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Preliminary assessment of air quality for carbon monoxide and benzene in the Netherlands under EU legislation

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Abstract

Before implementing the second European directive, the member states of the European Union should assess the air quality for carbon monoxide and benzene in their country. Checks against the limit values show no exceedances in the Netherlands in 2000. The concentrations of benzene and carbon monoxide show a downward trend. A further decrease is expected for both components. If the air quality were only determined on the basis of measurements, a total of 15 measurement stations would be compulsory in the Netherlands for carbon monoxide and 19 for benzene. The requirement for carbon monoxide can be met, if the current National Air Quality Monitoring Network (LML) stations are classified differently. For benzene, the current configuration is not sufficient. As the concentrations are expected to decrease further, here has been chosen for a combination of new monitors with additional instruments to assess the air quality.

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Samenvatting

De tweede dochterrichtlijn luchtkwaliteit van de Europese Unie is op 13 december 2000 gepubliceerd en moet uiterlijk 13 december 2002 in de nationale wetgeving zijn geïmplementeerd. De richtlijn heeft betrekking op de stoffen koolmonoxide en benzeen. Voorafgaand aan de implementatie van deze richtlijn dienen de lidstaten van de Europese Unie in een Voorlopige Beoordeling de luchtkwaliteit van deze stoffen in hun land, voor de verschillende zones en agglomeraties, te beoordelen

Toetsing van metingen en gecombineerde gegevens van modellen en metingen aan grenswaarden van koolmonoxide en benzeen, levert geen overschrijdingen op in Nederland.

Weging van de beoordelingsdrempels voor koolmonoxide en benzeen leidt tot een zelfde indeling in regimes voor alle agglomeraties en op één na alle zones. Alleen voor zone Midden is de regimevaststelling voor benzeen strenger dan voor koolmonoxide:

Regime-indeling van de verschillende zones en agglomeraties (1=strengste; 3=laagste). Tussen haakjes wordt het aantal verplichte meetstations (bij metingen als enige informatiebron), dat af hangt van het regime, weergegeven

Zone	Regime (aantal meetpunten)		Agglomeratie	Regime (aantal meetpunten)
	CO	Benzene		CO/Benzene
North	3 (0)	3 (0)	Amsterdam/Haarlem	1 (5)
Middle	3 (0)	2 (4)	Rotterdam/Dordrecht	2 (2)
South	2 (3)	2 (3)	Den Haag/Leiden	2 (2)
			Utrecht	2 (1)
			Eindhoven	2 (1)
			Heerlen/Kerkrade	2 (1)

Als de luchtkwaliteit **alleen** op basis van metingen zou worden vastgesteld zijn er in Nederland in totaal 15 stations nodig voor koolmonoxide en 19 voor benzeen. Inzet van aanvullend instrumentarium om de luchtkwaliteit te beschrijven kan leiden tot een vermindering van het aantal meetstations.

De concentraties van benzeen en koolmonoxide vertonen in de laatste 5 jaar een dalende trend. Voor zowel koolmonoxide als benzeen wordt een verdere daling verwacht. De huidige beoordeling is gebaseerd op gegevens van 2000 en daarvoor om een inschatting te maken van de luchtkwaliteit voor 2003. Worden de verwachte emissietrends doorgetrokken en de regimes daaraan beoordeeld, dan wordt voor 2003 geen verandering in regime-indeling verwacht. Bij de evaluatie van de indeling in zones, agglomeraties en regimes, die binnen vijf jaar moet plaatsvinden, wordt wel een indeling in minder strenge regimes voor zowel koolmonoxide als benzeen verwacht.

Wordt alleen het Landelijk Meetnet Luchtkwaliteit (LML) gebruikt voor metingen dan zal voor koolmonoxide, door een andere rangschikking van de huidige 22 stations, de verplichting voor 15 stations kunnen worden ingevuld. Voor benzeen is de huidige configuratie van 9 stations niet voldoende. Omdat verwacht mag worden dat binnen 5 jaar de regimes reeds minder streng zullen zijn voor benzeen, lijkt het niet zinvol de maximale meetinspanning in te vullen. Met het inrichten van 10 stations in combinatie met passieve monstername en modellering van benzeen, kan aan de informatie-eisen van de EU worden

voldaan. Zonder het gebruik van modellen zijn 9 meetpunten voor passieve monstername nodig.

De concentraties rondom benzinetankstations en parkeergarages worden niet verwacht de bovenste beoordelingsdrempel te overschrijden op plekken waar mensen langdurig zullen verblijven. De concentratieverhoging rondom grote industriële bronnen in Amsterdam-Noord en in het Rijnmondgebied beperkt zich tot industrieel terrein. Blootstelling van de bevolking aan concentraties boven de bovenste beoordelingsdrempel is in deze gevallen niet waarschijnlijk. De luchtkwaliteit kan op deze plekken met modellen in kaart worden gebracht.

Summary

The second daughter directive of the European Union was published on 13 December 2000 and must be implemented in the national legislation by 13 December 2002 at the latest. The directive relates to carbon monoxide and benzene. Before implementing this directive, the member states of the European Union should assess, in a Preliminary Assessment, the air quality for these substances in their own countries for the different zones and agglomerations.

Testing the measurements and a combination of measurements and model results against the limit values of carbon monoxide and benzene revealed no exceedances in the Netherlands in 2000.

Weighting the assessment thresholds for carbon monoxide and benzene leads to the same classification into regimes for all agglomerations and for all but one zone. Only for the Middle zone is the regime assignment for benzene stricter than that for carbon monoxide:

Regime classification of the various zones and agglomerations (1=strictest; 3=lowest). The number of compulsory monitoring stations depending on the regime classification (if measurements are the only information) is given in parentheses.

Zone	Regime (number of monitoring sites)		Agglomeration	Regime (number of monitoring sites)
	CO	Benzene		CO/Benzene
North	3 (0)	3 (0)	Amsterdam/Haarlem	1 (5)
Middle	3 (0)	2 (4)	Rotterdam/Dordrecht	2 (2)
South	2 (3)	2 (3)	The Hague/Leiden	2 (2)
			Utrecht	2 (1)
			Eindhoven	2 (1)
			Heerlen/Kerkrade	2 (1)

If the air quality were **only** determined on the basis of measurements, a total of 15 monitoring stations would be compulsory in the Netherlands for carbon monoxide and 19 for benzene. The use of additional instruments to describe air quality can lead to a decrease in the number of monitoring stations to meet the EU information requirements.

The concentrations of benzene and carbon monoxide have shown a downward trend in the last five years. A further decrease is expected both for carbon monoxide and benzene. The current assessment is based on the data for 2000 and earlier, which will be used for estimating the air quality for 2003. Extrapolating the expected emission trends, and using these trends to assess the regimes, will bring no change in the regime classification expected with the new observations that come available before 2003. Evaluating the division into zones, agglomerations and regimes, which must take place within five years, is expected to yield a classification into less strict regimes for both carbon monoxide and benzene.

If only the National Air Quality Monitoring Network (LML) is used for measurements, then the requirement for 15 stations for carbon monoxide can be met, if the current 22 stations are classified differently. For benzene, the current configuration of nine stations is not sufficient. As the regimes are expected to be less stringent within five years, there is not much point in making the maximum effort to measure benzene . The EU-information requirements for benzene can also be met within the set up of ten stations, combined with additional passive

samplers and model calculations. When no models are used, nine passive-sampler sites are needed.

The concentrations around petrol stations and multi-storey car parks are not expected to exceed the upper assessment threshold in places where people stay for long periods of time. The increased concentration around large industrial sources in Amsterdam-Noord and in the Rijnmond area is limited to industrial areas. Exposure of the population to concentrations above the upper assessment threshold is not likely in these cases. The air quality in these areas can be mapped using models.

1. Introduction

In 1996 the *'Council Directive 96/62/EC for ambient air quality assessment and management'*, known in short as the Framework directive, came into force (EU, 1996). This general directive of the European Union has provided a reference framework for assessing and managing ambient air. It defines targets for preventing harmful effects of air pollutants on human health and the environment. It also gives a list of 13 air pollutants, for which further legislation at European level will need to be developed. This further elaboration takes place in so-called daughter directives.

The first daughter directive for sulphur dioxide (SO_2), nitrogen dioxide (NO_2) and nitrogen oxides (NO_x), particulate matter (PM10) and lead (Pb) came into force in 1999 (EU, 1999). The second daughter directive for carbon monoxide (CO) and benzene (C_6H_6) came into force in 2000 (EU, 2000). In this directive, limit values, margins of tolerance and related assessment values are defined, against which the air quality must be checked. Before the implementation of the directive, the member states are required to give a general description of the air quality of the respective components in the form of a so-called *Preliminary Assessment (PA)*. To make this preliminary assessment use has been made of the report '*Guidance on assessment under the EU Air Quality Directives',* compiled by an EU working group, and the supporting report '*Guidance report on preliminary assessment under EC air quality directives'* (Van Aalst et. al., 1998).

The aim of the preliminary assessment is to determine the extent and the nature of the required assessment instruments, using assessment thresholds and the air quality in zones and agglomerations. Van Breugel and Buijsman (2001) have already made a *Preliminary Assessment* of the first daughter directive. This report describes the results of the preliminary assessment of the air quality for carbon monoxide and benzene in the Netherlands.

Chapter 2 deals with the instruments used to assess the air quality, such as the Dutch National Air Quality Monitoring network (LML) and the models. The examination framework formulated in the second daughter directive is also presented here. Finally, the definitions of zones and agglomerations are given, along with the reasoning behind them.

Chapter 3 gives a global description of the current air quality for carbon monoxide and benzene in the Netherlands. The focus here is on the air pollution levels in relation to the limit values according to the second daughter directive. The measured and modelled air pollutant levels are also compared to the upper and lower assessment values from the second daughter directive.

In Chapter 4, the division into zones and agglomerations, along with testing the air quality against assessment thresholds, is used to determine the EU requirements for future test instruments. Possible consequences for future monitoring strategies are also dealt with.

Chapter 5 closes the report with discussion and conclusions.

2. Data and methods

2.1 Measurements

The Dutch National Air Quality Monitoring network (LML) is the national infrastructure for monitoring the air quality in the Netherlands. The LML consists of 54 stations, characterised according to location and environmental characteristics (Van Elzakker, 2001):

- *Regional stations*: monitoring stations, situated outside built-up areas and positioned to avoid the influence of local sources.
- *City stations*: placed in urban areas, so that the number of passing vehicles within a radius of 35 m of the station is less than 2750 per 24 hours (Anonymous, 1987; Eerens et al., 1993).
- *Street stations*: located in urban areas, so that the number of passing vehicles within a radius of 35 m of the station is at least 10,000 every 24 hours (Anonymous, 1987; Eerens et al., 1993).

The current number of stations for the components - carbon monoxide and benzene- are given in Van Elzakker (2001) (Table 2.1). The implementation of the first and second daughter directives will lead to changes in the monitoring network.

