data coverage is more than 14%. These stations are focused on central to north-west Europe, with very little or no information reported to AirBase for Scandinavia, southern and eastern Europe. Whilst monitoring networks have observed cadmium for a number of years prior to legal requirements, the number of stations is not high.

Cadmium has to be determined in the PM_{10} fraction according to EN 12341. The reference method for its analysis is atomic absorption spectroscopy or ICP mass spectroscopy. A Member State may also use any other method which it can demonstrate gives results equivalent to the reference method.

One quarter (25%) of stations explicitly state in their EoI submission for 2006 that PM_{10} is sampled. For the remainder the method is unknown. Around 15% of stations report use of X-ray fluorescence (XRF) for analysis of cadmium, although it is doubtful that the method has sufficient limits of detection for present-day ambient levels. Around 70% of stations use AAS or ICP-MS.

3.3. Lead

i. Introduction and standards

Exposure to lead is mainly by inhalation and by ingestion via food, water or soil. Lead accumulates in the body, and causes damages to organs (kidneys, liver), the brain and nerves. Indeed, exposure to high levels causes serious brain damage: mental retardation, behavioural disorder, memory problems and mood changes. Children exhibit vulnerability to the toxic effects of lead at much lower concentrations than adults. It has been shown that there is a strong link between high lead exposures and impaired intelligence. A Limit Value of 0.5 $\mu g/m^3$ as annual mean has been set in the first daughter Directive, with an Upper Assessment Threshold of 0.35 $\mu g/m^3$ and a Lower Assessment Threshold of 0.25 $\mu g/m^3$.

ii. Air quality and comparison with standards

According to AirBase data, in 2006 the limit value has been exceeded at a few industrial hotspots in Bulgaria and Romania. The exceedance in Bulgaria (observed annual mean is 0.55 $\mu g/m^3$) is measured at one urban background station in Karjaly. The zone in which this station is located has a total population of 1.2 million inhabitants. In Romania at five stations (two urban industrial sites, two urban background sites and one rural background site) an exceedance have been observed.

In the case of lead, the lower assessment threshold is 0.25 $\mu g/m^3$; this level has been exceeded in 2006 at 8 stations only indicating that the lower assessment threshold is not reached in large parts of the EU27.

Model results from EMEP can also be used to indicate the degree of agreement with data reported to AirBase, and to point towards potential levels away from monitoring sites. As the model gives background values (e.g. 50x50 km^2 grid), an urban increment scaling factor can be introduced to estimate the higher exposure levels of the urban population. Actual empirical scaling factors of around 2 are found in AirBase data. Using a high scaling factor of 3 provides a severe case, and when applying this screening in 2006 no sites were found to approach the threshold values (see Figure 7 - EMEP 2008).

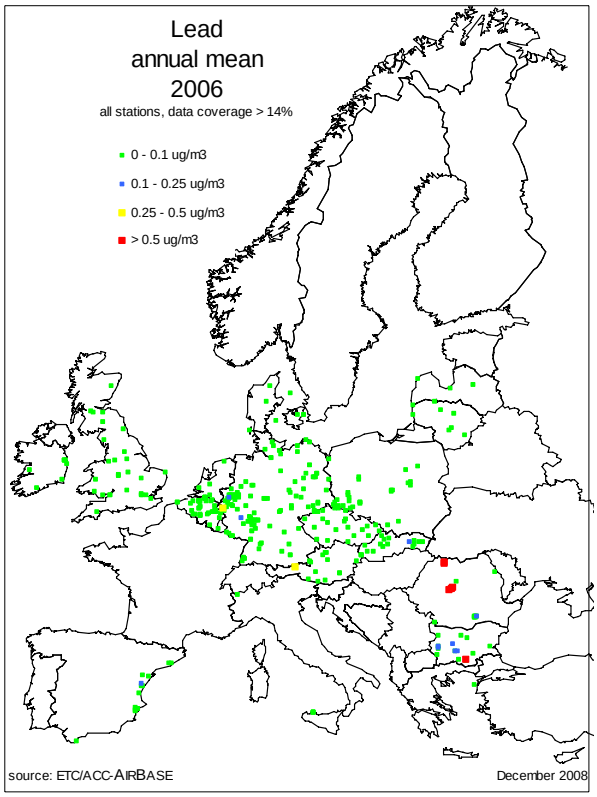

Figure 6 Annual mean concentrations of lead (µg/m3) in 2006. Source: AirBase

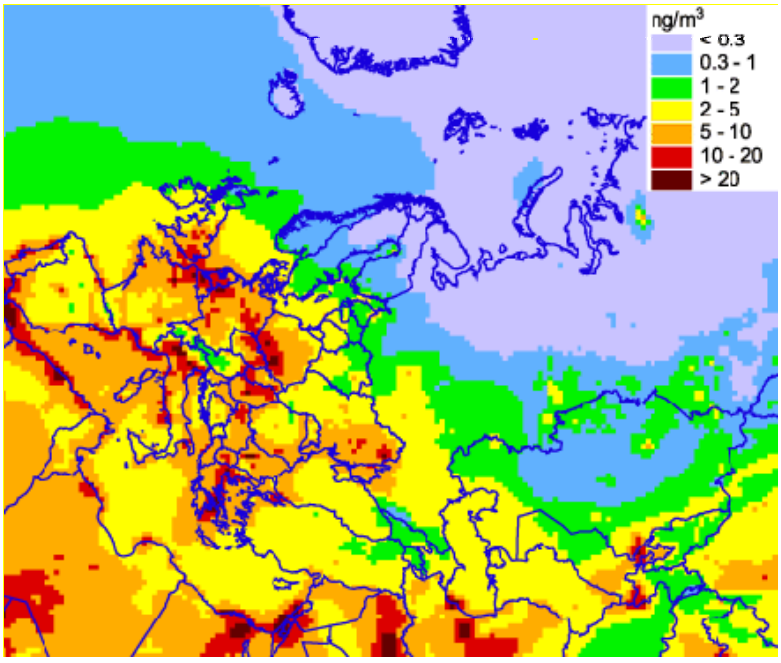

Figure 7 Modelled air concentrations of lead (ng/m3) (EMEP, 2008)

The measurements undertaken by EMEP and OSPAR may also be used for comparison with AirBase data and for approximation to thresholds. Screening by using the same urban increment scaling factor of 3 for all years since 2000 at background sites also indicates limited exceedance of the various criteria. Using a high factor of 3 to scale from background observations to possible hotspot

concentrations indicates that the LAT, UAT or Limit Value has not been reached in any of the years since 2000. Concentrations were last at such levels in the early 1990's.

Information on the air quality in a zone in relation to the upper and lower assessment threshold is available from the questionnaire used for the annual reporting under the framework directive (EU, 1996; EU, 2004). Providing this information, however, is not mandatory; nevertheless, 23 Member States provided this information on 550 zones and agglomerations; in 539 of them (covering 65% of the EU27 land area) the concentration is below the lower assessment threshold. In these zones and agglomerations monitoring of lead concentrations at fixed location is not longer mandatory.

The air quality status of lead in the zones and agglomerations as defined under the first daughter directive is given in Figure 8 (Vixseboxse and de Leeuw, 2008). In line with the AirBase information the map shows that exceedances of the lead limit value have been observed in Bulgaria. The exceedances observed in AirBase are not seen in the zone map; the reason may be that the definition of zones and agglomerations for lead is largely missing in Romania (see de Leeuw and Vixseboxse, 2008). Preliminary analysis of the 2007-data indicates exceedances of the lead LV in Belgium and Bulgaria. It should also be noted, however, that for 17 of the 21 AQ management zones in Romania no information was available. (de Leeuw and Vixseboxse, 2008). It can be concluded that, except for the few peak concentrations commented, current lead concentrations are in general well below the limit value set for protection of human health.

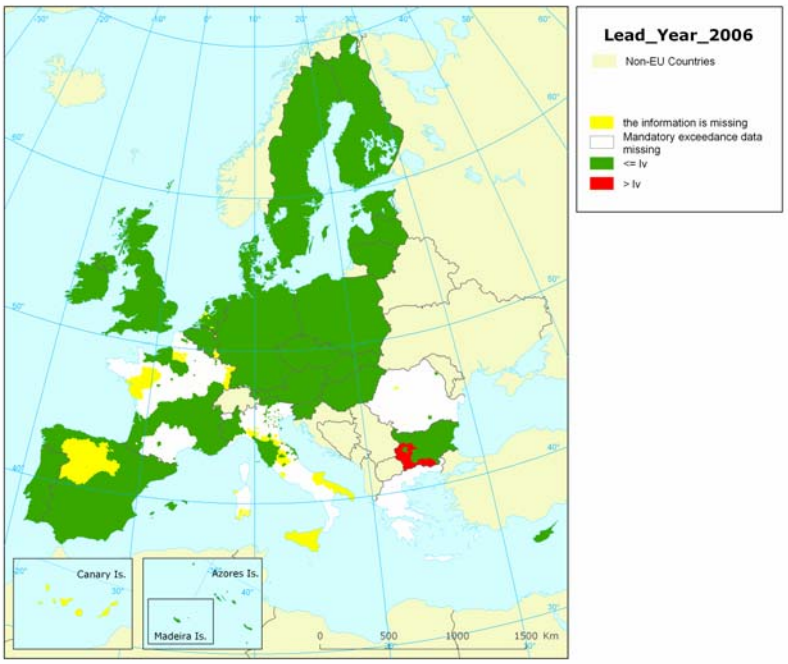

Figure 8 Air quality status of the zone and agglomerations defined for lead in relation to the limit value of 0.5 µg/m^3 set for the protection of human health. Source: Vixseboxse and de Leeuw, 2008.

iii Emission changes and comparison with air quality

Total lead emissions have decreased significantly in recent decades. Emissions from the EU27 in 2006 were less than 15% of what they were in 1990 (see Figure 9). Transport was an important source of lead in the atmosphere, representing over 75% of the emissions in 1990 (see Figure 9). The increasing uptake of unleaded petrol marked by the 1992 Rio Summit calling for a worldwide ban and a total EU ban coming into action in 2000 (Dumitrescu, 2006), has heavily contributed to the decrease in lead emissions. This reduction of transport lead emissions accounts for over 80% of the total decrease in lead emissions in the EU27 from 1990 to 2006. Lead emissions from all sectors have

reduced over the period, however the reduction from energy emissions has been the least with a 34% decrease. Overall, emissions have remained fairly stable from 2002 to 2006 (Figure 9). In 2006 industry contributed the greatest proportion of total lead emissions with energy generation from industry and industrial processes representing 34% and 18% respectively. Furthermore, the metal production industry alone was seen to be the largest source (about 28% of total emissions in 2003).

