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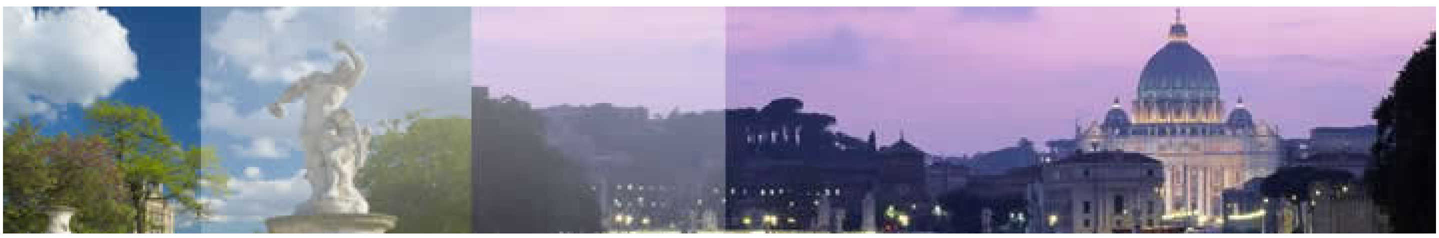
Comparing Urban Air Quality Across Borders

A review of existing air quality indices and the proposal of a common alternative



Component 3

Comparing Urban Air Quality Across Borders

A review of existing air quality indices and the proposal of a common alternative

June-2007, final version

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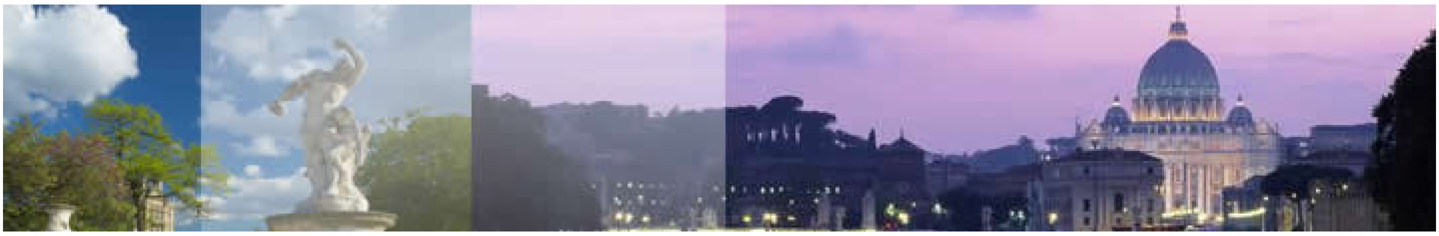

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Executive Summary

This document is based on a paper presented in 2005 in Istanbul, during the 3rd International Symposium on Air Quality Management at Urban, Regional and Global Scales (Elshout, et al. 2005). Since then the text was expanded and the calculation grid revised.

The document is one of the products of the CITEAIR project (see annex 6). This document presents a new Common Air Quality Index (CAQI), to be used to compare air quality in different countries. To our knowledge this is the first index that is not tied to national or regional authorities and has gained acceptance (for the purpose of comparing) by a wide variety of cities (see www.airqualitynow.eu).

The first four chapters follow the sections of the AQM2005 paper and present a review of a number of existing air quality indices (chapter 2); the difficulties of comparing cities in different countries in real time (chapter 3) and the proposal of a common, international, index that facilitates comparing cities in different countries in real time (chapter 4). Chapter 5 is new and discusses the potential of an index characterising year average values. As the indices described in this document are the product of a project ending in 2007, chapter 6 concentrates on the likely future developments. One of the annexes details a number of indices collected during the development of the CITEAIR common index[1].

This document and the proposed indices have been revised a number of times. An index is always a work in progress but revisions once indices are used, should be minimised. This doesn't mean that comments are not welcome, it means that we will collect them and consider them in due time (see chapter 6). Anyone considering using the index is kindly requested to register their names (at caqi@airqualitynow.eu, see chapter 6). This way, users can be kept informed in case of further developments concerning the index.

Acknowledgements

We would like to thank many people, users and potential users of the index, who have commented on various versions of the indices and the way the grids were developed.

1 Indices keep being revised by their users. A number of indices in the annex have undergone changes since they were first included in the inventory. Sometimes grids were updated or a note is made that the presented data are no longer correct at the time of writing. However, a reader interested in the index should always consult the website to be sure to get the latest version.

1 Introduction

The Framework directive and associated daughter directives (EU, 2007a) on air quality in the European Union not only oblige member states to monitor and report on their air quality but also to actively inform the public on the status of the ambient air quality. The Aarhus convention, ratified by the EU in 2005 (EU, 2007b) further enforces the concept that citizens have the right to be informed on the environmental conditions they live and work in. Over the past years a good number of cities and countries have started to display monitored or modelled air quality data on the internet. For most of the monitoring organisations, the internet is the easiest way to meet the dissemination of information requirements of the European (and/or national) legislation. The fact that so much air quality information is available on the internet makes it tempting to compare different cities in different countries. However, this proves particularly difficult. Apart from the European Environmental Agency's ozone website there are no possibilities to compare cities/countries side by side (EEA, 2007). Even if one surfs from one site to the other, comparison is not easy: air quality is presented in different ways using different interpretation criteria and a different typology of stations, which is usually not clearly explained.

The most widespread way to interpret air quality on websites is the use of an index ranging from good to bad to make the detailed measurements in micrograms more understandable for the general public. A review of existing websites and the associated air quality indices shows that the way air quality is interpreted differs considerably across the world. More surprisingly, even amongst the EU member states that share common legislation, the indices in use do vary. There are a number of reasons to explain these differences. Some of them are historical and conceptual: the index existed before the EU regulations came into force and the index was based on health and exposure criteria, e.g. the UK index (DEFRA, 2007). The fact that air quality problems (sources, meteorological conditions, etc.) tend to differ is also one of the reasons. The indices tend to be calibrated to the local situation to make sure that there is some variation in the index from day to day (to attract repeated visits to a website) and that the typical range of pollutant conditions occurring locally is being covered.

To facilitate the international comparison of (near real time) air quality the CITEAIR[2] project has developed a common operational website (www.airqualitynow.eu) where cities can display their air quality information side by side. The project aims to make air quality comparable across Europe and www.airqualitynow.eu is open for any city to join. The website was launched in 2006. The common website needs a common air quality index (CAQI). The CAQI is *not* aimed at replacing existing local indices. This would be an unrealistic ambition as in many cities the public has got used to the local, tailor-made index, and the CAQI will be, by the nature of the fact that is common, a non-specific compromise. CITEAIR envisages that there is room for two sources of air quality information on the internet: a local website[3], in the national language with a dedicated presentation (using a well established and known local index relying on more detailed air quality information); and a common website aimed at comparing - in near real time - the air quality in your own city to the air quality in other European cities. The comparison possibilities offered to the public are on an hourly, daily and yearly basis and the indices were developed keeping in mind that the general public is the end user.

The CAQI presented
The CAQI was compared to other indices in a review by the European Topic Centre on Air and Climate Change ETC/ACC (Leeuw and Mol, 2005). It was presented during: - the 3rd International Symposium on Air Quality Management at Urban, Regional and Global Scales (2005); - Urban Air Quality (2007); - Air Pollution (2007); and shown as a poster at EnviroInfo 2005 and 2006.

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[2] More information on CITEAIR and its products is available in annex 5 and at http://citeair.rec.org

[3] Occasionally, websites are used to inform people for pollution episodes. E.g. people with respiratory difficulties might want to adapt their behaviour and/or medication. We believe that this is a typical role for the local websites and not for www.airqualitynow.eu.

2 Review of air quality indices

There are a substantial number of different ways to interpret air quality in near real time. The most common way to do so is the use of an index. The index is generally based on a number of sub-indices for individual pollutants[4]. There is a wealth of indices and even countries that share the same legislation, or sometimes areas/cities within the same country have different indices. Some of the differences can be explained by the local differences in the nature of the air quality problems. Some other differences are due to fundamentally different approaches. The UK and the US indices (US-EPA, 2007) for example are strongly related to perceivable effects. The bands in the index are explained in health terms. This implies that the index covers a very wide range of pollutant concentrations and that actual concentrations are very often in the “good” or “moderate” end of the scale. Air quality in Europe, fortunately, is rarely bad enough to cause acute health effects in the general public so any index based on health impacts tends to trail at the lower end of the scale for most of the time.[5]

Other indices take a different approach. For example the ATMO index, based on a national regulation concerning all French cities larger than 100 000 inhabitants (Airparif, 2007) has bands that are somehow linked to values that are also used in the current EU directives. The alert thresholds in the directives tend to define the higher end of the scale. In these cases the top end of the index scale ends somewhere in the middle of the health effect based scales. For example the worst end (very poor) of the NO_2-index in France corresponds to 400 μg/m3. In the UK this is in the lower end of the “moderate” band and in the US it is even considered too low to calculate an index value.

Communication-wise the health-based indices have both a clear advantage and a disadvantage. The advantage is that the index value displayed at the website is easy to interpret: it does or does not cause health effects. The disadvantage is that the index is almost always indicating that air quality is good and pollution is low whereas the limit values for long-term exposure are often exceeded. This leads to an apparent paradox: a citizen regularly checking the local air quality website will always get the message that the air quality is good whereas at the end of the year local government puts out a report that he or she is living in a hotspot area for which an action plan is required. This is the paradox between short- and long-term air quality criteria. The criteria for short-term exposure are often met except for episodes, like for example in the summers of 2003 and 2006. The criteria for long-term exposure are often not met in Europe’s urban areas. The ATMO-type of indices provide some differentiation at the lower end of the scale to assure that the air quality is not always “good”. However in this case it is very difficult to attach some kind of health interpretation to the index and a qualification such as “moderate” or “poor” remains rather arbitrary.

The differences between the two approaches in making an index vary from one pollutant to the other. On ozone, the agreement tends to be quite reasonable but for NO_2 and SO_2 the differences are substantial. For PM_{10} the picture is mixed partly because the way PM_{10} affects health and on what timescale this occurs is still subject to a lot of research. This implies that during typical summer episodes the different indices tend to agree more or less. On days with less air pollution the interpretation gaps widen.