All monitoring stations are connected to the Computer Information System for Air (RIL), where all measurement data from the LML are stored. The air quality measurements reported here all originate from the RIL, unless stated otherwise.

Table 2.1. Measurement stations for carbon monoxide and benzene in the Dutch National Air Quality Monitoring Network, 2001 (Van Elzakker, 2001), categorised by the type of station.

Component	Regional	City	Street	Total
		Number of stations		
Carbon monoxide (CO)	6	4	12	22
Benzene (C_6H_6)	4	1	4	9

2.2 Models

OPS

The Operational Priority Components (OPS) model is an atmospheric-chemical transport model. The model uses as input, data on emissions, chimney heights, and where possible the heat content and meteorological data. The model can calculate time-averaged concentrations and depositions on a national or smaller scale. A detailed description of the model can be found in Van Jaarsveld (1989) and Van Jaarsveld (1995). The uncertainty in the concentrations calculated by the model is 15% for a specific year, and 10% for the long term. Validation of individual sources is limited due to the lack of data.

CAR

The acronym CAR stands for Calculation of Air pollution by Road traffic. The model assumes that concentrations at kerbside are composed of: 1. the regional background concentration; 2. the contribution from the city and 3. the traffic emissions from the street. The regional background is determined from measurements at regional stations in the LML. The city contribution is calculated from the virtual diameter of the city and a mean concentration increase (relative to the regional background per km of buildings). The traffic emissions are calculated from the number and type of vehicles per 24 hours, the mean speed and emission factors. The CAR model is calibrated yearly due to influences of meteorological circumstances on concentrations in the street and dynamics in the emission factors. A database with information on traffic density and other parameters relevant for the emission at local authority level is used for application of the model on a national scale Calculations on an individual stretch of road have shown an uncertainty of approximately 20% for yearly mean concentrations. Maximum 8-hour mean values such as those for carbon monoxide, are by definition more variable and therefore more uncertain. Obviously, the uncertainty in the input data (such as traffic intensities and emission factors) may increase the uncertainty in the end result. See Eerens et al. (1993) for a more comprehensive description of the model.

2.3 Examination framework

Limit values and margins of tolerance

The second daughter directive provides an examination framework for assessing air quality. A number of limit values are defined (Table 2.2*)*. Just as for the first daughter directive, the legislation for the second daughter directive defines the so-called 'margins of tolerance'. The margin of tolerance is the percentage of the limit value, which decreases with time, by which this limit value may be exceeded, pending the results of the air quality improvement measures (EU, 1996; Table 2.3). The margin of tolerance is somewhat comparable to the 'Exception limit value in busy traffic situations' used until recently in the Dutch legislation.

Table 2.2. Overview of limit values according to the second daughter directive (EU, 2000).

Component	Aim[1]	Unit	Limit value	Measuring period	Starting date
Carbon monoxide (CO)	H	mg/m^3	10	8 hour	1 January 2005
Benzene (C_6H_6)	H	µg/m^3	5	year	1 January 2010

[1] H: aimed at the protection of human health.

Table 2.3 Margins of tolerance of limit values according to the second daughter directive (EU, 2000).

Component	Limit value	Measuring period	Margin of tolerance
Carbon monoxide	10 mg/m³ CO	8 hour	6 mg/m^3 (60%) on 13 December 2000. On 1 January 2003 and thereafter every 12 months, decreasing by 2 mg/m^3 per year so that 0 is reached on 1 January 2005.
Benzene	5 µg/m³ benzene	year	5 µg/m^3 (100%) on 13 December 2000. On 1 January 2006 and thereafter every 12 months, decreasing by 1 µg/m^3 per year so that 0 is reached on 1 January 2010.

Assessment thresholds

Under the framework directive and the second daughter directive, the amount of effort required to determine the air quality decreases as the concentrations continue to drop under the limit values. For this purpose, two so-called assessment thresholds, the lower and the upper, have been defined in the daughter directive for every component. The corresponding values differ per component, and are defined as percentages of the limit values for the component in question. The assessment thresholds are designed to aid in the air quality assessment strategy. Three situations can be distinguished (Figure 2.1):

- *The concentration exceeds the upper assessment threshold*[1] *(Regime 1)*. Measurements are always compulsory in this situation. If measurements are the only instruments to assess the air quality in this case, a certain minimum number of monitoring stations will be required per zone or agglomeration. This minimum number is determined by the number of inhabitants or, in the case of a limit value for the protection of ecosystems, by the surface area. Furthermore, in addition to measurements, other instruments may always be used to describe the air quality. The previously mentioned requirement for the minimum number of monitoring stations is then no longer valid. However, certain quality criteria have been set down for the instruments to be used (Van Aalst et al., 1998).
- *The concentration is found between the lower and the upper assessment thresholds (Regime 2).* Measurements should be use, but in combination with models if required. No further requirements are given for the number of monitoring stations and the accuracy of the instruments to be used.
- *The concentration is below the lowest assessment threshold (Regime 3).* Measurements are not compulsory under these circumstances. The air quality can be described using models or objective estimates.

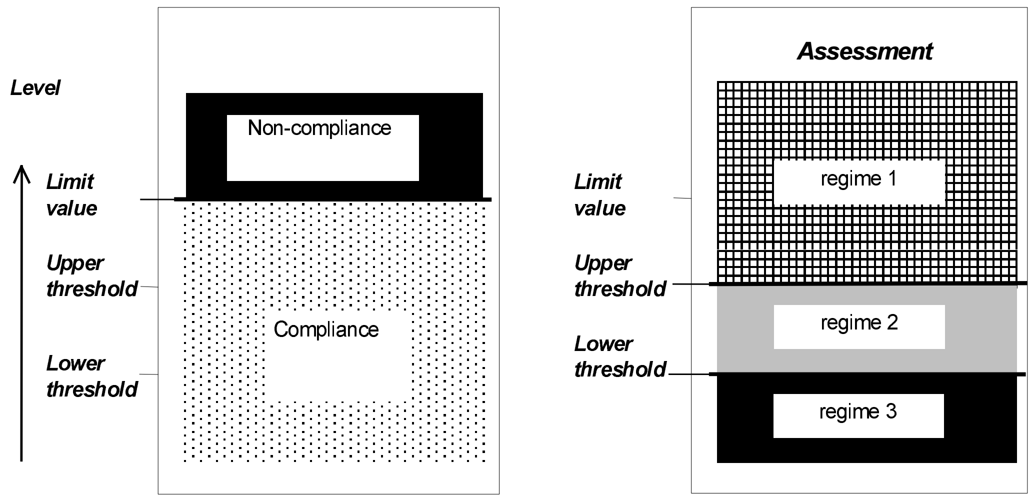

Figure 2.1 Implication of exceeding the limit value, the upper and lower assessment thresholds and the resulting assessment method (adapted freely from Van Aalst et al., 1998).

It is important to note that exceedance of a threshold value in an area does not mean that the air quality in that entire area is poor. Though the upper threshold is exceeded, it is possible

[1] This includes the situation in which the concentration exceeds the limit value.

that the European limit values are still complied with (see Figure 2.1). Furthermore, an area must be characterised by the *highest* concentration recorded in the relevant area. As a guideline, the determined concentration should be representative of air quality in a surrounding area of no less than 200 m^2 at traffic-orientated sites, and of several square kilometres at urban-background sites (EU, 2000). The assessment method for an area should be determined in relation to the values for the lower and upper assessment thresholds, as given in the second daughter directive (Table 2.4).

Table 2.4 Limit values and related upper and lower assessment thresholds (EU, 2000).

Component	Nature of the limit value	Unit	Limit value	Upper assessment threshold	Lower assessment threshold
Carbon monoxide (CO)	8-hour mean protection of human health	mg CO/m^3	10	7	5
Benzene (C_6H_6)	Yearly mean protection of human health	µg C_6H_6/m^3	5	3.5	2

The examination of assessment thresholds must be determined on the basis of concentrations during the previous five years provided sufficient data are available. In this case, an assessment threshold deems to have been exceeded if it exceedance took place in the course of at least three separate years out of the preceding five years. The concentration of carbon monoxide should be determined at the pavement (within five metres from the edge of the road), whereas the benzene concentrations at the outer wall should be determined such that it represents the concentration at the building line (EU, 2000).

2.4 Zones and agglomerations

The air quality in a country must be described using zones and agglomerations. The classification into zones and agglomerations is then used as a tool to arrive at a description of the air quality for the whole area, with an eye to both the spatial variability and generalisations. The Netherlands was classified into zones and agglomerations in the preliminary assessment for the first daughter directive (Van Breugel and Buijsman, 2001).

This classification, together with information about the air quality, contribute to determining the future strategy for air quality. The extent of the monitoring effort for diffuse sources for carbon monoxide and benzene depends on the number of inhabitants in a zone or agglomeration (Table 2.5). For the assessment of pollution in the vicinity of point sources, the number of sampling points for fixed measurements should be calculated taking into account emission densities, the likely distribution patterns of ambient air pollution, and potential exposure of the population (EU, 2000).

Table 2.5 Minimum number of monitoring sites in zones and agglomerations using measurements as the only source of information (EU, 2000)

Number of inhabitants in the zone/agglomeration	Concentration above the upper assessment level[2]	Concentration between the upper and lower assessment levels
x 1000	Number of monitoring sites	
0-250	1	1
250-499	2	1
500-749	2	1
750-999	3	1
1000-1499	4	2
1500-1999	5	2
2000-2749	6	3
2750-3749	7	3
3750-4749	8	4
4750-5999	9	4
≥6000	10	5

The following criteria have been used when determining the number and the boundaries of the zones and agglomerations in the Netherlands:

- Borders are taken as the area boundaries used by local air quality management, the authorities responsible for taking measures against exceedances of air quality standards in their areas.
- Adjoining areas with similar air quality should preferably be combined, since the measures will only be effective if they are co-ordinated. Dependency in air quality between areas can play a role if there is a substantial impact on local air quality across area boundaries due to dispersion, or if areas have the same source characteristics and/or densities.
- The different limit values and assessment thresholds of substances in the EU daughter directives should be considered collectively to arrive at a zone classification. This

[2] To include at least one urban-background station and one traffic-oriented station provided this does not lead to an increase in the number of sampling points

enhances the possibility of obtaining a clear, overall picture of the air quality, and increases the efficiency of the reporting by reducing the number of zones.
- The choices are not determined by scientific considerations alone. The definition of zones and agglomerations must be as practical and as workable as possible.

A global view of the air quality in non-urban areas shows the levels of carbon monoxide to be the lowest in the north and highest in the south. For benzene, the concentrations are lowest in the north, the east and in Zeeland, and are highest in the middle and the south. This information, together with the criteria mentioned above, is the reason for dividing the Netherlands up into the same three zones, North, Middle and South, as for the preliminary assessment in the first daughter directive (Table 2.6).

Table 2.6 Zones in the Netherlands (CBS, 2001).