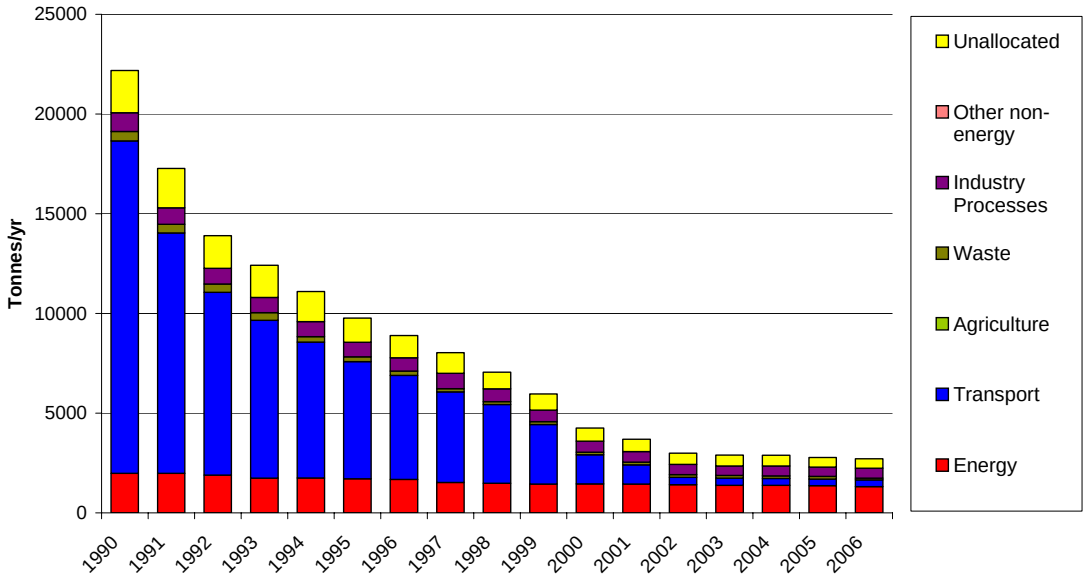

Figure 9 Lead emissions 1990-2000 by sector, EU27 (tonnes/year). Source: Webdab.
Note: The Energy sector here includes: Energy Industries, Other (energy), Fugitive, and Industry (energy). Unallocated refers to the difference between national totals and the sum of reported/gap-filled sectors.

The decrease in lead emissions has not occurred uniformly over Europe (see Figure 10). In 1990 France, Spain, Italy and the UK were the major emitters, with emissions of over 2000 tonnes/yr. By 2006 their emissions had greatly reduced. Poland and Greece are currently the largest sources, emitting close to 500 tonnes/yr.

Traffic was previously an important source of lead in the atmosphere. Since the introduction of unleaded petrol emissions have been decreased sharply, see Figure 9. The contribution of traffic to the total lead emission has been fallen from 85% in 1990 to about 6% in 2003

The concentration of lead in air show a corresponding decrease since 1990 (see Figure 11). In the recent trends (period 2002-2006, Figure 12) the decreasing trend seems to level off, concentrations are stable over the last five years. The peak in 2003 may be associated with the specific meteorological situation in this year, other pollutants like PM10 show similar peak levels. Note that Figure 12 is based on a small number of stations and not representative for the whole of Europe.

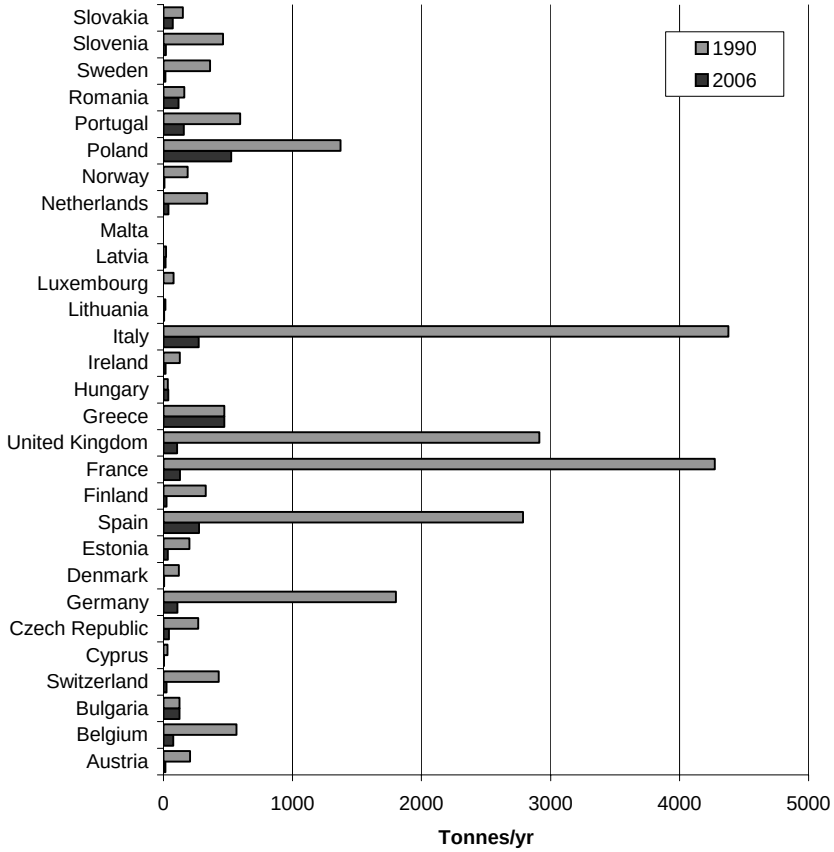

Figure 10 National total lead emissions in Europe for 1990 and 2006. Source: Webdab.

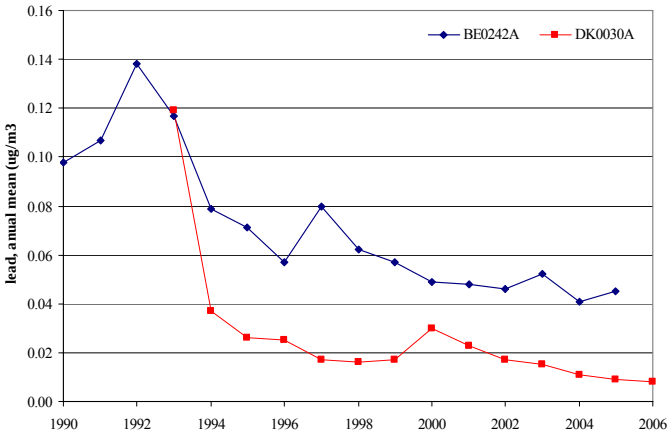

Figure 11 Long-term changes in lead concentration (annual mean in µg/m^3) for a suburban industrial station in Belgium and an urban traffic station in Denmark. Source: AirBase.

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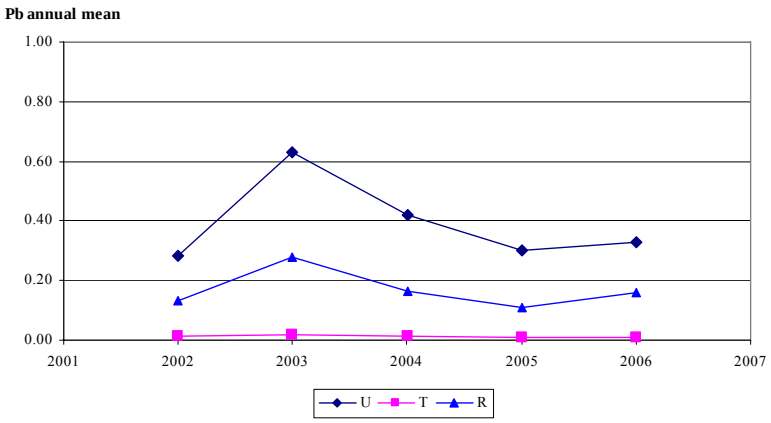

Figure 12 Recent trends in lead concentrations (annual mean).Thirty stations having valid measurements during the full 5-year period. Source: AirBase.

iv Data availability and quality

In 2006, 387[2] stations (of which 358 station have a data coverage of more than 14%, see below) reported lead concentration data to AirBase. The number of stations reporting is relatively small compared to the other regulated pollutants (Mol et al, 2008). In the case of lead, the lower assessment threshold is 0.25 µg/m^3; this level has been exceeded in 2006 at only 8 stations, indicating that the LAT is not reached in large parts of the EU27.

The first daughter directive (EU, 1999) defines reference methods for sampling and analysis of lead. After 1 January 2005 – the date on which the limit value had to be met - lead should be measured on the PM_{10} fraction. For 252 stations out of the 393 stations providing lead data in 2006 it is not known on which size fraction lead is analysed.

The reference method for the analysis of lead is atomic absorption spectroscopy (AAS) but a MS may use any other methods which gives results equivalent to the reference method. Within the EMEP monitoring network, inductively coupled plasma mass spectroscopy (ICP-MS) is chosen to be the reference technique (EMEP, 2001). A summary of the methods applied by the MS in 2006 is given in Figure 13. The reference methods chosen by the EU (AAS) or EMEP (ICP-MS) is in use for 60% of the stations. For 21% of the station no information is provided. Less frequently used methods are inductively coupled plasma atomic emission spectrometry (1%) and x-ray fluorescence (11%). The "other" methods include (questionable) methods like gravimetry, chromatography, spectrophotometry.