The long-term $\leftrightarrow$ short-term paradox typically occurs on the internet. In an annual report the focus is on long term air pollution. On text TV pages dedicated to smog warnings the focus and interpretation is based on health effects. However, internet presentations often serve multiple roles: informing the public, but also making the public aware of air quality issues. In this case the paradox is difficult to resolve: highly variable hourly (or daily) data is being presented to assure an attractive and frequently changing presentation that encourages repeated visits. On the other hand, the most challenging limit values appear to be the criteria for the year average so interpreting commonly occurring hourly values in terms

[4] A list of indices collected in the course of the development of the CAQI is available in the annex.

[5] It should be mentioned that there is increasing evidence indicating that PM_{10} has both short and long-term effects even at moderate concentration levels.

of good or bad is fairly arbitrarily. They are not bad from the short-term exposure point of view but might be bad from the long-term exposure point of view. An attempt to overcome this was described by Elshout (2004). For NO_2 and PM_{10} an expected hourly pattern is established for a whole year, based on historic data. This pattern is scaled (up or down) in such a way that it provides a reference pattern that would lead exactly to the limit value. In this way a, be it hypothetical, identification of hourly values that contribute to the exeedence of the year average limit value can be made. This way the interpretation becomes somewhat less arbitrary.

Air quality indices aim to translate the chemical characteristics of a quite complex mixture of pollutants in the air into one single figure. From a scientific point of view this is obviously a gross generalisation but for communication purposes it is considered an essential generalisation.[6] An index is also always a compromise between several objectives and potentially occurring situations. The trade-offs in developing the CAQI indices were made keeping in mind that they should be applicable over a wide range of conditions and interesting to the public. The latter has led, for example, to the use of an hourly time scale and a grid ranging from 1 to 100. This can be justified by the need for frequent changes but is rather overambitious when considering the accuracy of the individual measurements.
For additional discussion on the communication aspects of air quality indices see for example Shooter and Brimblecombe (2005) and Elshout *et al* (2007).

[6] However, this assumption has never been tested. Shooter and Brimblecombe (2005), in a review article on air quality indices, mention (citing Burden and Ellis, 1996) that in Australia, public confidence in reporting on air pollution fell following the introduction of an index.

3 Comparing cities on the internet

3.1 Comparing air quality using different indices

Apart form the fact that the bands differ from one country/city/area to the other, the data behind the index also differ. Whereas most websites have a page explaining how the index is calculated, other methodological aspects are generally not explained. Does the index represent measurements at background stations, traffic stations, a mixture? And in case of PM, how is it monitored, if automated equipment is used is it corrected? In the UK the index for PM depends on the monitoring method (see DEFRA, 2007) but in most cases there is no way of knowing how PM concentrations were established.

CITEAIR aims to provide a common index (the CAQI) in addition to the existing local indices. A second step to make data more comparable is that the CAQI distinguishes between background and traffic stations. The potential of having one common index will be illustrated in the following example in which we try to compare air quality at a given day in four cities. These indices are described in table 1.

Table 1: Indices used on the internet in Paris, Leicester, Rome and Rotterdam

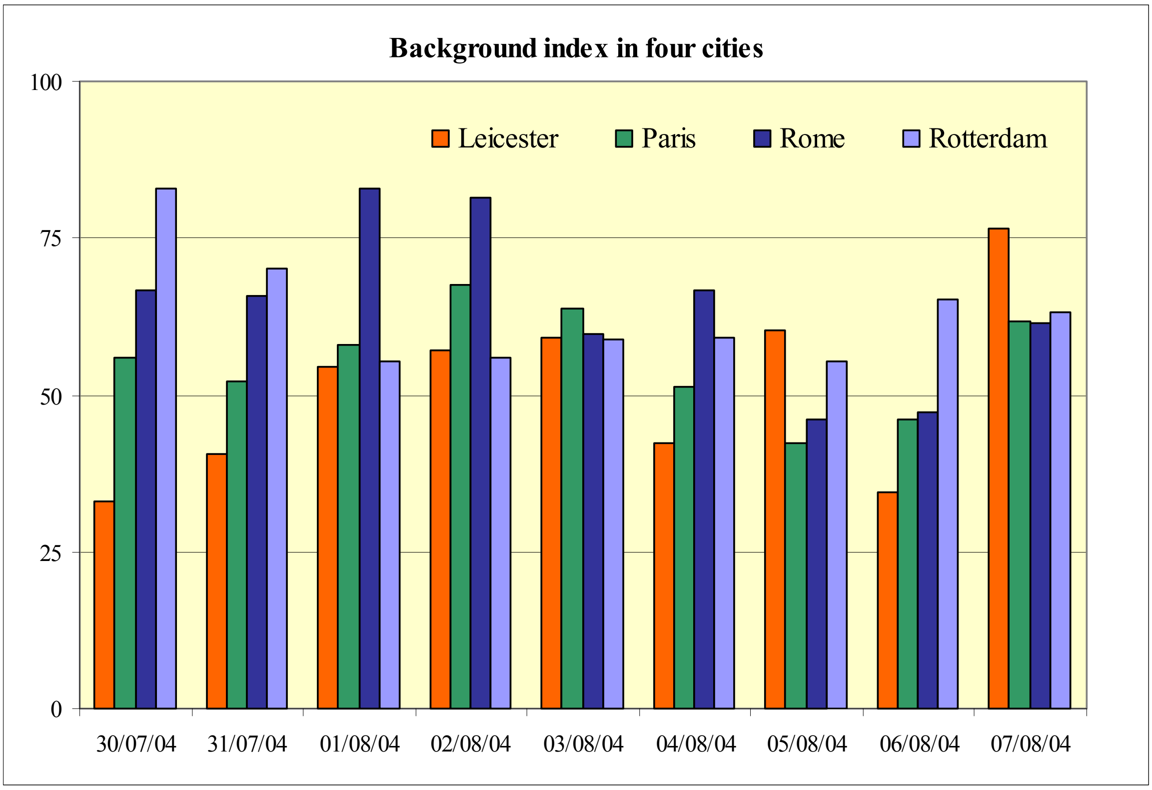
ATMO Paris	ozone-1h	PM10-24h	NO2-1h	index	**UK**	ozone-8h	PM10-24h	NO2-1h	index
Very good	29	9	29	1	low	32	21	95	1
	54	19	54	2		66	42	190	2
good	79	29	84	3		99	64	286	3
	104	39	109	4	moderate	126	74	381	4
average	129	49	134	5		152	86	477	5
mediocre	149	64	164	6		179	96	572	6
	179	79	199	7	high	239	107	635	7
poor	209	99	274	8		299	118	700	8
	239	124	399	9		359	129	763	9
Very poor	>=240	>=125	>=400	10	very high	>=360	>=130	>=764	10

Rome	ozone-1h	PM10-24h	NO2-1h	index	**Rotter-dam***	ozone-1h	PM10-24h	NO2-1h	index
good	90	100	100	50	good		20	100	-
moderate	135	150	150	75	moderate	180	40	200	-
mediocre	180	200	200	100	bad	240	60	400	-
unhealthy	360	400	400	200	very bad	>240	>60	>400	-
very unhealthy	> 360	> 400	> 400	>200					

* Ozone classification from the national smog pages, other classes from a local traffic website.

Three out of four cities have an index, two indices range from 1 to 10, the other from 1 to 200. Two cities have 10 classes, one has 5, one has 4.Two describe air quality in terms of good and bad, one in terms of health and the fourth in terms of pollution levels. The class boundaries are very different. If someone would want to compare these four cities at a given moment he or she would not only have to visit four websites but also be faced with four completely different presentations and qualifications.

Figure 1: The CAQI applied to background stations in four cities July-August 2004



As an example, look at the period end of July - early August 2004. The background index was quite high in all cities. On the 3rd of august the cities would have had a similar CAQI value. The cause of the elevated background concentrations was different though: PM10 in Leicester and Paris, and ozone in Rome and Rotterdam. If someone had looked at the four different websites he or she would have had no possibility of comparing the information. Paris looks substantial worse than Leicester as both seem to have a similar scale (1 to 10) and how to compare the score of 79 of Rome to the others: is it safe to assume that 79 out of 200 would amount to 4 on a 1 to 10 scale?

Table 2: the CAQI and the local indices on a day with above average concentrations

	City index		Pollutant	City classification	CAQI	Pollutant
	value	scale				
Leicester	4	1-10	Ozone	low-moderate	59	PM10
Paris	6	1-10	PM10	mediocre	64	PM10
Rome	79	1-200	Ozone	mediocre	60	Ozone
Rotterdam	-	-	PM10	Bad	59	Ozone

3.2 Scope of the common index

The CAQI is not aimed at replacing existing local indices. This would be an unrealistic ambition as in many cities the public has got used to the local, tailor-made index, and the CAQI will be, because it is “common”, a non-specific compromise. CITEAIR envisages that there is room for two sources of air quality information on the internet: a local website, in the national language with a dedicated presentation (using a well established and known local index relying on more detailed air quality information); and a common website aimed at comparing - in near real-time - the air quality in your own city to the air quality in other European cities.

Another approach at comparing cities on the internet was demonstrated by the MARQUIS project. Marquis also has a common website (currently not available) where regions from different countries contribute their air quality data. The index for all regions is calculated by using the index from the user's own region. E.g. a German visitor would see Spanish data displayed with the German index and vice versa. Though this is a very interesting approach, it might potentially lead to strange results if a local index was tailored to local conditions that might not occur in the place of interest.

4 A common air quality index (CAQI)

4.1 Definition of the CAQI

The CAQI is calculated according the grid in table 3 and by linear interpolation between the class borders. The final index is the highest value of the sub-indices for each component. As can be seen there are two CAQI-s: one for traffic monitoring sites and one for city background sites. The traffic index comprises NO_2 and PM_{10}, with CO as an auxiliary component. The background index obligatory comprises NO_2, PM_{10} and O_3, with CO and SO_2 as auxiliary components. In most cities the auxiliary components will rarely determine the index (that is why they are auxiliary) but in a city with industrial pollution or a seaport SO_2 might occasionally play a greater role. Benzene is considered a long-term exposure issue. The number of cities with online monitoring of benzene is limited and it is therefore not included in the short-term indices.