No.	Zone	Provinces	Number of inhabitants[1]
			x 1000
1	North	Groningen, Friesland, Drenthe, Overijssel, Flevoland	3087
2	Middle	Gelderland, Utrecht, Noord-Holland, Zuid-Holland	4756
3	South	Limburg, Noord-Brabant, Zeeland	3230

[1] The inhabitants of agglomerations are not included in the number of inhabitants for the zones; see Table 2.7.

The basis for arriving at the number and location of the agglomerations is the spatial distribution of the population density on a scale of 1×1 km². A connected area with a population density above 750 inhabitants per km² is nominated as an agglomeration if the total number of inhabitants in that area is in excess of 250,000. For the Netherlands, this results in six agglomerations (Table 2.7, Figure 2.3).

There are just less than 250,000 inhabitants in Heerlen/Kerkrade. Here, it was decided to define Heerlen/Kerkrade as an agglomeration on the basis of location (in a cross-border urban area) and demographic developments.

The Netherlands has a high population density with many urban areas situated on land with a relatively small surface area. Besides the already defined agglomerations (Table 2.7), there are also other urban areas in the zones (Figure 2.3). This calls for a subtle approach when describing the air quality in the zones: in the first place, an assessment of the air quality in the regional part of the zone (the largest surface area). In the second place, an assessment of the air quality in the urban parts of the zone, the air quality might be assessed lower for some components due to the presence of local sources. Explicit attention should be paid to these areas, in conformance with the EU directive due to the large number of people living in the urban areas.

Table 2.7 Agglomerations in the Netherlands (CBS, 2001).

No.	City centre	Surrounding municipalities	Number of inhabitants
			x 1000
1	Amsterdam/ Haarlem	Amsterdam, Aalsmeer, Amstelveen, Uithoorn, Ouder Amstel, Diemen, Zaanstad, Heemskerk, Beverwijk, Velsen, Haarlem, Bloemendaal, Zandvoort, Heemstede, Bennebroek, Haarlemmerliede and Haarlemmermeer	1505
2	Rotterdam/ Dordrecht	Rotterdam, Schiedam, Vlaardingen, Maassluis, Rozenburg, Spijkenisse, Albrandswaard, Capelle a/d IJssel, Ridderkerk, Barendrecht, Heerjansdam, Zwijndrecht, Hendrik-ido-Ambacht, Dordrecht, Papendrecht and Sliedrecht	1265
3	The Hague/ Leiden	The Hague, Monster, s'Gravenzande, Naaldwijk, De Lier, Maasland, Schipluiden, Wateringen, Delft, Rijswijk, Voorburg, Leidschendam, Wassenaar, Voorschoten, Leiden, Oegstgeest, Katwijk, Valkenburg, Rijnsburg and Leiderdorp	1056
4	Utrecht	Utrecht, Houten, Nieuwegein, IJsselstein and Maarssen	426
5	Eindhoven	Eindhoven, Best, Veldhoven, Geldrop, Mierlo, Nuenen and Helmond	416
6	Heerlen/ Kerkrade	Heerlen, Kerkrade, Landgraaf, Brunssum, Voerendaal and Nuth	247

Figure 2.2 Zones and agglomerations in the Netherlands.

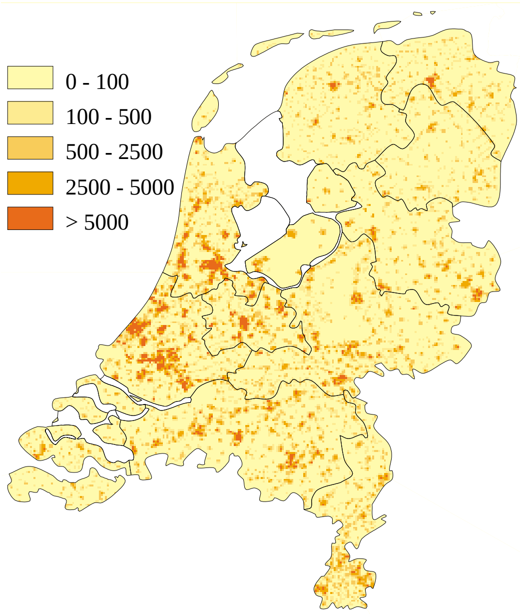

Figure 2.3 Population density in the Netherlands as the number of inhabitants per km² (CBS, 2000)

3. Results

A combination of measurements and model results are used in this report to give a general picture of the air quality in the Netherlands. Measurements, in the form of maximum 8-hour mean values for carbon monoxide and yearly means for benzene, are shown for the year 2000. The reference year is given for the model calculations. Concentrations of the components in this preliminary assessment are also checked against the European limit values. The air quality objectives formulated in the daughter directive sometimes deviate from the parameters used up to now in the Netherlands to describe the air quality. The air quality will, as far as possible, be described in this chapter in such a way as to provide insight into the relationship between the air quality in the Netherlands and the objectives in the daughter directive. In addition, the different concentration levels in the Netherlands will be checked on a regional scale against the defined upper and lower threshold levels. Where possible, measurements have been used for this purpose from a five-year time period, from 1996 to 2000. The checking of the assessment thresholds is used as a starting point to establish the strategy for determining the air quality in the Netherlands in Chapter 4.

3.1 Carbon monoxide

3.1.1 Air quality and checking against the standards

The carbon monoxide concentration in the Netherlands is showing a downward trend. Both the national average and the concentrations in the streets are decreasing. Emission-reducing measures in industry and the introduction of the catalytic converter in road traffic (European standards) have both contributed. The average across the Netherlands of the 8-hour maximum mean concentration was 1.2 mg/m^3 in 2000 (RIVM, 2002). The background concentrations are the lowest in the north and the highest in the south. Local increases occur along busy roads in urban areas, particularly in the large cities in the Randstad. No exceedances of the 10 mg/m^3 were detected in 2000.

In the coming years, emissions from cars and lorries will further decrease due to a tightening up of the existing euro standards and the introduction of new ones. This will result in a further decrease in the concentrations of CO.

From calculations using CAR-VMK (Table 3.1), it seems that the highest concentrations seem to occur in Amsterdam and Rotterdam. The calculated concentrations here are found below the standard. No calculations have been done for the Hague, but the concentrations are expected to be lower, as it is situated close to the sea. In Eindhoven, Arnhem, Haarlem, Venlo, Breda and Den Bosch, the maximum levels are lower still, and therefore comfortably under the standard.

Estimates for 2000 calculated using CAR-VMK are found below the lower assessment thresholds in Apeldoorn, but above those in Eindhoven. This is in agreement with the highest measurement values from the LML in these cities. In Haarlem, the measured value lies just under the calculated value of CAR-VMK.

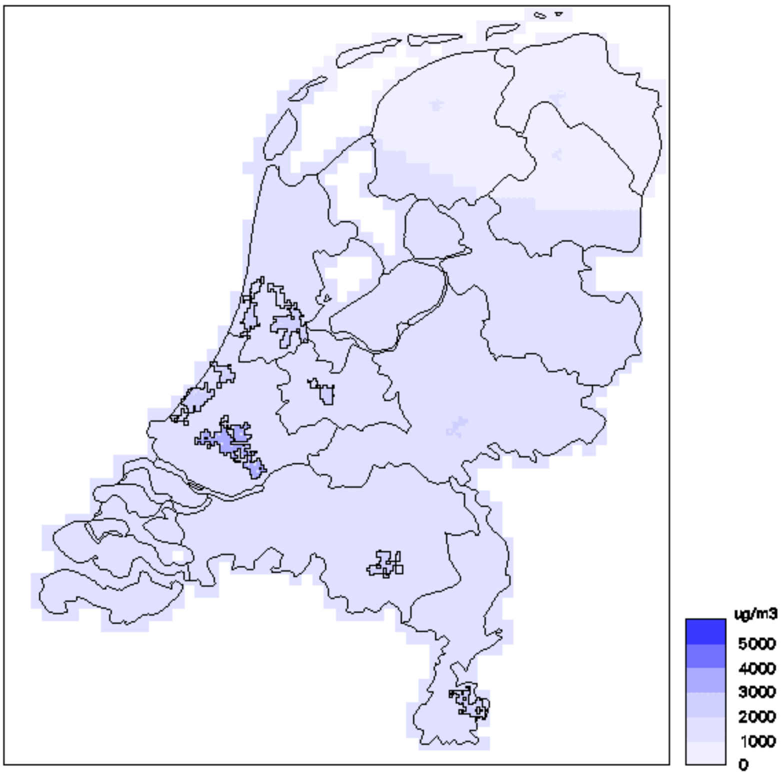

Figure 3.1 Spatial distribution of the maximum 8-hour mean carbon monoxide concentration, based on measurements for 2000.

3.1.2 Checking against assessment thresholds

Measurements
The measurement data of carbon monoxide from the period 1996-2000 were checked against the lower and upper assessment thresholds for the maximum of the 8-hour mean concentration per calendar year (5 and 7 mg/m^3). An assessment threshold is deemed to have been exceeded if exceedance occurred in the course of at least three separate years out of the preceding five years. As the standard is formulated for health protection purposes, the type of station has no influence on the test.

For CO, lower assessment thresholds are not exceeded at any of the regional stations. At city stations, only two exceedances of the lower assessment threshold were observed, namely in Amsterdam. At street stations in Eindhoven, one was found to have exceeded the lower assessment threshold four times. Another street station registered three exceedances of the lower assessment threshold. The street station in Haarlem registered three exceedances of the lower standard, while in Utrecht one station measured four exceedances of the lower assessment threshold and another three exceedances. In Apeldoorn, the limit allowed for the lower assessment threshold was not exceeded. No street measurements were available for Amsterdam, Rotterdam and The Hague. On the basis of size of the agglomeration, these cities would be expected to have the highest concentrations.

Table 3.1 Length of traffic roads (in km) and indication of the concentration at the outer wall (+=inside interval;0=outside interval) of residences in Dutch cities with the related class for the maximum value of the 8-hour mean in 2000. Calculations using CAR-VMK in 98 percentiles are converted to maximum values of the 8-hour mean with a linear regression relation. Green: values in regime 3; Yellow: values in regime 2; Red: values in regime 1.