In the Exchange of Information Decision (EU, 1997) it is described that all stations used in the implementation of the air quality directives have to be included in the data exchange, in other words: all stations listed in the Frame Work Directive (FWD) questionnaire have to deliver data to AirBase. According to the FWD-questionnaire in total 600 stations were operational in 2006 in the EU27 for assessing air quality by lead. For nearly all of these stations (538) meta information is available in AirBase; however, only for 381 of these stations is recent (2006) information on lead (raw data and/or statistics) available in AirBase.

For lead, as well as for the other pollutants, it cannot be excluded that occasionally incorrect data is submitted due to mistakes in rounding or in units; routine acceptance checks applied when data is submitted to AirBase (Mol and van Hooydonk, 2005) do not always flag this type of mistake. When questionable data is detected, the data supplier is always contacted.

[2] Stations which delivered no raw data but only annual statistics have been included.

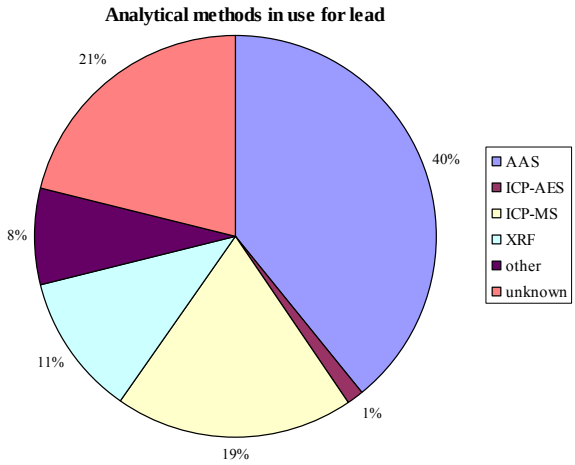

Figure 13 Analytical methods in use in 2006 for analysing lead on aerosol. Source: AirBase.

3.4. Nickel

i. Introduction and standards

In small quantities nickel is assumed to be essential for human nutrition. However, a too large uptake can be a danger for human health, nickel compounds being carcinogenic by inhalation exposure. As well as an increase in the chance of development various forms of cancer (lung, nose, larynx, prostate), lung embolism, asthma and chronic bronchitis, and heart disorders can develop. An allergic reaction of the skin is a common effect from chronic skin contact with nickel (jewellery).

On the basis of the most recent information of exposure and risk estimated in industrial populations, an incremental risk of 3.8×10^{-4} can be given for a concentration of nickel in air of 1 $\mu g/m^3$. The concentrations corresponding to an excess lifetime risk of 1:10 000, 1:100 000 and 1: 1 000 000 are about 250, 25 and 2.5 ng/m^3, respectively.(WHO, 2000).

One station in the United Kingdom reported an exceedance of the target value of 20 ng/m^3 in 2006; one station in Spain also reported an exceedance but the data coverage did not fulfil the 14% criterion. At more than 90% of the stations a concentration below the lower assessment threshold was measured. The data available in AirBase is not sufficient to show any long-term or recent trend in the concentrations.

In their voluntary submission on the state of air quality by nickel, three Member States (Germany (2 zones) , Estonia (1 zone) and United Kingdom(1 zone)) indicated problems with nickel; ten other MS reported that the target value was not exceeded in any of their AQ management zones (de Leeuw and Vixseboxse, 2008). For both zones in Germany the exceedances are related to local industrial emissions; the total area of exceedance is estimated to be 14 km^2 with a total exposed population of less than 20000. The exceedance in the United Kingdom has been based on a station that has a data capture of less than 70%.

Examination of EMEP measurements since the year 2000 at background sites also indicates limited exceedance of the various criteria. Using a high factor of 3 to scale from the background observations by EMEP to possible hotspot concentrations indicates the Target Value may have been reached in Spain and Iceland in 2005 and 2006, with such levels otherwise only experienced in UK and Belgium around 2000-2002. The Upper Assessment Threshold (UAT) may have been reached in Iceland and Belgium in various years, and the Lower Assessment Threshold (LAT) also occasionally in Latvia and Spain. All criteria were more often reached during the 1990's.

ii Air quality and comparison with standards

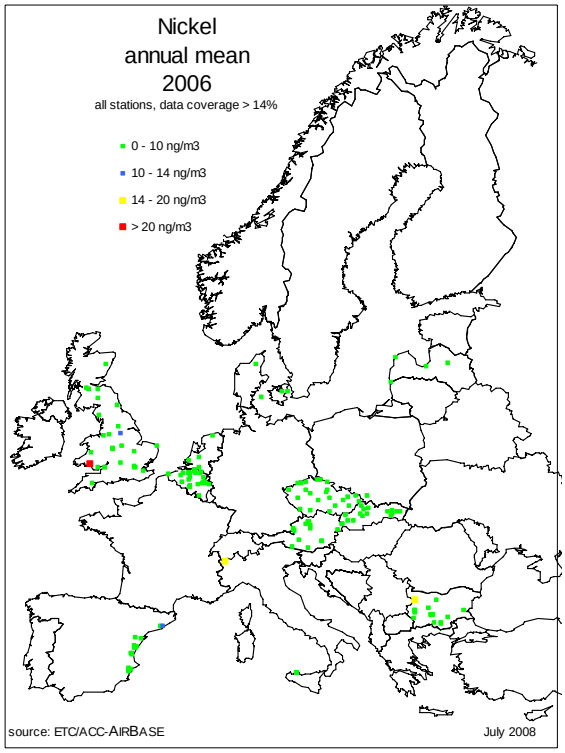

Figure 14 Annual mean value of nickel, 2006. Concentrations of 10, 14 and 20 ng/m^3 correspond to the lower assessment threshold, upper assessment threshold and target value, respectively. Source: AirBase

The same examination of OSPAR observation data for North Sea coastlines points to regular exceedance on the Icelandic coast of the LAT, sometimes the UAT, and on occasions the LT. This may be expected to arise due to local geothermal activity. Also in regular (five of seven years) potential exceedance is the Belgian coastline. Indeed, in years 2000, 2001 and 2002 concentrations actually exceeded the LAT without application of the urban increment scaling factor. With the factor, the potential is for exceedance of the LV in those years. In recent years the potential exceedance in Belgium has been of the LAT and UAT. Data quality may be an issue which acts to overstate the problem.

iii. Emission changes and comparison with air quality

Releases from industrial combustion, power generation, waste incineration and the metallurgic industry form the most important anthropogenic sources. In 2000, the EU27 emissions are estimated as1966 tonne per year decreasing to 959 tonne (- 50%) in 2020 (Hettelingh et al., 2006). However, Spain's emissions increased up to 1995. Spain is the largest emitter followed by Poland emitting 16% and 12% of the EU27 total in 2006.

Nickel emissions have gradually declined by around 40% over the period of 1990 to 2006, with a steady mean of 3%/yr (see Figure 15). The energy sector remained the dominated emissions source, accounting for around 75% throughout the period. The transport sector emissions actually increased from 136 tonnes/yr to 158 tonnes/yr, whilst all other sectors decreased significantly.

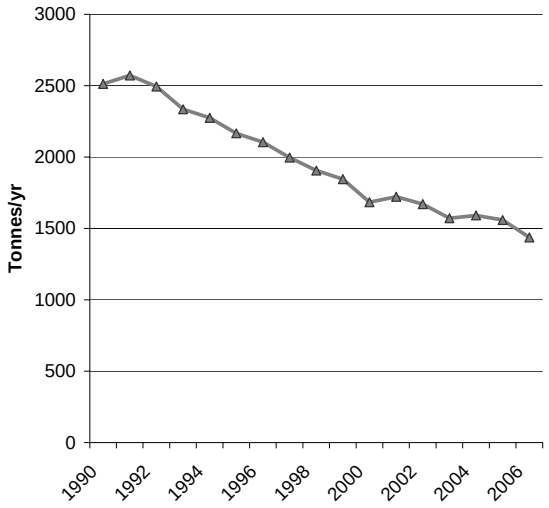

Figure 15 Nickel emissions, 1990-2006 (tonnes/yr), EU27. Source: Webdab

iv. Data availability and quality

A total of 242 stations reported annual mean data to AirBase in 2006. Nickel has to be determined in the PM10 fraction according to EN 12341. The reference method for its analysis is atomic absorption spectroscopy or ICP mass spectroscopy. A Member State may also use any other methods which it can demonstrate give results equivalent to the reference method.

Only 11% of stations explicitly state in their EoI submission for 2006 that PM10 is sampled. For the remainder the method is unknown. For over a quarter of sites unreported or other methods than AAS or ICP-MS were used in 2006. The use of X-ray fluorescence (XRF) is used at 18% of the stations, although there is some doubt whether the limits of detection obtainable with this method are sufficient for measurement of present-day ambient levels.

3.5. Carbon monoxide (CO)

i. Introduction and standards

Carbon monoxide (CO) is a colourless, odourless gas that is formed during the incomplete combustion of fossil fuels and biofuels. The CO concentrations tend to vary with the traffic patterns during the day; the highest CO levels are found in urban areas, typically during rush hours at traffic locations. The atmospheric lifetime of CO is about 3 months. It is slowly oxidized to carbon dioxide. During this oxidation process ozone is formed and CO contributes to the hemispheric ozone background concentrations.

Carbon monoxide enters the body through the lungs. In the blood it is strongly bound to haemoglobin and thereby it reduces the oxygen delivery to the body's organs and tissues. Those who suffer from cardiovascular disease are the most sensitive towards CO exposure. In the second daughter directive (EU, 2000) the EU has set limit values for the protection of human health: the CO daily maximum 8-hour mean values may not exceed 10 mg/m^3.

ii. Air quality and comparison with standards

At 1065 stations the CO daily maximum 8-hour mean values fulfil the data coverage criteria of 75%. In large parts of the EU27 the CO concentrations are below the lower assessment threshold of 5 mg/m3. The health-related limit value is not exceeded at the few operational rural background stations. Exceedances are observed at 3 urban background and 6 traffic stations (about 1% of all stations).