Table 3: Pollutants and calculation grid for the CAQI

Index class	Grid	Traffic				City Background					
		Mandatory pollutant			Auxiliary pollutant	Mandatory pollutant				Auxiliary pollutant	
		NO_2	PM_{10} 1-hour	PM_{10} 24-hours	CO	NO_2	PM_{10} 1-hour	PM_{10} 24-hours	O_3	CO	SO_2
Very low	0	0	0	0	0	0	0	0	0	0	0
	25	50	25	12	5000	50	25	12	60	5000	50
Low	26	51	26	13	5001	51	26	13	61	5001	51
	50	100	50	25	7500	100	50	25	120	7500	100
Medium	51	101	51	26	7501	101	51	26	121	7501	101
	75	200	90	50	10000	200	90	50	180	10000	300
High	76	201	91	51	10001	201	91	51	181	10001	301
	100	400	180	100	20000	400	180	100	240	20000	500
Very High*	> 100	> 400	>180	>100	>20000	> 400	>180	>100	>240	>20000	>500
NO_2, O_3, SO_2:	hourly value / maximum hourly value in µg/m^3										
CO	8 hours moving average / maximum 8 hours moving average in µg/m^3										
PM_{10}	hourly value / daily value in µg/m^3										

* An index value above 100 is not calculated but reported as "> 100"

Comparing air quality in different cities is a complex issue: is the air quality being determined in the same way (this mainly applies to particulate matter) and at comparable locations? This is not an issue that we, as the CITEAIR project and the proponents of the QACI, can solve. The website will accept the values supplied by a city as input in either category. However, as a first step to improve comparability, the index will be reported both for roadside and city background locations. This is considered an important improvement over city averages: some monitoring networks are designed to monitor or spot areas of poor air quality (with possibly a high number of roadside stations) whereas others are aimed at providing an average city picture.

The CAQI is used both for a daily index and for an hourly index. In the website the daily index will be shown for the past day (D-1). For the current day, the past 24 values of the hourly index will be available, to be updated every hour. A daily index for today would need forecasting or 'nowcasting' a facility that is not available in each city with a monitoring network, hence the option of an hourly index.

The hourly index is also a reasonably dynamic parameter, enticing repeated visits to a website. This is considered important for a website mainly in support of raising awareness on air quality. In this respect PM_{10} is a troublesome component. As the EU guidelines focus on daily average values many networks only provide daily concentration readings or 24-hour moving averages. From a communication point of view this is not ideal: one cannot see the rush-hours and even incidents like a fire, or the fire-works celebrating New Year are impossible to observe (the effect is limited and the timing is delayed). Some networks do provide hourly measurements so two different index grids are needed (see section 4.2).

Participating cities are advised to submit average data from the stations they qualify as city background and traffic. The use of averages leads to more representative data and a reduction in missing data. However, if a city wants to select (or only has) one station in each category, that data will be used as a sole source.

The choice of the classes in the CAQI is heavily inspired by the EU legislation and based on a compromise between the participating cities. The dividing line between medium and high is often linked mainly to the values mentioned in the directives: alert thresholds (SO2, NO_2, O_3) or air quality objectives when available on a daily basis (CO and PM_{10}). Class borders were regularly spaced for the main components. For the setting of the CO and SO_2 borders additional inspiration was sought from the DAPPS (Cairncross and John, 2004) index which aims to define the component sub-indices based on the relative risks attributed to each component.

The CAQI resembles for example the ATMO index discussed above and it differs substantially from for example the UK and US-EPA indices. It therefore shares the drawbacks of the ATMO (no clear link with health effects, fairly arbitrarily quality interpretation of hourly values). But it also shares its advantage: frequently changing index values that capture the hour-by-hour changes and make a website dynamic. The latter was of overriding importance as raising awareness is a key objective of the common website.

4.2 Consistency between hourly and daily index for PM_{10}

The calculation grid for the hourly and daily values is the same for most components. However, for PM_{10} the averaging time increases from 1 to 24 hours and hence the concentration readings decrease. Using a selection of 52 urban and suburban monitoring stations from Airbase for the period 2001-2004, the average ratio between daily maximum hourly concentration and daily average concentration appears to be 0.55. See table 4. This ratio is lower than a previously reported figure based on 1 year of data for Leicester, Paris, Rome and Rotterdam. This new figure, based on a wider selection of stations, is used to link the hourly and daily index grids. For the cities providing hourly data this implies that, on average, the PM_{10} sub-index based on hourly values on a given day will be (on average) consistent with the daily value once it is calculated (the next day). However, due to the variation in the ratio, minor inconsistencies on a daily basis cannot be avoided. This is considered less important than the consequences of switching to a purely daily index calculation for PM_{10}.

Table 4: Ratio between daily average and daily maximum hourly concentration[7]

	minimum	maximum	Average ratio	Average std
Urban background	0.08	1.0	0.54	
Traffic	0.07	1.0	0.55	0.12

[7] See annex 4 for more details.

4.3 Sample application of the CAQI

To test and demonstrate the CAQI during the development phase, yearly data (April 2004 - March 2005) from Leicester, Paris, Rome and Rotterdam was analysed using the CAQI. Currently the CAQI is operational on www.airqualitynow.eu.

Table 5: Percentage of hours that a pollutant determines the final index

Traffic Index	Leicester	Paris	Rome	Rotterdam
NO_2	85	53	31	49
PM_{10}	14	47	69	51
CO	1	0	0	0
	100	100	100	100

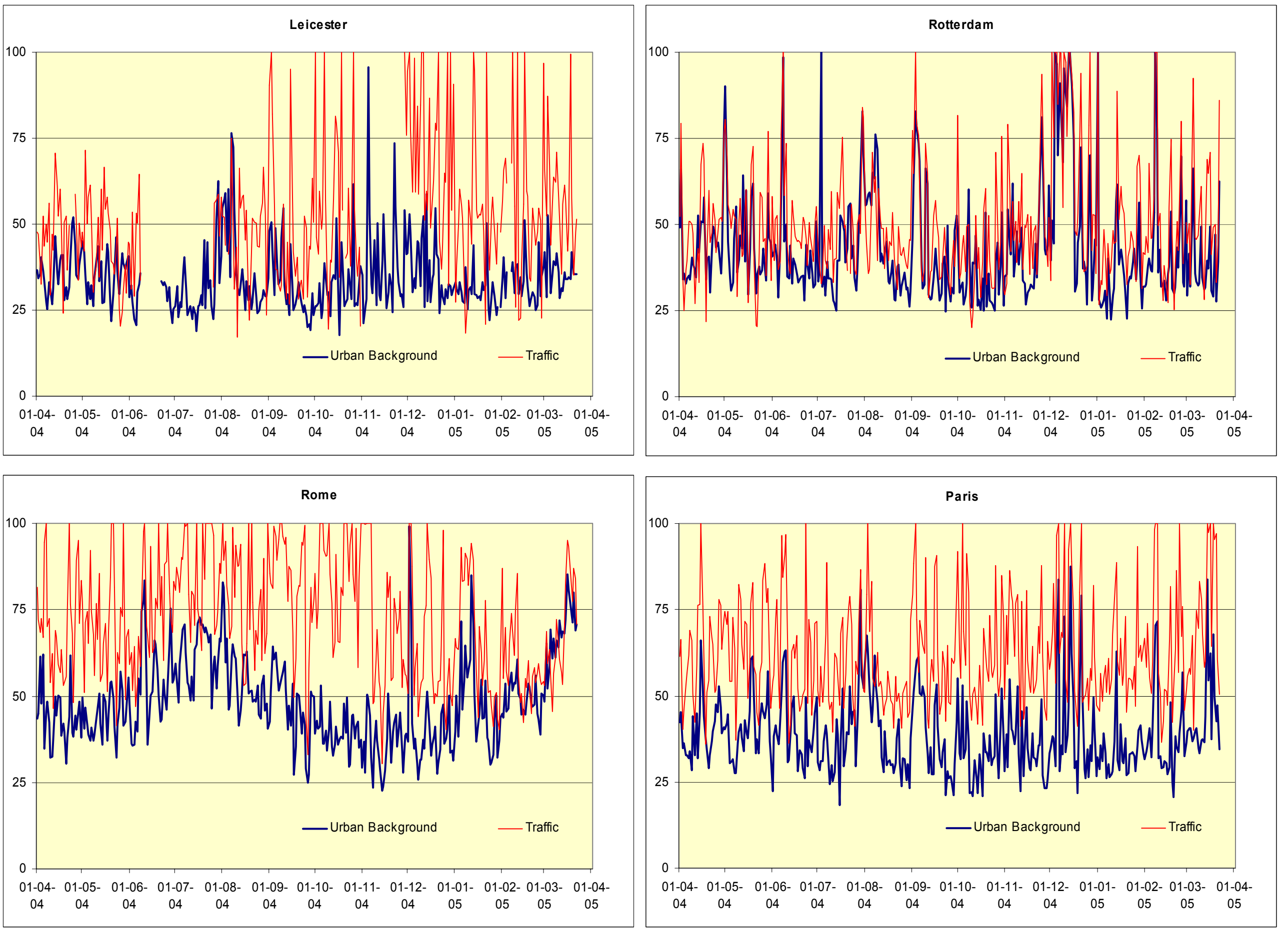
City background Index	Leicester		Paris		Rome		Rotterdam	
	main	main + auxiliary	main	main + auxiliary	main	main + auxiliary	main	main + auxiliary
NO_2	30	33	35	35	24	24	21	20
PM_{10}	24	25	27	27	36	35	46	45
O_3	46	42	38	38	40	42	34	26
CO		0		0		0		0
SO_2		0		0		0		9
	100	100	100	100	100	100	100	100

The tables show that in these four cities CO almost never plays a determining role in neither the traffic nor the background index. For the second auxiliary variable SO2 the situation is slightly different. In Rotterdam, with a seaport and a petrochemical industry, in 9 % of the hours SO2 would have determined the index[8].

Figure 2 shows the daily indices in the four test cities for a period of twelve months. The Rome background index shows a distinct seasonal pattern. In summer the background index is mainly determined by ozone, in winter by PM10 and, to a lesser extent, NO2. The seasonal pattern is absent in the other cities, though the shift in pollutants is fairly identical. The winter of 2004/2005 was rather mild so only some days with a higher index can be seen. The winter doesn't show up clearly. The traffic index is significantly higher than the background in Rome and Paris. This was to be expected in large cities with a big vehicle fleet, typical street-canyons, large ring roads, etc. In the much smaller city of Rotterdam the traffic index is only slightly higher than the background index. Leicester provides a mixed picture. With NO_2 being the dominant traffic pollutant in Leicester, the traffic index is relatively low in summer and higher in winter.

[8] In fact even in Rotterdam this is exceptional. SO_2 determined the index in a short period with flares due to unexpected maintenance in a petrochemical plant and otherwise low concentrations.