Concentration interval (mg/m^3 CO)	<5		5-7		7-10		>10	
	Road (km)	Outer wall	Road (km)	Outer wall	Road (km)	Outer wall	Road (km)	Outer wall
Alphen a/d Rijn	**64**	+	0	0	0	0	0	0
Amersfoort	**57**	+	0	0	0	0	0	0
Amsterdam	**351**	+	**45**	+	**3**	+	0	0
Apeldoorn	**139**	+	0	0	0	0	0	0
Arnhem	**152**	+	0	0	0	0	0	0
Breda	**56**	+	**1**	0	0	0	0	0
Den Bosch	**186**	+	**3**	0	0	0	0	0
Dordrecht	**140**	+	0	0	0	0	0	0
Ede	**66**	+	0	0	0	0	0	0
Eindhoven	**139**	+	**1**	0	0	0	0	0
Gouda	**66**	+	0	0	0	0	0	0
Haarlem	**126**	+	**2**	+	0	0	0	0
Haarlemmermeer	**116**	+	0	0	0	0	0	0
Hengelo	**38**	+	0	0	0	0	0	0
Hilversum	**47**	+	0	0	0	0	0	0
Hoorn	**19**	+	0	0	0	0	0	0
Maastricht	**136**	+	0	0	0	0	0	0
Purmerend	**44**	+	0	0	0	0	0	0
Roosendaal	**52**	+	0	0	0	0	0	0
Rotterdam	**490**	+	**8**	+	0	0	0	0
Spijkenisse	**33**	+	0	0	0	0	0	0
Venlo	**84**	+	**2**	0	0	0	0	0
Zaanstad	**169**	+	0	0	0	0	0	0

Available for Amsterdam is the 98th percentile of the 8-hour-mean values for streets from 1994 and 1995. The highest values were around 4.0-4.8 mg/m^3, which is in agreement with 9.5-11.5 mg/m^3 as the maximum of the 8-hour mean value. If the downward trend from the street stations is extrapolated to these values (-5% per year), this produces values which, up to and including 2000, are found above the upper assessment threshold.

Model outcomes

From calculations using CAR-VMK (Table 3.1) the highest concentrations appear to occur in Amsterdam and Rotterdam. Only in Amsterdam are the calculated concentrations above the upper assessment threshold. No calculations have been done for The Hague, but it is expected that its situation close to the sea will mean that the concentrations will be lower than in Rotterdam. The concentrations will lie between the upper and lower assessment thresholds. In Eindhoven, Haarlem, Venlo, Breda and Den Bosch, the highest values are also found between the upper and lower assessment thresholds. For a large agglomeration such as Heerlen/Kerkrade, the maximum concentrations are expected to be between those from Eindhoven and Venlo/Den Bosch, and are therefore between the lower and upper assessment threshold.

In large cities to the east and the north of the Randstad, such as Hengelo, Amersfoort and Apeldoorn, the concentrations lie under the lower assessment threshold. None of the large cities in the north are expected to be above the lower assessment threshold, considering the background concentration decreases as one goes north, and the largest cities in the north are not substantially larger than the cities mentioned above.

3.2 Benzene

3.2.1 Air quality and checking against the standards

The spatial picture of the Netherlands for 2000 is based on a combination of measurements and model calculations. Here, background concentrations and concentration increases due to large point sources are calculated separately and are added together to come to a complete spatial picture of the Netherlands. Background concentrations were calculated using emissions from diffuse sources in 1995, and then scaled using the 2000 measurements at three regional stations. Increases due to industrial point sources are calculated using data on large industrial point sources over 1998 from the commission registration (approx. ⅔ (≈0.2 Kton) of the total industrial point-source emissions in the country). The total benzene emission is about 6 Kton in the Netherlands for 2000 (RIVM, 2001). Other point sources are calculated with 1995 emissions scaled according the national 1995-2000-emission trend.

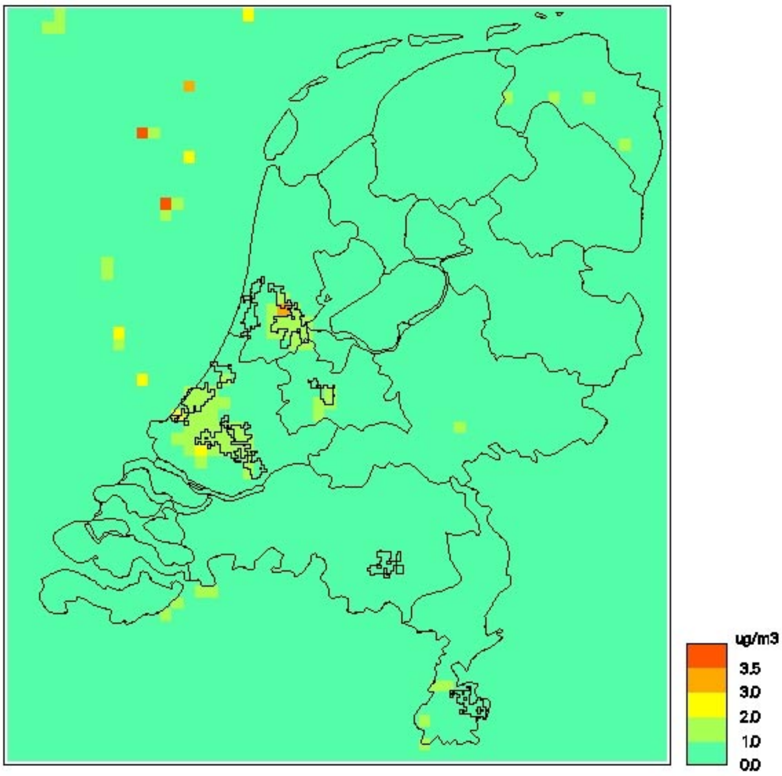

Figure 3.2 Spatial distribution of yearly mean benzene concentrations, based on measurements and calculations using OPS, for 2000.

Results for 2000 show no exceedances for the yearly mean of the background concentrations (Figure 3.2) in the Netherlands. Increased values appear mainly in urban areas in the Randstad (in decreasing order of concentrations: Amsterdam, Rotterdam, The Hague and Utrecht). The highest background values occur due to large point sources in the port of Amsterdam (storage and transfer of fuels) and in the Rijnmond area (chemical industry). The figure also shows the large local contribution of the oil and gas extraction from the North Sea.

The yearly mean benzene concentration shows a downward trend, which is the strongest at street stations (Figure 3.3). The concentration at street stations has halved in the last four years. This striking fall is the result of the introduction of the regulated three-way catalytic converter, technical improvements in cars, and the reduction of the benzene levels in petrol. As of 1 January 2000, the standard for the benzene level in petrol was reduced from 5 to 1% (Staatsblad, 1999). The mean benzene level in the nineties was 2-2.5%. According to spot

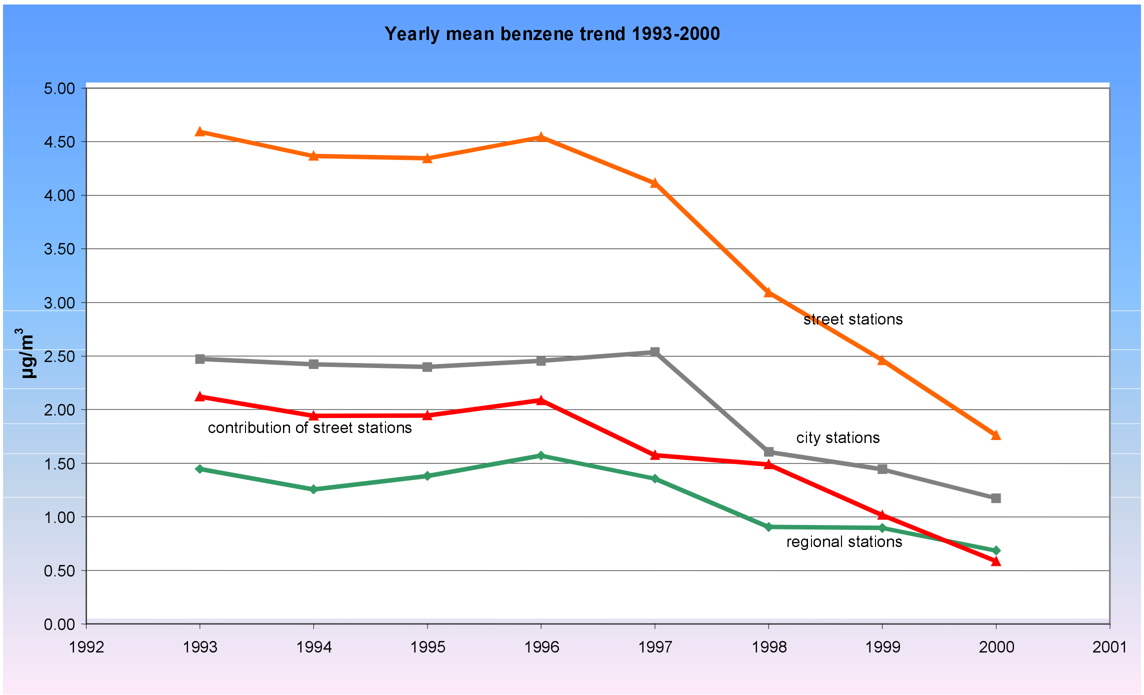

Figure 3.3 Yearly mean benzene trend 1993-2000.

checks by the Inspectorate for the Environment, the benzene level had already conformed to this new standard in October 1999.

From calculations using CAR-VMK (worked out with measurements), the highest concentrations seem to occur in Amsterdam and Rotterdam (Table 3.2). The calculated concentrations here are below the standard. Although no calculations have been done for The Hague, concentrations are expected to be lower as it is situated close to the sea. In cities such as Eindhoven, Arnhem, Haarlem, Venlo, Breda and Den Bosch, the maximum levels are lower still, and are therefore comfortably under the standard.

Table 3.2 Length of traffic roads (in km) and an indication of concentration at the outer wall (+=inside interval;0=outside interval) of residences in Dutch cities, with the related class for yearly mean benzene concentration in 2000..

Concentration interval (µg/m³ benzene)*	<2		2-3.5		3.5-5		>5	
	Road (km)	Outer wall	Road (km)	Outer wall	Road (km)	Outer wall	Road (km)	Outer wall
Alphen a/d Rijn	**64**	+	0	0	0	0	0	0
Amersfoort	**57**	+	0	0	0	0	0	0
Amsterdam	**345**	+	**52**	+	**3**	+	0	0
Apeldoorn	**139**	+	0	0	0	0	0	0
Arnhem	**150**	+	**2**	+	0	0	0	0
Breda	**53**	+	**4**	+	0	0	0	0
Den Bosch	**185**	+	**4**	0	0	0	0	0
Dordrecht	**140**	+	**1**	0	0	0	0	0
Ede	**66**	+	0	0	0	0	0	0
Eindhoven	**137**	+	**3**	+	0	0	0	0
Gouda	**65**	+	**1**	0	0	0	0	0
Haarlem	**124**	+	**4**	+	0	0	0	0
Haarlemmermeer	**116**	+	0	0	0	0	0	0
Hengelo	**37**	+	**1**	0	0	0	0	0
Hilversum	**47**	+	0	0	0	0	0	0
Hoorn	**19**	+	0	0	0	0	0	0
Maastricht	**135**	+	**1**	+	0	0	0	0
Purmerend	**44**	+	0	0	0	0	0	0
Roosendaal	**52**	+	0	0	0	0	0	0
Rotterdam	**487**	+	**11**	+	0	0	0	0
Spijkenisse	**33**	+	0	0	0	0	0	0
Venlo	**82**	+	**4**	+	0	0	0	0
Zaanstad	**168**	+	0	0	0	0	0	0

* Calculations using CAR-VMK scaled to measurements

Point sources

Large sources of benzene emissions are represented by storage and transfer of oil products, the chemical industrial plants, refineries, and oil and gas extraction. The standards can, in principle, be exceeded in living areas in the vicinity of such sources.
Figure 3.2 shows that in Amsterdam-Noord and the Rijnmond area concentrations of benzene are increased. Detailed calculations have been made for point sources in Amsterdam and Rotterdam for the situation in 2000 using OPS.