Exceedances are observed in a number of countries: Bosnia and Herzegovina, Bulgaria, FYR of Macedonia, Italy, Portugal, Romania and Serbia, see Figure 16.

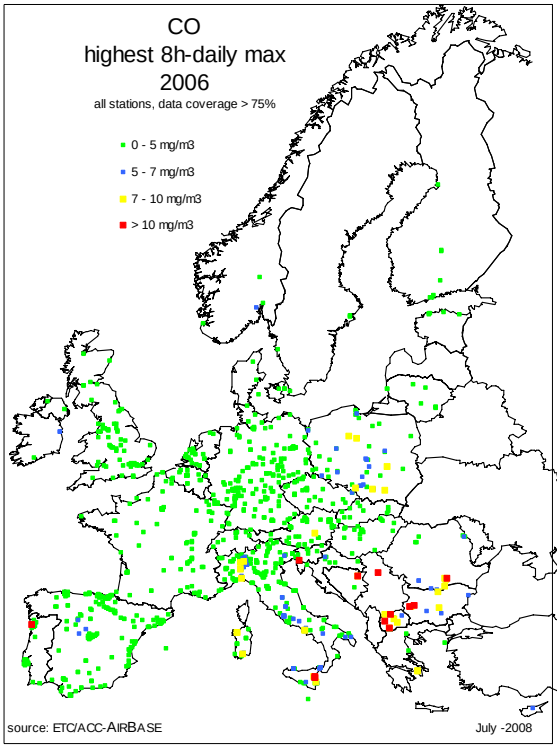

Figure 16 Highest observed value of the daily maximum 8-hour mean value of CO. Concentrations of 5, 7 and 10 mg/m^3 corresponds to the lower assessment threshold, upper assessment threshold and limit value, respectively. Source: AirBase.

In Figure 17 a map of the air quality in zones agglomerations in relation to the CO limit value is given (Vixseboxse and de Leeuw, 2008). According to this map, based on the FWD-questionnaire, the CO limit value has been exceeded in 2006 in 5 zones (in Bulgaria (2 zones), Italy, Poland and Romania); nearly 5 million people are living in these zones. The information for Bulgaria and Romania presented in Figure 16 and 17, respectively is in agreement. In Italy the exceedance in the zone Area Triestina is also seen in the AirBase map (Figure 16). The information on the AQ status of zones on Sicily is missing in Figure 17; the AirBase data suggest that exceedances have occurred in this region. The Polish zone Powiat m. Jelenia Góra reports an exceedance with the remark "more restricted standard for specially protected area". At the (single) monitoring station in this zone the maximum CO concentrations is 5.1 mg/m^3 which is below the limit value. The exceedance observed in AirBase in Portugal cannot be traced in Figure 17. The exceedance is observed at the station PT0100A, Vila Nova da Telha located in the agglomeration Porto Litoral. Although the station is used under the framework directive for various other pollutants, the CO data is not used for compliance checking, most likely because the data coverage (84%) did not met the 90% quality objective as required under the second DD..

The preliminary analysis of the 2007 FWD-questionnaire (de Leeuw and Vixseboxse, 2008) reveals that in three zones (from the 663 zones for which information has been given) in Bulgaria, Italy and Romania, the CO concentration is above the limit value.

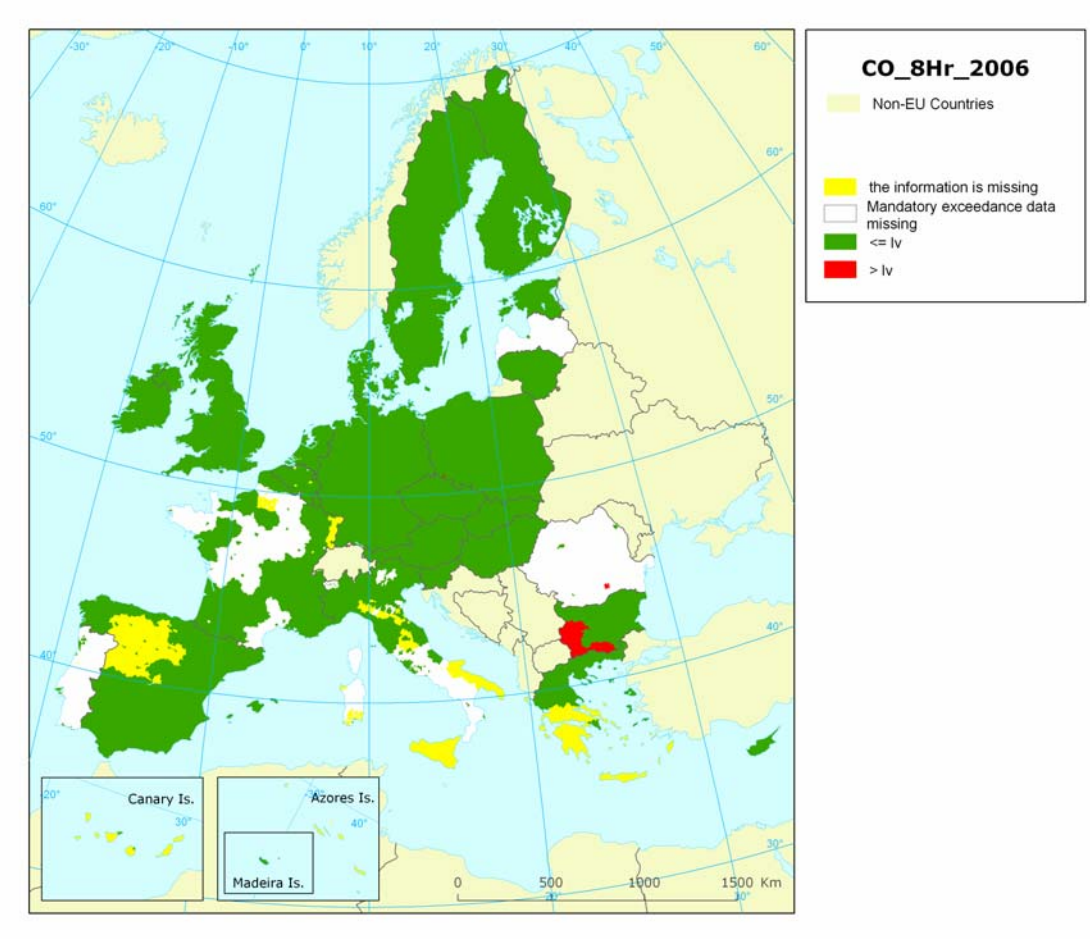

Figure 17 Air quality status of zones and agglomerations defined for carbon monoxide in relation to the limit value set for the protection of human health. Source: Vixseboxse and de Leeuw, 2008.

iii. Emission changes and comparison with air quality

Carbon monoxide (CO) emissions have been more than halved from 1990 to 2006 in the EU27 (see Figure 18). This decrease has been steady over the period with a mean decline of 5%/yr. Transport accounts for the greatest contribution of emissions with 59% and 45% for 1990 and 2006, respectively (see Figure 18), despite road transport emissions decreasing nearly 70 % over the period. The production of road transport fitted with catalytic converters is likely to have contributed to this decrease, with road transport being the only sector whose contribution to emissions decreased over the period. All sectors decreased over the period.

The vast majority of European countries' emissions fell between 1990 and 2006, with around two-thirds reducing emissions by more than 40%. Romania and Slovenia CO emissions increased compared to 1990 by 72% and 35% respectively, and Bulgaria's remained at similar levels. However, France and Germany continue to be the largest emitters by volume at over 4 million tonnes in 2006.

Carbon monoxide emissions have halved over the period 1990-2005 in the EU27 Member States. Over the periods 1997-2005 and 2001-2005 the decrease in emissions is 32% and 15% respectively. Whilst the relative contribution of road traffic has decreased from 53% in 1990 to 38% in 2005, the contribution from the energy sector has increased from 34% in 1990 to 40% in 2005.

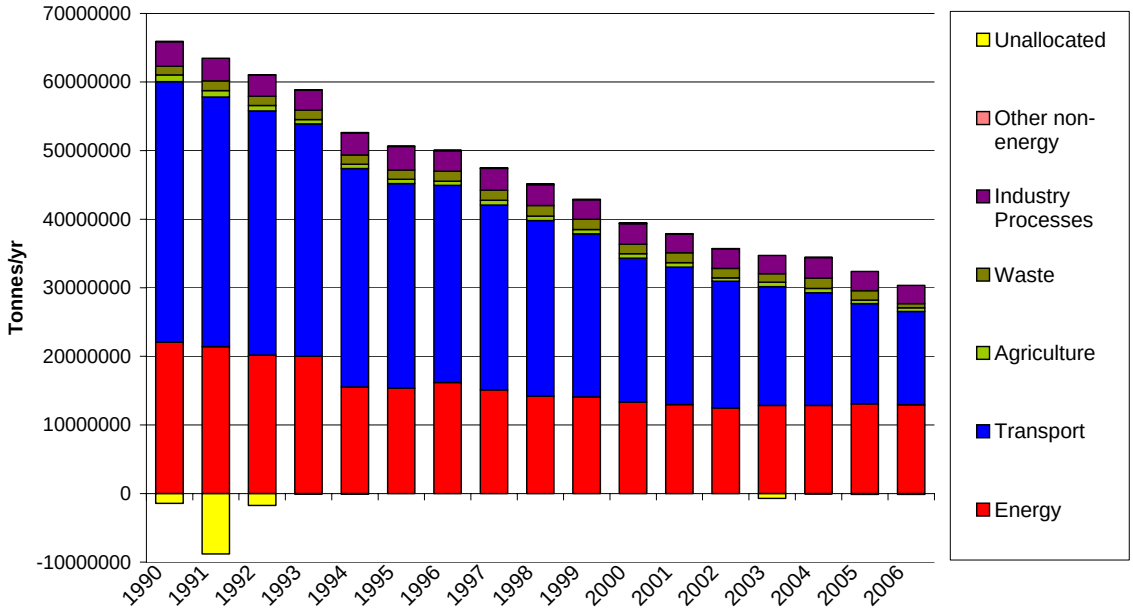

Figure 18 Annual CO emissions from 1990-2006 in the EU27 by sector. Source: Webdab

The changes in ambient concentrations are in agreement with this, see Figure 19 and 20. On average the CO concentrations reported to AirBase (annual mean of 8h daily maximum values) have decreased at traffic and urban background stations, relatively close to the sources, with 45-55% from 1997-2006.