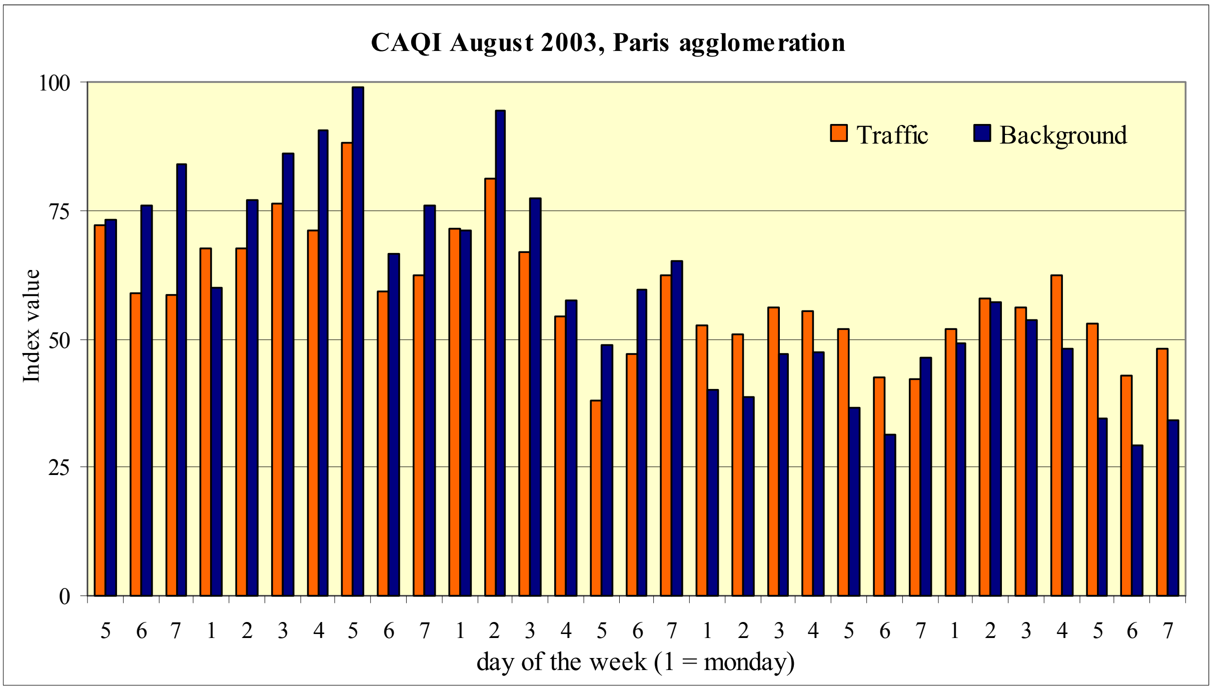
Figure 2: The CAQI (traffic and background) in four cities



The usefulness of a separate background and traffic index can be seen from figure 3 showing the daily index in Paris in August 2003. August 2003 was characterised by hot weather and poor dispersion conditions, leading to very high ozone concentrations. Except for a few days at the end of the month the background index was dominated by ozone. The traffic index was mainly determined by nitrogen dioxide with a few days of PM_{10}.

The poor dispersion conditions, combined with a large amount of imported ozone, are evident from the fact that the background index is similar or even higher than the traffic index, whereas normally (e.g. good dispersion conditions) there would be a gap of 15 to 25 index points between traffic and background. From the graph it can be seen that the traffic index drops in weekends (days labelled 6 and 7) whereas the background index rises. In this ozone-dominated month, the relative lack of fresh exhaust (NO) emissions, leads to higher ozone concentrations in the weekend. This weekend ozone effect is well documented (Lawson, 2003).

Figure 3: The traffic and background indices during an episode in Paris



5 A year average index

5.1 Introduction

Year average indices are not very common in air quality reporting but they are nevertheless a useful indicator, facilitating the comparison of cities at a glance. Comparing cities by their individual pollutant levels is difficult as one city might do better on one pollutant and worse on the other. In addition, some cities might monitor other pollutants than others. Even comparing progress in a single city from one year to the other is difficult as progress might be made for one pollutant whereas in another field things might have deteriorated. E.g., was the progress on NO_2 more important than the drawback on PM_{10}? How to judge progress in such a case? The year average index is obviously a generalisation but it does provide an easy way to make a relative assessment of one city to the other or for one city from year to year.

A year average index can be devised according to a concentration grid in the same way as the traditional short-term indices discussed before. Akkan *et al* (2004) propose such an index for Baden-Württenberg in Germany (**L**ong-term **A**ir **Q**uality inde**x** - LAQx). This index uses long-term exposure (one year) health risks as a guiding principle for classifying air quality. Like the short-term exposure indices, the worst pollutant determines the index. Apart from its methodological merits, health (risks) being the main public concern, this is a very interesting approach.

Another way of making a (long-term) index is the "distance to target" principle. One advantage of the distance to target principle is that each parameter considered contributes to the index (unlike the principle where the worst parameter determines the index). A distance to target indicator calculates for each pollutant (or other parameter, in other disciplines) a ratio of how far the actual measurement is away from the target value, for example a limit value. The overall index/indicator is the average of the sub-indices. A distance to target index is based on policy targets or limit values and, as such, it has only an indirect link to health risks. Still, it is considered an appropriate way to present air quality in a European context. The limit values have important implications both for environmental policy makers and for the public[9]. The year average index presented in this paper and used on www.airqualitynow.eu is of the distance to target type.

5.2 Calculation and presentation

Like the hourly and daily index, the Year Average Common Air Quality Index (YACAQI) is calculated for traffic and city background sites. Preferably a city's data for each index is based on the average of a number of sites, however it is up to each city what they want to contribute and how they determine their contribution[10]. The www.airqualitynow.eu website will accept whatever a city submits as their city year average concentrations for each pollutant for traffic and city background situations (or for one of the indices if they don't want to supply both). In most cases, but this is up to individual cities, the data provided to the website will be based on the situation at one or more monitoring sites. This implies that it is not necessarily the complete and balanced picture a city reports under the EU-guidelines. Inferences on city compliance should therefore be based on the official city report and not on the index values on the website as they might not show the full picture. The website indices are generalised data for comparison purpose, between cities in the same year or for a city from year to year.

[9] In several countries all kind of economic developments, road construction and housing developments are being blocked by non-compliance to the limit values.

[10] Though all data analyses made in this document are based on monitored data, a city without a network for which modelled data are available (for instance delivered by the relevant authority) could even consider providing modelled year average concentrations for the sake of participating on the website and making themselves comparable relative to the other cities participating.

The sub-indices are calculated as follows:

- For each index, sub-indices are calculated for each pollutant by dividing the actual year average by the EU limit value for the year average.
- For ozone the number of days with an 8-hour above 120 µg/m^3 are divided by 25 days. This is the provisional target value. The long-term target value is 0 days. Using the long term target in the calculation provides conceptual difficulties: all sub-indices have a value of 1, once the target value is reached, and drop below 1 if the air pollution drops even further. Using 0 exceedences for ozone would lead to an index of 0 once the target is achieved and the index cannot improve any further. By using the provisional target of 25 days to calculate the index, the calculation mechanism of the other sub-indices is mimicked.
- For PM_{10} two criteria are used: the year average and the number of exeedences of the daily average of 50 µg/m^3. Though both criteria were originally meant to be more or less equivalent in many places the daily parameter appears to be a much more critical one. This unbalance is further aggravated if the distance-to-target parameter is calculated as the number of daily averages above 50 µg/m^3 divided by 35, the limit value. It appears that there is a relation between the number of exceedences of a daily average above 50 µg/m^3 and the year average concentration (See annex 5). A year average concentration of approximately 31 µg/m^3 seems to correspond to 35 days of exeedences. The sub-index is thus calculated as year average/31.
- For SO_2 the limit value for human health (a daily average of 125 µg/m^3 not to be exceeded for more than 3 times a year) should be used. However in many cities this would lead to a sub-index of 0. Alternatively the year average limit values for eco-systems could be used though this might be a difficult target for cities with a lot of old industries. For the time being the eco-system limit value is being used and depending on the actual readings in the subscribing this might be changed at a later date.
- For CO, no year average index is being calculated, as it is really a short-term exposure concern.

The calculation of the sub-indices is straightforward. See table 6.

Table 6: Calculation basis for the year average index

Pollutant	Target value / limit value	Calculation
NO_2	Year average is 40 µg/m^3	Year average / 40
PM_{10}	Year average is 40 µg/m^3	Year average / 40
	Max. number of daily averages above 50 µg/m^3 35 days ≈ year average of 31 µg/m^3	Year average / 31
Ozone	25 days with an 8-hour average value >= 120 µg/m^3	# days with 8-hour average >=120 / 25
SO_2	Year average is 20 µg/m^3	Year average / 20
Benzene	Year average is 5 µg/m^3	Year average / 5
CO	-	Not calculated

The overall city index is the average of the sub-indices for NO_2, PM_{10} (both year average and daily averages) and ozone for the city background index. For the traffic year average index the averages of the sub-indices for NO_2 and PM_{10} (both year average and daily averages) are being used. The other pollutants, if data are available, are used in the presentation of the YACAQI but do not enter the calculation of the city average index. They are treated as additional pollutants like in the hourly and daily indices. The main reason is that not every city is monitoring the full range of pollutants. Furthermore for SO_2 we expect that the situation in different kinds of cities is very far apart, being no problem in most cities and a concern in others.

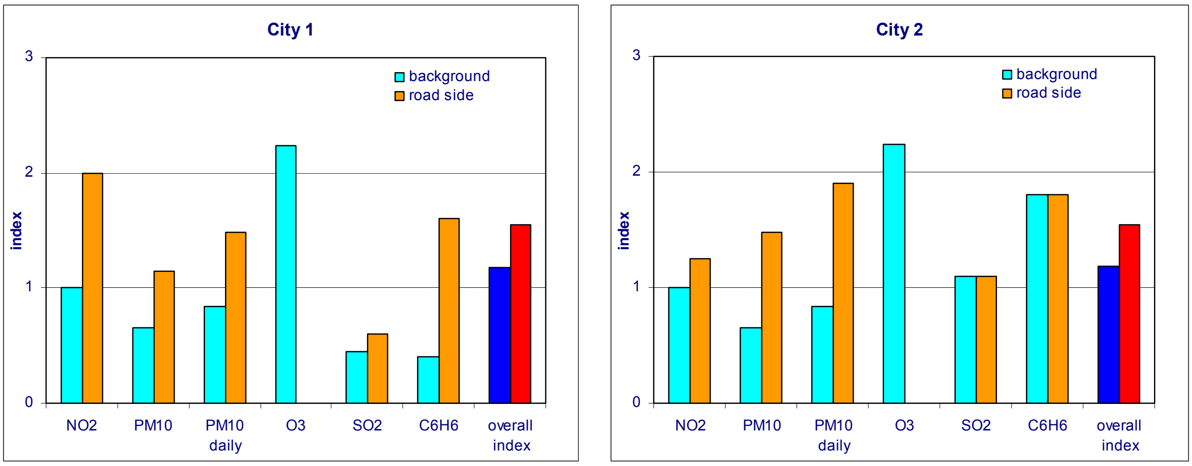
Table 7 presents an imaginary example for two cities. The two cities in the example have the same YACAQI but different air quality problems. This can be visualised by the bar charts shown in figure 4.