There is a local increase in the benzene concentration in the port of Amsterdam, mainly due to the storage and transfer of fuels (Figure 3.4). However, this increase is limited to the industrial port area, so that there is no question of the population being exposed.

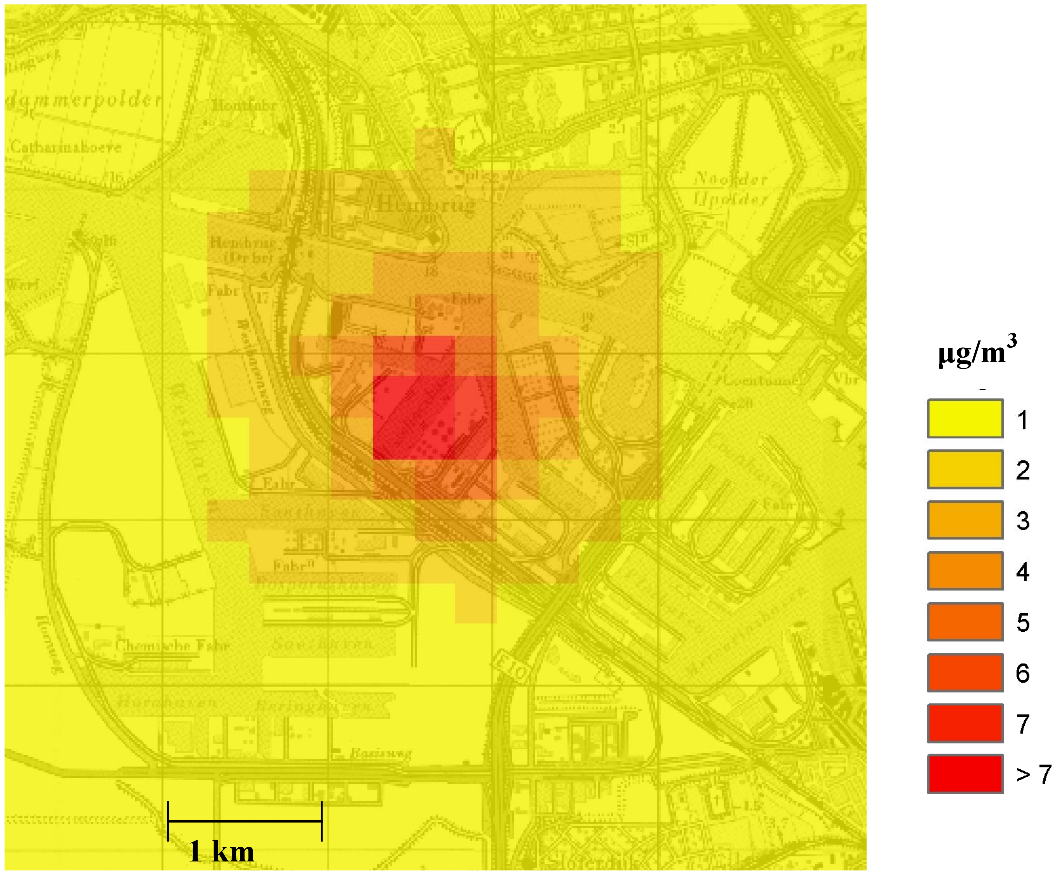

Figure 3.4 Yearly mean benzene concentration in the port area of Amsterdam in 2000.

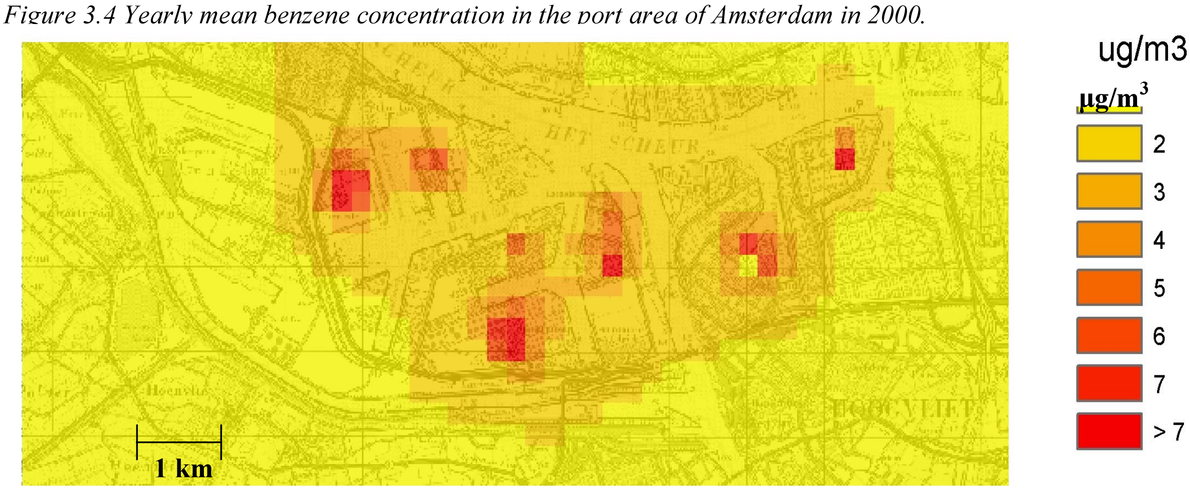

Figure 3.5 Yearly mean benzene concentration around point sources in the Rijnmond area in 2000.

In the Rijnmond area, there are also a number of local increases due to point sources, namely the chemical plants (Figure 3.5). Here too, the increase is limited to industrial areas, and there is no question of the population being exposed.

Measurements at the Schiedam and Hoogvliet DCMR stations of DCMR show a 20% higher concentration than the calculations using OPS. This can partly be explained by the location of both stations close to a motorway. Since the contribution of the motorway (diffuse source) is divided over an entire grid cell in the calculations (5000 x 5000 m), the contribution at the monitoring location is too small. The LML station in Maassluis agrees well with the calculated value.

Petrol stations and multi-storey car parks

Specific local sources of increased benzene concentrations are, in addition to busy roads, petrol stations and multi-storey car parks. Any exceedances of the standard will only occur on an extremely limited scale, at a distance of a few metres from these sources. In such cases, margins of tolerance will depend on the specific characteristics of the source. To make an estimate of the situation, a few characteristic ones are assumed, as there is no complete picture of the individual sources.

There are no recent measurements for concentrations around petrol stations. The situation around petrol stations in the Netherlands was last investigated by the RIVM using measurements in 1987 (Van den Anker, 1988). The concentrations are the highest downwind at a 15-m distance from the source at approximately 7 to 50 $\mu g/m^3$, with a mean of approximately 25 $\mu g/m^3$. This distance is representative for a surface area of approximately 200 m^2. A surface area of 200 m^2 is the minimum area to which the European legislation applies. CONCAWE reports measured concentrations of 1 to 94 $\mu g/m^3$ at the edge of petrol stations in Europe (CONCAWE, 1994). The mean concentration is 26 $\mu g/m^3$ at the downwind edge of the petrol stations, which is equivalent to a distance of between 5 and 10 m from the source. For a distance of 15 m downwind, this will be approximately 10 to 15 $\mu g/m^3$. The lower concentrations from the CONCAWE report will be partly the result of the technical progress between 1987 and 1994. It should be remembered that the petrol stations in southern Europe are also considered in this European-wide study, where temperatures are higher and benzene evaporates more quickly, so that they will have a higher emission than in the Dutch situation.

Since then, the concentrations of benzene in petrol have more than halved (in the Netherlands from 2.5-2% at the start of the 1990s to less than 1% in 1999). Dutch petrol stations with a throughput of more than 500 m^3 per year will also have had to install a vapour return system, with stage I (petrol station supply) and stage II (filling up vehicles), by 1 July 1999 at the latest (Staatsblad, 1996). This means a further drop in the emission of minimally 80% when filling up cars, and an almost complete emission reduction during stocking up at the petrol station. Based on this introduction of vapour return systems and the lowering of the benzene level since 1994, the emission reduction will be more than 90%, with a contribution to concentrations downwind at 15 m of approximately 1 $\mu g/m^3$ on average. At larger petrol stations, this contribution can rise to approximately 3 $\mu g/m^3$. The increase is limited to a short distance and does not reach the residential areas. Large petrol stations are usually situated along the motorways. This makes it unlikely that the situation around petrol stations in cities, with an urban background concentration of approximately 1 $\mu g/m^3$, will regularly lead to exceedances of the upper assessment threshold.

According to a study from 1995, concentration increases of 5 to 10 μg/m^3 will occur around multi-storey car parks, at a 1-m distance from the outer wall, based on some characteristic types of multi-storey car parks (Den Boeft and Thijsse, 1996). For a multi-storey car park open on one side, a distance of 2 m is considered the minimum representative distance for 200 m^2. The concentration increase in this case is approximately 5 μg/m^3 for estimates from 1996. In practice, however, it seems unlikely that people will stay for any length of time at locations that are so close to the car-park wall. A distance of 5 m from an open multi-storey car-park outer wall can be assumed as the minimum for long-term stays. This distance is also representative for a surface area of approximately 200 m^2. According to the 1996 report, the concentrations at this distance are around 2 μg/m^3.

Since the publication of this report , the level of benzene in petrol has more than halved. Other technical measures, such as the further enforcement of the regulated three-way catalytic converter and the introduction of the carbon canister, will also have been responsible for the approximate halving of the emissions in multi-storey car parks (TNO 2001, oral statement). It is expected that benzene concentrations have currently risen by approximately 0.5 μg/m^3 at a distance of 5 m from the outer wall of the car parks considered here. It is therefore unlikely that the multi-storey car parks in cities will lead to exceedances of the upper assessment threshold at locations where people are present for long periods of time.

3.2.2 Checking assessment thresholds

Measurements

The measurement data of benzene from the 1996-2000 period was checked against the lower and upper assessment thresholds of the limit values for the yearly mean (2 and 3.5 μg/m^3). An assessment threshold is deemed to have been exceeded if exceedance had taken place in at least three separate years out of the preceding five years. Since the standard is formulated for health protection purposes, the type of station has no influence on the test.

Of the non-urban stations only Maassluis, situated close to large industrial plants, exceeded the lower assessment threshold for one year, while two exceedances are permitted. For the LML in Utrecht, the only complete available measurement series for 1996-2000 is for the city background. The measured concentration in Utrecht is below the lowest assessment threshold. For two stations in the agglomeration Rotterdam/Dordrecht there is only data from 1995 and 1996. During these years there was an exceedance of the lower assessment threshold. From 1996 to 2000 an obvious downward trend of approximately 9% per year can be observed at the regional monitoring stations. The same fall is assumed to have occurred in the urban contribution, and it is not likely that the series would have continued with three or more exceedances up to 2000. For the non-LML stations, all three monitoring sites of DCMR in the Rijnmond area, situated close to large industrial plants, show a fivefold exceedance of the lower assessment threshold.