Since 1999 a consistent set of 11 rural background stations has reported CO concentrations under the EoI. An averaged decrease of about 20% has been observed at these stations which is slightly less than the decrease in EU27-emissions. With an atmospheric reference time of about 3 months the rural concentrations will to a large extent be determined by sources outside the EU27. Between 2001 and 2006 a 35% reduction has been observed at traffic stations; in the urban background the reduction is about 25%.

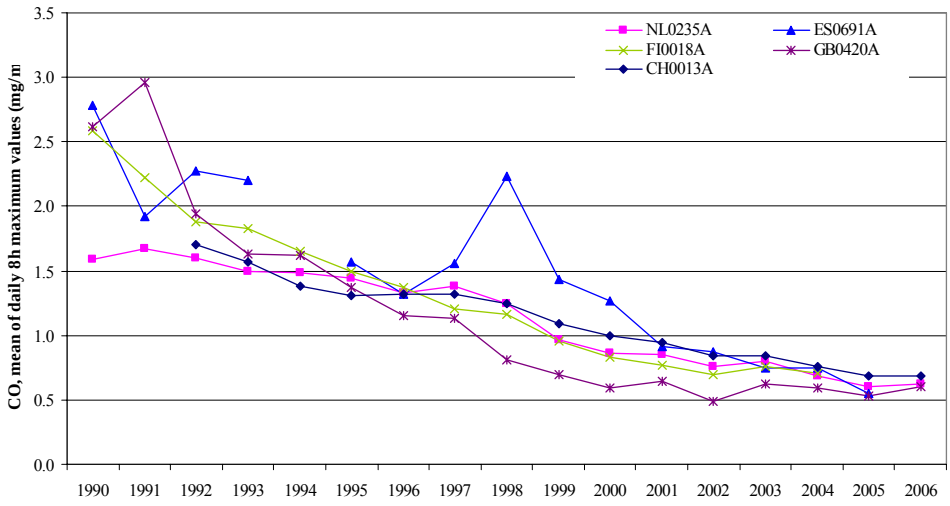

Figure 19 Long-term changes in CO concentrations (annual mean of daily 8h-max) for selected stations in Spain, Finland, France, UK and the Netherlands. Source: AirBase.

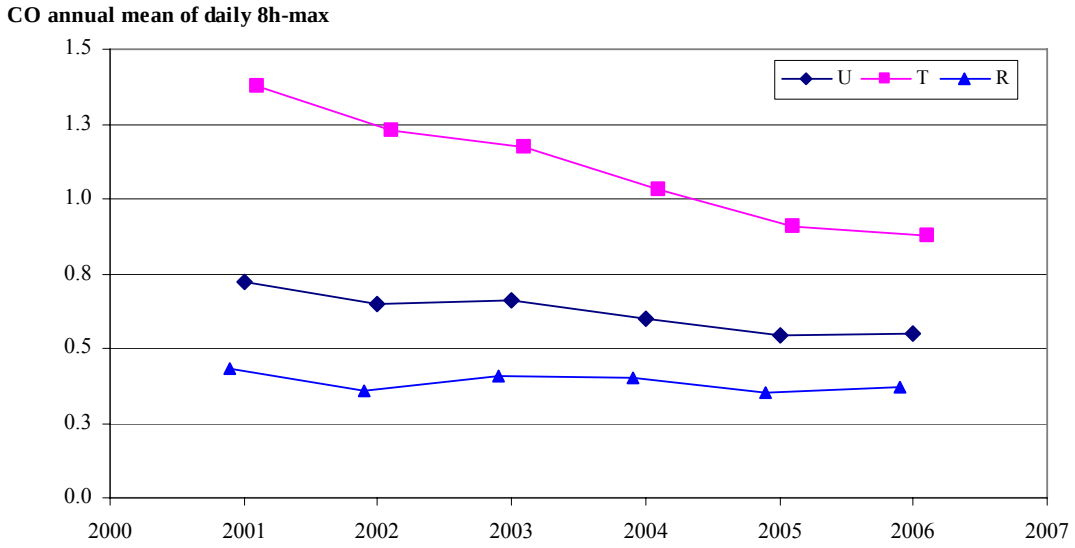

Figure 20 Recent trends in carbon monoxide concentrations (annual mean of daily 8h-maximum). Only stations having valid measurements during at least 5 years within the 2001-2006 period are included in the trend analysis. Source: AirBase.

iv. Data availability and quality

Non-dispersive infra-red spectrometry is defined in the second daughter directive (EU, 2000) as the reference method for the analysis of carbon monoxide. At 75% of the CO-stations operational in 2006 an infrared method is used. For 12% of the station no information on measuring method is given. The remaining stations report, not always correctly, a variety of methods. In the FWD-questionnaire 1101 stations are reported to measure CO. Of those, 1065 stations and their associated meta-information are included in the AirBase database. For 2006, CO concentration data is available for 953 stations.

3.6. Benzene

i. Introduction and standards

Benzene is carcinogenic to humans and no safe level of exposure can be recommended. The most significant adverse effects from prolonged exposure are haematotoxicity, together with genotoxicity and carcinogenicity. Chronic exposure to benzene can depress bone marrow, and cause haematological effects such as decreased red and white blood cell count in workers occupationally exposed to high concentrations. Inhalation is the dominant pathway for benzene exposure in humans, food and water consumption being only a minor source. Smoking is a large source of personal exposure.

The geometric mean of the range of estimates of the excess lifetime risk of leukaemia at an air concentration of 1 µg/m^3 is 6×10^{-6}. The concentrations of airborne benzene associated with an excess lifetime risk of 1/10 000, 1/100 000 and 1/1 000 000 are 17, 1.7 and 0.17 µg/m^3, respectively. (WHO, 2000). The second Daughter Directive (EC, 2000) set an annual average concentration limit value of 5 µg/m^3 for benzene in ambient air, to be met by 2010. Including the margin of tolerance, annual mean concentrations may not exceed 9 µg/m^3 in 2006.

ii. Air quality and comparison with standards

The long-term trend of benzene concentration is decreasing (Figure 21). Up to 2001 benzene monitoring data has been submitted to AirBase for less than 100 stations. Since 2001 onwards the number of stations annually reporting data might be as large as 500 although at a large number of the

stations the data coverage criteria of 50% have not been met. For 80 traffic stations a complete time series (at least five out of the six years with valid data) has been reported over the period 2001 – 2006. On the average these traffic station show a reduction by 50% in this period. The reduction at traffic stations is in relative and absolute terms larger than for the urban or rural background stations; this confirms the large contribution from road traffic to the benzene emissions.

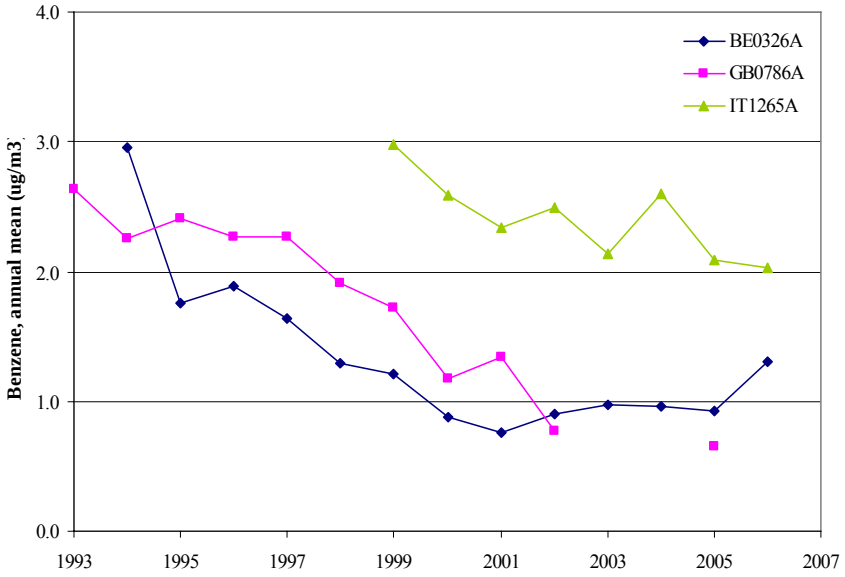

Figure 21 Long-term changes in benzene concentrations (annual mean) for selected stations in Belgium, Italy, and United Kingdom. Source: AirBase.

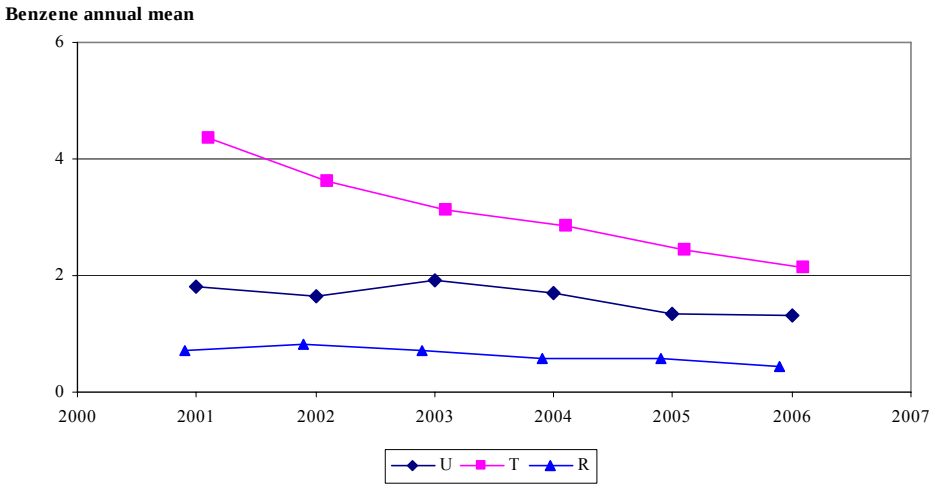

Figure 22 Recent trends in benzene concentrations (annual mean) Only stations having valid measurements during at least 5 years within the 2001-2006 period are included. Source: AirBase.