The presentation provides valuable additional information when comparing two cities or the same city over two years. It is instantly evident what the main problems are and/or where progress for the situation is satisfactory. Note that the background index is the same in both cities despite the fact that SO_2 and benzene are very different: they don't enter into the calculation of the average index. For traffic city 1 has a NO_2 problem and city 2 a PM_{10} problem.

Table 7: An example of the calculation of the YACAQI

	NO_2		PM_{10}-year average		PM_{10}-exceed. daily av.		Ozone days with 8h av. >120		SO_2		Benzene		Index = average of sub-indices	
Target value	40		40		31		25		20		5			
	B	T	B	T	B	T	B	T	B	T	B	T	B	T
year average city 1	40	80	26	46			56		9	12	2	8		
year average city 2	40	50	26	59			56		22	22	9	9		
Target index	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.00	1.00
Index city 1	1.0	2.0	0.7	1.2	0.8	1.5	2.2		0.5	0.6	0.4	1.6	1.18	1.54
Index city 2	1.0	1.3	0.7	1.5	0.8	1.9	2.2		1.1	1.1	1.8	1.8	1.18	1.54

Figure 4: Presentation of the YACAQI and its components



5.3 The YACAQI applied to some cities in 2003

For several years the city of Lintz has been collecting year average air quality data from various cities in Europe (Sameh and Hager, 2003, 2004). Like www.airqualitynow.eu this is a bottom-up initiative to make air quality comparable. In the following figures and tables a selection of their data has been used to calculate the YACAQI as an example of the application of the urban background index[11].

2003 was a notoriously bad year for air quality. Comparing the YACAQI for 2002 and 2003 indeed shows that most indices (Milan being an exception) were better in 2002 than in 2003. The graphs show a city where the YACAQI hardly changed from 2002 to 2003 (Milan), and a city with a marked change (Lintz). The case of Lintz shows that if a city is in compliance with the limit values in one year there is no guarantee that the air quality is satisfactory. In fact to be sure that the limit values

[11] The city of Lintz does not collect the number of days with an 8-hour average ozone concentration >= 120 µg/m^3. In this example the ozone index was calculated as the maximum hourly value divided by 180!

will always be met one has to aim at air quality standards that are somewhat lower than the limit values. The Lintz graph also shows that all pollutants were higher in 2003 than in 2002, indicating that poor dispersion has probably played a major role.

Figure 5: YACAQI urban background in 2002 (left) and 2003 (right) in the cities of Lintz and Milan[12]

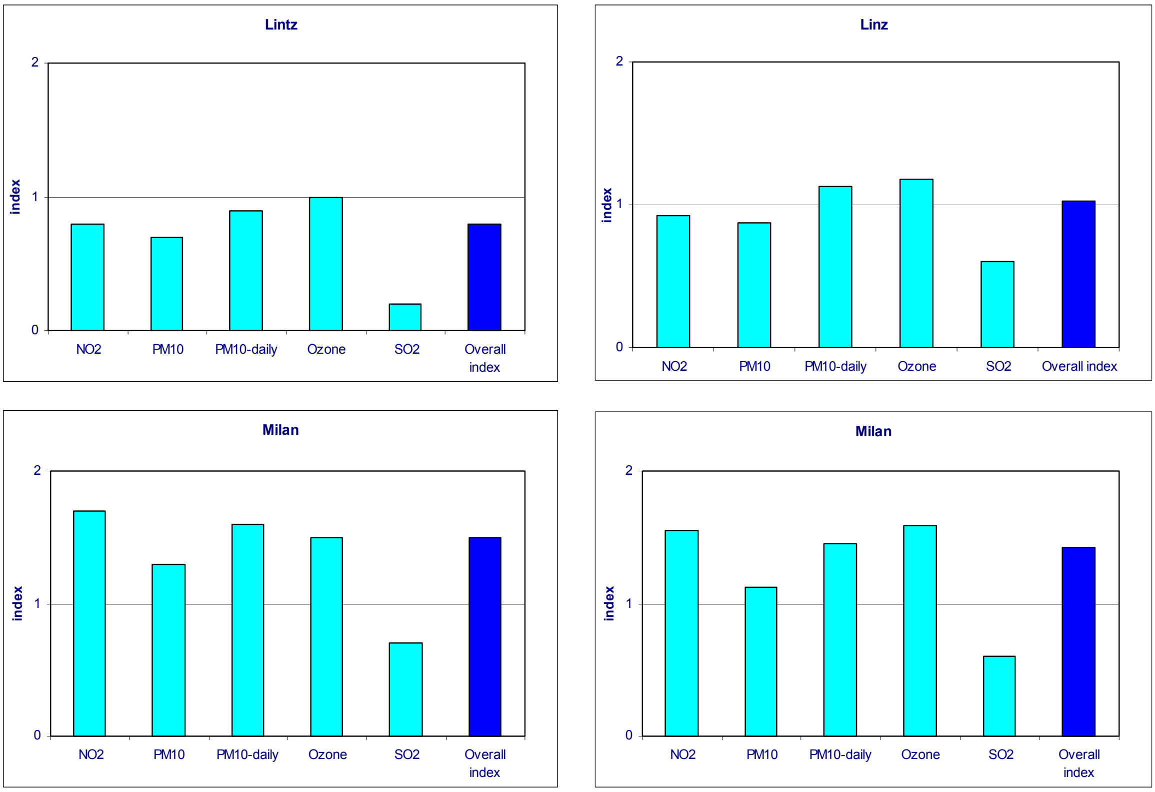


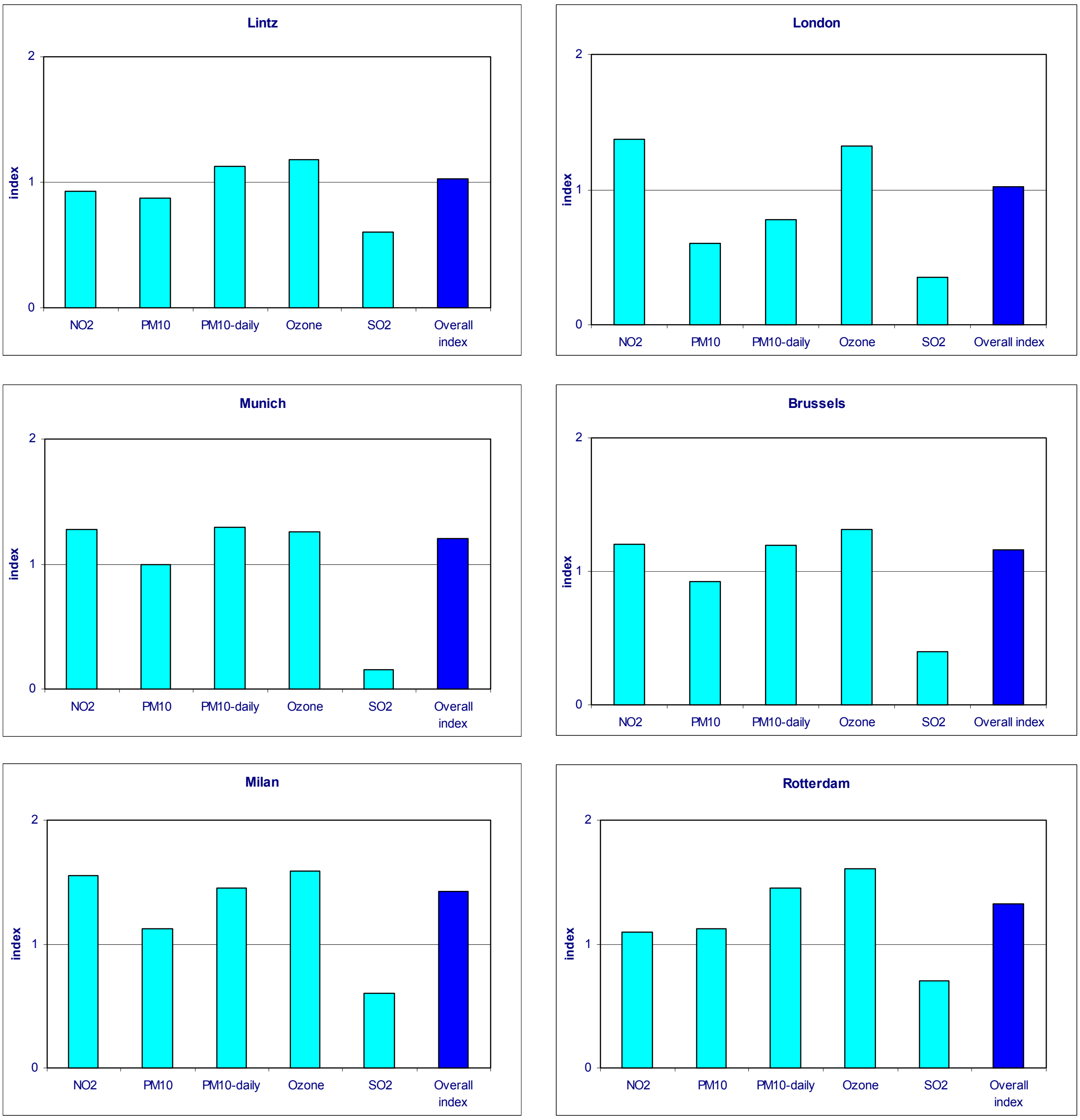
Table 8: Year average index applied to urban background data from 6 cities in the annual Lintz survey for 2002 and 2003 (see footnote).