Two street stations in Utrecht show four exceedances of the lower assessment threshold. The street station in Apeldoorn also shows four exceedances of the lower assessment threshold. If the measurement value from 1996 in Eindhoven were to follow the trend of other street stations (60% reduction 1996-2000), Eindhoven would, on the basis of this series, have exceeded the lower assessment threshold.

Of the non-LML stations, two OMEGAM street stations in Amsterdam show three exceedances of the upper assessment threshold for 1996-1998. As the measurement series was not continued after 1998, no hard conclusions can be drawn for 1999 and 2000. If the trend of the four previous measurement years were continued, this would also result in values above the upper assessment threshold for 1999 and 2000. Apart from the concentrations for 1999 and 2000, this series also shows the upper assessment threshold to be exceeded.

Model

From calculations using CAR-VMK, the highest concentrations seem to occur in Amsterdam and Rotterdam (Table 3.2). The calculated concentrations here are found above the upper assessment threshold at outer walls. No calculations have been done for The Hague, but it is expected that its location, close to the sea, will mean that the concentrations will be lower than in Rotterdam. The concentrations will, at most, be found between the upper and lower assessment thresholds. In Eindhoven, Arnhem, Breda and Venlo, the highest values are also between the upper and lower assessment thresholds at outer walls. For a large agglomeration such as Heerlen/Kerkrade, the maximum concentrations are expected between Eindhoven and Venlo/Den Bosch. Maximum concentrations in Heerlen/Kerkrade will be between the lower and upper assessment thresholds.

In large cities, to the east and the north of the Randstad, such as Amersfoort and Apeldoorn, the calculated concentrations are found under the lower assessment threshold. Only Hengelo has of road concentrations above the lower assessment threshold, however, not at the outer walls (where it should be determined). None of the large cities in the north would be expected to be above the lower assessment threshold, considering the background concentration decreases somewhat as you go north, and the largest cities in the north are not substantially larger than the cities mentioned above.

4. Assessment

Chapter 3 presented data on the air quality for carbon monoxide and benzene in the Netherlands. Data can be used as an aid for assigning a regime to the assessment of the air quality for the Dutch zones and agglomerations for diffuse sources. In addition to measurement data[3] and the results of model calculations, other sources of information may also be used to arrive at a definition of an assessment regime for a zone or agglomeration. For example, information about current or intended policy or emission trends in the Netherlands and abroad, etc, could also be considered. As there are little measurements available for the 'hot spots' (streets in cities), mainly for benzene use is made of calculations for 2000 based on CAR-VMK.

The regime-classification applied in this chapter is outlined in section 2.3.2 and the regimes briefly described below.

- *Regime 1.* The concentration is higher than the upper assessment threshold. Measurements are always compulsory in this situation.
- *Regime 2.* The concentration is between the lower and the upper assessment thresholds. Measurements should be used in combination with models.
- *Regime 3.* The concentration is below the lowest assessment threshold. Measurements are not compulsory under these circumstances. The air quality can be described using models or objective estimates.

For the assessment of pollution in the vicinity of **point sources**, the number of sampling points for fixed measurements should be calculated taking into account emission densities, the likely distribution patterns of ambient air pollution and potential exposure of the population (EU, 2000).

4.1 Carbon monoxide

In section 3.1.2, measurement data of carbon monoxide from 1996-2000 were checked against the lower and upper assessment thresholds of the limit value for the daily mean. The highest values occur along busy roads in cities. These cities are both in the agglomerations and in the zones. As many people live in cities in the zones, it is mainly these cities that will be concentrated on. Street measurements are only available for Eindhoven, Haarlem, Utrecht and Apeldoorn. As there are no measurements available for many cities, use is made of calculations for 2000 based on CAR-VMK for these cities. CAR-VMK results give an indication of the highest concentrations in cities.

Based on the measurements and calculations in Haarlem, the Amsterdam/Haarlem agglomeration would belong in regime 2. Since the highest values are expected in Amsterdam, this agglomeration is assigned regime 1 on the basis of calculations. The Rotterdam/Dordrecht agglomeration is also assigned regime 2 on the basis of calculations. The Hague/Leiden agglomeration is assigned regime 2; due to its situation near the sea, concentrations are expected to be lower than in Rotterdam, but because of the size of the agglomeration they are expected to be higher than in Utrecht. From measurements, it seems that Utrecht falls into regime 2. The Eindhoven agglomeration falls into regime 2, based both

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[3] See Appendix C for the division of the monitoring stations into zones and agglomerations.

on measurements and calculations. Heerlen/Kerkrade falls into regime 2, as this agglomeration is expected to have concentration values between those in Eindhoven and Venlo/Den Bosch.

The south zone is placed in region 2 on the basis of calculated concentration values in Venlo, Den Bosch and Breda. Calculations and measurements in Apeldoorn come under the lower assessment threshold, like the calculations in Arnhem. The middle zone is therefore placed in regime 3. No exceedances of the lower assessment threshold are expected for the north zone. Values in the north will be comparable to or lower than those in Amersfoort, Apeldoorn and Arnhem. This is why the North zone is assigned regime 3.

Table 4.1 Assessment regimes for carbon monoxide

Zone	Regime	Agglomeration	Regime
North	3	Amsterdam/Haarlem	1
Middle	3	Rotterdam/Dordrecht	2
South	2	The Hague/Leiden	2
		Utrecht	2
		Eindhoven	2
		Heerlen/Kerkrade	2

Assessment instruments
Regime 1&2
Measurements only or Measurements together with additional instruments
Regime 3
Models or objective estimates

4.2 Benzene

In section 3.2.2, measurement data of benzene from 1996-2000 were checked against the lower and upper assessment thresholds of the limit value for the yearly mean. The highest values occur along busy roads in cities. Street measurements are only available for Eindhoven, Utrecht and Apeldoorn and partially for Amsterdam. To get an additional indication of values in other cities, just as for carbon monoxide, use was made of CAR-VMK calculations for 2000.

The Amsterdam/Haarlem agglomeration falls into in regime 1, based both on measurements and calculations. Rotterdam/Dordrecht is also assigned regime 2 on the basis of calculations. The Hague/Leiden agglomeration is assigned regime 2; due to its situation near the sea, the concentrations are expected to be lower than in Rotterdam, but due to the size of the agglomeration they are expected to be higher than in Utrecht. Measurements show that the Utrecht agglomeration belongs in regime 2. Eindhoven is assigned regime 2 on the basis of calculations. Heerlen/Kerkrade falls into regime 2, as this agglomeration is expected to have concentration values between the calculated values of Eindhoven and Venlo/Den Bosch.

The South zone is placed in region 2, based on the calculated values in Venlo, Den Bosch and Breda. According to the measurements in Apeldoorn, this city, and therefore the Middle zone, belong to regime 2. Calculations for Apeldoorn do give an indication for regime 3, but calculations for Arnhem, which is also in the Middle zone, and produce values that belong in regime 2. Values in the north will be comparable to or lower than those in Amersfoort and Apeldoorn. This is why the North zone is assigned regime 3.

Table 4.2 Assessment regimes for benzene

Zone	Regime	Agglomeration	Regime
North	3	Amsterdam/Haarlem	1
Middle	2	Rotterdam/Dordrecht	2
South	2	The Hague/Leiden	2
		Utrecht	2
		Eindhoven	2
		Heerlen/Kerkrade	2

Assessment instruments
Regime 1&2
Measurements only or Measurements together with additional instruments
Regime 3
Models or objective estimates

Point sources
At large industrial sources in Amsterdam and Rijnmond increased concentration are mainly limited to industrial areas. There is no exceedance of the upper assessment threshold outside the industrial or port areas. Outside the industrial area, no-one suffers long-term exposure to concentrations above the upper assessment threshold. The air quality in these areas can be mapped using models.

The concentrations around multi-storey car parks and at petrol stations are not expected to exceed the upper assessment threshold. It is not likely that the population will be exposed to concentrations above the upper assessment threshold. The air quality in these areas can be mapped using models.

4.3 Consequences for the LML

The classification into assessment regimes for the zones and agglomerations has been derived in the previous sections. It seems that the assessment regimes in all agglomerations and all but one zone are the same for benzene and carbon monoxide. Only the regime in the Middle zone differs for carbon monoxide and benzene. An overview of the regime-classification for carbon monoxide and benzene can be made (Table 4.3). This, along with the criteria for the number of monitoring stations in relation to the assessment regime according to the daughter directive (Table 2.5), leads to the determination of the number of required monitoring stations (Table 4.4).

The Amsterdam/Haarlem agglomeration is the only one assigned regime 1. In this agglomeration, five monitoring stations are needed for carbon monoxide and benzene, as measurements are the only source of information. Of these, at least one station must determine the urban-background, and at least one station should be traffic-oriented, for both components. All other agglomerations and zones fall into regime 2 or 3. Lower requirements are set for the number of monitoring sites in regime 2, than in regime 1. In regime 3, models or estimates suffice. Table 4.4 indicates that the minimum monitoring effort consists of a configuration of 15 monitoring stations for carbon monoxide and 19 for benzene if measurements are the only source of information.

Table 4.3 Regime-classification for the zones and agglomerations

Agglomeration / zone	Carbon monoxide	Benzene
Agglomerations		
Amsterdam/Haarlem	1	1
Rotterdam/Dordrecht	2	2
The Hague/Leiden	2	2
Utrecht	2	2
Eindhoven	2	2
Heerlen/Kerkrade	2	2
Zones		
North	3	3
Middle	3	2
South	2	2

Table 4.4 Size of the minimum monitoring effort if measurements are the only source of information, and the proposed for LML adjustments, with supplemental measurements sites with passive samplers for benzene if passive samplers are the only additional information source for benzene

Agglomeration / zone	Carbon monoxide			Benzene			
Number of monitoring sites							
	EU requirement	LML 2001	LML after adjustments	EU requirement	LML 2001	LML after adjustments	Passive sampler
Agglomerations							
Amsterdam/Haarlem	5	2	5	5	0	3	2
Rotterdam/Dordrecht	2	2*	2	2	1*	1	1
The Hague/Leiden	2	1*	2	2	0	1	1
Utrecht	1	5	3	1	4	1	0
Eindhoven	1	3	1	1	0	1	0
Heerlen/Kerkrade	1	0	1	1	0	1	0
Zones							
North	0	1	1	0	1	0	0
Middle	0	7	2	4	2	1	3
South	3	1	4	3	1	1	2
Total	15	22	21	19	9	10	9

* One station is situated outside the urban area of the agglomeration

4.3.1 LML adjustments for carbon monoxide

There are enough measurement schemes for carbon monoxide to meet the required minimum (by measurements alone) for information to the EU. The measurement schemes will have to be reclassified.