At rural background stations no exceedance of the limit value is observed. Exceedance of the limit value is observed at 15 urban stations (three urban background stations, ten urban traffic stations, one urban industrial station and one unspecified urban station). At two of these stations exceedances of the limit value plus margin of tolerance have been reported (one urban background station (Poland) and one industrial station (Czech Republic)).

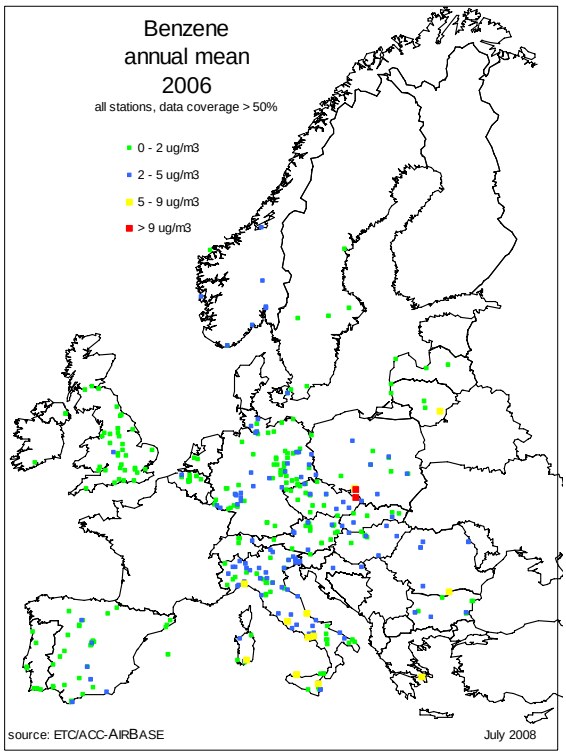

Figure 23 Annual mean value of benzene, 2006. Concentrations of 2, 5 and 9 µg/m3 corresponds to the lower assessment threshold, limit value, and limit value plus margin of tolerance, respectively. Source: AirBase.

In Figure 24 a map of the air quality in zones agglomerations in relation to the benzene limit value (plus margin of tolerance) is given (Vixseboxse and de Leeuw, 2008); this map is based on the analysis of the FWD-questionnaire. According to this map the benzene limit value has been exceeded in 2006 in 16 zones of which 2 zones (in Poland and the Czech Republic) also exceeded the limit value plus margin of tolerance. The total population in these 16 zone potentially exposed to concentration in excess of the limit value is 14.5 million.

There are some agreements, some discrepancies between the maps in Figures 23 and 24. The exceedances of LV plus margin of tolerance on the border of Poland and Czech Republic are seen in both maps. Additionally, in Poland there are a number of zones with concentrations between LV and margin of tolerance but in AirBase only one station with concentration in this range can be found. The reason of this difference must be sought in the limited number of stations delivering benzene data to AirBase (21 stations) while according to the questionnaire 198 benzene station are operational. A similar situation is found in Germany. The exceedance in Essen is not found in AirBase as data has not been delivered for all stations under the EoI (data has been received for 60% of the stations reported in the FWD questionnaire). For the zone Yorkshire & Humberside in the UK the exceedance of the LV is assesses by models and therefore it can not be traced in AirBase. For Greece and some zones in Italy an agreement is found. The discrepancies seen in Italy, Lithuania and Romania can be explained by various reasons:

- Information on the AQ status of zones is missing in the FWD-questionnaire
- Health related zones for benzene are not assigned for the whole territory
- Not all monitoring information used under the FWD has been submitted to AirBase.
- The differences in selection criteria: in this report an annual mean values having a data coverage of at least 50% is judged to be representative while the directive requires a coverage of 90% for fixed measurements.

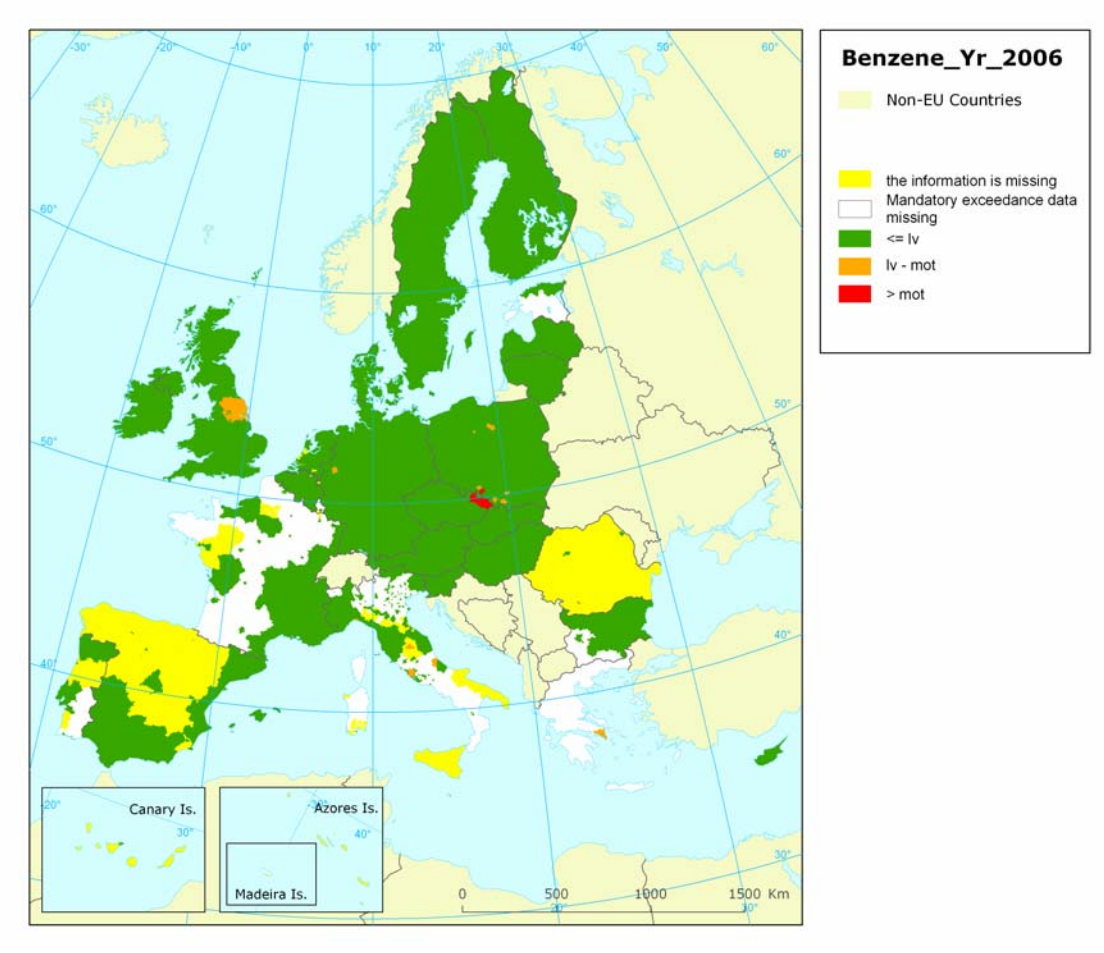

Figure 24 Air quality status of zones and agglomerations defined for benzene in relation to the limit value set for the protection of human health. Source: Vixseboxse and de Leeuw, 2008

According to the 2007 FWD questionnaire the limit value of benzene is exceeded in 6 zones (1 zone each in Czech Republic, Greece and Italy and three zones in Poland); in two of these zone the 2007-concentrations are above the LV plus margin of tolerance (de Leeuw and Vixseboxse, 2008). The total population potentially exposed to concentration in excess of the limit value is 5.8 million substantially less than in 2006. This reflects the ongoing decrease in emissions although the better dispersion condition in 2007 also play an important role

iii Emission changes and comparison with air quality

European wide data on benzene emissions is not available, so patterns from the UK data is used to illustrate trends over time. Benzene emissions in the UK have been cut by about 75% from 1990 to 2006 (see Figure 25). The majority of this reduction is from road transport emissions having been reduced by more than 15-fold, which represents over 90% of the total emissions reduction of the period. All other sectors also decreased between 15-33% over the period.