2003	Sub-indices					City Index
	NO_2	PM_{10}	PM10-daily	Ozone (max)	SO_2	
Brussels	1,2	0,9	1,2	1,3	0,4	1,2
Linz	0,9	0,9	1,1	1,2	0,6	1,0
London	1,4	0,6	0,8	1,3	0,4	1,0
Milan	1,6	1,1	1,5	1,6	0,6	1,4
Munich	1,3	1,0	1,3	1,3	0,2	1,2
Rotterdam	1,1	1,1	1,5	1,6	0,7	1,3

2002	Sub-indices					City Index
	NO_2	PM_{10}	PM10-daily	Ozone (max)	SO_2	
Brussels	1,0	0,9	1,1	1,2	0,4	1,0
Linz	0,8	0,7	0,9	1,0	0,2	0,8
London	1,2	0,6	0,7	1,0	0,4	0,9
Milan	1,7	1,3	1,6	1,5	0,7	1,5
Munich	1,2	0,8	1,0	1,0	0,2	1,0
Rotterdam	1,0	1,1	1,4	1,1	0,7	1,1

[12] The city of Lintz does not collect the number of days with an 8-hour average ozone concentration >= 120 µg/m^3. In this example the ozone index was calculated as the maximum hourly value divided by 180!

Figure 6: Year average index applied to data from 6 cities in the annual Lintz survey for 2003[13].



[13] The city of Lintz does not collect the number of days with an 8-hour average ozone concentration >= 120 µg/m^3. In this example the ozone index was calculated as the maximum hourly value divided by 180!

6 Future developments

The CAQI and YACAQI were developed in the course of the CITEAIR project (2004-2007). The index has been revised early 2007. CITEAIR ends in 2007 but the website will continue and also some form of continuation of the project is anticipated. The project team is exploring possibilities to establish an organisational framework to enable both the continuation and expansion (e.g. involving more cities) of the website and ensuring the further maintenance/development (revision of directives, new insights in air quality and health issues) of the indices and the web platform as appropriate.

A potential important change to the index is the anticipated arrival of a $PM_{2.5}$ limit value. It is likely that by 2008 a good number of cities will be monitoring $PM_{2.5}$ and inclusion of it in the indices will be feasible. We expect that $PM_{2.5}$ will be included in the daily and hourly versions of the CAQI index. The YACACI already has two PM sub-indices and adding a third could be considered as exaggeration. The most likely development will be that the $PM_{2.5}$ sub-index will replace the PM_{10} year average sub-index.

Maintaining the CAQI implies that cities using this index need to be consulted about, and informed of any changes to the index otherwise there will be multiple versions of the CAQI and the very concept of one index to facilitate comparison across borders will be completely lost. If you consider using the CAQI and/or YACAQI please inform us at caqi@airqualitynow.eu.

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Annexes

Annex 1 Review of some indices found on the internet

Introduction

In the following tables you will find some of the indices found during the website review done by CITEAIR in late 2004 and early 2005.[14] The list is not exhaustive but the message is clear: everybody does something different, sometimes even within a country, so there is scope for a common index. Differences include the pollutants monitored, the class borders, the number of classes, etc.

Indices change so the data presented here might no longer be accurate by the time you read it. For example, since the review was done it was discovered that the UK index for PM now differs according to the monitoring method and that the Brussels index has a roadside and city background presentation that was not there before.

Care was taken to be as accurate as possible, though, especially on the sites without an english translation interpretation was sometimes difficult.

Observations relative to the findings

- All the indexes are used to give a quality judgement for short-term exposure (generally a day).
- Some sites do not provide an overall index, just indexes for individual pollutants.
- In the case where an overall index is presented the worst of the sub-indexes is generally chosen. There is one exception: the DAPPS (Cairncross and John, 2004) from South Africa. DAPPS is based on quantitative health criteria and this provides a basis for summing the sub-indexes according to the authors (I disagree to some extend: both health effects and concentrations of different pollutants are not independent phenomena; SE)
- The US and UK indexes use very high concentration values as they are base on real health effects. Most other indices reviewed seem somehow inspired by EU limit values, at least for the main pollutants.
- (Short) descriptions of health effects are available in the US-EPA, UK and the NILU indices.
- On the US EPA website (http://cfpub.epa.gov/airnow/index.cfm?action=aqibroch.index) there is a document with good descriptions of health effects and messages one might use to communicate to the public.
- The DAPPS is, theoretically the most objective index in comparing health effects of different pollutants. The results, as they are presented here use the WHO data (as in the original paper). If one is to use the DAPPS concept correctly local RR-s and mortality data would have to be used. This would provide a powerful tool for comparing health impacts from one city to the other but would make it difficult to compare actual air quality measurements from one city to the other. It seems that the APHEIS project (Monitoring the Effects of Air Pollution Health in Europe) is doing something in this direction. See: http://www.apheis.net.
- In France ATMO has been declared a national standard. In the Netherlands and in Italy (for example) there are regional differences in the interpretation of air quality.
- ATMO France, the Brussels index and a number of others are very similar but not identical.
- There are several indexes that don't use a 1 to 10 range. This avoids the confusing communication message that in some fields (education) the 10 points indicate the best and in the AQ business it indicates the worst situation.

[14] For another review of air quality indices see Garcia and Colossio (2002).

- Emillia Romagna region now uses a classification based entirely on the short term exposure criteria in the EU guidelines.
- As has been observed by some people: presenting short-term exposure air quality interpretation might send a confusing message. In most instances short-term exposure at a certain site will not pose a problem throughout the year (e.g. moderate to good) and at the end of the year the site does not meet the criteria for the year average. This could be resolved by a few lines of text underneath the graph/table. E.g. “hourly concentrations from 50 to 100 do not pose an acute health threat but when concentrations in this range dominate the air quality is not likely to meet the criteria for long-term (a year or several years) exposure”. There are technical ways to provide a long-term judgement for short time resolution measurements but they are difficult to implement. (See also main text chapter 3.)

Annex 2 Summary of indices *(situation 2003-2004!!)*

NB: All concentrations in µg/m^3

US EPA 1999 *(NB: a 2003 version exists)*	ozone-8h	ozone-1h	PM2.5-24h	PM10-24h	CO-8h	SO2-24h	SO2-1h	NO2-1h	index	**Remarks** the index for each component is calculated as a linear interpolation between class borders; On the website there is a document with extensive health information: http://cfpub.epa.gov/airnow/index.cfm?action=aqibroch.index
good	132	-	15	54	5302	94		-	50	Air quality is considered satisfactory, and air pollution poses little or no risk.
moderate	174	-	40	154	11327	397		-	100	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people. For example, people who are unusually sensitive to ozone may experience respiratory symptoms.
unhealthy sensitive	215	339	65	254	14942	617		-	150	members of sensitive groups may experience health effects. This means they are likely to be affected at lower levels than the general public. For example, people with lung disease are at greater risk from exposure to ozone, while people with either lung disease or heart disease are at greater risk from exposure to particle pollution. The general public is not likely to be affected when the AQI is in this range
unhealthy	256	421	150	354	18557	837		-	200	Everyone may begin to experience health effects when AQI values are between 151 and 200. Members of sensitive groups may experience more serious health effects.
very unhealthy	773	835	250	424	36632	1663		2455	300	AQI values between 201 and 300 trigger a health alert, meaning everyone may experience more serious health effects.
hazardous	go to 1 h column	1041 1248	350 500	504 604	48682 60732	2214 2765		3247 4039	400 500	AQI values over 300 trigger health warnings of emergency conditions. The entire population is more likely to be affected

WHO guidelines for exposure	ozone-8h	ozone-1h	PM2.5-24h	PM10-24h	CO-8h	SO2-24h	SO2-1h	NO2-1h	index	
Guidelines 2000	120				10000	125		200		www.euro.who.int/document/e71922.pdf
Guidelines 2005	100		25	50	10000	20		200		whqlibdoc.who.int/hq/2006/WHO_SDE_PHE_OEH_06.02_eng.pdf

ATMO Paris	ozone-8h	ozone-1h	PM2.5-24h	PM10-24h	CO-8h	SO2-24h	SO2-1h	NO2-1h	index
very good		29		9			39	29	1
		54		19			79	54	2
Good		79		29			119	84	3
		104		39			159	109	4
Average		129		49			199	134	5
Mediocre		149		64			249	164	6
		179		79			299	199	7
Poor		249		99			399	274	8
		359		124			599	399	9
very poor		>=360		>=125			>=600	>=400	10

Remarks: the index is based on 4 pollutants, the worst sub-index giving the final result.
Surprisingly, there are no precise, specific comments describing the health effects for specific target group associated to each index.
Index principle is based on specific values for crucial indexes (8 is related to the french "information to the public" hourly value, 10 is based on the alert hourly value.
Ozone and SO2 grids are currently under evolution (see new grid suggested).
Airparif worked also on a specific hourly PM grid allowing the use of Atmo on a hourly basis.

Conversion between US EPA and Atmo for "interesting" days

Day	Pollutant	Value (µg/m3)	Atmo	US EPA
08/08/2003	O3	238	Bad (8)	Very unhealthy (201, O3)
10/02/2004	NO2	139	Mediocre (6)	Unhealthy sensitive (109, PM2.5)
30/09/1997	NO2	251	Poor (8)	Moderate (85, PM10)
03/02/1998	NO2	204	Poor (8)	Moderate (69, PM10)
05/02/1998	PM10	124	Poor (9)	Moderate (87, PM10)
11/08/1998	O3	251	Poor (9)	Very unhealthy (201, O3)

UK *NB: a newer version exists!*	ozone-8h	ozone-1h	PM2.5-24h	PM10-24h	CO-8h	SO2-24h	SO2-***15 min***	NO2-1h	index	**Health**
low	32			16			88	95	1	effects are unlikely to be noticed even by individuals who know they are sensitive to air pollutants
	66			32			176	190	2	
	99			49			265	286	3	
moderate	126			57			354	381	4	mild effects, unlikely to require action, may be noticed amongst sensitive individuals
	152			66			442	476	5	
	179			74			531	572	6	
high	239			82			708	635	7	significant effects may be noticed by sensitive individuals and action to avoid or reduce these effects may be needed (e.g. reduce exposure, asthmatics use inhaler).
	299			91			886	700	8	
	359			99			1063	763	9	
very high	>=360			>=100			>=1064	>=764	10	Effects for 'high' may worsen