Table 4.4 shows what the LML will look after the adjustments. Nine new stations will be set up to meet the information requirements from the daughter directive. This proposal is intended to produce a balanced set up of monitoring sites, whereby both the EU and other information requirements are met. The aim is that the measurements are carried out so that there is a clear as possible picture of the amount (concentration) and extent (spatial) of the air quality and any exceedances. When stations are moved, these criteria are taken into consideration e.g. the value of continuing the measurement of trends at individual locations.

In the adjusted LML, Amsterdam/Haarlem gets five stations, of which three are newly set up. Of these three new stations, one is situated along a busy ring road where traffic is often at a standstill, one on a motorway (A10 West) and one to measure an urban-background concentration. This agglomeration already has one station measuring the urban-background concentration and one street station in Haarlem. Rotterdam/Dordrecht has one station measuring the urban background, and one new street station has been added. Two new stations have been set up for The Hague/Leiden: one will measure the urban background and one is located on a busy street. Utrecht keeps two street stations and one station measuring the urban background. Eindhoven keeps one street station and Heerlen/Kerkrade gets a new street station.

Two new stations have been set up in the South zone. A new street station will be provided in a city in the South zone (e.g. Venlo) and a new street station in Breda. Together with two regional sites zone South has four stations in total. It should be noted that there are also two other agglomerations with two monitoring sites in the South zone. In chapter 3 it turned out that the other cities in the South zone are comparable to these agglomerations with regards to carbon monoxide concentrations. These monitoring sites therefore give also a good indication of the air quality in other urban areas in the South zone.

In contrast to NO_2 and particulate matter, the choice of at least two stations per agglomeration was not made. The two smallest agglomerations (Eindhoven and Heerlen/Kerkrade) both have just one station. This is because exceedances of limit values are not expected for carbon monoxide and the monitoring requirement for carbon monoxide is less strict. Therefore just one monitoring site is needed in Eindhoven and Heerlen/Kerkrade. As described above only in a confined area in these agglomerations concentrations are to be expected between the lower and upper assessment thresholds. If the current trend continues concentrations values will only decrease more.

The LML has 21 CO stations. The stations are configured to provide a complete picture of the air quality in the Netherlands. With 15 of these stations the information supply to the EU can be met.

The chosen limit values-unit (**maximum** of the 8-hour mean) is difficult to model, by definition, even with the current instruments (CAR). With regards the drawing up of inventories by local authorities, one option might be to model the 98th percentile. For example, from the relationship between the 98th percentile and the maximum of the 8-hour mean, it can be derived that an exceedance of the EU standard is unlikely for a 98th percentile lower than 3000 $\mu g/m^3$ (Appendix D). Considering that no exceedances occur currently and that concentrations will fall further, thought should be given to dropping the requirement for local authorities to draw up an inventory altogether. It should be noted that it is unlikely now that exceedances of the limit value of carbonmonoxide do not coincidence with exceedances of the limit value of nitrogen dioxide.

4.3.2 LML adjustments for benzene

Whereas there are sufficient measurement schemes available for carbon monoxide, there are too few for benzene. As the regimes are expected to be less strict for benzene within five years, there does not seem to be a point in exerting a maximum monitoring effort. In zone South and Middle and in the three smallest agglomerations exceedance of the lower assessment threshold only takes place on a small scale (a few kilometres road). In the agglomeration Amsterdam/Haarlem exceedance of the upper assessment threshold is taking place on a confined scale. If the above-mentioned zones and agglomerations end up in a lower regime, then the amount of mandatory monitoring sites (for measurements only) will decrease to six.

In the proposal for adjustments to the LML (Table 4.4) at least one monitoring site is provided in every zone and agglomeration where measurements have to be carried out. The agglomeration Amsterdam/Haarlem has the highest concentrations and accommodates a lot of people. Therefore two extra monitoring sites have been provided there. These monitoring sites also provide useful information for modelling. This means that in total 10 stations will be set up. To meet the EU-requirements, complementary instruments can be used such as passive measurements and models. If no models are used complementary measurements with temporary passive samplers on the nine monitoring sites, without continuous measurements, can be carried out to meet the EU-requirements (Table 4.4). A method for passive samplers is currently being developed in the CEN work group for passive measurements (CEN/TC264/WG11:Air Quality). The use of models can decrease the number of passive samplers.

The current measurement scheme for benzene consists of five non-automated measurement schemes, which are used in turn. Continuous GC-monitors are more accurate and cheaper than continuing the current method. The obvious choice is to purchase ten new GC-monitors.

In the LML proposal, one station is positioned in each agglomeration and in the Middle and South zones. These will be street and city stations, which take measurements where high concentrations are expected and where people live. In Amsterdam, an extra station is placed along the motorway (A10 West) and in the urban area (to measure the urban background), as extra information for both the EU and for the modelling. The nine possible complementary passive measurements will take place on 3 sites in zone Middle, on 2 sites in the agglomeration Amsterdam/Haarlem and zone South and on 1 site in the agglomerations Rotterdam/Dordrecht and The Hague/Leiden.

In contrast to NO_2 and particulate matter, the choice of two stations per agglomeration was not made. This is because exceedances of limit values are not expected for benzene (and carbon monoxide) and the measurement requirement for benzene (and carbon monoxide) is less strict. Therefore fewer monitoring sites are needed. Only in a confined area concentrations are to be expected between the lower and upper assessment thresholds, while only in Amsterdam are concentration values expected above the upper assessment threshold (on a small scale). Here, benzene is hardly a problem and with continuation of the current downward trend in benzene the problem will only get smaller. Finally, it can be noted that a failure is less critical for measuring the yearly mean for benzene than for hourly or daily values.

For practical reasons, the measurement schemes for benzene will be positioned next to those for carbon monoxide (benzene may be measured on the outer wall facing the street; carbon monoxide must be measured at the kerbside). The concentrations for benzene will therefore be higher than if they were determined on the outer wall.

The old measurement schemes that are being replaced by continuous GC-monitors may later be used for hydrocarbon measurements for ozone. These measurements will be mainly regional, rather than urban. They can therefore also be used to get a nation-wide picture of the background concentration for benzene.

An attempt is being made to come to some agreement with DCMR and DSM, so that their measurements at industrial plants can be included in the reporting to the EU.

5. Discussion and conclusions

5.1 Discussion

When determining assessment regimes, series of measurements are used wherever possible. For a large number of urban areas with important traffic contributions, no measurements were available. For these situations, model calculations from CAR-VMK for the year 2000 were used. These results are less accurate than measurements for a specific location, but do give a more complete picture of the entire urban situation. To arrive at a corresponding estimate using measurements, the calculations are scaled to the measurements. The results are judged on a kilometre scale, instead of on details about stretches of road. This last point is to prevent inaccuracies at the level of the stretch of road resulting in outliners and in incorrect regime-classifications.

For cities where CAR-VMK has determined the regime, and where exceedance was uncertain (Arnhem, Rotterdam and Venlo), the input data have been checked by the relevant local authorities.

From a comparison of measurements and calculations using CAR-VMK, it appears that these estimates for all zones and agglomeration, where there are both measurements and calculations, result in the same regime-classification.

CAR-VMK does not contain all relevant cities in the Netherlands, but with the current 23 cities it can be considered to be a representative set for all cities in the Netherlands.

If only measurements are used to assess the air quality, then a total of 15 monitoring stations are compulsory for carbon monoxide and 19 for benzene in the Netherlands. The application of complementary instruments, such as models, to describe the air quality can actually lead to a decrease in the number of monitoring stations. For example, the air quality for benzene and carbon monoxide in agglomerations can be measured, and mapped, using models in the urban areas in the Middle and South zones. Thus, not all new monitoring points in the Middle and South zones would be needed for a good description of the air quality. Models are also used, even in cities where measurements are taken, to arrive at a more accurate description of the air quality in the entire urban area.

The concentrations of benzene and carbon monoxide show a downward trend in the last five years (CO approximately 15% and benzene 50%). This is mainly due to measures in industry and cleaner vehicles (including catalytic converters and cleaner fuel). In the coming years, emissions from cars and lorries will fall further due to a tightening of existing European standards and the introduction of new standards. A fall in the emissions of road traffic of 5% per year is expected, both for carbon monoxide and benzene (Feimann et al., 2000). With this, the number of compulsory measurements would seem to decrease further in the near future.

The current assessment is based on data that is available for 2000 and earlier. The final preliminary assessment intends to sketch a picture of the air quality in 2003, before 2003 itself. Extrapolating the expected emission trends described above, and using them to assess the regimes, no change in the regime-classification is expected for benzene and carbon monoxide in 2003. When evaluating the classification into zones, agglomerations and regimes, which must take place within five years (EU, 2000), a classification into less strict regimes for both carbon monoxide and benzene is expected.

For the assessment of petrol stations and multi-storey car parks, no complete and detailed overview for the Netherlands was available. Here, use was made of estimates based on current policy and old case studies.

Also note that the Dutch Air Quality Monitoring network is not only an instrument in relation to legislation and regulations. The monitoring network also meets other information needs (international requirements, validation of models, monitoring of trends and spatial picture; see Buijsman, 1995). In the future, the monitoring sites will also be needed for other purposes [4].

5.2 Conclusions

Checks of measurements and a combination of measurements and model results against the limit values of carbon monoxide and benzene have shown no exceedances in the Netherlands in 2000.

There are three assessment regimes for the assessment of the air quality. The assessment regimes for carbon monoxide and benzene are the same in all agglomerations and in all but one zone. The regime-classification is less strict for carbon monoxide than for benzene for the Middle zone only:

Amsterdam/Haarlem agglomeration: Regime 1
Rotterdam/Dordrecht, The Hague/Leiden, Utrecht, Eindhoven, Heerlen/Kerkrade agglomerations: regime 2.

Zone North: Regime 3 for both components
Zone Middle: For benzene regime 2 and for carbon monoxide regime 3
Zone South: Regime 2 for both components

If the air quality were to be determined **only** on the basis of measurements, a total of 15 monitoring stations would be needed in the Netherlands for carbon monoxide and 19 for benzene to meet the requirements in the second daughter directive.

If only the LML is used for measurements, then the requirement for 15 stations for carbon monoxide can be met if the current 22 stations are classified differently. For benzene, the current configuration of nine stations is not sufficient and, in addition to a different classification, a minimum of ten new measurement schemes would have to be purchased to be able to meet the requirement for 19 stations.

As the regimes are expected to be less strict within five years, there does not seem to be any point in exerting the maximum monitoring effort for benzene. The EU information requirements for benzene can also be met with the scheme of ten stations equipped with GC-monitors combined with passive samplers and model calculations. If no models are used, nine additional passive sampler sites are needed.

The concentrations around petrol stations and multi-storey car parks are not expected to exceed upper assessment threshold levels in places where people have long-term stays. The

[4] This will be worked out in a yet to publish RIVM report within the project 'Monitoring Air'.

concentration increases around large industrial sources in Amsterdam-Noord and in the Rijnmond area are limited to industrial areas. Exposure of the population to concentrations above the upper assessment threshold is in this case not likely. The air quality in these areas can be mapped using models.