Incomplete burning from combustion is the most significant source of the carcinogenic pollutant benzene. It is an additive to petrol with a maximum concentration of 1% v/v. At the European scale, 80-85% of benzene emissions are due to vehicular traffic. This results from both the benzene content of the fuel and partial combustion of the petrol. A further 5% comes from the handling, distribution and storage of petrol and approximately 1% comes from oil refining. Emissions also come from benzene-producing and handling industries. In general the contributions of domestic heating are small (about 5%) but with sharp geographic patterns. Wood combustion might be an important local source

of benzene (Hellen et al., 2008). In Sweden the domestic contribution reaches over 50%. Removal of benzene from the atmosphere is mainly by reaction with the hydroxyl (OH) radical. Photo-oxidation does contribute to ozone formation, although benzene reactivity is relatively low. A lifetime of several days at representative tropospheric OH- concentrations is sufficient for benzene to be transported over long distances.
Recent summaries of the benzene emissions in the EU27 countries do not exist. For a limited number of countries emission data representative for the last decade of the previous century is presented in the position paper on benzene in support to the preparation of the second daughter directive. More recent, expert-based emission data have been prepared for the Auto Oil Programme (EEA, 2001). These studies indicate decreasing benzene emissions but a further quantification is not possible. Most important control methods to reduce benzene emissions include the reduction of benzene content of petrol to 1% in 2000, the introduction of catalytic converters and vapour recovery of petrol deliveries

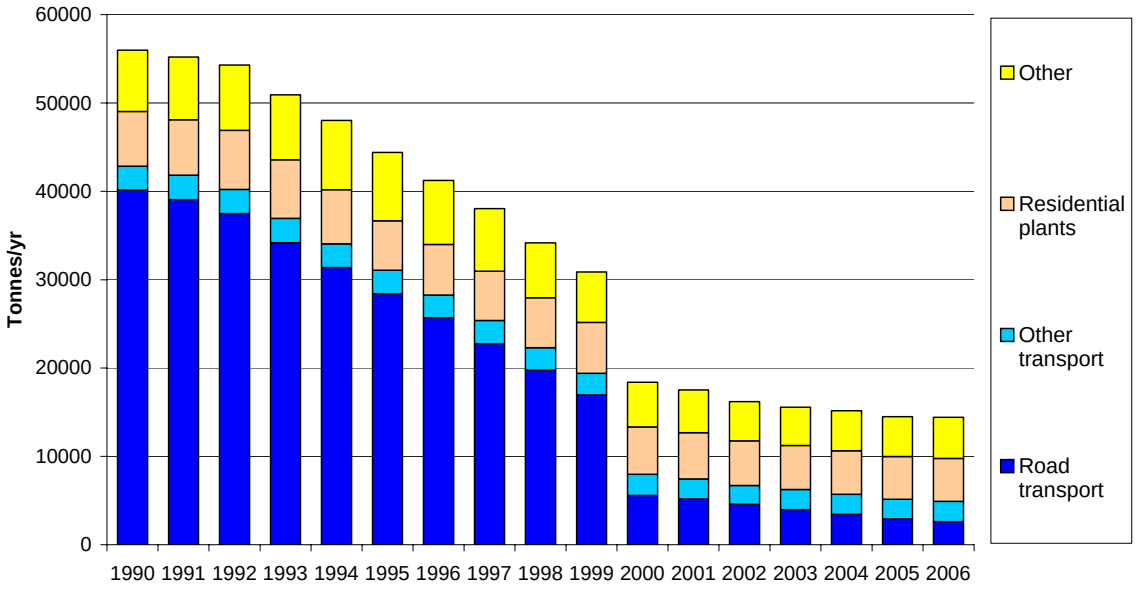

Figure 25 Annual Benzene emissions, 1990-2006, UK by sector. Source: Webdab

iv. Data availability and quality

Benzene is not always measured continuously. For discontinuous measurements a lower data coverage than 75% will not largely increase the uncertainties in the annual mean values as long as the measurements take place randomly spread over the year (Working group on benzene, 1998). For this reason we have applied a data coverage criterion of better than 50%. This criterion is fulfilled in 2006 at 408 stations measuring benzene.

The reference method for sampling/analysis of benzene is pumped sampling followed by gas chromatographic determination. This is used for most of the stations: a more than 75% of the station a(gas) chromatography is used although at a limited number of stations passive sampling is used. In 15% of the case the sampling/analysis method is not reported.

In the FWD-questionnaire for 2006 877 stations are reported to measure benzene. Of those, 719 stations and their associated meta-information are included in the AirBase database. However, benzene concentration data is for 2006 available for 433 stations listed in the questionnaire.

3.7. Benzo(a)pyrene – PAH

i. Introduction and standards

Benzo(a)pyrene or B(a)P is one of a group of compounds called polycyclic aromatic hydrocarbons (PAH). PAH are not commercially produced nor used; they enter the environment as a result of incomplete combustion. Main sources are wood and waste burning, coke and steel production, and mobile sources. B(a)P is carcinogenic and long-term exposure may have developmental and reproductive effects. The 4th DD sets the target value for B(a)P at 1 ng/m^3 as annual mean.

No specific guideline value can be recommended for PAHs as such in air. These compounds are typically constituents of complex mixtures. Some PAHs are also potent carcinogens, which may interact with a number of other compounds. In addition, PAHs in air are mostly attached to particles, which may also play a role in their carcinogenicity. Although food is thought to be the major source ofhuman exposure to PAHs, part of this contamination may arise from air pollution with PAHs. The levels of PAHs in air should therefore be kept as low as possible. In view of the difficulties in dealing with guidelines for PAH mixtures, the advantages and disadvantages of using a single indicator carcinogen to represent the carcinogenic potential of a fraction of PAH in air were considered. Evaluation of, for example, B(a)P alone will probably underestimate the carcinogenic potential of airborne PAH mixtures, since co-occurring substance are also carcinogenic.

Based upon epidemiological data from studies in coke-oven workers, a unit risk for B(a)P as an indicator in air constituent is estimated to be 8.7×10^{-5} (ng/m3)-1 which is the same as that established by WHO in 1987. The corresponding concentrations of B(a)P producing excess lifetime cancer risks of 1/10 000, 1/100 000 and 1/1 000 000 are 1.2, 0.12 and 0.012 ng/m^3 respectively. (WHO, 2000)

ii. Air quality and comparison with standards

In AirBase 101 stations (91 with a data coverage of more than 14%) reported data for 2006. At a large fraction of these stations (n=35) the annual mean exceeds the target value. The stations reporting an exceedance are located in Germany, Austria, the Czech Republic and Bulgaria. Exceedances are observed both in the (sub)urban background as well as on hot-spots (traffic, industrial) locations. With the exception of a few stations in the UK, the data available in AirBase is not sufficient to show any long-term or recent trend in the concentrations

According to the voluntary reporting on the 4th DD, the largest problems are observed for B(a)P: in 28 of the 170 zones an exceedance of the target value has been observed in 2007. (de Leeuw and Vixseboxse, 2008). For all zones in the Czech Republic an exceedance, either based on modelling or monitoring, has been reported; it has been estimated that about 45% of the population is exposed to concentrations above the TV. Traffic, local industry and domestic heating are the main reasons. Also the exceedances in Austria (highest observed concentration is 2.3 ng/m^3) and Bulgaria (max concentration is 4.7 ng/m^3) are attributed to domestic heating and local industry. In Germany it concerns one 6 km^2-sized area closed to industry. France and Greece provide no further information on the exceeding zone. In the United Kingdom it concerns one station with an annual mean of 1.2 ng/m^3.

The 4th DD also requires measurement of other relevant PAH at a limited number of measurement sites. Only the UK has reported (from 24 stations) on levels of these PAH.

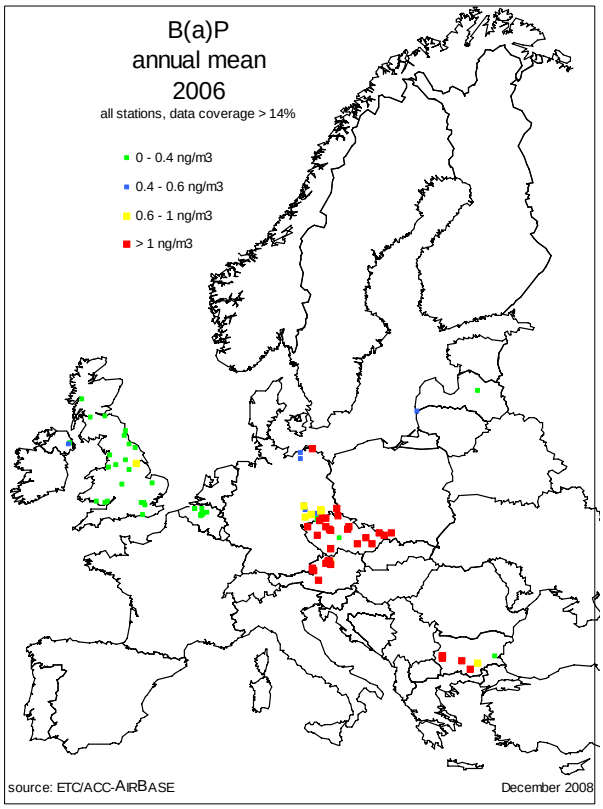

Figure 26 Annual mean value of B(a)P, 2006. Concentrations of 0.4, 0.6 and 1 ng/m^3 corresponds to the lower assessment threshold, upper assessment threshold and target value, respectively. Source: AirBase.

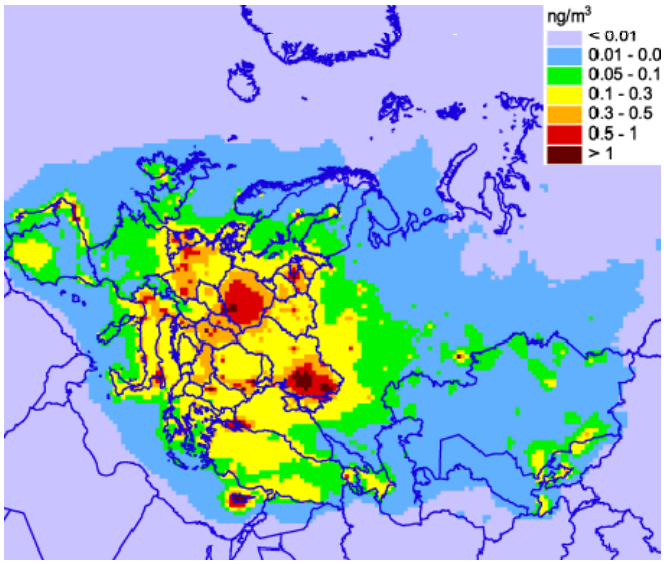

Figure 27 Modelled air concentrations of benzo(a)pyrene (ng/m^3) (EMEP, 2008)

iii. Emission changes and comparison with air quality

Emissions of polycyclic aromatic hydrocarbons, such as benzo(a)pyrene, decreased substantially by 60% between 1990 to 2002 and then stabilised around 1700 tonnes/yr (see Figure 28). Benzo(a)pyrene, mainly emitted by the energy sector, represents between 5-10% of the PaH emissions and shows a more consistent drop in emissions over the time-period. The energy sector and industrial

processes are the main sectors attributing to PAH emissions, with the majority of the decrease in emissions coming from lower industrial processes emissions.