DAPPS (South Africa)	ozone-8h (max)	ozone-1h	PM2.5-24h	PM10-24h	CO-8h	SO2-24h	SO2	NO2-1h	index	**Remarks**
based on RR : 1	0	0	0	0	0	0	0	0	0	Class borders are such that the Relative Risk (RR) is the same in each class for each substance. See Caircross and John 2004, Section 3.2.4. Is not fully correct in my (SE) view. Concentrations are not fully independent and summing them might be wrong.
1.015	30	33		21	3900	38		51	1	
1.031	60	67		41	7900	77		102	2	
1.046	90	**100**		62	11800	115		153	3	
1.061	120	133		83	15700	153		204	4	The DAPPS was fixed to the UK system using the value of ozone at index class 3 (100) and the associated Relative Risk for each pollutant allows to fit the rest of the class borders into the system.
1.077	150	167		104	19700	192		256	5	
1.092	180	200		124	23600	230		307	6	
1.107	210	233		145	27500	268		358	7	
1.123	241	267		166	31500	307		409	8	
1.138	271	300		186	35400	345		460	9	
>1.153	>=301	>=333		>=207	>= 39300	>= 383		>= 511	10	

Brussels	ozone-8h	ozone-1h	PM2.5-24h	PM10-24h	CO-8h	SO2-24h	SO2-1h	NO2-1h	Index
excellent	30			10		15		25	1
very good	45			20		30		45	2
good	60			30		45		60	3
fairly good	80			40		60		80	4
moderate	100			50		80		110	5
poor	120			70		100		150	6
very poor	150			100		125		200	7
bad	200			150		165		270	8
very bad	270			200		250		400	9
horrible	>270			>200		>250		>400	10

Nordrhein-Westfalen	ozone-8h	ozone-1h	PM2.5-24h	PM10-24h	CO-8h	SO2-24h	SO2-1h	NO2-1h	index
very good	20	33		10			25	25	
	50	65		20			50	50	
	80	120		35			120	100	
	120	180		50			350	200	
	160	240		100			500	400	
very bad	>160	>240		>100			>500	>400	

Norway (NILU-powerpoint)	ozone-8h	ozone-1h	PM2.5-24h	PM10-24h	CO-8h	SO2-24h	SO2-1h	NO2-1h	index	Remarks
good			20	35				100		No health effects
moderate			35	50				150		Asthmatics may experience health effects in streets with heavy traffic, especially during physical activities
poor			60	100				200		Asthmatics and people with serious hart- and bronchial diseases should avoid longer outdoor stays in areas with high air pollution
Very poor			>60	>100				>200		Asthmatics and pe0ple with serious hart- and bronchial diseases should avoid areas with high air pollution. Healthy people may experience incidentally irritations in the muscular membrane and unpleasantness.

Oslo	ozone-8h	ozone-1h	PM2.5-24h	PM10-24h	CO-8h	SO2-24h	SO2-1h	NO2-1h	index
good			40	50			150	100	
moderate			60	100			250	150	
poor			100	150			350	200	
Very poor			>100	>150			>350	>200	

Heaven Rotterdam/ Dutch smog guidelines	ozone-8h	ozone-1h	PM2.5-24h	PM10-24h	CO-8h	SO2-24h	SO2-1h	NO2-1h	index
good				20				100	
moderate		180		40		350		200	
bad		240		60		500		400	
very bad		>240		>60		>500		>400	

Province of Limburg (Netherlands)	ozone-8h	ozone-1h	PM2.5-24h	PM10-24h	CO-8h	SO2-24h	SO2-1h	NO2-1h	index
very good		32		9.9	999	24	24	24	
good		64		19.9	1999	49	49	49	
reasonable		179		49.9	9999	164	164	199	
bad		>180		>50	>10000	>165	>165	>200	

Rome	ozone-8h	ozone-1h	PM2.5-24h	PM10-24h	CO-8h	SO2-24h	SO2-1h	NO2-1h	index
good		90		100	5000			100	50
moderate		135		150	7500			150	75
mediochre		180		200	10000			200	100
unhealthy		360		400	20000			400	200
very unhealthy		> 360		> 400	>20000			> 400	>200
		max 24 h			max 24 h			max 24h	

ARPA Toscane	ozone-8h	ozone-1h	PM2.5-24h	PM10-24h	CO-8h	SO2-24h	SO2-1h	NO2-1h	index
good		60		25	2500			50	
moderate		180		50	15000			200	
poor		360		75	30000			400	
bad		>360		>75	>30000			>400	

Emilia Romagna	ozone-8h	ozone-1h	PM2.5-24h	PM10-24h	CO-8h	SO2-24h	SO2-1h	NO2-1h	index
Below limit value/below information threshold		180		50	10000	125	350	200	
Margin of tolerance/ Information threshold		240						250	
Above limit value/ alarm threshold		>240		>50	>10000	>125	>350	>250	

Annex 3 Websites consulted during the review

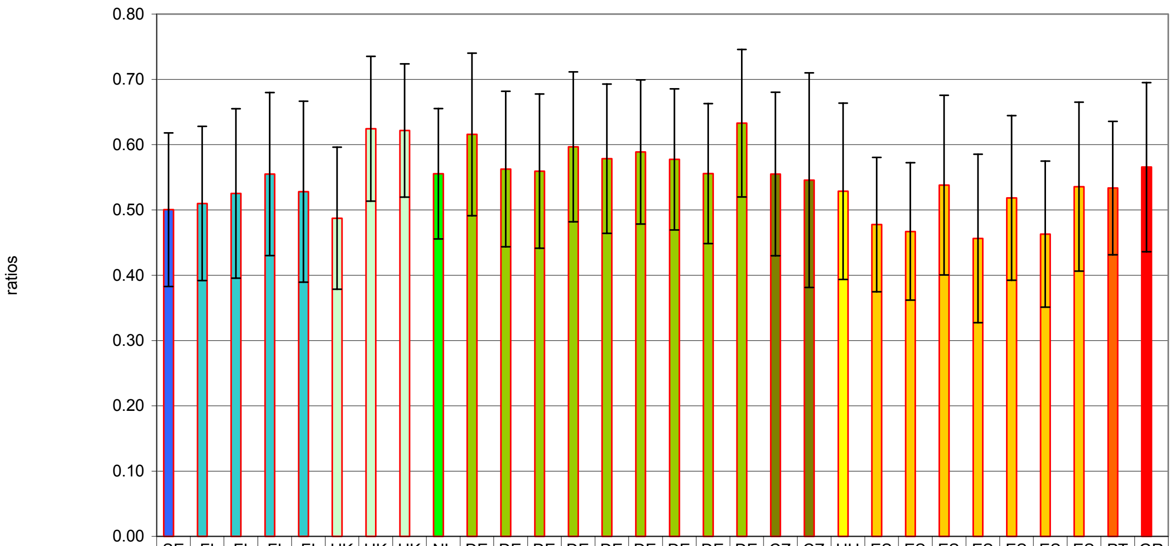
Below a list of the web addresses of a number of sites showing air quality information, indices and related information. These sites were visited during the review (2004-2005). As with the indices: websites change so not all links might be operational.

http://www.irceline.be/
http://www.vmm.be/servlet/be.coi.gw.servlet.MainServlet/standard?toDo=open&amp
http://www2.dmu.dk/1_Viden/2_miljoe-tilstand/3_luft/4_maalinger/5_maaleprogrammer/oversigtskort_en.asp
http://www.umweltbundesamt.de/uba-info-daten/daten/aod.htm
http://www.hamburger-luft.de/Stationen/Uebersicht.asp
http://www.umwelt.schleswig-holstein.de/servlet/is/1448/
http://www.umeg.de/messwerte/aktuell/
http://62.8.156.193/cgi-bin/db4web_c.exe/Projekt3/Projekt3/index.htm?th=2&kn=250145&adresse=1
http://www.lua.nrw.de/luft/immissionen/aktluftqual/eu_luft_akt.htm
http://www.ytv.fi/english/air/now.html
http://www.airparif.asso.fr
http://www.atmo-alsace.net
http://ww.airpl.org
http://www.airmaraix.com
http://www.atmo-rhonealpes.org
http://members.chello.hu/dasy.kft/forecast/Budapest.htm
http://www.arpa.emr.it
http://www.arpalombardia.it/qaria/
http://www.arpat.toscana.it/aria/ar_monitoraggio.html
http://www.comune.torino.it/ambiente/inquinamento
http://www.arpa.umbria.it
http://www.arpa.veneto.it/aria.htm
http://www.lml.rivm.nl
http://www.dcmr.nl/lucht/
http://www.dcmr.nl/heaven/
http://www.luchtkwaliteit.limburg.nl/nl/html/algemeen/meetwaarden/dagwaarden/dagwaarden.asp
http://www.nilu.no
http://www.umweltbundesamt.at/umwelt/luft/luftguete_aktuell/tgl_bericht/
http://www.ooe.gv.at/umwelt/luft/luftguet
http://www.airquality.co.uk
http://www.londonair.org.uk/london/asp/PublicBulletin.asp
http://www.ivl.se/miljo/projekt/urban/intro.asp
http://www.slb.mf.stockholm.se
http://www.umwelt-schweiz.ch/buwal/de/fachgebiete/fg_luft/luftbelastung/aktuell/grafiken/
http://www.eea.europa.eu/maps/ozone/map
http://www.epa.gov/airnow/
http://www.gemsnet.org/can/templates/mn_hometemplate.asp?id=h
http://www.ace.mmu.ac.uk/eae/english.html
http://airnet.iras.uu.nl/
http://www.esa.int/export/esaEO/SEM340NKPZD_index_0.html
http://europa.eu.int/comm/environment/air/index.htm
http://eos-aura.gsfc.nasa.gov

Annex 4 Averaging time ratio's

The ratio between the daily average concentration on a given day and the hourly maximum concentration on that same day was determined for a number of urban background and traffic stations in Europe. Airbase data from the period 2001-2004 was used. The results are shown in the graphs.