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Appendix A Measurement methods in the LML

The information on the Dutch National Air Quality Monitoring network (LML) presented below is taken from Van Elzakker (2001).

Determination of carbon monoxide

Type	: automatic analyser
Measuring instrument	: Thermo Electron 48W
Measuring principle	: infrared gas filter correlation
Measuring range	: 0-58220 µg CO/m^3
Detection limit	: 120 µg CO/m^3
Time period	: 1 hour

Determination of benzene (part of VOC measurement)

Type	: active sampler
Sampling instrument	: Universal Sampler, RIVM fabricate
Sampling	: continually in certain periods
Adsorption medium	: active carbon (SKC, Coconut-Base 150 mg)
Flow	: 0.65 l/min (daily samples), 0.10 l/min (weekly samples)
Analysis	: elution with CS_2 followed by gas chromatographic separation and flame ionisation or electron-capture detection
Detection limit	: 0.1 µg/m^3
Time period	: 1 day, 1 week

Appendix B Checking measurement data against assessment thresholds

Table B1 Exceedance of the assessment thresholds for the 8-hour mean concentration of carbon monoxide. Green: Under the lowest assessment threshold (Regime 3), Yellow: Above the lower, but under the upper assessment threshold (Regime 2), Orange: Above the upper assessment threshold but under the standard (Regime 1); Red: Above the standard (Regime 1).

		maximum of 8-hour mean					
carbonmonoxide concentration	**statnr**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
regional stations, mean		1856	1680	1957	1250	1135	1192
Biest Houtakker-Biestsestraat	230	1730	1930	1600	1380	1410	1160
Schipluiden-Groeneveld	411	2290	2180	2610	1270	1620	1510
Zegveld-Oude Meije	633	2550	1700	2590	1210	1290	1230
Loenen-Eerbeeksedijk	733	1540	1640	1810	1500	840	1260
Kollumerwaard-Hooge Zuidwal	934	1170	1650	1520	910	770	800
Niehove-Heereburen	999		980	1610	1230	880	
city stations, mean		4205	3153	3915	4180	3490	2705
Rotterdam-Schiedamsevest	418	4070	2680	2800	3690	3000	2130
Dordrecht-Frisostraat	441	4270	3210	3620	4240	4990	3700
Amsterdam-Cabeliaustraat	518	5520	4500	5740	6090	4000	2960
Utrecht-Universiteitsbibliothe	640	2960	2220	3500	2700	1970	2030
street stations, mean		5534	4711	6656	5064	3764	3911
Eindhoven-Genovevalaan	236	7160	5160	9340	5110	4230	5490
Eindhoven-Noordbrabantlaan	237	6120	4920	6120	5860	4500	4510
Eindhoven-Piuslaan	238	5780	6040	6940	6830	4420	4460
Haarlem-Amsterdamsevaart	537	7230	5250	4980	5220	5130	3390
Utrecht-de Jongweg	636	6220	3830	9460	6130	3590	4510
Utrecht-Wittevrouwenstraat	637	6960	5480	6200	6000	3790	3610
Utrecht-Vleutenseweg	638	4670	4750	6920	5790	4270	3350
Utrecht-Erzeijstraat	639	5900	4400	8540	9250	5540	5590
Breukelen-Snelweg	641	2450	1660	2710	1470	1370	1430
Apeldoorn-Loolaan	727	4740	4950	6800	3240	2630	3020
Apeldoorn-Stationsstraat	728	4880	5480	5280	2800	3160	3670
Apeldoorn-Arnhemseweg	729	4300	4610	6580	3070	2540	3900

Table B2 Exceedance of the assessment thresholds for the yearly mean concentration of benzene. Green: Under the lowest assessment threshold (Regime 3), Yellow: Above the lower, but under the upper assessment threshold (Regime 2), Orange: Above the upper assessment threshold but under the standard (Regime 1); Red: Above the standard (Regime 1).

benzene concentration	statnr	1995	1996	1997	1998	1999	2000
regional stations, mean		1.37	1.45	1.49	1.04	0.96	0.80
Wijnandsrade	133	1.59	1.78				
Houtakker	230	1.38	1.57	1.36	1.02	0.90	0.69
Philippine	318	1.71	1.41				
Maassluis	415			2.48	1.52	1.46	1.29
Zegveld	633	1.19	1.24	1.17	0.95	0.80	0.63
Witteveen	928	0.96	1.26				
Kollumerwaard	934			0.95	0.68	0.67	0.60
city stations, mean		2.50	2.49	1.69	1.37	1.23	1.00
Rotterdam-Centrum	418	2.45	2.32				
Dordrecht	441	2.55	2.67				
Utrecht - Universiteitsbib.	640			1.69	1.37	1.23	1.00
street stations, mean		4.34	4.54	3.93	2.98	2.37	1.69
Eindhoven - Genovevalaan	236	5.04	5.28				
Utrecht -De Jongweg	636			3.33	2.78	1.88	1.52
Utrecht - Vleutenseweg	638			4.44	3.33	2.65	2.00
Utrecht - Const. Erzeijstr.	639	4.37	5.13	4.60	3.08	2.77	1.69
Apeldoorn - Stationsstraat	728	3.61	3.22	3.35	2.73	2.16	1.57
non LML-stations, mean		7.98	5.84	5.94	4.60	2.12	1.75
OMEGAM-Haarlemmerweg		9.3	8.7	8.80	7.60		
OMEGAM-Stadhouderskade		8.8	7.6	7.40	5.90		
OMEGAM-Van Diemenstraat		5.6	5.4	6.00			
OMEGAM-Beursplein		8.2	8.4	7.60			
DCMR-Schiedam			3.5	4.30	3.80	3.20	2.60
DCMR-Hoogvliet			3.7	4.10	3.00	2.70	2.20
DCMR-Maassluis			3.6	3.40	2.70	2.80	2.40
Prov NH-Badhoevedorp	561					1.7	1.7
Prov NH-Oude Meer	562					1.3	1
Prov NH-Hoofddorp	564					1	0.6

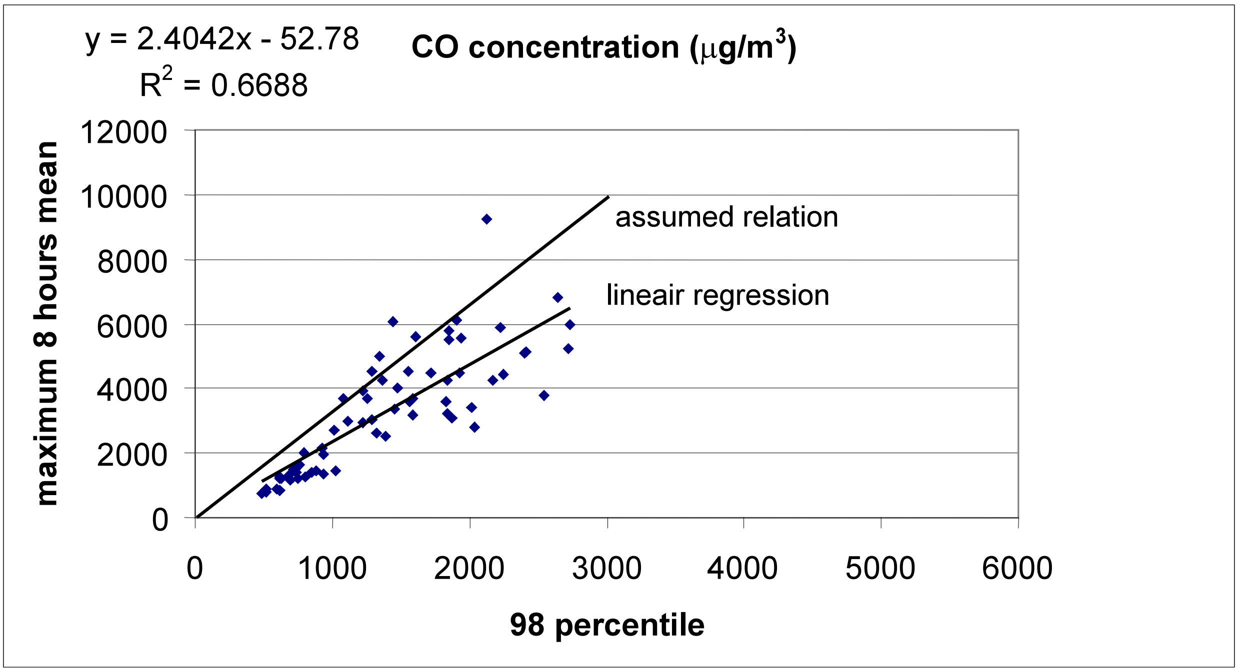
Appendix C Measurement sites in the zones and agglomerations

The table below shows operational monitoring sites in the Dutch National Air Quality Monitoring Network for CO and benzene broken down into zones and agglomerations (Van Elzakker, 2001).

Measurement site	Type	Carbon monoxide (CO)	Benzene (C_6H_6)
Agglomeration Amsterdam			
518-Amsterdam-Cabeliaustraat	City	●	
537-Haarlem	Street	●	
Agglomeration The Hague			
411-Schipluiden	Regional	●	
Agglomeration Rotterdam			
415-Maassluis[5]	Regional		●
418-Rotterdam	City	●	
441-Dordrecht	City	●	
Agglomeration Utrecht			
636-Utrecht-de Jongweg	Street	●	●
637-Utrecht-Wittevrouwenstraat	Street	●	
638-Utrecht-Vleutenseweg	Street	●	●
639-Utrecht-Erzeijstraat	Street	●	●
640-Utrecht-University library	City	●	●
Agglomeration Eindhoven			
236-Eindhoven-Genovevalaan	Street	●	
237-Eindhoven-Noordbrabantlaan	Street	●	
238-Eindhoven-Piuslaan	Street	●	
Agglomeration Kerkrade			
Zone North			
934-Kollumerwaard	Regional	●	●
Zone Middle			
627 Bilthoven	Regional	●	
633-Zegveld	Regional	●	●
641-Breukelen	Street	●	
727-Apeldoorn-Loolaan	Street	●	
728-Apeldoorn-Stationsstraat	Street	●	●
729-Apeldoorn-Arnhemseweg	Street	●	
733-Loenen	Regional	●	
Zone South			
230-Biest-Houtakker	Regional	●	●
Total		22	9

[5] This station is primarily 'industrially oriented'.

Appendix D Relations for CO concentration for 98 percentile and max. 8-hour mean



Concentrations (blocks) at LML stations over 1998-2000

Appendix E Mailing list

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4. Ir. J.A. Herremans, Directie Lokale Milieukwaliteit en Verkeer
5. Drs.R.Warmenhoven, Directie Lokale Milieukwaliteit en Verkeer
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7. M. Wichmann-Fiebig DG Environment European Commission, Brussels
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9. Drs. R. Braakenburg, Ministerie van Verkeer en Waterstaat,
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13. J.M. Godthelp, Provincie Friesland, M & O afd. Milieuvergunningen
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15. Herrmann, Provincie Overijssel, Afdeling MAB-I
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