In 1990 the Netherlands and the Czech Republic produced 39% and 18% of the EU27 emissions, respectively. Both countries have seen dramatic decreases of 72% and 98% over the period, the majority of which came within 1990 to 2000. Several other countries have shown an increase in emissions, particular Italy which has increased by nearly 50% to 134 tonnes/yr by 2006.

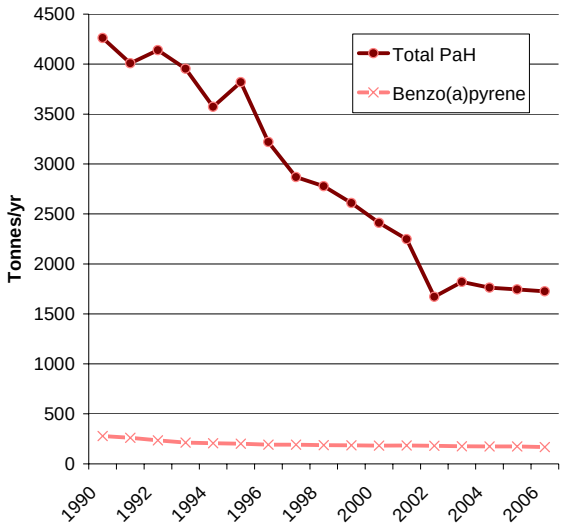

Figure 28 Total PAH and B(a)P emissions, 1990-2006, EU27 (tonnes/yr). Source: Webdab.

iv. Data availability and quality

The 4DD defines that B(a)P has to be determined in the PM_{10} fraction according to EN 12341 and furthermore it describes the reference methods for chemical analysis. For B(a)P the reference analytical method is gas chromatography followed by mass spectroscopy (GC-MS).

Only for the German stations where B(a)P is measured is it explicitly stated in the 2006 information submitted under the EoI that sampling was on the PM_{10} fraction. At 27 of the 101 reporting stations the method of analysis is unreported, whilst at two of them it is reported incorrectly as ICP-MS – an unsuitable method for determination of B(a)P. Some form of Gas chromatography (GC) is used at 72 sites, with 44 of them explicitly reporting the use of GC-MS.

4. Preliminary view of health impacts: the example of Moravia-Silesia

At the European scale the available air quality information for heavy metals and B(a)P is too scattered or of too low quality to permit exposure estimates. Coverage of carbon monoxide and benzene data is better, but not at the stage to move to population exposure estimates. However, by way of initial exploration of the topic we present a summary of an evaluation into the health impact of air quality in the Silesia region of the Czech Republic. This review does not present conclusions, but points to the nature of the issue.

The Moravian-Silesian region (MSR) is amongst the most polluted regions in the Czech Republic, as well as in Europe. PM10, ozone, benzo(a)pyrene (B(a)P) , benzene and arsenic ambient concentrations all exceed limit and target values. Indeed, in 2006 all 6 localities in Moravia-Silesia measuring B(a)P recorded concentrations in excess of the target value. Five of seven localities exceeded the target limit value for ground-level ozone.

As well as the highest emission fluxes occurring in heavy industrial cities, the population is concentrated in urban areas. Almost 62 % live in towns of more than 20 000 inhabitants, only about 25 % in settlements under 5 000. Whilst emissions of lead have decreased substantially due to the ban on leaded petrol, other emissions (PAHs, Ni, Cd) have increased (Figure 29), or not changed substantially (tsp, VOC).

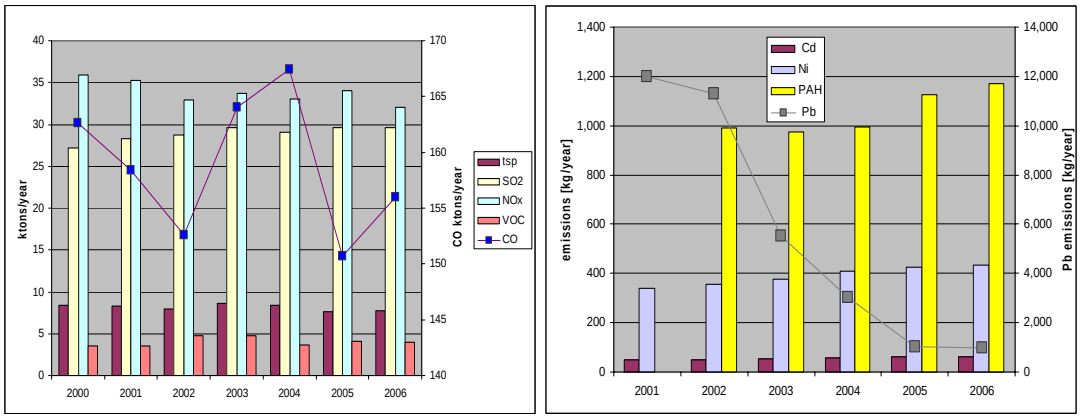

Figure 29 Time evolution of emission of basic pollutants(left)and emissions of Cd, Ni Pb and PAHs(right) since 2000 in the Moravian-Silesian region.

Individual lifetime cancer risk (ILCR) from exposure to the carcinogenic pollutants is higher than $1x10^{-6}$ for current concentrations of arsenic, of benzene and of PAHs. At the WHO unit risk for B(a)P in air (8.7×10^{-5} $(ng/m^3)^{-1}$) the concentrations producing excess lifetime cancer risks of 1/10 000 and 1/100 000 are 1.2 and 0.12 ng/m^3 respectively. Figure 30 would suggest that all urban areas (containing over 60% of the population) exceed the 1/100 000 criteria, and substantial parts of major cities exceed the 1/10,000 risk concentrations. Determination of health impact requires careful statistical assessment at this point. Nevertheless, it is clear that there is a notable risk to the whole population of excess cancers from B(a)P alone, to say nothing of the risks from heavy metals and benzene, alongside the impact of traditional pollutants such as PM.

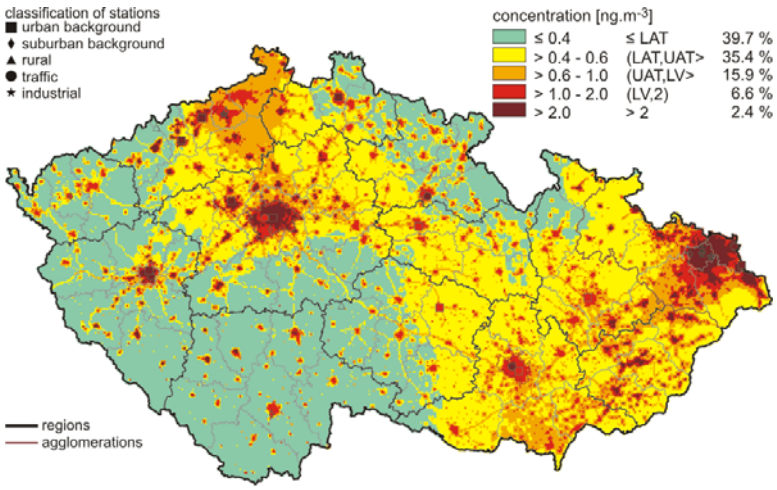

Figure 30 Annual average concentrations of benzo(a)pyrene in ambient air in the Czech republic, year 2006. (CHMI, 2007).

5. Conclusions

- Not for all stations used for compliance checking (listed in the FWD questionnaire) meta-information or (raw) data on the regulated pollutants is available in AirBase. For a proper assessment, a more complete submission to AirBase is needed.
- The descriptive information in AirBase on sampling and analysing methods is incomplete and needs improvement. In particular for the pollutants bound on particulate matter the reference methods as defined in the directives is for many stations not followed by the Member States.
- While preparing this report in a number of cases incorrect or suspicious data has been detected in AirBase. In all cases the data supplier has been contacted and asked for clarification. Corrected data will be included in future releases of AirBase.
- The available air quality information for heavy metals and benzo(a)pyrene (B(a)P) for the EU27 is too scattered or of too low quality to allow exposure estimates to be made. Coverage of carbon monoxide and benzene data is better, but requires further work to move to population exposure estimates.
- Arsenic shows very limited exceedance of air quality criteria. Only 1% of measurement stations exceeded the target value. In central Europe and on the southern North Sea coast the lower assessment threshold may be exceeded. Emissions of arsenic have fallen notably during the 1990's, and are expected to continue to decline through to 2010.
- Cadmium air concentrations are in excess of target values at 4% of locations, all in Romania and Bulgaria. Over 90% of stations across Europe are under the lower assessment threshold. Modelling also points to higher concentrations in Poland. Emissions have declined by 50% since 1990, and further decreases are expected.
- Lead air concentrations have declined considerably with the introduction of unleaded petrol. Some exceedances of the limit value continue in Bulgaria and Romania, but this appears to be a local issue only.
- Nickel air concentrations show limited but widespread exceedance of limit values. Iceland seems to frequently exceed criteria, likely due to geothermal emissions. The southern North Sea between eastern England at the Danish coast of the German Bight also seems to reach the value. Otherwise there is suggestion of exceedance in Spain and Germany. Emissions have declined 40% between 1990 and 2006. A further halving is anticipated in the two decades from 2000.
- Carbon monoxide concentrations exceed the limit value at about 1% of monitoring sites, mostly in south-east Europe. Around 5 million people live in zones exceeding the limit value. Emissions have been declining since 1990.
- Benzene limit values are not exceeded at background sites. A limited number of urban zones spread disparately across Europe are in exceedance, affecting nearly 15 million people. Emissions have been declining sharply since 1990.
- Benzo(a)pyrene target values are exceeded at around one third of monitoring points, both urban and rural background. There is some concentration of impact around central Europe, e.g. 45% of Czech population subject to concentrations above the target value, although zones as far apart as the UK and Greece are also affected. Dramatic declines in emissions have occurred since 1990.

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