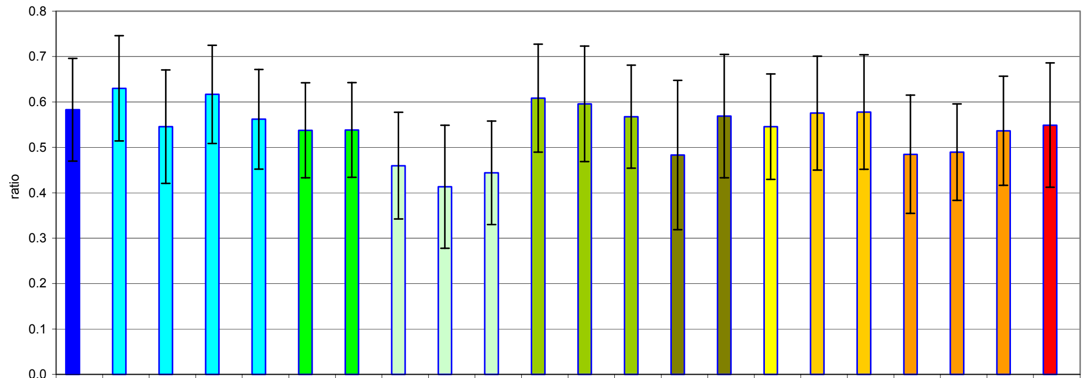
ratios PM10 daily 24hmean/daily 1hMax



	SE	FI	FI	FI	FI	UK	UK	UK	NL	DE	DE	DE	DE	DE	DE	DE	DE	DE	CZ	CZ	HU	ES	ES	ES	ES	ES	ES	ES	PT	GR
Mean	0.50	0.51	0.53	0.56	0.53	0.49	0.62	0.62	0.56	0.62	0.56	0.56	0.60	0.58	0.59	0.58	0.56	0.63	0.56	0.55	0.53	0.48	0.47	0.54	0.46	0.52	0.46	0.54	0.53	0.57
Std. Deviation	0.12	0.12	0.13	0.12	0.14	0.11	0.11	0.10	0.10	0.12	0.12	0.12	0.11	0.11	0.11	0.11	0.11	0.11	0.13	0.16	0.13	0.10	0.11	0.14	0.13	0.13	0.11	0.13	0.10	0.13

traffic sites

ratios PM10 daily 24hmean/daily 1hMax at urban background stations



	SE	UK	UK	UK	UK	NL	NL	PL	PL	PL	DE	DE	DE	CZ	CZ	SI	ES	ES	PT	PT	PT	GR
Mean	0.58	0.63	0.55	0.62	0.56	0.54	0.54	0.46	0.41	0.44	0.61	0.60	0.57	0.48	0.57	0.55	0.58	0.58	0.48	0.49	0.54	0.55
Std. Deviation	0.11	0.12	0.13	0.11	0.11	0.10	0.10	0.12	0.14	0.11	0.12	0.13	0.11	0.16	0.14	0.12	0.13	0.13	0.13	0.11	0.12	0.14

urban background stations

Annex 5 The relation between the two PM_{10} limit values

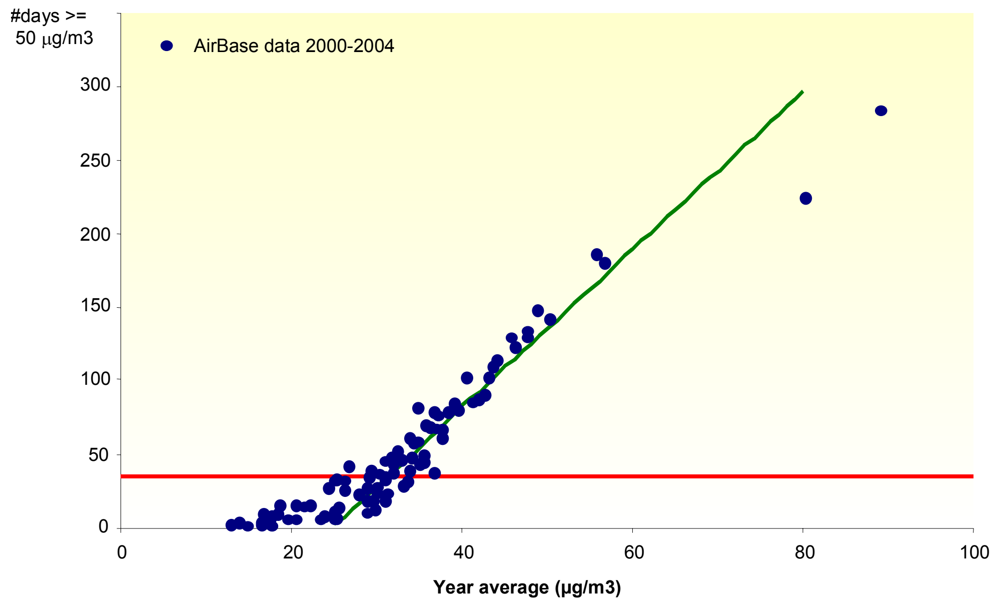
In section 5.2 it was mentioned that there seems to be a fairly generally applicable relation between the year average PM_{10} concentration and the number of days with a daily average concentration above 50 μg/m^3. In the Netherlands this relation was empirically determined as:

Number of exeedences = 5.367 * year average concentration – 132.4

This linear relation is applicable for year average concentrations above 25 μg/m^3 and is applied in some of the air quality models that are prescribed for use in assessment of compliance with the EU directives. In fact, in the Netherlands a lognormal relation exists that applies over the full range of concentrations (Wesseling, p.c.). This is not surprising as lognormal distributions have since long been shown to be a fair approximation of air quality concentration distributions.

The above equation shows that a year average concentration of 31.2 μg/m^{3}corresponds to exactly 35 days with a daily average >= 50 μg/m^3. Various contacts suggested that a value between 30 and 32 μg/m^3 also applied in Belgium, France and Germany. To test this general applicability of a single year average value a sample for a number of years, traffic and background stations and a number of countries was drawn from Airbase and analysed.

The data set includes 12 countries with 12 traffic stations and 11 background stations. The period considered was 2000-2004. Before 2000 there are few PM_{10} measurements. At least 90% of the daily average observations had to be present for the station and the year to be included. This leads to 60 data pairs for the analysis[15]. The results are shown in the graph.



The diverse European data set also seems to adhere to a simple linear relation without too much scatter. The two most deviant points belong to one traffic station. A cross check with other stations from the same country revealed that they did fit in the general pattern. Hence it was concluded that the number of exceedences of the limit value for the daily average concentration can be approximated by a year average concentration and the value of 31μg/m^3 was chosen to be used in the index calculation.

[15] All in all there were 110 data pairs. The results from the full and the restricted set were almost identical.

Annex 6 Description of the CITEAIR project

Introduction

The development of Europe´s urban centres is in many ways linked with the development of sustainable mobility options. Changes in behaviour, economic growth or recession and structure of the population are factors that have an immediate impact on transport and mobility patterns. The EU Air Quality Directives are increasingly devolving responsibility for action to the Cities and regions, where the most complex challenges in transport and environment need to be solved.

Air quality has unquestionably adverse effects on human health. Because the dominant source of environmental impacts in most urban areas is traffic, local and regional authorities must find efficient and integrated solutions for their environmental and traffic problems to increase the quality of life for its citizens. The pressure on European cities and regions to implement the related EU regulations on air quality has led to a multitude of initiatives to develop a concrete sustainability perspective, which compromises between environmental quality and economic growth.

However, the absence of a common approach for the implementation of these regulations has led to isolated solutions, which requires an initiative for a) developing better solutions, b) more efficient solutions, c) solutions that go beyond the obligations of the related EU directives, d) creating synergies and e) sharing the expertise, knowledge and experiences.

The overall objectives of CITEAIR are:

- to jointly develop better and more efficient solutions for assessing the impact of traffic on air quality in large urban areas using Information Society Technologies,
- to inform professional users and the public on the environmental situation based on common guidelines and
- to give guidance on efficient measures to abate adverse environmental situations through close co-operation, experience exchange and joint developments with European Cities and Regions.

The CITEAIR project started in March 2004, and lasted 46 months. It was led by Leicester (UK), supported by Paris (FR), Prague (CZ), Rotterdam (NL), Rome (I), the Region Emilia Romagna (I), Munich (DE), Coventry (UK) The Hague (NL) Bratislava (SK) and Brussels (BE). The project contributes to the development and implementation of efficient solutions to assess and reduce the impact of traffic on air quality in large urban areas. Through close co-operation, exchange of experiences and joint developments between European regions and cities, the project develops solutions to inform the public and local authorities about the environmental situation in a comparable and easy understandable way and offers guidance on efficient measures to reduce environmental damage mainly caused by transport. Other municipalities are encouraged to contribute to the initiative via a user network.

The products

CITEAIR project partners have been working on the development of the following products:

Guidebook on air quality management

Built on experiences in European cities and regions, it identifies gaps in knowledge and strategies in air quality management and proposes solutions for efficient environmental management. The guidebook was developed to inform professional users on efficient abatement measures.

Guidebook on city annual air quality reports

The aim of this guidebook is to recommend a common reporting format for air quality applicable for European cities. The format obviously contains all data that have to be reported under the EU obligations but also suggests additional sections that facilitate the use of the report for city to city comparison and help in making action plans. The ultimate goal is to develop an automated form where the relevant pollutant concentrations can be inserted and a complete report is generated.

Guidebook on communicating air quality

In many cities efforts are being made to inform the public on air quality – which is an obligation under the EU Framework Directive on ambient air quality and under the Aarhus Convention ratified by the EU in 2005 - and to influence behaviours, particularly where traffic is the dominant source of air pollution in urban areas. The guidebook was produced to provide a strategy for disseminating information on air quality. It also contains good practices, which could be used as models for the future.

Comparing air quality across borders (CAQI)

As one of the cornerstones in public information CITEAIR developed the first air quality index for use at the European level. This common air quality index (CAQI) is a set of two indices: one for roadside monitoring sites and one for average city background conditions. Differentiating between roadside and general city conditions is a first step in assuring consistence in the parameters that are being compared. It is not aimed at replacing existing local indices. It is dedicated to comparing air quality in European cities and bringing simple information to the European citizens, easily accessible. The full description of the CAQI is available at http://citeair.rec.org and at www.airqualitynow.eu

The Common Operational Website (COW)

As environment is a theme of high importance, the public should be able to assess to what extent they are affected by air quality. The COW provides an attractive platform to compare air quality in different participating cities in real time applying the CAQI. The COW is operational since March 2006 (www.airqualitynow.eu) and displays data from 21 cities (status July 2007) in real time.

Guidebook on transferring a traffic-environmental models chain

This guidebook allows the transfer of experiences in developing a Decision Support System (DSS) that assesses the environmental impacts of urban traffic in near-real time, from a local scale to a wide area (regional scale). The main asset is a concrete implementation plan for the DSS definition that meets the needs and requirements of the Emilia-Romagna region and represents guidance for future transfers to other European cities and regions.

For more **information** on CITEAIR or to **download** CITEAIR products: http://citeair.rec.org

To **contact** the CITEAIR team: info-citeair@citeair.rec.org.